

GREENWICH ASTRONOMICAL OBSERVATIONS, 1905.

INTRODUCTION.

I. *Personal Establishment and Arrangement.*

At the beginning of the year 1905 the Established Staff in the Astronomical Department of the Observatory consisted of the following persons :—

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

Assistants,—Edward Walter Maunder ; Thomas Lewis ; William Grasett Thackeray ; Henry Park Hollis, B.A. ; Andrew Claude de la Cherois Crommelin, B.A.

Clerical Assistant,—Henry Outhwaite.

Established Computer (Higher Grade),—Charles Davidson.

Established Computers,—William Bowyer ; Herbert Henry Furner ; William Moody Witchell, B.Sc. ; John Storey ; Philibert Melotte ; William Stevens ; William Wood Burkett ; Joseph Edward Evans.

In addition to the Assistants and Established Computers, twenty-five 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.

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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. 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 measurement and reduction of the photographs taken for the Astrographic Chart and Catalogue.

Mr. Davidson has charge of the measurement of the photographs taken with the Thompson Equatorial and the reduction of the measures.

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 were generally made by Mr. Bryant, Mr. Witchell, Mr. Storey, and Mr. Evans. 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 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, or Mr. Stevens.

Observations with the 28-inch refractor were made by Mr. Lewis, Mr. Bowyer, Mr. Furner and M. Van Biesbroeck, who came to the Observatory for some weeks to study methods of observation at Greenwich.

Observations with the Altazimuth were made by Mr. Crommelin, Mr. Furner and Mr. Vagg.

Photographs with the Thompson Equatorial (26-inch refractor and 30-inch reflector) were generally taken by Mr. Dyson, Mr. Davidson, Mr. Edney and Mr. Melotte.

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 1905 :—

W. H. M. Christie	WC	C. Davidson	- - CD	H. W. Moore	- HM
F. W. Dyson	- D	D. J. R. Edney	- DE	R. Fowler	- RF
P. H. Cowell	- C	W. Bowyer	- WB	R. T. Cullen	- RC
E. W. Maunder	- M	H. H. Furner	- HF	S. Daniels	- SD
T. Lewis	- - L	W. M. Witchell	- W	E. V. Vagg	- V
W. G. Thackeray	- T	J. Storey	- JS	A. W. James	- J
H. P. Hollis	- - H	W. Stevens	- WS	J. Shepperd	- S
A. C. D. Crommelin	AC	P. Melotte	- PM	B. D. Evans	- BE
W. W. Bryant	- B	J. E. Evans	- E		

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 dismantled 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 dismantled, 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 old altazimuth.

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

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

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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 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, Microme- ter Head to Right.	Vertical Error, Microme- ter Head Above.	N. P. D. Pointer Reading.	Horizontal Error, Microme- ter Head to Right.	Vertical Error, Microme- ter Head Above.	N. P. D. Pointer Reading.	Horizontal Error, Microme- ter Head to Right.	Vertical Error, Microme- ter Head Above.	N. P. D. Pointer Reading.	Horizontal Error, Microme- ter Head to Right.	Vertical Error, Microme- ter Head Above.
0	"	"	0	"	"	0	"	"	0	"	"
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 in the *Transit-Circle Tables* 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 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 $2\frac{3}{4}^{\circ}$, 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. $67\frac{1}{4}^\circ$, 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 $5\frac{1}{2}^\circ$ 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

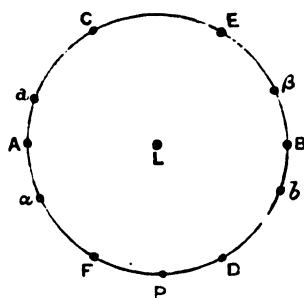
is then made by bringing, by means of its R.A. micrometer, the central vertical wire several times in succession upon the proper point of the image of the nearly vertical wire of the north collimator, and several times upon the corresponding point of the south collimator, and reading the micrometer for 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 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.

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 electric 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. Provision is made for ten micrometer-microscopes and a pointer-microscope, arranged in the following order:—



L is the electric light for illumination. P is the pointer-microscope furnished with an eyepiece of low power 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 determinations of 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. For 1898 and subsequent years, and in the Star Catalogue and Planetary Results for 1897

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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 to the end of 1896 and in the earlier sections in 1897, and the mean of the three for 1898 and subsequent years, and 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 the *Introduction* for 1897.

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 in 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* at the end of the *Introduction* 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 the *Introduction* for 1896, 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 eyepiece 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, $0^{\circ}.050$ 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. For stars within 15° of the pole, it has been the practice since 1899 to take transits over one of the wires at different settings of the transit micrometer, as stated in the footnotes, the slide carrying the wires being moved by means of the micrometer screw and the readings noted by the observer. For stars

within 3° of the pole (except the nine azimuth stars), the transits are observed by eye-and-ear, the chronograph being used for all other stars, including the nine azimuth stars. During the transit, by means of the zenith distance micrometer, the horizontal wire is made to bisect the star near the passage over one or more of the vertical wires, and punctures are made on the drum of the micrometer. The corresponding readings of the micrometer are then taken, and the vertical wires to which they correspond noted and the pointer and the six microscope-micrometers read. 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 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 circumpolar), 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 limbs for north polar distance. The assistance of a second observer is required to read the microscope-micrometers while the observer at the eye end of the telescopes makes the horizontal wire touch the limb with the telescope-micrometer and observes the transits. In observing the Moon two observers are required when the north polar distances of both limbs are observed. When the Moon is past full the observer reads the circle beforehand so that as soon as the punctures are made on the micrometer register he is able to unclamp and move the telescope and observe the transit of the second limb.

The Chronograph.—A detailed account of this apparatus, illustrated by engravings, is given in the *Appendix to Greenwich Observations* 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 is fully described in the *Introduction* for 1899 and previous years.

The Old 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, was in use till 1897 November 29, when observations with it were discontinued.

The New Altazimuth was constructed and erected by Messrs. Troughton and Simms in 1896, but was not brought into regular use till 1899, as it was found that various structural modifications were required particularly in regard to the arrangements for relieving the friction on the Y's.

This Altazimuth is virtually a reversible transit-circle (of Messrs. Troughton and Simms' well known form with some improvements), which can be planted in any definite azimuth (say 0° , 45° , 60° , 70° , 80° , 90° E. or W.), and then used for a complete set of observations (including stars for clock and azimuth error) essentially as a transit-circle, giving directly azimuth and zenith distances for the same instant of time. This is arranged by mounting the iron supports of the transit-circle on a circular base resting at three points of its circumference on a circular casting planed on its upper surface. The change from one azimuth to another is effected by turning the instrument about a central pivot on which it is slightly raised, the weight being relieved by friction rollers near the circumference of the circular base.

For observations in the meridian, the instrument is used exactly in the same way as a transit-circle.

The principle of the method of observing when out of the meridian is to secure observations of azimuth and zenith distance such that the mean of the times is as nearly as possible the same for the two sets of observations. Transits are taken over vertical wires and over horizontal wires so arranged as to secure complete observations in both elements in the different azimuths. The near agreement of the means of the times of transit is obtained by providing in addition to the systems of vertical and horizontal wires (each carried on a micrometer slide) a wire carried by a position circle micrometer which is set before the observation to the approximate inclination of the path of the object to be observed. When the star or other object enters the field the telescope is moved in zenith distance till it is on the position wire; the telescope is then clamped, and the transits are observed across a series of vertical and horizontal wires symmetrically with respect to the centre, as the star moves in its oblique course through the centre of the field, the position wire (which is only used for setting) having been previously moved away from the star.

The tube and axis of the telescope are made of phosphor-bronze, the axis and central part of the telescope tube being in one casting. This central part is barrel-shaped (instead of being in the form of a cube as in the transit-circle), and is stiffened inside by diaphragms so as to minimize flexure of the axis. A clear aperture of 6 inches diameter is made in it on each side, to admit of one collimator being viewed by the other when the telescope is in a vertical position. The two portions of the telescope tube, which are exactly alike and are slightly conical, are bolted to the central casting. Two zenith distance circles are provided, one of which is fixed while the other can be turned on the axis and, by means of a clamp and slow motion, fixed in any position, so that it may be made available for the determination of division errors by comparison of corresponding angular intervals on the two circles. These circles are discs of phosphor-bronze 3 feet in diameter, the divisions being on thin bands of palladium silver alloy let into the face of the bronze discs.

The pivots are of steel, and of 6 inches diameter. They rest on segmental bearings of bell-metal. The weight of the instrument on the Y's is relieved by live rings (ball bearings) round the axis, suspended freely by strong springs carried by the iron supports of the instrument, an arrangement which was substituted with success for the friction-rollers with upward thrust, originally supplied, as these were found to cause torsion in the axis and bearings.

Each circle is read by four microscopes. To carry the microscopes two broad wheels made of bronze are fixed to the iron supports of the instrument, the centres of the wheels being in the axis of the telescope. These wheels are screwed to the iron supports and are in addition pinned near their centres to prevent any possibility of movement.

As previously stated the instrument is reversible in its Y's. The counterpoise springs with the live rings are carried by the reversing gear during reversal so as to avoid the necessity for removal and readjustment of these springs. Another form of reversal of the instrument is obtained by turning it through 180° in azimuth, so that there are in all four essentially different positions in which it may be used.

The object glass is of 8 inches aperture and 8 feet focal length. The full aperture is always used. The magnification employed is 168 for stars, and 180 for the Sun.

The instrument is provided with two collimators in the meridian, each of 6 inches aperture and of 69 inches focus. They are each mounted on two pairs of parallel arms (counterpoised) turning about centres below, so that they can be brought up into the position for observation, or lowered to be clear of the telescope and dome, when they are housed under hinged flaps.

The situation of the Altazimuth is about half-way between the Old Observatory and the New Building. Its exact position relative to the centre of the transit-circle is 141 feet ($= 0^{\circ}15$) E. and 166 feet ($= 1''67$) S. It is mounted on a pier of concrete, 20 feet above the ground and has a clear view all round. This pier, which is quite clear of the observing floor, rises from a large concrete foundation, 6 feet deep, on which the whole building rests. The dome is built in two halves which can be opened to a clear width of $4\frac{1}{2}$ feet, and is capable of rotation, so that the opening may be in any required azimuth.

The Chronograph used with the New Altazimuth since 1900 March, was made by Sir Howard Grubb. The barrel is of the same dimensions as for the Transit Circle Chronograph, $19\frac{3}{4}$ inches long and $11\frac{3}{4}$ inches in diameter, revolving once in 2 minutes, so that 1 second of time is represented by a space of 0.3 inch on the sheet; one sheet will take a run of about 6 hours. The registration both of clock-signals and of observations is made by means of a single stylographic pen which, through the action of an electro-magnet, taps the slowly rotating barrel lightly, and leaves a dot of ink on the paper, when the circuit is completed, whether by the observer or by the Standard Sidereal Clock. The barrel is turned smoothly by a driving-clock of the usual form, without electric control, uniform motion between the clock-taps being the essential condition in this case. Four chronograph barrels, which can readily be interchanged, are provided. The chronograph is mounted in the ground floor of the Altazimuth Pavilion.

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 *Greenwich Observations* 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 about 18 feet south-west of the transit-circle.

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 $1\frac{1}{2}$ 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 *Greenwich Observations* 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 ins. focal length was made by Sir Howard Grubb from discs supplied by Messrs. Chance, of Birmingham, and was brought into use at the end of 1893. 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 6½ 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 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

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to accommodate the 28-inch refractor, the diameter being 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 wheels running freely on the horizontal surface of the wall-curb.

The Thompson Equatorial, made by Sir Howard Grubb.—This instrument, carrying a 26-inch photographic refractor and a 30-inch reflector on the same mounting, was presented to the Observatory by Sir Henry Thompson, and was brought into use at the end of 1898. It is erected on the central tower of the New Observatory building under the 30-feet dome, and is approximately 350 feet south and 224 feet east of the centre of the transit-circle. The equatorial mounting, which is of the German form, modified to allow of complete circumpolar motion without reversal, carries on one end of the declination axis the 26-inch photographic refractor, the Merz $12\frac{3}{4}$ -inch refractor (used as a guiding telescope), and the 9-inch photoheliograph; and on the other end the 30-inch Cassegrain reflector (made by Dr. Common), with a 6-inch refractor as a guiding telescope.

The instrument is driven by a clock with electrical control similar to that of the Astrographic Equatorial.

The 26-inch Refractor is a photographic telescope of 26 inches (0·66 metre) aperture and of 22 feet 5 inches (6·83 metres) focal length, so that its scale is double that of the Astrographic refractor, and one millimetre on the photographic plate represents $30''\cdot2$. The breech end of the instrument is arranged for a plate-carrier taking photographic plates 12 inches square, suitable adapters being inserted when smaller plates are used.

The *Merz Refractor*, of 12·8 inches aperture and 17 feet 10 inches focal length, is mounted as a guiding telescope to the 26-inch, and is above it when the instrument is pointing south, and the 26-inch is on the west of the pier of the equatorial. The eyepiece of the Merz is mounted on cross-slides (parallel and perpendicular to the equator) which permit of a guiding star being observed at a distance of 45' from the centre of the field, and are furnished with scales divided to minutes and read by verniers to 5".

The Thompson Photoheliograph, presented to the Observatory by Sir H. Thompson in 1891, is a photographic refractor by Sir H. Grubb of 9 inches aperture and 8 feet 10 inches focal length, with a Ross enlarging doublet of 4.3 inches focus. Its tube is mounted on the 26-inch refractor on the side opposite the Merz refractor. The image of the Sun in the primary focus is 1 inch in diameter, and this is enlarged by the doublet to about 7.4 inches on the photographic plate, the whole length of the instrument being about 12 feet 4 inches. At the principal focus cross spider-lines are placed, which give facilities for determining the position angles of sun-spots on the photographs. The exposure is given (as in the Dallmeyer photoheliograph, *see* page xxi) 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 a strong spring, in the Thompson, 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. This telescope is also provided with a 9-inch object-glass prism by Mr. Hilger.

The 30-inch Reflector.—This instrument was constructed under the supervision of Dr. Common who undertook the figuring of the mirrors. It may be used as a simple reflecting telescope for obtaining photographs in the principal focus, or as a Cassegrain. The mirrors are made of silver on glass, the concave being of 30 inches diameter, with a circular hole of 6 inches diameter. The weight of this mirror is 265 lbs., the glass of which it is composed being 4 inches thick. When not in use, it is covered by a plate-glass disc, with a hinge on one side which allows of its being turned so as to lie along the telescope tube (made D-shape to receive it) when observations are taken. The focal length of the large mirror is 3.48 metres or 11 feet 5 inches, so that 1^{mm}. at the principal focus corresponds to 59".3. Two convex mirrors of focal lengths 24 inches and 38 inches are provided, the equivalent focal lengths of the combinations being 76 feet and 49 feet respectively.

The convex mirror, or the photographic plate-holder, is carried by an arm mounted in a slide so that it can be fixed in a convenient position, and the final adjustment for focus can be made from the eye-end by means of a rod with geared wheels actuating a screw in the boss of the arm, which gives a small motion to the mirror or plate-holder.

The Hodgson 6-inch Refractor, of 7 feet 7 inches focal length, is mounted on the reflector as a guiding telescope. It is furnished with cross-slides like the Merz and Astrographic refractors. The scales on the slides are read by verniers to 5".

The dome was constructed by Messrs. T. Cooke and Sons, of York, in 1884, and was formerly used for the Lassell reflector. It is hemispherical, of 30 feet diameter,

and is covered with papier-mâché on a framework of angle-iron. It is carried by nine wheels or rollers (each 2 feet in diameter) fixed to the iron curb of the dome, and running on a flat rail, horizontal rollers being provided to prevent excessive lateral motion from the force of the wind or other cause, and it can thus be turned with great ease. The shutter-opening extends from beyond the zenith to the horizon, and is closed by a single curved shutter (3 feet 6 inches wide at the zenith, and 6 feet wide at the horizon), which turns about a point in the dome-curb opposite to the opening, and runs on guiding rails at the horizon and near the zenith, the curved shutter being continued by an open framework to complete the semicircle. The dome was erected on the central tower of the New Observatory building in 1896 September.

The Astrographic Telescope, of 13 inches aperture 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, and was brought into use at the end of 1890. 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 $0^m.33$, or $13^m.0$, and $10^m.0$ respectively, and the focal lengths of both telescopes $3^m.43$ or $135^m.1$, so that $1^{mm}.0$ on the plate corresponds to $1'.0$. [The focal length of the photographic telescope is more exactly $3^m.441$ or $135^m.4$, so that 1^{mm} represents $0'.9990$.] 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, so arranged 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 Sir David 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 telescope is also provided with an electric hand control, by means of which the observer can accelerate or retard the motion in right ascension and thus keep the guiding star bisected in the guiding telescope.

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 8 inches on the camera screen, where the sensitive plate is inserted, the whole length of the instrument being about 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. The instrument is equatorially mounted and provided with a driving clock.

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 Reflectors*, 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" 6-inch 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 a clear 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, 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.

The Sidereal Standard Clock, constructed by Messrs. E. Dent and Co., is fixed to the north wall of the Magnet-house 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[·]3 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 drives a galvanic chronometer placed, in the computing room, on the desk of the Superintendent of the Time Department; and the third is available for use in the Transit Pavilion. No practical difficulty is found in sub-dividing 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 below.

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 New Altazimuth dome, marked "Graham 1," with a mercurial pendulum; in the Thompson Equatorial dome, one marked "Dent 2016," with a zinc and steel pendulum and seconds' contact; and one marked "Graham 2," fitted with contact springs and with a zinc and steel pendulum, which is available for use in longitude determinations; 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 "Molyneux," with a wooden-rod pendulum in the Reflex Zenith-Tube room.

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 two relays, by means of which various electromagnetic 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; four are in the chronometer rooms, and are used in the daily comparisons of chronometers; one is in the upper computing room; one (of the dimensions of a chronometer) is upon the desk of the Superintendent of the Time Department; one is in the hall of the Astronomer Royal's dwelling-house and four are in the office rooms of the New Observatory building. A comparison of the mean time chronometer with the chronometer on the same desk synchronous with the sidereal standard clock (as mentioned

MEAN SOLAR CLOCK.

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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. The reversal of the current was found to be unnecessary and has been discontinued. 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.0, and the Portsmouth clock at 1^h. 0^m. 20^s.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:—
 "Mudge and Dutton," with a gridiron pendulum, in the upper chronometer room;

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"Dent 2014," with a wooden-rod 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 above). 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 2" 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 1905.*

Transit-Circle—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 is considered essential to maintain continuous observation of all stars in the *Nautical Almanac*, and *Connaissance des Temps* and all stars of fourth magnitude or brighter, visible in this latitude.

The other stars observed since the beginning of 1897 are taken from a 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, and Moon-culminating stars from the list in the *Appendix to the Nautical Almanac* for 1897.

The *Altazimuth* has been used in the meridian for observations of the Sun, Moon, planets and fundamental stars. Out of the meridian the instrument was generally used for the Sun, Moon and planets, and the necessary adjustment stars.

The Reflex Zenith tube.—Regular observations with this instrument were recommenced in June 1902. A working catalogue has been constructed of stars down to magnitude 7.0 which transit within 50' of the zenith at Greenwich, and stars were observed from this list continuously throughout the year with the object of determining the variation of latitude as well as the constants of aberration and nutation.

The Sheepshanks Equatorial has been used for observing occultations of stars by the Moon.

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

The Thompson Equatorial has been used for taking photographs of Neptune and its satellite with the 26-inch refractor, and of Comets α 1904, e 1904, a 1905, b 1905, and c 1905, and Minor Planets, and of Jupiter's Sixth and Seventh satellites with the 30-inch reflector.

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

The Astrographic Equatorial.—The photography for the Greenwich Section of the Astrographic Chart having been completed, work with this instrument has been mainly confined to replacing Chart plates which were inferior to the general standard.

In connection with the observations of Jupiter's Sixth and Seventh satellites with the Thompson Equatorial, a number of photographs of Jupiter were taken to determine the error of its Tabular place, also some fields of the reference stars used for its satellites.

The 10-inch guiding telescope has also been used for observing occultations of stars by the Moon.

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*.

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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 disc 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. xxxii. In the case of the Moon, observations of the crater Mösting A have been made as well as of the limbs whenever observable. 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 Radcliffe Catalogue (1845).
11. The No. in Carrington's Red Hill Catalogue.
12. 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."
13. 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 Catalogues of the *Astronomische Gesellschaft* (1875).

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 *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 azimuth stars 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 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 com-

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mutator 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 selected readings of the transit-micrometer. The actual readings are always mentioned in the notes.

The eye-and-ear method of observation is exclusively employed for stars, not being adjustment stars, within three degrees of the pole.

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 been observed over an unsymmetrical group of wires, corrections are applied to reduce each separately to the centre wire. When transits have been observed over all the wires, or over a selection of wires symmetrical with respect

to the centre wire, the necessary small correction is applied to the mean of the observed transits.

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), 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.

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

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

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 disc (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 $\frac{4}{3\pi}$ ($=0.424$) $\times$ 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 $0.4 \times$ 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 on page vii. 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 of the central wire 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 $+ 0^{\circ}.008$ 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. (See *Introduction to Greenwich Second Ten Year Catalogue* for 1890, p. 4.)

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. The algebraical excess of the reading for collimation above this is the error of collimation, with the sign as explained above, one revolution of the screw being equal to $37''.10$. To the excess thus converted into arc is then applied $-0''.19$ 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 this 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 middle wire as seen by reflexion from the surface of quicksilver coincide with the wire as seen directly, as is explained in the description of the instrument above, and in 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 $37''.10$ for 1^{rev} . The mean of the results is adopted sometimes for a longer or 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 three times 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

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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 :—

The error actually investigated is the error at the pole, usually denoted by the letter n , and not the error at the horizon or azimuth. Each of the nine circumpolar stars that may have been observed is reduced separately, and the following process is used :—The observation of the circumpolar star and a clock star (the nearest in right ascension that has been observed) being corrected for “reduction to centre wire” and for collimation error (but not level error), and denoting by m the instrumental errors at the equator and by E the clock error, then for each star—corrected time of transit $+ \frac{1}{15} n \cot \text{N.P.D.}$ $+ m + E$ = apparent tabular right ascension for the day, and hence by a subtraction it follows that n multiplied by the difference of value of the factor $\frac{1}{15} \cot \text{N.P.D.}$ for the two stars is equal to the difference for the two stars of the excess of the tabular R.A. over the corrected time of transit. On a few rare occasions it is necessary to apply a correction for the change in clock error between the two observations. The level and n being thus found from observation and their values being adopted by taking means of the groups into which the observed values appear to fall, the azimuth error and m are found by the formulæ

$$\begin{aligned} \text{Azimuth error} &= -n \operatorname{cosec. colat.} + l \cot \text{colat.} \\ 15 m &= -n \cot \text{colat.} + l \operatorname{cosec. colat.} \end{aligned}$$

The corrections are applied by the formula $\frac{1}{15} n \cot \text{N.P.D.} + m$.

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 and azimuth errors, 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 *Standard Mean Right Ascensions of Clock Stars based on 12-hour groups for 1890* printed in the Introduction to the *Second Ten Year Catalogue of Stars for 1890* (Appendix to *Greenwich Observations*, 1898), by the use of the precessions of that Catalogue. Since 1903 a correction of $+0^{\circ}.054$ has been applied to reduce the right ascensions to the Equinox of Prof. Newcomb's *Catalogue of Fundamental Stars* for 1900, this correction being sensibly the same as that resulting from observations of the Sun from 1886–1902. 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 Prof. Newcomb's proper motion has been used. For Cephei 51, the proper motion is taken from Prof. Auwers' *Catalog der Fundamental Sterne*, and for α Columbæ and δ Sculptoris from Prof. Auwers' *Fundamental-Catalog für Zonenbeobachtungen am Südhimmel und südlicher Polar-Catalog für die Epoche 1900* (*Astronomische Nachrichten*, Nos. 3431–2). The corrections necessary to bring up the stars' right ascensions to the day of observation are taken from the *Nautical Almanac* (with the exception of Groombridge 3548, for which the *Connaissance des Temps* is used), but corrections to the *Nautical Almanac*, published by the *Nautical Almanac Office* in a separate pamphlet, have been employed in order to continue the use of the Struve Peters Constants which were replaced in the *Nautical Almanac* in 1901, by the Constants adopted at the Paris Conference on Fundamental Stars, 1896. In the *Transit-Circle Tables*, at the end of this *Introduction*, are given the Mean Right Ascensions for 1905.0 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 1905.0.

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.

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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. For the determination of clock-rate, the clock errors found by each observer are corrected for that observer's personal equation, Mr. Bryant being taken as the Standard Observer. The values of the personal equation are derived from the observations of the previous year. 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, 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 one observer, and the other object by another, a correction for personal equation is required. 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 1905 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. These personal equations have been applied to the collected results of transits for the Sun, Moon, and planets, whenever they were needed throughout the year 1905. But those used in the adoption of clock-rate as explained on page xxxvi, referred to Mr. Bryant as

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standard, have been deduced from the observations in 1904. The investigation of these is given in the *Introduction to the Greenwich Astronomical Observations* for last year.

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*.

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:—

Mr. Bryant	$+0^{\circ}03_{11}^s$	Mr. Cullen	$-0^{\circ}02_{11}^s$
Mr. Furner	$-0^{\circ}03_3$	Mr. Daniels	$+0^{\circ}01_{11}$
Mr. Witchell	$-0^{\circ}02_{16}$	Mr. James	$-0^{\circ}03_{16}$
Mr. Storey	$-0^{\circ}11_{13}$	Mr. Shepperd	$+0^{\circ}03_{11}$
Mr. Evans	$-0^{\circ}02_{15}$		

The subscript numbers denote the number of observations on which the respective corrections depend.

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

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

For Mösting A the correction to reduce to the centre of the Moon has been obtained by interpolation with second differences from the *Berliner Jahrbuch*.

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*,

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vol. xxv. No. 3. The correction, which has been applied additively to the Nautical Almanac semidiameter during the year, is :—

$$+ 0.026 + 0.027 \times \text{tabular duration of passage of semidiameter.}$$

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 few 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 six clock-stars, distributed over six hours of right ascension, have been observed : no result is set down for an azimuth star unless at least three of the nine azimuth stars have been observed above pole, and three below pole, and no result is set down for other close circumpolar 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. On all days the view is taken through the pierced cube of the transit-circle. On Mondays the transit-circle is raised,

TRANSIT-CIRCLE.—ERRORS OF COLLIMATION, LEVEL AND AZIMUTH. xxxix

and observations are taken with an uninterrupted view of the S. collimator by the N. collimator as well as through the cube.

Immediately before the observations of the collimators with the transit-circle for determination of collimation-error, six readings of the micrometer of the N. collimator, for coincidence of the middle of the nearly vertical side of its square with the corresponding point of the square in the S. 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 xxxii). 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 " $+ 0.16 \times$ excess of first reading over second reading of N. collimator for coincidence with S. 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 $+0.008$ 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 -0.19 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 was the practice for a number of years, 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 xxxiii). 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. xxxiv. The first three columns require no explanation. In the fourth column is given the value of $\frac{1}{15} \cot N.P.D.$ for each polar and clock-star. The difference of the two quantities in the third column divided by the difference of the corresponding quantities in the fourth column is the value of n given in the fifth column. In the sixth column is given the adopted value, usually the mean of a number of separate determinations. The resulting error of azimuth in the seventh column is found from the adopted values of the level and n by the formula.

$$\text{Error of Azimuth} = \text{Error of level} \times \cot. \text{ colat.}, - n \operatorname{cosec} \text{ colat.}$$

§ 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. 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. Mösting A denotes the crater of that name on the Moon. The words Wire R 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 xi. 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 $\begin{smallmatrix} A, C, E \\ B, D, F \end{smallmatrix}$; 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

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f

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.

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 $29^{\circ}3$. Now, if the correction, by the addition of which each revolution of a micrometer may be converted into a minute of arc, were exactly $\frac{1}{30}$ part of the reading, then the sum of the runs would be $\frac{50}{51} \times 30^{\circ}000$, or $29^{\circ}4118$. If the sum of the runs is not exactly equal to this quantity, there will be a variable correction after adding $\frac{1}{30}$ part of the mean of the readings of the microscopes. To determine this quantity, let the sum of the runs

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FLEXURE: READINGS OF TELESCOPE-MICROMETER.

be $29^{\circ}.412 - x$. 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

$$r'' \times \frac{30.000}{29.412 - x}$$

or
$$r'' \left\{ 1 + \frac{1}{50} + 0.03468 \times x \right\}$$

Hence the correction, after adding $\frac{1}{50}$ part of the mean of readings, will be $+ r x \times 0.03468$. When the four supplementary microscopes are used these rules are modified.

CORRECTIONS FOR ERROR OF DIVISION AND FOR FLEXURE OF TELESCOPE.—The corrections for errors of division are the means of the determinations made in 1856, 1871, and 1898 for every 5° , and of those made in 1851, 1856, and 1898 for every 1° .

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 the 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 on the eye-end 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° 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 $1^{\text{rev.}}$ of this screw are given in the *Transit-Circle Tables*, 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 $1^{\text{rev.}}$ 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 $1^{\text{rev.}} = 37''.05$. 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

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CIRCLE-READING : ZENITH POINT CORRECTION. xlv

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) $\times \sin 2$ N.P.D. $\times t^2$, 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*) $\times$ sec. declination $\times \frac{\sin \text{Geoc. Z.D.}}{\sin \text{App. Z.D.}} \times \frac{14.8}{3600}$ (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 correction for division error, 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 $-0''.25$ has been applied to the nadir-observations in forming the adopted zenith-point, when there

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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	1893	— 0"34	1900	— 0"39
1887	+ 0"01	1894	— 0"27	1901	— 0"29
1888	— 0"12	1895	— 0"31	1902	— 0"20
1889	+ 0"07	1896	— 0"34	1903	— 0"23
1890	+ 0"08	1897	— 0"27	1904	— 0"41
1891	+ 0"07	1898	— 0"36	1905	— 0"22
1892	— 0"26	1899	— 0"41		

In consequence of the discordance shown in 1892, the errors of the microscope-micrometer-screws were re-determined 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 the years 1895 to 1905 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
1898	+ 0"16	0"00	+ 0"11	104
1899	+ 0"17	0"00	+ 0"19	152
1900	+ 0"14	0"00	+ 0"05	118
1901	+ 0"17	0"00	+ 0"09	123
1902	+ 0"20	0"00	+ 0"17	97
1903	+ 0"04	0"00	+ 0"09	103
1904	+ 0"06	0"00	+ 0"15	79
1905	+ 0"13	0"00	+ 0"04	74

The + sign indicates a greater circle-reading.

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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 1903, with the observations of 1901, it appears that the probable error of a complete determination of zenith-point (four stars and three nadir observations) is about $\pm 0''.11$.

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

$$\tan \theta = \operatorname{Cosec} P. \cos \delta_m. \tan \delta_s - \cot P. \sin \delta_m;$$

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

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

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

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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.

$$\text{Then} \quad \tan \delta_1 = \tan \delta_m \cdot \cos MP S_1.$$

$$\text{And} \quad \theta_1 = \delta_s - \delta_1.$$

$$\begin{aligned} \text{Also} \quad \sin \theta &= \sin \theta_1 \cdot \sin MS_1 P. \\ &= \sin \theta_1 \frac{\sin MP}{\sin S_1 P} \\ &= \sin \theta_1 \frac{\cos \delta_m}{\cos \delta_1}. \end{aligned}$$

From which θ is found.

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

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

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 $\times \sin \theta$; 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

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

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

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AND PLANETS: BAROMETER AND THERMOMETERS.

by an observer anywhere in the plane of this great circle, and the correction therefore will be

$$\text{Planet's semidiameter} \times \text{versin } \phi.$$

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 page xxxii.

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 the latest comparisons with the Standard Thermometer which agree well with previous determinations.

1904 July 5.

Temperature.	Error.
32° 1	+ 0° 1
50° 2	+ 0° 2
65° 0	+ 0° 3
72° 5	+ 0° 3
84° 8	+ 0° 2
94° 1	+ 0° 3

A correction -0.2 has been applied to the exterior thermometer from 1897 January 1.

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

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The following are the results of comparisons with the Standard Thermometer made on 1904 July 5.

Temperature.	Error.
°	°
32.7	+ 0.7
51.4	+ 0.8
65.5	+ 0.8
72.9	+ 0.7
85.2	+ 0.7
94.5	+ 0.6

A correction of $-0^{\circ}.5$ has been applied to the readings of the Interior Thermometer from 1889 March 15 to 1894 December 31, and of $-0^{\circ}.6$ from 1895 January 1.

Previous to its removal to the new Magnetic Pavilion the Meteorological Standard Thermometer was read at noon by the Transit-circle observer for comparison with the Exterior Thermometer. Since 1899 July 12, readings of this thermometer have been made each day at Apparent Noon as well as Mean Noon by the Meteorological observer. A comparison of the readings of the Exterior Thermometer and the Meteorological Standard is given in the *Transit-Circle Tables*.

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*, 1898. When the zenith-distance exceeds 85° 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:—

$$\log. \text{ parallax} = \log. \sin (\text{Z.D.} - 11'.12'') + \text{ar. co. log. distance} + 0.94596.$$

TRANSIT-CIRCLE.—PARALLAX : SEMIDIAMETER.

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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 :—

$$\text{Parallax} = \text{Hor. Equat. Par. from N.A.} \times \text{Sin Dist. from Geoc. Zenith} \times \text{Geocentric Radius (Log. = 9.9991136)} + \text{Corr. derived from the following table :—}$$

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

The correction tabulated above is the sum of two corrections, of which the first is due to the difference in parallax between the limb and centre of the Moon ; and the second is 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 Mösting A the log sine horizontal equatorial parallax of the crater is obtained by interpolation from the *Berliner Jahrbuch*.

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, the subscript numbers denoting the number of observations on which they depend :—

Mr. Bryant	— 0".41 ₁₁	Mr. Cullen	— 0".27 ₁₂
Mr. Witchell	+ 0".07 ₁₉	Mr. Daniels	— 0".02 ₁₄
Mr. Storey	— 1".85 ₁₆	Mr. James	+ 0".41 ₁₈
Mr. Evans	+ 0".01 ₁₇	Mr. Shepperd	+ 0".28 ₉

For Venus the correction $+ 0''.392 + 0.027 \times$ tabular semidiameter, derived from an investigation mentioned at page xxxviii, 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.

For Mösting A the correction to reduce to the centre of the Moon has been obtained by interpolation from the *Berliner Jahrbuch*.

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 $38^{\circ}.31'.21''.90$.

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

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 $\frac{50}{51} \times 30^r.000$, or to $29^r.4118$; 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 $29^r.4118$, is computed in the way that has been explained (page xlii).

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 xlv. 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. cxi-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 to 1898 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* for the years 1895, 1896, 1897, and 1898, together with a comparison with the R—D discordance obtained in the usual way.

§ 5. *Ledgers of Mean Right Ascensions and Mean North Polar Distances of Stars.*

The mean right ascensions and mean north polar distances for the beginning of the year 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. In the case of the North Polar distances a further correction for latitude variation has been applied since 1902.

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 *Éphémérides des Étoiles de Culmination lunaire et de Longitude*, 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.

In the case of Sirius and Procyon, the *Nautical Almanac* apparent place takes account of orbital motion, and the quantities given as star corrections include proper motion and orbital motion for the fraction of the year.

For other stars, star constants are formed for 1900.0, and the star corrections are computed by multiplying these by the day numbers with the help of Crelle's or Cotsworth's multiplication tables, thus avoiding the necessity for the use of logarithms.

The logarithms of the day numbers with the Struve Peters' values required for use are given in the American Ephemeris for mean midnight of each day at Washington, and it has been the practice to interpolate values of these quantities to within at least two hours of the time of observation. The additional correction depending on the longitude of the Moon is only taken into account for those stars for which apparent places are given in the ephemerides for every day of the year.

The proper motion for the fraction of the year elapsed since the beginning of the year is also applied in computing the R.A. and N.P.D. for 1905.0. The proper motion adopted is given in the *Catalogue of Mean R.A. and N.P.D.*

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. 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 xxviii, but they are more rigorously followed.

§ 6. *Catalogue of Mean R.A. and N.P.D. for 1900·0 of Stars observed in 1905.*

The mean right ascensions and north polar distances of stars observed in 1904 have for convenience been reduced to 1900·0, the epoch of the new Nine-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) corrected 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 $38^{\circ}.31'.21''\cdot90$, have been used in the reductions. From 1902 corrections have been applied for latitude variation. 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.

In the case of Sirius and Procyon, corrections have been applied to represent the orbital motion from the beginning of the year to the epoch of the catalogue.

The precessions and secular variations for 1900 have been computed with Struve's constants of precession.

The adopted 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 xxviii.

§7. *Horizontal and Vertical Diameters, Right Ascensions, and North Polar Distances of the Sun, Moon, and Planets, deduced from the Observations, and compared with the 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 118 measures of the value of this error made during the year is $+0^{\circ}037$. The values obtained by the several observers are given on p. xxxvii.

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 130 measures of the value of this error made during the year is $+0''31$. The values obtained by the several observers are given on p. li.

For the duration of the passage of the Moon's diameter, the correction for defect of illumination is investigated as on p. xxxi. There was no determination of the error of the Moon's tabular duration of passage made in this year.

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 xlvii). The mean of 4 determinations of the error of the Moon's tabular vertical diameter made during the year is $-0''70$.

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, Mars, and Jupiter 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 xlvii. The vertical diameters of the other planets are obtained in a similar way, excepting that there is no correction for defective illumination.

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 xxxvii. 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.

The following are the values of the mean error of tabular right ascension of the Sun's centre (mean of two limbs) found by the different observers:—

	AC	B	W	JS	E	RC	SD	J	Other Observers.
	^s	^s	^s	^s	^s	^s	^s	^s	^s
1905	— 0.16 ₂	+ 0.05 ₁₀	— 0.04 ₁₆	— 0.01 ₁₃	— 0.03 ₁₅	— 0.02 ₁₁	— 0.15 ₁₀	+ 0.11 ₁₅	0.00 ₂₁

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 following are the values of the mean error of tabular N.P.D. of the Sun's centre (mean of two limbs) found by the different observers:—

	AC	B	W	JS	E	RC	SD	J	Other Observers.
1905	— 0.46 ₂	+ 0.33 ₁₁	+ 0.19 ₁₈	— 0.72 ₁₆	+ 0.17 ₁₇	— 0.39 ₁₂	— 0.69 ₁₄	+ 0.01 ₁₈	+ 0.20 ₂₁

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 xxxi) is first applied to the proper limb, and the mean of the two is then taken without any further alteration.

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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 following are the values of the mean error of tabular right ascension of the Moon's centre, from observations of the first and second limbs, found by the different observers :—

Moon 1 L.							
	B	W	JS	E	RC	SD	Other Observers.
1905	$-\overset{s}{0\cdot36}_8$	$-\overset{s}{0\cdot41}_{13}$	$-\overset{s}{0\cdot46}_9$	$-\overset{s}{0\cdot50}_{12}$	$-\overset{s}{0\cdot55}_7$	$-\overset{s}{0\cdot44}_5$	$-\overset{s}{0\cdot59}_8$
Moon 2 L.							
1905	$-\overset{s}{0\cdot21}_{11}$	$-\overset{s}{0\cdot24}_{14}$	$-\overset{s}{0\cdot12}_7$	$-\overset{s}{0\cdot32}_7$	$-\overset{s}{0\cdot20}_4$	$-\overset{s}{0\cdot19}_1$	$-\overset{s}{0\cdot17}_8$

The observed north polar distances of the Moon's centre are taken from the section of *Zenith-Distances observed*, &c., corrected for discordance of direct and reflexion results and for the motion in N.P.D. during the passage from the mean of wires to the true meridian, and since 1902 for latitude variation.

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

The following are the values of the mean error of tabular north polar distance of the Moon's centre, from observations of the north and south limbs, found by the different observers :—

Moon N. L.							
	B	W	JS	E	RC	SD	Other Observers.
1905	$-\overset{s}{0\cdot38}_8$	$-\overset{s}{0\cdot15}_{15}$	$-\overset{s}{2\cdot80}_5$	$-\overset{s}{1\cdot68}_9$	$-\overset{s}{2\cdot69}_6$	$-\overset{s}{1\cdot01}_3$	$-\overset{s}{0\cdot20}_8$
Moon S. L.							
1905	$-\overset{s}{0\cdot08}_{11}$	$+\overset{s}{0\cdot51}_{11}$	$+\overset{s}{1\cdot49}_{10}$	$-\overset{s}{0\cdot77}_8$	$+\overset{s}{0\cdot49}_3$	$+\overset{s}{2\cdot46}_3$	$-\overset{s}{2\cdot01}_4$

From the beginning of 1905 the lunar crater Mösting A has been observed, as well as the Moon's limbs whenever practicable, the observations of transits serving to connect the observations of the first and second limbs made before and after Full Moon respectively, while the observations of zenith distance in combination with similar observations made at the Cape Observatory serve to determine the parallax of the Moon.

The following table gives a comparison between the errors of the tabular place

of the Moon's centre in R.A. and N.P.D. respectively, deduced from observations of the crater Mösting A and the limbs :—

Day of Observation.	Observer.	Difference of Errors of Tabular Place.			
		Mösting A.—D 1 L.	D 2 L.—Mösting A.	Mösting A.—D N.L.	D S.L.—Mösting A.
1905.		s	s	"	"
March 18	RC	+ 0.02		+ 0.59	
19	W	— 0.05		— 2.49	
21	E		+ 0.21		+ 1.94
April 22	RC		— 0.01		— 0.67
May 17	RC	+ 0.04		— 1.10	
July 13	RC	— 0.16		+ 2.32	
15	E	— 0.03		+ 1.33	
20	W		+ 0.07	— 0.11	
August 11	SD	+ 0.06		— 0.36	
16	SD		+ 0.03	+ 0.39	
September 7	W	+ 0.04			+ 1.89
8	JS	+ 0.23			+ 3.37
12	SD	+ 0.12			+ 0.11
18	W			+ 1.50	
19	J		— 0.19	— 0.22	
20	E		— 0.16	— 1.25	
October 10	JS	— 0.02			
16	W		+ 0.15	— 0.15	
November 6	W	— 0.05			+ 1.67
7	JS	+ 0.07			+ 2.62
December 8	W	— 0.10			+ 0.53
9	JS	+ 0.10			+ 1.13
	Mean	+ 0.019	+ 0.014	+ 0.04	+ 1.40

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 discordance of direct and reflexion results, and since 1902 for latitude variation. 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,

$$\begin{aligned} \text{Error of geoc. long.} &= \frac{R \times \cos \text{hel. lat.} \times \cos (\lambda - L)}{\Delta \times \cos \text{geoc. lat.}} \times \text{error of hel. long.} \\ &\quad - \frac{\sin (\lambda - L)}{\Delta \times \cos \text{geoc. lat.} \times \sin 1''} \times \text{error of projection of planet's radius vector.} \\ \text{Error of hel. E.P.D.} &= \frac{\Delta \times \cos \text{hel. lat.}}{R \times \cos \text{geoc. lat.}} \times \text{error of geocent. E.P.D.} \\ &\quad - \sin \text{hel. lat.} \times \cos \text{hel. lat.} \times \tan (\lambda - L) \times \text{error of geocent. long.} \\ &\quad - \frac{r \times \tan \text{geoc. lat.} \times \cos (L - l)}{R^2 \cos (\lambda - L) \times \sin 1''} \times \text{error of projection of planet's radius vector.} \end{aligned}$$

For the other planets, the following are used :—

$$\begin{aligned} \text{Error of geocent. long.} &= \frac{R \times \cos(\lambda - L)}{\Delta} \times \text{error of planet's heliocentric longitude,} \\ &- \frac{\sin(\lambda - L)}{\Delta \times \sin 1''} \times \text{error of projection of planet's radius vector,} \\ &- \frac{r \times \cos(\lambda - l)}{\Delta} \times \text{error of Earth's heliocentric longitude,} \\ &+ \frac{\sin(\lambda - l)}{\Delta \times \sin 1''} \times \text{error of Earth's radius vector.} \end{aligned}$$

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

The errors of the Earth's place are retained in the formulæ for the larger planets, as being probably comparable in magnitude with the errors of the places of the planets: but the errors of the tabular places of the small planets being in general large, in their case the Earth may be supposed to move exactly in the orbit assigned by the tables.

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.

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.

§ 8. *Meridian observations with the Altazimuth.*

The method of reduction of the transits and meridian zenith distances is similar to that for the transit-circle and no further explanation is required for the

section of Transits and Meridian Zenith Distances beyond the short notes at the beginning of these sections. As in the case of the Transit-Circle, the lunar crater Mösting A has been observed with the Altazimuth whenever practicable, and a comparison of the results with those from the limbs is given on pp. 72 and 73.

In the Altazimuth Tables at the end of this *Introduction* are given :—

The values of 1^{rev.} of the micrometer-screws.

The adopted wire intervals.

The adopted division errors.

Further details of the methods by which these were obtained are given in the Tables at the end of the Introduction for 1901.

A discussion of the R—D discordance and of the colatitude is also given in substantially the same form as for the transit-circle.

A comparison of the North polar distances observed in the four positions of the instrument is also given in the Altazimuth Tables at the end of this Introduction.

§ 9. *Extra-meridian observations with the Altazimuth.*

The method of observation has been already described on page xiii, the essential point being that the means of the times of observation in azimuth and zenith distance should be as nearly as possible the same, so that the azimuth and zenith distance can be readily referred to the same instant of time.

The following explanation refers to the observations and reductions as printed in this section.

The first twelve columns of this section require no explanation. The Apparent Error of Tabular Z.D. in the thirteenth column is the excess above the concluded Zenith Distance of the Tabular Zenith Distance, which is taken from tables constructed for each azimuth with argument N.P.D. according to the formula

$$\begin{array}{lcl} \cos (Z + \theta) & = & \sec \gamma_0 \cos \Delta \\ \text{where } \sin \gamma_0 & = & \sin \gamma \sin A \\ \tan \theta & = & \tan \gamma \cos A \end{array}$$

Z being the tabular zenith distance, or the zenith distance on crossing the standard azimuth corresponding to the tabular N.P.D. which is denoted by Δ . The colatitude is denoted by γ and the azimuth reckoned from the south by A .

The tabular places are taken, whenever possible, from the Greenwich Clock Star List

or recent Greenwich Catalogues, or from Newcomb's Fundamental Catalogue, in this order of preference.

The fourteenth column is derived from the thirteenth by converting arc into time at the rate $15'' \sin \gamma \sin A = 15 m$ to a second of time. This is the rate of motion in zenith distance and is constant throughout the same azimuth.

The second column of the right hand page is the mean of the separate taps over the horizontal wires registered on the chronograph reduced to the centre wire by a process analogous to the completion of transits in the meridian. In this case, however, the reduction to the centre wire is simpler, because the transits are usually symmetrical, and also because the motion in zenith distance is constant throughout the azimuth. The observed time of transit over the centre wire includes the correction for curvature of the star's path, when sensible.

The fourth column gives the tabular time T of transit over the standard azimuth, computed with the help of tables from the formulæ :—

$$\begin{aligned} \cos (T - \alpha + \phi) &= \tan \gamma_0 \cot \Delta \\ \tan \phi &= \sec \gamma \cot A \end{aligned}$$

where

α being the tabular right ascension.

The clock error is the excess of this latter quantity over the quantity in the second column corrected by the application of the quantity in the last column of the left hand page. The clock rate is taken from the transit circle observations, and the clock error reduced to 0^h sidereal with this rate is exhibited in the fifth column. Means are taken in this column for each group observed by the same observer on the same side of the zenith.

The sixth column gives the adopted clock error, which is the mean of the two groups observed, east and west of the zenith.

The observed time of transit over the centre vertical wire given in the seventh column is corrected for curvature of the star's path, when sensible. The errors of collimation and level given in the ninth column are converted into time by the divisors $15 m \cot S$ and $15 m \cot S \sec Z$ respectively, S being the parallactic Angle. The seconds corrected are given in the tenth column. The result in the tenth column is corrected for the clock error and rate given in the sixth column, and the excess of the tabular transit T over the quantity thus derived is set down in the eleventh column, under the heading Apparent Error of Tabular Time of Transit. From this apparent error is deduced the Apparent Error of Azimuth, the quantity set down in the twelfth column being the determination of this error from the particular star, derived by multiplying the quantity in eleventh column by $15 m \cot S \operatorname{cosec} Z$.

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In the thirteenth column is given the adopted error of azimuth, the weighted mean of the quantities in the preceding column, the weight assigned being the nearest integer to $10 \sin^2 Z$. The Apparent Errors of Tabular Place in Azimuth and Zenith Distance given in the fourteenth and fifteenth columns are derived by multiplying the excess of the azimuth error and clock error as determined from the particular star, over their adopted values by $\sin Z$ and $15 m$ respectively.

The remaining columns require no explanation.

At the foot of the page are given details of the reductions for the Sun, Moon and Planets.

The second column of the left hand page gives the quantity in the seventh column of the right hand page above corrected for clock error, rate, collimation, level, and azimuth. The clock error used for Azimuth observations is derived from stars on both sides of the Zenith; that for Zenith Distance observations from stars on the same side of the Zenith as the object observed. Correction is still required on account of semidiameter, parallax, and orbital motion. This correction is calculated as a fraction $\frac{A}{B}$ whose numerator and denominator are approximately equal to the semidiameter and $15 m \cot S$, a quantity called the collimation divisor. The numerator of this fraction, A , requires to be corrected for parallax and curvature. The former correction is the same fraction of the semidiameter that the perpendicular from the centre of the Earth upon the standard azimuth is of the linear semidiameter of the object observed. The correction for curvature is $\frac{1}{2} \times \frac{(15 t)^2}{206265} \sin \Delta \cos \Delta$ in seconds of arc applicable to N.P.D. Its horizontal component is found by multiplication by $\sin S$. It will be observed that $\sin \Delta \sin S$ is a constant for the azimuth and that $\cos \Delta$ varies between small limits and is never far different from unity. A sufficient approximation to the value of t in the numerator is obtained by dividing the semidiameter by the collimation divisor.

For the denominator B , of the fraction, the collimation divisor requires correction for the contribution of the object's orbital motion to the apparent motion across the azimuth of the instrument.

The contribution arising from the orbital motion in R.A. is the same fraction of the collimation divisor that the orbital motion in R.A. is of the diurnal motion, $15 \sin \Delta$. In the case of the Moon, however, the mean orbital motion is considered as coalescing with the diurnal motion, and the inequalities of its motion are alone attributed to orbital motion. As a consequence, the fraction whose value is exhibited in the ninth column of the printed results is expressed in lunar seconds in the case of

the moon and sidereal seconds for the sun and planets. A lunar second denotes the $\frac{1}{86,400}$ part of a lunar day, which is the mean interval between consecutive transits. The contribution to the collimation divisor of a motion in N.P.D. of one second of arc in a second of time is clearly $\sin S$, and for a greater or less motion in N.P.D., the effect is in proportion.

This suffices for the explanation of the third to the ninth columns inclusive. The tenth column is the result of the application of the ninth column (which must be reduced to sidereal seconds when necessary) to the second column.

The eleventh column is taken from the second column of the right hand page above corrected for clock-error and rate. The clock-error employed is derived from the stars on the same side of the zenith only, and is that set down in brackets in the fifth column of the right hand page above.

The difference $T-t_2$, the excess of the tenth column over the eleventh is always small: the twelfth column exhibits this difference converted into arc by the factor $15m$ corrected for orbital motion in R.A. and N.P.D. The method of correction is analogous to the correction of the collimation divisor.

The thirteenth column exhibits the semidiameter, interpolated from the *Nautical Almanac*.

The fourteenth column exhibits the horizontal parallax, reduced to the geocentric distance of the instrument, and multiplied by $\sin(z - \zeta)$ where ζ is the angle of the vertical projected upon the plane of the instrument ($11' 12'' \cos A$), the ellipticity of the Earth being assumed to be $1/300$ and the height of the instrument above sea level being taken as 170 feet.

The fifteenth column exhibits the excess of the true correction for semidiameter and parallax.

$$\sin^{-1}[(\rho \sin(z - \zeta) \pm \mu) \sin p]$$

over the sum of the preceding corrections. In this formula, ρ denotes the geocentric distance of the instrument, μ the linear diameter of the planet and p its equatorial horizontal parallax.

On the right hand page the second column gives the application of the corrections in the four last columns to the zenith distance in the twelfth column of the left hand page above.

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The third and fourth columns contain the N.P.D. and hour angle corresponding to Z , the latter combined with T gives the R.A. in the fifth column: the remaining columns require no further explanation.

The method of reducing lunar observations is described by Mr. Cowell in the *Monthly Notices*, vol. lxii. p. 503, where full formulæ and an example are given.

§ 10. *Ledgers of Mean Right Ascension and North Polar Distances and Catalogue.*

The star ledgers and the annual star catalogue are printed together. The position of the instrument is indicated in each case, and the Mean N.P.D. is given as obtained from each circle separately. The separate results are corrected for latitude variation, and the means of groups in each position of the instrument are corrected for the $R - D$ discordance.

§ 11. *Results of observations of Planets.*

The planetary results are similar to those obtained with the transit-circle and require no further explanation.

§ 12. *Meridian Zenith Distances of Stars observed with the Reflex Zenith Tube.*

It was pointed out by Mr. Chandler in the *Astronomical Journal*, No. 511 (1901 November) that the anomalous results found from observations of γ Draconis with this instrument were to be explained by the variation of latitude and that the instrument was well adapted for the determination of the amount of this variation.

It was decided, therefore, early in 1902, to resume without delay the observations of γ Draconis, which had been intermitted since 1899 May (when all the wires were found broken) and to observe such other stars as passed sufficiently near the zenith and were sufficiently bright. By suitable modification of the illumination it has been found possible to observe stars down to the magnitude 7.0, and, by mounting the eyepiece in a slide, good definition at a distance of 50' or more from the zenith (centre of the field) has been secured.

A working catalogue of suitable stars was prepared and systematic observations began in 1902 June. The daily results are given in substantially the same form as the observations of γ Draconis in volumes up to that for 1881, to which reference may here be made.

An account of the determinations of the mean value of 1 revolution of the screws, of

the errors of the screws, and of the intervals of the wires is given in the *Reflex Zenith Tube Tables* for 1903.

§ 13. *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. The Moon's geocentric place and horizontal equatorial parallax are interpolated with second differences from the *Nautical Almanac*, and are used without alteration. From the beginning of 1900 a correction has been applied to the *Nautical Almanac* semidiameter, to reduce it from Hansen's bright limb value $15' 34''\cdot09$ to Struve's dark limb value $15' 32''\cdot65$. 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 a table given in the *Introduction* to the *Greenwich Observations* of 1899, the principles of the formation of which are given in the volumes of the *Greenwich Observations* from 1843 to 1849.

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 the volumes, from 1843 to 1849, it may be shown that

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

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

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

$$F = \log. \sin \text{ star's hour-angle} + \log. \text{ seconds of corrected eq. hor. parallax} + 9\cdot4942268.$$

$$G = \log. \sin \text{ star's N.P.D.} + \log. \sin \text{ star's hour-angle} + \log. \text{ seconds of corrected eq. hor. parallax} + 9\cdot8913966.$$

(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 = $\frac{1}{300}$).

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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 :—

$$\begin{aligned}\log. \frac{1}{2} (\theta - \theta') \text{ in seconds} &= F - \log. \sin \delta' + \log. \frac{\text{sine}}{\text{arc}} \text{ for hor. parallax} \\ &\quad + \log. \frac{\text{arc}}{\text{sine}} \text{ for } (\theta - \theta'). \\ \log. 1^{\text{st}} \text{ number} &= G + \log. \secant \frac{1}{2} (\theta - \theta') + \log. \frac{\text{sine}}{\text{arc}} \text{ for hor. parallax} \\ &\quad + \log. \frac{\text{arc}}{\text{sine}} \text{ for } (\delta - \delta') - \log. \text{sine } \frac{1}{2} (\theta + \theta'). \\ \log. 2^{\text{nd}} \text{ number} &= \log. \frac{1}{2} (\theta - \theta') \text{ in seconds} + \log. \frac{\tan}{\text{arc}} \text{ for } \frac{1}{2} (\theta - \theta') \\ &\quad + \log. \sin (\delta + \delta' - 180^\circ) + \log. \cot \frac{1}{2} (\theta + \theta') + \log. \frac{\text{arc}}{\text{sine}} \text{ for } (\delta - \delta'). \\ \delta - \delta' &= 1^{\text{st}} \text{ number} + 2^{\text{nd}} \text{ number.}\end{aligned}$$

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 :—

$$\begin{aligned}\log. \tan \psi &= \log. \text{diff. R.A. of Moon's centre and corresponding point} + \frac{1}{2} \log. \\ &\quad \sin \text{N.P.D. of Moon's centre} + \frac{1}{2} \log. \sin \delta' - \log. \text{diff. N.P.D. of} \\ &\quad \text{Moon's centre and corresponding point};\end{aligned}$$

$$\begin{aligned}\text{Then } \log. \text{dist.} &= \log. \text{diff. N.P.D.} - \log. \cos \psi, \\ \text{or} &= \log. \text{diff. R.A.} + \frac{1}{2} \log. \sin \text{N.P.D. of centre} + \frac{1}{2} \log. \sin \delta' - \log. \sin \psi.\end{aligned}$$

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 :—

$$\log. 1^{\text{st}} \text{ number} = 2 \log. \text{diff. R.A.} + \log. \text{sine (sum of N.P.D.)} - \log. \text{dist.} + 4.0835.$$

$$\log. 2^{\text{nd}} \text{ number} = \log. \text{diff. N.P.D.} - \log. \text{distance.}$$

$$\text{Coefficient of variation of greater N.P.D.} = 1^{\text{st}} \text{ number} + 2^{\text{nd}} \text{ number.}$$

$$\text{Coefficient of variation of smaller N.P.D.} = 1^{\text{st}} \text{ number} - 2^{\text{nd}} \text{ number.}$$

$$\text{Log. coefficient of variation of diff. R.A.} =$$

$$\log. \text{diff. R.A.} + \log. \sin \delta' + \log. \sin \text{Moon's N.P.D.} - \log. \text{distance.}$$

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 $1 : 1 + \frac{m}{1000}$ 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 $\frac{m}{1000} \times$ 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 =

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

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 $\frac{m}{1000} \times$ correction for parallax in N.P.D.
- 3rd. The increase of hour-angle (considered positive when the Moon is west of the meridian), depending on the alteration of time t^s , will alter the correction for parallax in N.P.D. by the following quantity:—

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

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 $\times \frac{n}{1000}$; 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.

§ 14. *Micrometric Observations of Double Stars.*

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^{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 $12''.06$. It was determined in 1894 November from transits of stars near the pole. The observations are given in the volume for 1894.

The nomenclature of the stars in column 1 refers to the original observer's catalogue. 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. 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 original observers' catalogues. Column 9 gives the epoch of the observations, expressed as the fraction of the year. In column 10 the magnifying power used is given, and in column 11 such remarks as appear necessary.

§ 15. *Observations of Comets and Minor Planets from Photographs taken with the 30-inch Reflector of the Thompson Equatorial in the years 1903, 1904 and 1905.*

The Thompson Equatorial, carrying the 26-inch photographic refractor at one end of the declination axis, and the 30-inch reflector at the other, is briefly described in

the *Introduction*. The focal length of the reflector is approximately 11 feet 5 inches, giving a scale of 1' to the millimetre nearly.

The photographs are taken on plates 16 centimetres square, on which a *réseau* of cross lines 5 millimetres apart is printed in the same manner as for the Photographic Map of the Heavens.

The measurement of the photographs was made with the Astrographic Micrometer, which has a glass diaphragm with cross scales at the focus of the microscope. These scales are divided into 100 parts, and the micrometer is readily adjusted so that 100 divisions of the scale are equal very nearly to the distance between two *réseau* lines as viewed with the microscope. The intersection of the scales is made to bisect the object, and the positions of the *réseau* lines on each side are read off on the scales by estimation to the thousandth part of a *réseau* interval. The rectangular co-ordinates of the images are thus obtained in units of 1 *réseau* interval, which for both the 30-inch reflector and the 13-inch refractor is approximately 5'.

The plates are in all cases measured in reversed positions to eliminate personality. Where several images of the same object are obtained on a plate, they are all measured and the mean taken. The magnifying power used is 15.

The determination of Right Ascension and Declination is made by Professor Turner's method (*Monthly Notices, R.A.S.*, vol. liv., p. 11), as follows:—

With an assumed Right Ascension and Declination of the centre of the plate, the "Standard Co-ordinates," ξ and η , of those stars which are used as reference stars are computed by the formula—

$$\xi = \tan(\alpha - A) \cos \phi \sec(\phi - D),$$

$$\eta = \tan(\phi - D)$$

$$\text{where } \tan \phi = \tan \delta \sec(\alpha - A)$$

In this formulæ—

α is the R.A. of the star,

A „ „ centre of the plate

δ is the Dec. of the star

D „ „ centre of the plate

and ϕ is an auxiliary angle.

The "Standard Co-ordinates" of the reference stars are compared with the measured co-ordinates x, y ; and from equations of the form—

$$\xi - x = ax + by + c$$

$$\eta - y = dx + ey + f$$

the constants of each plate a, b, c, d, e, f are deduced. By means of these constants,

the "Standard Co-ordinates" of any object on the plate are obtained by applying corrections $ax' + by' + c$, $dx' + ey' + f$ to the measured co-ordinates x' , y' , from which the Right Ascension and Declination are deduced by inversion of the trigonometrical formulæ given above.

It should be noticed that the Right Ascension and Declination obtained in this way are referred to the equator and equinox of the catalogue of the reference stars used, and that the position of a comet or minor planet obtained in this way is corrected for the part of the aberration arising from the Earth's motion.

In each case the uncorrected measures of the co-ordinates of the reference stars and the comet are given, and the deduced Right Ascension and Declination for the equator and equinox of the catalogue. For the reference stars the comparison with the assumed Right Ascension and Declination is also given.

The adopted plate constants, and the Apparent Right Ascension and Declination reduced to the equator and equinox of 1903·0, 1904·0 or 1905·0, are given in separate tables.

§ 16. *Observations of the Satellite of Neptune from Photographs taken with the 26-inch Refractor of the Thompson Equatorial during the opposition 1904-5.*

In taking the photographs from which these observations were made, an occulting shutter placed immediately in front of the plate was used to screen the planet during the greater part of the long exposure on the satellite, a series of very short exposures being given at intervals of 20 seconds. The shutter is pivoted, and is worked by a small electro-magnet arranged to give exposures automatically at the necessary intervals of time.

The zero of position angle was obtained by stopping the clock and giving a short supplementary exposure. Generally, several short exposures were given, the clock being stopped for a short time between each of them, so that each photograph contains in addition to the long exposure image of the Satellite a series of short exposure images of Neptune.

The photographs were measured in a position micrometer in direct and reversed positions by Mr. Edney and Mr. Burkett, the means of the measures being taken.

Corrections have not been applied separately to the distances or angles for refraction. These will in all cases be less than $0''\cdot01$. The mean effects of refraction and aberration have, however, been included in the adopted value of the scale.

The value of 1^{rev} of the screw of the measuring micrometer was determined in terms of a *réseau* interval of one of the *réseaux* used in photographic work with the Thompson and Astrographic Equatorials. For photographs with the 26-inch refractor cleared of the effect of differential refraction and aberration, the *réseau* interval adopted was $150''.91$. The correction for differential refraction on these photographs of Neptune varies from $+ 0''.042$ to $+ 0''.105$, and for aberration from $+ 0''.006$ to $- 0''.014$. A mean total correction of $+ 0''.07$ has been adopted, giving the *réseau* interval = $150''.98$. This value of the scale has been used for all the photographs.

The tabular positions were computed from the data given in the *Connaissance des Temps*, based on the elements given by Dr. Hermann Struve. The eccentricity of the orbit has been neglected, owing to the uncertainty of the present position of the periastron.

§ 17. *Measures of Positions and Areas of Sun Spots and Faculae on Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn and at the Kodaikânal Observatory in India, and at the Royal Alfred Observatory, Mauritius, in the year 1905; 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; at the Kodaikânal Observatory, Southern India; or at the Royal Alfred Observatory, Mauritius.

The photographs of the Greenwich series were taken either with the Thompson or with the Dallmeyer Photoheliograph. The Thompson Photoheliograph, which was in regular use for the greater part of the year, is a photographic refractor of 9 inches aperture, presented to the Royal Observatory by Sir Henry Thompson, which has been fitted with an enlarging doublet by Ross, and with a camera and shutter for rapid exposure so as to take photographs of the Sun on a scale of about 7.5 inches to the solar diameter. The Dallmeyer, which was substituted for the Thompson from 1905 July 21 to October 2, while the latter was in use for the Eclipse expedition to Tunis, is an instrument used in the Transit of Venus expedition to New Zealand, which, as now adapted, gives a solar image of nearly 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.

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The photographs from Dehra Dûn, 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; the Kodaikânal photographs were taken under the superintendence of Professor C. Michie Smith, Director of that Observatory; and the Mauritius photographs were taken under the superintendence of Mr. T. F. Claxton, Director of the Royal Alfred Observatory, Mauritius. At each observatory the instrument employed was a Dallmeyer Photoheliograph giving an image of the Sun about 8 inches in diameter. The plates and development used have been much the same at each of the four collaborating observatories.

Photographs of the Sun were available for measurement in 1905 on 364 days, the only day in the year without record being 1905 January 1. The photographs selected for measurement were supplied by the different observatories as under :—

Greenwich	.	.	.	.	.	.	183
Dehra Dûn	.	.	.	.	.	.	160
Kodaikânal	.	.	.	.	.	.	17
Mauritius	.	.	.	.	.	.	4
Total							364

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 at Dehra Dûn, in India, are distinguished by the letter D, those taken at Kodaikânal Observatory, India, by the letter K, 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 1905 :—

E. W. Maunder	-	-	M	A. H. Smith	-	-	-	AS	
R. Fowler	-	-	-	RF	C. F. Lait	-	-	-	CL

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 $0^\circ, 90^\circ, 180^\circ$, 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 Thompson and Dallmeyer Photoheliographs

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employed at Greenwich has been determined by the measurement of a plate which has 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 tables give the correction for zero of position for the mean of the two wires as thus determined :—

Thompson Photoheliograph, to 1905 July 21.

Date, Greenwich Civil Time.			Correction for Zero.	Date, Greenwich Civil Time.			Correction for Zero.
	d	h	° ' "		d	h	° ' "
1904	December	12. 12	+ 0. 31	1905	April	6. 13	+ 0. 17
1905	January	26. 13	+ 0. 30		May	3. 11	+ 0. 26
	February	11. 11	+ 0. 18		June	19. 13	+ 0. 32
		28. 11	+ 0. 31		July	13. 13	+ 0. 40
	March	10. 11	+ 0. 31			21. 12	+ 0. 37

A correction of $+0^{\circ}.6$ for zero of position has been applied to all photographs taken with the Thompson Photoheliograph up to 1905 July 21.

Dallmeyer Photoheliograph, from 1905 August 10 to October 2.

Date, Greenwich Civil Time.			Correction for Zero.	Date, Greenwich Civil Time.			Correction for Zero.
	d	h	° ' "		d	h	° ' "
1905	August	22. 11	+ 0. 28	1905	September	12. 13	— 0. 19
		29. 14	0. 0			14. 13	— 0. 10

A correction of $+0^{\circ}.5$ for zero of position has been applied to all photographs taken with the Dallmeyer Photoheliograph from 1905 August 10 to August 26, and a correction of $-0^{\circ}.2$ from August 26 to October 2. A change was made in the position of the wire-frame on August 26.

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Thompson Photoheliograph, from 1905 October 2.

Date, Greenwich Civil Time.			Correction for Zero.	Date, Greenwich Civil Time.			Correction for Zero.
	d	h	° ' "		d	h	° ' "
1905	November	6. 11	— 0. 5	1905	December	19. 10	— 0. 17
		7. 12	— 0. 6	1906	January	16. 12	— 0. 0
	December	9. 12	— 0. 9			19. 12	— 0. 18

A correction of $-0^{\circ}.2$ for zero of position has been applied to all photographs taken with the Thompson Photoheliograph from 1905 October 2 to December 31.

The Thompson Photoheliograph was mounted on the tube of the 26-inch Thompson Photographic refractor throughout the year, except from 1905 July 21 to October 2, when it was dismounted for use in the observation of the Total Solar Eclipse of 1905 August 30. The Thompson Photoheliograph is not fitted with a position-circle, and the position-angle of the wires, which are approximately parallel and perpendicular to the circle of declination, cannot be altered.

The Dallmeyer Photoheliograph was mounted on the tube of the 26-inch Thompson Photographic refractor, in the place of the Thompson Photoheliograph, from 1905 July 21 to July 30, and again from August 10 to October 2. From 1905 July 30 to August 10 it was mounted on the equatorial stand belonging to it, which was erected 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 $354^{\circ}.0$ throughout 1905.

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

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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 Director of the Kodaikānal Observatory has reported, for each of the photographs that he has supplied, the amount of the correction for zero of position of wires that it is necessary to apply.

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 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 $c = \sin 57''.5 = \frac{1}{3600}$ 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 δr 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 δr 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 $\delta R = + c . \tan^2 z \times R \times \frac{1}{2} \left\{ \frac{1 + \cos 2 (\theta_0 - v)}{2} + \frac{1 + \cos 2 (\theta_0 + 90^\circ - v)}{2} \right\} = + \frac{1}{2} c R . \tan^2 z$, 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—

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

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

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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. This position-angle of the Sun's axis from the North point is also given (in brackets) in the *fifth* column.

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. $\sin \rho$ and log. $\cos \rho$, 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—

$$\begin{aligned} \sin \lambda &= \cos \rho \sin D + \sin \rho \cos D \cos \chi \\ \sin(L - l) &= \sin \chi \sin \rho \sec \lambda. \end{aligned}$$

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—

$$\begin{aligned} \tan L &= \cos I \tan(\odot - N) \\ \sin D &= \sin I \sin(\odot - N) \end{aligned}$$

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—

$$\begin{aligned}\tan G &= \tan \omega \cos \odot \\ \tan H &= \tan I \cos (\odot - N)\end{aligned}$$

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 $7^{\circ}.15'$, $74^{\circ}.26'$, and $23^{\circ}.27'.5$ 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.

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The individual spots in a group have in many 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.

§ 18. *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 1905.*

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.

§ 19. *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 1905.*

This section requires no further explanation.

W. H. M. CHRISTIE.

*Royal Observatory, Greenwich,
1907 March.*

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ROYAL OBSERVATORY, GREENWICH.

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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 throughout the year:—

r						s					
For Wire M	+	18.054	=	+	44.654	For Wire T		0.000	=	0.000	
N	+	12.055	=	+	29.816	U	-	2.895	=	- 7.160	
O	+	6.032	=	+	14.919	V	-	3.915	=	- 9.683	
P	+	5.054	=	+	12.500	W	-	4.898	=	- 12.114	
Q	+	4.082	=	+	10.096	X	-	5.895	=	- 14.580	
R	+	1.993	=	+	4.929	Y	-	11.881	=	- 29.386	
S	+	1.061	=	+	2.624	Z	-	17.958	=	- 44.416	

The adopted value of 1^{rev.} of the micrometer is $37''.10 = 2^s.4733$.

Factors for Instrumental-Errors.

N.P.D.	Collimation.	Level.	Azimuth.	N.P.D.	Collimation.	Level.	Azimuth.
	$\frac{1}{15 \sin N.P.D.}$	$\frac{\cos Z.D.}{15 \sin N.P.D.}$	$\frac{\sin Z.D.}{15 \sin N.P.D.}$		$\frac{1}{15 \sin N.P.D.}$	$\frac{\cos Z.D.}{15 \sin N.P.D.}$	$\frac{\sin Z.D.}{15 \sin N.P.D.}$
-45. 0	-0.094	-0.011	+0.094	-24. 0	-0.164	-0.076	+0.145
-44. 0	-0.096	-0.013	+0.095	-23. 0	-0.171	-0.082	+0.150
-43. 0	-0.098	-0.014	+0.096	-22. 0	-0.178	-0.088	+0.155
-42. 0	-0.100	-0.016	+0.098	-21. 0	-0.186	-0.094	+0.160
-41. 0	-0.102	-0.018	+0.100	-20. 0	-0.195	-0.102	+0.166
-40. 0	-0.104	-0.021	+0.102	-19. 30	-0.200	-0.106	+0.170
-39. 0	-0.106	-0.023	+0.104	-19. 0	-0.205	-0.110	+0.173
-38. 0	-0.108	-0.025	+0.105	-18. 30	-0.210	-0.114	+0.176
-37. 0	-0.111	-0.027	+0.107	-18. 0	-0.216	-0.119	+0.180
-36. 0	-0.113	-0.030	+0.109	-17. 30	-0.222	-0.124	+0.184
-35. 0	-0.116	-0.033	+0.111	-17. 0	-0.228	-0.129	+0.188
-34. 0	-0.119	-0.036	+0.114	-16. 30	-0.235	-0.134	+0.192
-33. 0	-0.122	-0.039	+0.116	-16. 0	-0.242	-0.140	+0.197
-32. 0	-0.126	-0.042	+0.119	-15. 30	-0.249	-0.146	+0.202
-31. 0	-0.129	-0.045	+0.121	-15. 0	-0.257	-0.153	+0.207
-30. 0	-0.133	-0.049	+0.124	-14. 30	-0.266	-0.160	+0.213
-29. 0	-0.138	-0.053	+0.127	-14. 0	-0.276	-0.168	+0.219
-28. 0	-0.142	-0.057	+0.130	-13. 30	-0.286	-0.176	+0.225
-27. 0	-0.147	-0.061	+0.133	-13. 0	-0.296	-0.184	+0.232
-26. 0	-0.152	-0.065	+0.137	-12. 30	-0.308	-0.194	+0.240
-25. 0	-0.158	-0.070	+0.141	-12. 0	-0.321	-0.204	+0.248
-24. 0	-0.164	-0.076	+0.145	-11. 30	-0.334	-0.214	+0.256

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Factors for Instrumental-Errors—continued.

N.P.D.	Collimation.	Level.	Azimuth.	N.P.D.	Collimation.	Level.	Azimuth.
	$\frac{1}{15 \sin N.P.D.}$	$\frac{\cos Z.D.}{15 \sin N.P.D.}$	$\frac{\sin Z.D.}{15 \sin N.P.D.}$		$\frac{1}{15 \sin N.P.D.}$	$\frac{\cos Z.D.}{15 \sin N.P.D.}$	$\frac{\sin Z.D.}{15 \sin N.P.D.}$
-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
-7. 0	-0.547	-0.383	+0.390	38. 0	+0.108	+0.108	-0.001
-6. 30	-0.589	-0.416	+0.417	39. 0	+0.106	+0.106	+0.001
-6. 0	-0.638	-0.455	+0.447	40. 0	+0.104	+0.104	+0.003
6. 0	+0.638	+0.538	-0.343	41. 0	+0.102	+0.101	+0.004
6. 30	+0.589	+0.499	-0.312	42. 0	+0.100	+0.099	+0.006
7. 0	+0.547	+0.466	-0.286	43. 0	+0.098	+0.097	+0.007
7. 30	+0.511	+0.438	-0.263	44. 0	+0.096	+0.096	+0.009
8. 0	+0.479	+0.413	-0.243	45. 0	+0.094	+0.094	+0.011
8. 30	+0.451	+0.391	-0.226	46. 0	+0.093	+0.092	+0.012
9. 0	+0.426	+0.371	-0.210	47. 0	+0.091	+0.090	+0.013
9. 30	+0.404	+0.353	-0.196	48. 0	+0.090	+0.088	+0.015
10. 0	+0.384	+0.337	-0.183	49. 0	+0.088	+0.087	+0.016
10. 30	+0.366	+0.323	-0.172	50. 0	+0.087	+0.085	+0.017
11. 0	+0.349	+0.310	-0.161	51. 0	+0.086	+0.084	+0.018
11. 30	+0.334	+0.298	-0.152	52. 0	+0.085	+0.082	+0.020
12. 0	+0.321	+0.287	-0.143	53. 0	+0.083	+0.081	+0.021
12. 30	+0.308	+0.277	-0.135	54. 0	+0.082	+0.080	+0.022
13. 0	+0.296	+0.267	-0.128	55. 0	+0.081	+0.078	+0.023
13. 30	+0.286	+0.259	-0.122	56. 0	+0.080	+0.077	+0.024
14. 0	+0.276	+0.251	-0.116	57. 0	+0.080	+0.075	+0.025
14. 30	+0.266	+0.244	-0.111	58. 0	+0.079	+0.074	+0.026
15. 0	+0.257	+0.236	-0.105	59. 0	+0.078	+0.073	+0.027
15. 30	+0.249	+0.230	-0.099	60. 0	+0.077	+0.072	+0.028
16. 0	+0.242	+0.224	-0.093	61. 0	+0.076	+0.070	+0.029
16. 30	+0.235	+0.218	-0.088	62. 0	+0.076	+0.069	+0.030
17. 0	+0.228	+0.212	-0.084	63. 0	+0.075	+0.068	+0.031
17. 30	+0.222	+0.207	-0.080	64. 0	+0.074	+0.067	+0.032
18. 0	+0.216	+0.202	-0.076	65. 0	+0.073	+0.066	+0.033
18. 30	+0.210	+0.197	-0.072	66. 0	+0.073	+0.065	+0.034
19. 0	+0.205	+0.193	-0.068	67. 0	+0.072	+0.064	+0.035
19. 30	+0.200	+0.189	-0.065	68. 0	+0.072	+0.063	+0.035
20. 0	+0.195	+0.185	-0.062	69. 0	+0.071	+0.061	+0.036
21. 0	+0.186	+0.177	-0.056	70. 0	+0.071	+0.060	+0.037
22. 0	+0.178	+0.171	-0.051	71. 0	+0.071	+0.059	+0.038
23. 0	+0.171	+0.164	-0.046	72. 0	+0.070	+0.058	+0.039
24. 0	+0.164	+0.159	-0.041	73. 0	+0.070	+0.057	+0.039
25. 0	+0.158	+0.153	-0.037	74. 0	+0.069	+0.056	+0.040
26. 0	+0.152	+0.148	-0.033	75. 0	+0.069	+0.055	+0.041
27. 0	+0.147	+0.144	-0.029	76. 0	+0.069	+0.054	+0.042
28. 0	+0.142	+0.140	-0.026	77. 0	+0.068	+0.053	+0.043
29. 0	+0.138	+0.136	-0.023	78. 0	+0.068	+0.053	+0.043
				79. 0	+0.068	+0.052	+0.044

Factors for Instrumental-Errors—continued.

N.P.D.	Collimation.	Level.	Azimuth.	N.P.D.	Collimation.	Level.	Azimuth.
	$\frac{1}{15 \sin N.P.D.}$	$\frac{\cos Z.D.}{15 \sin N.P.D.}$	$\frac{\sin Z.D.}{15 \sin N.P.D.}$		$\frac{1}{15 \sin N.P.D.}$	$\frac{\cos Z.D.}{15 \sin N.P.D.}$	$\frac{\sin Z.D.}{15 \sin N.P.D.}$
79. 0	+0.068	+0.052	+0.044	103. 0	+0.068	+0.029	+0.062
80. 0	+0.068	+0.051	+0.045	104. 0	+0.069	+0.028	+0.063
81. 0	+0.067	+0.050	+0.045	105. 0	+0.069	+0.027	+0.063
82. 0	+0.067	+0.049	+0.046	106. 0	+0.069	+0.027	+0.064
83. 0	+0.067	+0.048	+0.047	107. 0	+0.070	+0.026	+0.065
84. 0	+0.067	+0.047	+0.048	108. 0	+0.070	+0.025	+0.066
85. 0	+0.067	+0.046	+0.048	109. 0	+0.071	+0.024	+0.066
86. 0	+0.067	+0.045	+0.049	110. 0	+0.071	+0.023	+0.067
87. 0	+0.067	+0.044	+0.050	111. 0	+0.072	+0.022	+0.068
88. 0	+0.067	+0.043	+0.051	112. 0	+0.072	+0.021	+0.069
89. 0	+0.067	+0.042	+0.052	113. 0	+0.073	+0.020	+0.070
90. 0	+0.067	+0.041	+0.052	114. 0	+0.073	+0.018	+0.071
91. 0	+0.067	+0.040	+0.053	115. 0	+0.074	+0.017	+0.072
92. 0	+0.067	+0.040	+0.054	116. 0	+0.075	+0.016	+0.072
93. 0	+0.067	+0.039	+0.054	117. 0	+0.075	+0.015	+0.073
94. 0	+0.067	+0.038	+0.055	118. 0	+0.076	+0.014	+0.074
95. 0	+0.067	+0.037	+0.056	119. 0	+0.076	+0.013	+0.075
96. 0	+0.067	+0.036	+0.057	120. 0	+0.077	+0.012	+0.076
97. 0	+0.067	+0.035	+0.057	121. 0	+0.078	+0.011	+0.077
98. 0	+0.067	+0.034	+0.058	122. 0	+0.079	+0.009	+0.078
99. 0	+0.067	+0.033	+0.059	123. 0	+0.080	+0.008	+0.079
100. 0	+0.068	+0.032	+0.060	124. 0	+0.080	+0.007	+0.080
101. 0	+0.068	+0.031	+0.060	125. 0	+0.081	+0.005	+0.081
102. 0	+0.068	+0.030	+0.061	126. 0	+0.082	+0.004	+0.082
103. 0	+0.068	+0.029	+0.062				

Assumed Mean Right Ascensions of Clock Stars and Circumpolar Stars, with the Corrections to the R.A. of the Nautical Almanac, for 1905.0.

Star's Name.	Mag.	Assumed Mean R.A. 1905.0.	Correction to N.A.	Approx. N.P.D.	Star's Name.	Mag.	Assumed Mean R.A. 1905.0.	Correction to N.A.	Approx. N.P.D.
		h m s	s	° ' "			h m s	s	° ' "
α Andromedæ...	2.1	0. 3. 28.490	-0.009	61. 26	μ Andromedæ...	3.9	0. 51. 28.610	-0.011	52. 1
γ Pegasi.....	3.0	0. 8. 20.558	-0.003	75. 21	ϵ Piscium	4.5	0. 58. 0.687	-0.013	82. 37
ϵ Ceti.....	3.6	0. 14. 35.237	-0.037	99. 21	β Andromedæ...	2.2	1. 4. 24.584	+0.017	54. 53
44 Piscium.....	5.8	0. 20. 31.937	-0.008	88. 35	ζ^1 Piscium.....	4.2	1. 8. 45.986	-0.033	82. 56
12 Ceti	6.2	0. 25. 11.431	-0.019	94. 29	θ Ceti.....	3.8	1. 19. 16.461	-0.011	98. 40
ϵ Andromedæ ...	4.6	0. 33. 31.979	-0.011	61. 12	Polaris	2.2	1. 24. 42.121	+0.267	1. 12
β Ceti	2.1	0. 38. 49.280	-0.012	108. 30	η Piscium.....	3.7	1. 26. 23.871	-0.001	75. 9
δ Piscium.....	4.6	0. 43. 45.127	-0.027	82. 56	ν Piscium.....	4.7	1. 36. 29.167	-0.018	85. 0
20 Ceti.....	5.0	0. 48. 9.130	+0.023	91. 40	σ Piscium.....	4.4	1. 40. 22.509	-0.033	81. 19

NOTE.—The Right Ascensions are deduced from the "Standard Mean Right Ascensions of Clock Stars for 1890.0 based on Twelve hour Groups" printed at the end of the *Introduction to the Second Ten Year Catalogue* for 1890, a correction of +0.054 being applied to refer them to the Equinox of Prof. Newcomb's *Catalogue of Fundamental Stars* for 1900. (See pp. 10 and 45 of the *Introduction*.) The Proper Motions are taken from Prof. Auwers' *Neue Reduction der Bradleyschen Beobachtungen, Erster Band*, for all stars contained in that work with the exception of μ Andromedæ, ζ^1 Piscium, and α Aquilæ, for which the Proper Motions are taken from Prof. Newcomb's *Catalogue of Fundamental Stars*. For Cephei γ the Proper Motion is taken from Prof. Auwers' *Catalog der Fundamental Sterne*, and for α Columbe and δ Sculptoris from Prof. Auwers' *Fundamental Catalog für Zonenbeobachtungen am Südhimmel und Südlicher Polar-Catalog für die Epoche 1900* (*Astronomische Nachrichten*, Nos. 3431-2). The Proper Motions of Groombridge 1119, Groombridge 2283, and Groombridge 3548, are derived from a paper in the *Monthly Notices of the Royal Astronomical Society* for 1897, December.

TRANSIT-CIRCLE TABLES.

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Assumed Mean Right Ascensions of Clock Stars and Circumpolar Stars, with the Corrections to the R.A. of the Nautical Almanac, for 1905'0—continued.

Star's Name.	Mag.	Assumed Mean R.A. 1905'0.	Correction to N.A.	Approx. N.P.D.	Star's Name.	Mag.	Assumed Mean R.A. 1905'0.	Correction to N.A.	Approx. N.P.D.
β Arietis.....	2.8	h m s 1. 49. 23.378	+ 0.012	69. 39	ξ Geminorum....	3.7	h m s 6. 58. 28.511	- 0.007	69. 17
α Arietis.....	2.0	2. 1. 48.934	+ 0.008	66. 59	γ Canis Majoris..	4.1	6. 59. 27.593	- 0.050	105. 30
ξ^1 Ceti.....	4.4	2. 7. 57.769	- 0.023	81. 36	δ^1 Geminorum....	5.4	7. 7. 55.008	- 0.030	73. 41
δ^1 Ceti.....	5.5	2. 12. 14.637	- 0.011	96. 52	δ Geminorum....	3.2	7. 14. 27.026	- 0.018	67. 50
ξ^2 Ceti.....	4.4	2. 23. 6.372	- 0.014	81. 58	β Canis Minoris	3.1	7. 21. 59.970	- 0.012	81. 31
ν Ceti.....	4.9	2. 30. 53.216	- 0.014	84. 49	Castor.....	2.7	7. 28. 32.435	+ 0.038	57. 54
δ Ceti.....	4.1	2. 34. 36.725	- 0.009	90. 5	Procyon.....	0.5	7. 34. 19.809	+ 0.035	84. 32
γ^2 Ceti.....	3.0	2. 38. 22.610	0.000	87. 10	Pollux.....	1.1	7. 39. 30.271	+ 0.017	61. 45
σ Arietis.....	5.5	2. 46. 14.724	- 0.015	75. 19	ξ Argus.....	3.4	7. 45. 17.894	- 0.040	114. 37
ϵ Arietis.....	4.6	2. 53. 46.649	+ 0.009	69. 2	δ Cancri.....	5.0	7. 57. 41.123	- 0.025	61. 56
α Ceti.....	2.7	2. 57. 18.724	- 0.005	86. 17	Groomb. 1119...	7.1	8. 3. 25.371	- 0.588	1. 5
δ Arietis.....	4.5	3. 6. 11.668	- 0.015	70. 38	ρ Argus.....	2.9	8. 3. 29.883	+ 0.001	114. 2
τ^1 Arietis.....	5.2	3. 15. 44.402	- 0.023	69. 12	β Cancri.....	3.8	8. 11. 21.837	- 0.007	80. 31
α Tauri.....	3.8	3. 19. 41.956	- 0.008	81. 18	α^1 Cancri.....	5.9	8. 17. 55.525	- 0.017	71. 22
f Tauri.....	4.3	3. 25. 37.574	- 0.028	77. 23	η Cancri.....	5.5	8. 27. 13.011	+ 0.001	69. 14
ϵ Eridani.....	3.7	3. 28. 27.216	- 0.026	99. 47	γ Cancri.....	4.8	8. 37. 47.406	- 0.019	68. 11
ι^1 Tauri.....	6.5	3. 35. 5.729	- 0.004	64. 59	ϵ Hydrae.....	3.8	8. 41. 44.761	- 0.019	83. 14
δ Eridani.....	3.7	3. 38. 41.768	- 0.053	100. 5	ϵ Cancri.....	4.3	8. 53. 17.570	- 0.004	77. 46
η Tauri.....	3.0	3. 41. 50.113	+ 0.001	66. 11	κ Cancri.....	5.0	9. 2. 36.185	- 0.002	78. 57
γ^1 Eridani.....	3.0	3. 53. 35.779	- 0.031	103. 47	δ^3 Cancri.....	6.6	9. 13. 40.844	- 0.038	71. 53
α^1 Tauri.....	4.4	3. 59. 4.627	0.000	68. 11	α Hydrae.....	2.0	9. 22. 55.153	- 0.013	98. 15
ω^1 Tauri.....	5.8	4. 3. 37.772	- 0.029	70. 39	ξ Leonis.....	5.2	9. 26. 49.579	- 0.020	78. 17
α^1 Eridani.....	4.1	4. 7. 13.635	- 0.029	97. 5	α Leonis.....	3.8	9. 36. 4.898	- 0.008	79. 41
γ Tauri.....	3.9	4. 14. 23.130	- 0.014	74. 36	ϵ Leonis.....	3.1	9. 40. 27.661	+ 0.008	65. 47
ϵ Tauri.....	3.7	4. 23. 4.086	+ 0.003	71. 2	μ Leonis.....	4.1	9. 47. 21.769	+ 0.028	63. 33
Aldebaran.....	1.0	4. 30. 28.101	+ 0.017	73. 41	π Leonis.....	5.0	9. 55. 11.641	- 0.008	81. 30
τ Tauri.....	4.4	4. 36. 32.501	- 0.014	67. 13	Regulus.....	1.4	10. 3. 18.839	+ 0.001	77. 34
μ Eridani.....	4.3	4. 40. 45.102	- 0.007	93. 26	γ^1 Leonis.....	2.0	10. 14. 44.216	+ 0.024	69. 41
ι Aurigæ.....	2.7	4. 50. 48.344	+ 0.027	56. 59	μ Hydrae.....	4.1	10. 21. 29.714	- 0.018	106. 21
ϵ Leporis.....	3.3	5. 1. 26.352	0.000	112. 30	ρ Leonis.....	4.0	10. 27. 48.605	- 0.011	80. 12
Rigel.....	0.3	5. 9. 58.320	+ 0.014	98. 19	δ^4 Sextantis....	6.9	10. 37. 43.154	- 0.044	85. 55
β Tauri.....	1.9	5. 20. 17.157	+ 0.013	61. 28	ι Leonis.....	5.3	10. 44. 15.890	- 0.015	78. 57
δ Orionis.....	2.4	5. 27. 9.160	- 0.008	90. 22	α Leonis.....	5.0	10. 55. 39.281	- 0.007	85. 52
α Leporis.....	2.7	5. 28. 32.363	- 0.047	107. 53	χ Leonis.....	4.7	11. 0. 7.021	- 0.028	82. 9
ϵ Orionis.....	1.8	5. 31. 23.550	- 0.005	91. 16	δ Leonis.....	2.8	11. 9. 3.468	- 0.006	68. 57
α Columbae.....	2.7	5. 36. 12.520	- 0.021	124. 7	δ Crateris.....	3.9	11. 14. 35.408	- 0.002	104. 16
κ Orionis.....	2.2	5. 43. 15.039	- 0.010	99. 42	τ Leonis.....	5.1	11. 23. 3.114	- 0.012	86. 37
α Orionis.....	1.4	5. 50. 1.715	+ 0.005	82. 37	ν Leonis.....	4.5	11. 32. 5.073	- 0.010	90. 18
ι Geminorum....	4.3	5. 58. 20.723	- 0.013	66. 44	β Leonis.....	2.2	11. 44. 12.891	- 0.010	74. 54
ν Orionis.....	4.4	6. 2. 8.855	- 0.039	75. 13	β Virginis.....	3.7	11. 45. 44.801	- 0.008	87. 42
η Geminorum....	3.2	6. 9. 8.597	- 0.029	67. 28	π Virginis.....	4.4	11. 56. 0.282	- 0.007	82. 51
μ Geminorum....	3.2	6. 17. 12.813	- 0.004	67. 26	α Virginis.....	4.3	12. 0. 22.223	+ 0.001	80. 44
β Canis Majoris..	2.0	6. 18. 30.938	- 0.019	107. 55	ϵ Corvi.....	3.1	12. 5. 14.221	- 0.018	112. 5
ν Geminorum....	4.0	6. 23. 19.353	+ 0.004	69. 44	Bradley 1672...	6.3	12. 14. 24.830	+ 0.393	1. 46
γ Geminorum....	2.0	6. 32. 13.455	- 0.003	73. 31	γ Virginis.....	4.0	12. 15. 2.713	- 0.024	90. 8
ξ Geminorum....	3.4	6. 39. 57.462	- 0.012	77. 0	δ^2 Corvi.....	3.0	12. 24. 56.839	- 0.018	105. 59
θ Canis Majoris..	4.2	6. 49. 46.570	- 0.023	101. 55	β Corvi.....	2.8	12. 29. 23.665	- 0.003	112. 52
ϵ Canis Majoris..	1.5	6. 54. 53.498	- 0.030	118. 51	ρ Virginis.....	5.1	12. 37. 4.572	- 0.029	79. 14
Cephei δ^1	5.3	6. 56. 12.583	+ 0.684	2. 48	δ^3 Virginis.....	6.9	12. 43. 1.142	- 0.038	85. 55

The correction to the R.A. of Procyon for the effect of orbital motion from 1890 (the epoch of the *Ten-Year Catalogue*) to 1905'0 is -0.040. This correction is derived from Prof. Auwers' "Elements" (*Astronomische Nachrichten*, Nos. 1371, 1372, 1373). The Right Ascensions of the *Nautical Almanac* for 1905'0 are derived from Prof. Newcomb's *Catalogue of Fundamental Stars*.

lxxxviii INTRODUCTION TO GREENWICH ASTRONOMICAL OBSERVATIONS, 1905.

Assumed Mean Right Ascensions of Clock Stars and Circumpolar Stars, with the Corrections to the R.A. of the Nautical Almanac, for 1905⁰—continued.

Star's Name.	Mag.	Assumed Mean R.A. 1905 ⁰ .	Correction to N.A.	Approx. N.P.D.	Star's Name.	Mag.	Assumed Mean R.A. 1905 ⁰ .	Correction to N.A.	Approx. N.P.D.
31 Comæ.....	5 ⁰	h m s 12. 47. 4 ³ 46	+ 0 ⁰ 031	61. 57	β ¹ Lyrae.....	3 ⁴	h m s 18. 46. 34 ³ 51	+ 0 ⁰ 008	56. 45
δ Virginis.....	3 ⁷	12. 50. 49 ⁰ 59	— 0 ⁰ 001	86. 5	ε Aquilæ.....	4 ¹	18. 55. 18 ⁰ 40	+ 0 ⁰ 003	75. 4
ε Virginis.....	3 ⁰	12. 57. 26 ⁰ 880	+ 0 ⁰ 004	78. 32	ζ Aquilæ.....	3 ¹	19. 1. 2 ⁰ 615	0 ⁰ 000	76. 17
θ Virginis.....	4 ⁴	13. 5. 1 ⁰ 787	— 0 ⁰ 013	95. 2	ψ Sagittarii.....	5 ²	19. 9. 42 ⁰ 979	+ 0 ⁰ 016	115. 25
Spica.....	1 ²	13. 20. 11 ⁰ 205	— 0 ⁰ 006	100. 40	ω Aquilæ.....	5 ¹	19. 13. 21 ⁰ 449	+ 0 ⁰ 003	78. 35
ζ Virginis.....	3 ⁵	13. 29. 51 ⁰ 090	+ 0 ⁰ 006	90. 7	λ Ursæ Minoris..	6 ⁵	19. 16. 48 ⁰ 115	+ 0 ⁰ 958	1. 0
m Virginis.....	5 ³	13. 36. 37 ⁰ 455	— 0 ⁰ 008	98. 13	δ Aquilæ.....	3 ⁵	19. 20. 42 ⁰ 523	+ 0 ⁰ 004	87. 5
τ Boötis.....	4 ⁵	13. 42. 44 ⁰ 872	+ 0 ⁰ 011	72. 4	α Vulpeculæ.....	4 ⁷	19. 24. 45 ⁰ 153	+ 0 ⁰ 025	65. 32
η Boötis.....	2 ⁹	13. 50. 9 ⁰ 698	+ 0 ⁰ 011	71. 8	μ Aquilæ.....	4 ⁷	19. 29. 26 ⁰ 932	— 0 ⁰ 007	82. 49
τ Virginis.....	4 ⁴	13. 56. 48 ⁰ 647	— 0 ⁰ 008	88. 0	h ² Sagittarii.....	4 ⁶	19. 30. 55 ⁰ 631	+ 0 ⁰ 014	115. 6
94 Virginis.....	6 ⁸	14. 1. 15 ⁰ 814	— 0 ⁰ 019	98. 26	e ¹ Sagittarii.....	5 ⁶	19. 35. 16 ⁰ 873	— 0 ⁰ 025	106. 31
κ Virginis.....	4 ³	14. 7. 49 ⁰ 573	— 0 ⁰ 026	99. 50	γ Aquilæ.....	2 ⁸	19. 41. 44 ⁰ 605	+ 0 ⁰ 012	79. 37
Arcturus.....	0 ⁰	14. 11. 19 ⁰ 679	+ 0 ⁰ 003	70. 19	α Aquilæ.....	1 ⁰	19. 46. 8 ⁰ 906	+ 0 ⁰ 008	81. 23
f Boötis.....	5 ⁴	14. 22. 2 ⁰ 239	+ 0 ⁰ 017	70. 21	β Aquilæ.....	4 ⁰	19. 50. 38 ⁰ 805	— 0 ⁰ 008	83. 50
ρ Boötis.....	3 ⁶	14. 27. 44 ⁰ 160	— 0 ⁰ 009	59. 13	c Sagittarii.....	4 ⁷	19. 56. 49 ⁰ 093	+ 0 ⁰ 008	117. 58
e ² Boötis.....	3 ⁰	14. 40. 50 ⁰ 309	+ 0 ⁰ 018	62. 32	θ Aquilæ.....	3 ⁴	20. 6. 24 ⁰ 206	— 0 ⁰ 012	91. 6
α Libræ.....	3 ⁰	14. 45. 37 ⁰ 244	— 0 ⁰ 006	105. 39	α ² Capricorni.....	3 ⁸	20. 12. 47 ⁰ 067	— 0 ⁰ 010	102. 50
ξ ² Libræ.....	5 ⁸	14. 51. 36 ⁰ 683	+ 0 ⁰ 002	101. 2	β Capricorni.....	3 ⁴	20. 15. 40 ⁰ 483	— 0 ⁰ 034	105. 5
ψ Boötis.....	4 ⁵	15. 0. 22 ⁰ 501	+ 0 ⁰ 010	62. 41	ρ Capricorni.....	5 ⁰	20. 23. 26 ⁰ 585	— 0 ⁰ 004	108. 8
χ ¹ Libræ.....	4 ⁹	15. 6. 48 ⁰ 244	+ 0 ⁰ 013	109. 26	δ Delphini.....	4 ¹	20. 28. 40 ⁰ 467	+ 0 ⁰ 013	79. 1
Groomb. 2283 ...	7 ¹	15. 7. 38 ⁰ 997	+ 0 ⁰ 209	2. 24	α Delphini.....	4 ⁰	20. 35. 13 ⁰ 537	— 0 ⁰ 009	74. 25
β Libræ.....	2 ⁷	15. 11. 53 ⁰ 566	— 0 ⁰ 035	99. 2	ε Aquarii.....	3 ⁸	20. 42. 32 ⁰ 041	— 0 ⁰ 018	99. 51
o ² Libræ.....	6 ³	15. 17. 43 ⁰ 735	— 0 ⁰ 018	104. 48	μ Aquarii.....	4 ⁸	20. 47. 31 ⁰ 832	— 0 ⁰ 017	99. 20
ε ¹ Libræ.....	6 ²	15. 22. 53 ⁰ 796	— 0 ⁰ 020	106. 23	32 Vulpeculæ....	5 ¹	20. 50. 30 ⁰ 661	+ 0 ⁰ 003	62. 18
α Coronæ.....	2 ⁴	15. 30. 39 ⁰ 931	+ 0 ⁰ 011	62. 58	θ Capricorni.....	4 ³	21. 0. 36 ⁰ 510	+ 0 ⁰ 019	107. 37
α Serpentis.....	2 ⁷	15. 39. 35 ⁰ 280	+ 0 ⁰ 012	83. 17	ζ Cygni.....	3 ⁵	21. 8. 53 ⁰ 565	+ 0 ⁰ 012	60. 10
ε Serpentis.....	3 ⁷	15. 46. 4 ⁰ 772	+ 0 ⁰ 004	85. 14	α Equulei.....	4 ¹	21. 11. 4 ⁰ 531	+ 0 ⁰ 017	85. 9
γ Serpentis.....	4 ⁰	15. 52. 3 ⁰ 865	— 0 ⁰ 008	74. 2	ι Capricorni.....	4 ⁴	21. 16. 57 ⁰ 492	— 0 ⁰ 024	107. 14
β ¹ Scorpii.....	2 ⁰	15. 59. 54 ⁰ 635	— 0 ⁰ 010	109. 33	Groomb. 3548 ...	7 ⁴	21. 18. 37 ⁰ 350	...	3. 22
δ Ophiuchi.....	2 ⁸	16. 9. 21 ⁰ 943	— 0 ⁰ 019	93. 27	β Aquarii.....	3 ¹	21. 26. 33 ⁰ 526	+ 0 ⁰ 006	95. 59
γ Herculis.....	3 ⁸	16. 17. 43 ⁰ 727	— 0 ⁰ 006	70. 37	ε Aquarii.....	4 ⁸	21. 32. 41 ⁰ 733	— 0 ⁰ 005	98. 17
Antares.....	1 ¹	16. 23. 34 ⁰ 841	+ 0 ⁰ 001	116. 13	ξ Pegasi.....	2 ⁴	21. 39. 31 ⁰ 203	+ 0 ⁰ 004	80. 34
λ Ophiuchi.....	4 ⁰	16. 26. 7 ⁰ 260	— 0 ⁰ 011	87. 49	δ Capricorni.....	3 ⁰	21. 41. 47 ⁰ 920	— 0 ⁰ 002	106. 34
ζ Ophiuchi.....	2 ⁸	16. 31. 55 ⁰ 566	— 0 ⁰ 023	100. 23	16 Pegasi.....	5 ⁰	21. 48. 44 ⁰ 327	— 0 ⁰ 017	64. 31
ζ Herculis.....	3 ¹	16. 37. 42 ⁰ 302	+ 0 ⁰ 019	58. 14	α Aquarii.....	3 ²	22. 0. 54 ⁰ 286	— 0 ⁰ 023	90. 47
κ Ophiuchi.....	3 ⁴	16. 53. 10 ⁰ 265	+ 0 ⁰ 007	80. 29	ι Pegasi.....	4 ⁰	22. 2. 35 ⁰ 273	— 0 ⁰ 009	65. 7
ε Herculis.....	4 ⁰	16. 56. 39 ⁰ 276	+ 0 ⁰ 005	58. 56	θ Aquarii.....	4 ³	22. 11. 49 ⁰ 279	— 0 ⁰ 006	98. 15
η Ophiuchi.....	2 ⁶	17. 4. 55 ⁰ 709	+ 0 ⁰ 005	105. 36	γ Aquarii.....	4 ¹	22. 16. 44 ⁰ 977	— 0 ⁰ 017	91. 52
α ¹ Herculis.....	3 ¹	17. 10. 18 ⁰ 919	+ 0 ⁰ 001	75. 30	σ Aquarii.....	4 ⁸	22. 25. 37 ⁰ 234	— 0 ⁰ 027	101. 10
θ Ophiuchi.....	3 ⁴	17. 16. 10 ⁰ 424	— 0 ⁰ 019	114. 54	η Aquarii.....	4 ²	22. 30. 28 ⁰ 496	— 0 ⁰ 008	90. 36
σ Ophiuchi.....	4 ⁴	17. 21. 48 ⁰ 028	— 0 ⁰ 019	85. 47	ζ Pegasi.....	3 ⁶	22. 36. 43 ⁰ 416	— 0 ⁰ 014	79. 40
α Ophiuchi.....	2 ²	17. 30. 31 ⁰ 457	+ 0 ⁰ 003	77. 22	μ Pegasi.....	3 ⁷	22. 45. 25 ⁰ 005	— 0 ⁰ 029	65. 54
β Ophiuchi.....	2 ⁹	17. 38. 46 ⁰ 742	— 0 ⁰ 018	85. 24	λ Aquarii.....	3 ⁸	22. 47. 39 ⁰ 535	— 0 ⁰ 004	98. 5
μ Herculis.....	3 ⁵	17. 42. 44 ⁰ 395	— 0 ⁰ 015	62. 13	Fomalhaut.....	1 ³	22. 52. 24 ⁰ 181	— 0 ⁰ 007	120. 8
89 Herculis.....	5 ⁶	17. 51. 35 ⁰ 246	— 0 ⁰ 017	63. 56	α Pegasi.....	2 ⁶	23. 0. 1 ⁰ 667	— 0 ⁰ 002	75. 18
72 Ophiuchi.....	3 ⁸	18. 2. 50 ⁰ 742	+ 0 ⁰ 013	80. 27	γ Piscium.....	3 ⁸	23. 12. 14 ⁰ 411	— 0 ⁰ 008	87. 14
δ Ursæ Minoris..	4 ³	18. 2. 55 ⁰ 568	+ 0 ⁰ 301	3. 23	κ Piscium.....	5 ⁰	23. 22. 3 ⁰ 743	— 0 ⁰ 014	89. 16
μ Sagittarii.....	4 ¹	18. 8. 4 ⁰ 911	+ 0 ⁰ 011	111. 5	Bradley 3147....	5 ⁶	23. 27. 47 ⁰ 890	+ 0 ⁰ 965	3. 13
η Serpentis.....	3 ⁴	18. 16. 23 ⁰ 612	— 0 ⁰ 003	92. 55	ι Piscium.....	4 ³	23. 35. 3 ⁰ 789	— 0 ⁰ 025	84. 53
λ Sagittarii.....	3 ¹	18. 22. 6 ⁰ 451	— 0 ⁰ 027	115. 28	δ Sculptoris.....	4 ⁶	23. 43. 58 ⁰ 745	+ 0 ⁰ 045	118. 39
α Lyrae.....	0 ²	18. 33. 43 ⁰ 320	+ 0 ⁰ 002	51. 18	ω Piscium.....	4 ²	23. 54. 25 ⁰ 929	— 0 ⁰ 017	83. 40
2 Aquilæ.....	4 ⁸	18. 37. 4 ⁰ 366	— 0 ⁰ 012	99. 9	2 Ceti.....	4 ⁶	23. 58. 52 ⁰ 432	0 ⁰ 000	107. 52

TRANSIT-CIRCLE TABLES.

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*Determination of the Personal Equation of the various Observers using the
Chronographic Method of observing Transits.*

The Observers, in order of seniority, are :—

D, H, B, CD, WB, HF, W, JS, WS, PM, E, RC, SD, J, S, BE.

The personal equation of J having apparently changed during the year, his observations for the two halves of the year are treated separately, and are distinguished by the suffixes 1 and 2, corresponding to Jan.-June and July-Dec. respectively.

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, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.	Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.
Jan. 24	^h 2	S D D	^s + 0.28	Apr. 12	^h 4	B W S	^s + 0.17
Jan. 24	0	J ₁ D	- 0.09	May 26	2	B W S	+ 0.19
Mar. 12	0	H J ₁	- 0.24	May 23	7	R C B	- 0.03
Mar. 12	2	S H	+ 0.33	July 19	8	B R C	- 0.15
Jan. 17	3	B C D	- 0.04	Oct. 19	6	R C B	+ 0.05
Jan. 5	3	B W	- 0.01	Jan. 5	2	B S D	+ 0.08
Apr. 12	2	B W	- 0.04	" 28	7	S D B	+ 0.04
" 28	1	B W	- 0.02	Feb. 25	3	B S D	- 0.02
Jan. 5	2	B J S	- 0.31	Mar. 22	4	B S D	+ 0.06
" 17	8	B J S	- 0.41	" 30	8	B S D	+ 0.10
" 28	2	J S B	- 0.36	Apr. 12	10	B S D	+ 0.10
Mar. 22	0	J S B	- 0.37	" 13	5	B S D	+ 0.04
" 30	1	J S B	- 0.33	May 5	6	B S D	+ 0.05
May 5	2	B J S	- 0.32	July 19	4	S D B	- 0.02
" 26	1	B J S	- 0.30	Oct. 19	8	S D B	+ 0.09
June 14	6	B J S	- 0.34	Jan. 17	2	B J ₁	- 0.28
Oct. 19	6	J S B	- 0.34	" 28	7	J ₁ B	- 0.32
" 24	0	B J S	- 0.34	Mar. 2	3	B J ₁	- 0.33
Nov. 21	1	J S B	- 0.32	Apr. 12	6	B J ₁	- 0.34
" 29	4	J S B	- 0.32	" 19	2	B J ₁	- 0.45
Dec. 7	1	B J S	- 0.31				
" 26	1	J S B	- 0.24*				
" 31	2	B J S	- 0.30				

GREENWICH OBSERVATIONS, 1905.

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Observations for Personal Equations—Chronographic—continued.

Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.	Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.
May 5	h 0	B S	^s + 0.02	Oct. 20	h 7	B E W B	+ 0.26
June 21	4	S B	+ 0.02	June 16	2	J S H F	- 0.23
July 12	2	S B	+ 0.04	Sept. 8	2	J S H F	- 0.25
„ 14	1	S B	+ 0.10	Oct. 30	0	J S H F	- 0.23
„ 26	11	B S	+ 0.11	Nov. 7	0	H F J S	- 0.21
Oct. 21	4	B S	+ 0.01	Jan. 27	11	H F E	+ 0.09
Nov. 21	1	S B	+ 0.04	Sept. 8	1	E H F	+ 0.11
Oct. 19	3	B E B	+ 0.17	Jan. 27	2	H F S D	+ 0.15
Jan. 25	10	C D W	+ 0.09	Jan. 27	3	H F J ₁	- 0.17
Jan. 17	5	C D J S	- 0.37	Oct. 30	0	H F B E	+ 0.11
„ 25	1	J S C D	- 0.30	Jan. 5	1	J S W	- 0.30
Jan. 25	3	C D S D	+ 0.19	„ 25	11	J S W	- 0.39
Jan. 17	1	J ₁ C D	- 0.24	Mar. 23	0	W J S	- 0.33
„ 25	3	C D J ₁	- 0.15	May 6	1	J S W	- 0.33
Sept. 18	9	W B W	+ 0.09	„ 10	0	J S W	- 0.26
Oct. 20	6	W B W	+ 0.13	June 22	7	J S W	- 0.24
Sept. 18	0	J S W B	- 0.19	Sept. 18	9	J S W	- 0.28
Oct. 20	7	J S W B	- 0.20	Oct. 31	2	J S W	- 0.33
Dec. 25	0	J S W B	- 0.18	Nov. 6	1	J S W	- 0.26
Sept. 5	1	W B E	+ 0.09	Dec. 19	11	J S W	- 0.26
„ 12	11	W B E	- 0.01	„ 28	0	J S W	- 0.19
„ 15	0	E W B	+ 0.13	„ 30	9	J S W	- 0.32
„ 19	0	W B E	+ 0.09	Apr. 12	2	W W S	+ 0.21
Sept. 19	1	R C W B	+ 0.16	July 18	1	W E	+ 0.06
Sept. 12	0	S D W B	+ 0.08	Sept. 23	1	W E	0.00
Aug. 23	8	W B J ₂	- 0.29	Jan. 18	3	W R C	- 0.03
Sept. 15	1	W B J ₂	- 0.34	June 22	7	R C W	+ 0.06
„ 19	10	W B J ₂	- 0.46	Aug. 8	1	W R C	+ 0.09
Aug. 24	1	W B S	+ 0.16	Jan. 5	1	S D W	+ 0.09
Sept. 6	1	S W B	+ 0.09	„ 10	0	S D W	+ 0.10
„ 17	5	W B S	+ 0.09	„ 18	1	S D W	+ 0.06
				„ 25	7	S D W	+ 0.10

TRANSIT-CIRCLE TABLES.

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Observations for Personal Equations—Chronographic—continued.

Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.	Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.
Mar. 11	^h 1	W S D	^s + 0.09	Sept. 8	^h 2	J S E	^s + 0.36
Apr. 12	8	W S D	+ 0.14	,, 13	8	E J S	+ 0.26
Dec. 30	8	S D W	+ 0.02	,, 20	11	J S E	+ 0.46
Jan. 18	0	J ₁ W	- 0.31	Oct. 17	2	J S E	+ 0.34
,, 25	7	J ₁ W	- 0.24	Nov. 15	7	J S E	+ 0.37
Mar. 23	7	W J ₁	- 0.36	,, 24	5	E J S	+ 0.31
Apr. 12	4	W J ₁	- 0.30	Dec. 2	3	J S E	+ 0.35
May 6	4	W J ₁	- 0.35	Jan. 13	9	J S R C	+ 0.35
July 25	11	J ₂ W	- 0.32	,, 19	1	J S R C	+ 0.34
Aug. 4	3	W J ₂	- 0.36	,, 26	12	R C J S	+ 0.19
,, 23	6	J ₂ W	- 0.50	Mar. 27	9	R C J S	+ 0.22
Dec. 8	4	W J ₂	- 0.55	Apr. 29	3	J S R C	+ 0.27
Mar. 15	1	S W	+ 0.11	June 22	1	R C J S	+ 0.30
,, 31	4	S W	+ 0.08*	Sept. 14	4	J S R C	+ 0.31
May 10	2	S W	+ 0.03	Oct. 17	1	J S R C	+ 0.40
Aug. 4	2	W S	+ 0.18	,, 19	0	R C J S	+ 0.39
Oct. 5	4	B E W	+ 0.08	Jan. 5	0	S D J S	+ 0.39
Nov. 23	1	B E W	+ 0.08	,, 9	5	S D J S	+ 0.40
Jan. 19	1	J S W S	+ 0.52	,, 11	1	J S S D	+ 0.31
Mar. 24	2	J S W S	+ 0.49	,, 13	4	J S S D	+ 0.44
May 26	1	J S W S	+ 0.49	,, 19	1	S D J S	+ 0.48
June 28	1	J S W S	+ 0.42	,, 25	4	J S S D	+ 0.49
Dec. 9	2	J S W S	+ 0.33	,, 28	5	S D J S	+ 0.40
Jan. 11	4	J S P M	+ 0.30	Mar. 22	4	J S S D	+ 0.43
Mar. 24	9	J S E	+ 0.36	,, 24	2	J S S D	+ 0.39
June 13	5	J S E	+ 0.36	,, 27	4	S D J S	+ 0.39
,, 28	1	J S E	+ 0.32	,, 30	10	J S S D	+ 0.43
				May 5	4	J S S D	+ 0.37
				,, 9	3	J S S D	+ 0.37
				,, 22	3	S D J S	+ 0.23
				June 19	3	S D J S	+ 0.35
				Oct. 4	0	S D J S	+ 0.33
				,, 18	0	S D J S	+ 0.40
				,, 19	2	S D J S	+ 0.43

Observations for Personal Equations—Chronographic—continued.

Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.	Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.	Excess of Clock Slow by Junior Observer.
Nov. 22	^h 4	J S S D	^s + 0.24	June 28	^h 1	W S E	^s - 0.10
Dec. 9	6	J S S D	+ 0.31	Oct. 31	1	E W S	- 0.12
„ 11	2	S D J S	+ 0.31*	Jan. 19	1	R C W S	- 0.18
„ 19	7	S D J S	+ 0.25	May 17	2	R C W S	- 0.09
„ 30	1	J S S D	+ 0.34	Jan. 19	2	S D W S	- 0.04
Jan. 9	4	J ₁ J S	+ 0.09	Mar. 24	1	W S S D	- 0.10
„ 13	8	J S J ₁	+ 0.14	Apr. 12	6	W S S D	- 0.07
„ 17	6	J ₁ J S	+ 0.13	Dec. 9	4	W S S D	- 0.02
„ 19	1	J ₁ J S	+ 0.08	Jan. 19	3	J ₁ W S	- 0.44
„ 25	4	J S J ₁	+ 0.15	Apr. 12	2	W S J ₁	- 0.51
„ 28	4	J ₁ J S	+ 0.04	Nov. 20	4	J ₂ W S	- 0.67
Mar. 23	6	J ₁ J S	- 0.03	Oct. 31	3	B E W S	- 0.12
Apr. 5	1	J S J ₁	+ 0.04*	Jan. 11	3	S D P M	+ 0.01
May 6	4	J S J ₁	- 0.02	Sept. 19	2	R C E	+ 0.07
Oct. 16	1	J S J ₂	- 0.07	Oct. 17	2	R C E	+ 0.06
„ 18	5	J S J ₂	- 0.21	Jan. 12	0	S D E	+ 0.09
Dec. 19	3	J ₂ J S	- 0.20	„ 27	9	S D E	+ 0.06
May 5	1	S J S	+ 0.34	Mar. 24	6	S D E	+ 0.03
„ 9	1	S J S	+ 0.30	Apr. 6	3	E S D	+ 0.07
„ 10	2	S J S	+ 0.29	Sept. 12	12	S D E	+ 0.09
June 24	2	J S S	+ 0.39	Jan. 14	2	E J ₁	- 0.30
Sept. 20	4	J S S	+ 0.43	„ 27	8	J ₁ E	- 0.26
Oct. 16	0	J S S	+ 0.40	June 20	5	J ₂ E	- 0.54
„ 21	8	S J S	+ 0.32	Sept. 15	1	E J ₂	- 0.47
Nov. 21	0	J S S	+ 0.36	„ 19	10	E J ₂	- 0.55
„ 27	2	J S S	+ 0.32	Mar. 9	2	S E	+ 0.11
Oct. 16	3	J S B E	+ 0.53				
„ 19	4	J S B E	+ 0.51				
„ 20	1	B E J S	+ 0.46				
„ 25	0	B E J S	+ 0.43				
„ 30	1	J S B E	+ 0.34				
Nov. 15	4	J S B E	+ 0.28				
„ 27	2	J S B E	+ 0.32				
Mar. 24	7	W S E	- 0.13				

TRANSIT-CIRCLE TABLES.

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Observations for Personal Equations—Chronographic—continued.

Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.	Day, 1905.	Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
Apr. 6	h 4	S	E	+ 0.03	Jan. 18	h 0	S D	J ₁	- 0.37
" 8	2	S	E	+ 0.03	" 19	0	J ₁	S D	- 0.40
" 14	0	E	S	+ 0.01	" 24	1	S D	J ₁	- 0.37
May 27	11	S	E	+ 0.13*	" 25	0	S D	J ₁	- 0.34
Sept. 20	7	S	E	- 0.03	" 27	1	S D	J ₁	- 0.32
					" 28	1	S D	J ₁	- 0.36
Oct. 31	2	B E	E	0.00	Feb. 10	1	J ₁	S D	- 0.28
Nov. 15	2	B E	E	- 0.09	Apr. 12	4	J ₁	S D	- 0.44
Jan. 13	5	S D	R C	+ 0.09	July 21	5	S D	J ₂	- 0.43
" 18	3	S D	R C	+ 0.09	Oct. 18	5	S D	J ₂	- 0.61
" 19	2	S D	R C	+ 0.14	Dec. 19	4	S D	J ₂	- 0.45
Feb. 8	1	S D	R C	+ 0.04	Feb. 17	0	S D	S	+ 0.04
" 17	6	R C	S D	+ 0.08	Apr. 6	7	S	S D	- 0.04
" 27	6	R C	S D	+ 0.14	" 15	10	S	S D	+ 0.03
Mar. 27	5	R C	S D	+ 0.17	May 5	6	S	S D	- 0.03
Apr. 22	2	S D	R C	0.00	" 9	4	S	S D	- 0.07
Oct. 19	1	S D	R C	+ 0.04	Oct. 19	5	S D	B E	+ 0.08
Jan. 13	0	J ₁	R C	- 0.21	Mar. 12	2	S	J ₁	+ 0.57
" 18	3	J ₁	R C	- 0.28	May 18	4	J ₁	S	+ 0.39
" 19	2	J ₁	R C	- 0.26	July 24	1	S	J ₂	+ 0.46
Aug. 1	11	R C	J ₂	- 0.46	Aug. 4	1	S	J ₂	+ 0.54
" 18	8	R C	J ₂	- 0.41	" 14	1	S	J ₂	+ 0.56
Sept. 19	11	R C	J ₂	- 0.62	" 17	5	S	J ₂	+ 0.44
Feb. 17	6	R C	S	+ 0.12	" 18	8	S	J ₂	+ 0.53
Mar. 18	1	R C	S	+ 0.20	" 20	5	J ₂	S	+ 0.46
July 8	1	R C	S	- 0.01	" 24	12	S	J ₂	+ 0.36*
Aug. 18	0	R C	S	+ 0.12	Oct. 16	1	S	J ₂	+ 0.47
Oct. 6	1	R C	B E	+ 0.22	Oct. 16	2	J ₂	B E	+ 0.60
" 19	4	R C	B E	+ 0.12	Oct. 16	3	S	B E	+ 0.13
Jan. 9	1	S D	J ₁	- 0.31	Nov. 27	0	S	B E	0.00
" 13	5	S D	J ₁	- 0.30					

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From these differences, if we form equations in which each observer's initial shall successively stand first, we obtain the following groups of equations:—

For D. $\begin{aligned} 2 (D - S D) &= - 0^s.56 \\ 2 (D - J_1) &= + 0^s.18 \end{aligned}$	For H F.—<i>continued.</i> $\begin{aligned} 2 (H F - S D) &= - 0^s.30 \\ 2 (H F - J_1) &= + 0^s.34 \\ 2 (H F - B E) &= - 0^s.22 \end{aligned}$
For H. $\begin{aligned} 2 (H - J_1) &= + 0^s.48 \\ 2 (H - S) &= - 0^s.66 \end{aligned}$	For W. $\begin{aligned} 6 (W - B) &= - 0^s.14 \\ 2 (W - C D) &= + 0^s.18 \\ 4 (W - W B) &= + 0^s.44 \\ 24 (W - J S) &= + 6^s.98 \\ 2 (W - W S) &= - 0^s.42 \\ 4 (W - E) &= - 0^s.12 \\ 6 (W - R C) &= - 0^s.24 \\ 14 (W - S D) &= - 1^s.20 \\ 10 (W - J_1) &= + 3^s.12 \\ 8 (W - J_2) &= + 3^s.46 \\ 7 (W - S) &= - 0^s.72 \\ 4 (W - B E) &= - 0^s.32 \end{aligned}$
For B. $\begin{aligned} 2 (B - C D) &= + 0^s.08 \\ 6 (B - W) &= + 0^s.14 \\ 29 (B - J S) &= + 9^s.58 \\ 4 (B - W S) &= - 0^s.72 \\ 6 (B - R C) &= + 0^s.26 \\ 20 (B - S D) &= - 1^s.04 \\ 10 (B - J_1) &= + 3^s.44 \\ 14 (B - S) &= - 0^s.68 \\ 2 (B - B E) &= - 0^s.34 \end{aligned}$	For J S. $\begin{aligned} 29 (J S - B) &= - 9^s.58 \\ 4 (J S - C D) &= - 1^s.34 \\ 6 (J S - W B) &= - 1^s.14 \\ 8 (J S - H F) &= - 1^s.84 \\ 24 (J S - W) &= - 6^s.98 \\ 10 (J S - W S) &= - 4^s.50 \\ 2 (J S - P M) &= - 0^s.60 \\ 20 (J S - E) &= - 6^s.98 \\ 18 (J S - R C) &= - 5^s.54 \\ 45 (J S - S D) &= - 16^s.65 \\ 17 (J S - J_1) &= - 1^s.20 \\ 6 (J S - J_2) &= + 0^s.96 \\ 18 (J S - S) &= - 6^s.30 \\ 14 (J S - B E) &= - 5^s.74 \end{aligned}$
For C D. $\begin{aligned} 2 (C D - B) &= - 0^s.08 \\ 2 (C D - W) &= - 0^s.18 \\ 4 (C D - J S) &= + 1^s.34 \\ 2 (C D - S D) &= - 0^s.38 \\ 4 (C D - J_1) &= + 0^s.78 \end{aligned}$	For W S. $\begin{aligned} 4 (W S - B) &= + 0^s.72 \\ 2 (W S - W) &= + 0^s.42 \\ 10 (W S - J S) &= + 4^s.50 \\ 6 (W S - E) &= + 0^s.70 \\ 4 (W S - R C) &= + 0^s.54 \end{aligned}$
For W B. $\begin{aligned} 4 (W B - W) &= - 0^s.44 \\ 6 (W B - J S) &= + 1^s.14 \\ 8 (W B - E) &= - 0^s.60 \\ 2 (W B - R C) &= - 0^s.32 \\ 2 (W B - S D) &= - 0^s.16 \\ 6 (W B - J_2) &= + 2^s.18 \\ 6 (W B - S) &= - 0^s.68 \\ 2 (W B - B E) &= - 0^s.52 \end{aligned}$	
For H F. $\begin{aligned} 8 (H F - J S) &= + 1^s.84 \\ 4 (H F - E) &= - 0^s.40 \end{aligned}$	

TRANSIT-CIRCLE TABLES.

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For W S.—*continued*.

8 (W S — S D)	= + 0 ^s .46
4 (W S — J ₁)	= + 1 ^s .90
2 (W S — J ₂)	= + 1 ^s .34
2 (W S — B E)	= + 0 ^s .24

For P M.

2 (P M — J S)	= + 0 ^s .60
2 (P M — S D)	= - 0 ^s .02

For E.

8 (E — W B)	= + 0 ^s .60
4 (E — H F)	= + 0 ^s .40
4 (E — W)	= + 0 ^s .12
20 (E — J S)	= + 6 ^s .98
6 (E — W S)	= - 0 ^s .70
4 (E — R C)	= - 0 ^s .26
10 (E — S D)	= - 0 ^s .68
4 (E — J ₁)	= + 1 ^s .12
6 (E — J ₂)	= + 3 ^s .12
11 (E — S)	= - 0 ^s .43
4 (E — B E)	= + 0 ^s .18

For R C.

6 (R C — B)	= - 0 ^s .26
2 (R C — W B)	= + 0 ^s .32
6 (R C — W)	= + 0 ^s .24
18 (R C — J S)	= + 5 ^s .54
4 (R C — W S)	= - 0 ^s .54
4 (R C — E)	= + 0 ^s .26
18 (R C — S D)	= - 1 ^s .58
6 (R C — J ₁)	= + 1 ^s .50
6 (R C — J ₂)	= + 2 ^s .98
8 (R C — S)	= - 0 ^s .86
4 (R C — B E)	= - 0 ^s .68

For S D.

2 (S D — D)	= + 0 ^s .56
20 (S D — B)	= + 1 ^s .04
2 (S D — C D)	= + 0 ^s .38
2 (S D — W B)	= + 0 ^s .16

For S D.—*continued*.

2 (S D — H F)	= + 0 ^s .30
14 (S D — W)	= + 1 ^s .20
45 (S D — J S)	= + 16 ^s .65
8 (S D — W S)	= - 0 ^s .46
2 (S D — P M)	= + 0 ^s .02
10 (S D — E)	= + 0 ^s .68
18 (S D — R C)	= + 1 ^s .58
20 (S D — J ₁)	= + 6 ^s .98
6 (S D — J ₂)	= + 2 ^s .98
10 (S D — S)	= + 0 ^s .14
2 (S D — B E)	= + 0 ^s .16

For J₁.

2 (J ₁ — D)	= - 0 ^s .18
2 (J ₁ — H)	= - 0 ^s .48
10 (J ₁ — B)	= - 3 ^s .44
4 (J ₁ — C D)	= - 0 ^s .78
2 (J ₁ — H F)	= - 0 ^s .34
10 (J ₁ — W)	= - 3 ^s .12
17 (J ₁ — J S)	= + 1 ^s .20
4 (J ₁ — W S)	= - 1 ^s .90
4 (J ₁ — E)	= - 1 ^s .12
6 (J ₁ — R C)	= - 1 ^s .50
20 (J ₁ — S D)	= - 6 ^s .98
4 (J ₁ — S)	= - 1 ^s .92

For J₂.

6 (J ₂ — W B)	= - 2 ^s .18
8 (J ₂ — W)	= - 3 ^s .46
6 (J ₂ — J S)	= - 0 ^s .96
2 (J ₂ — W S)	= - 1 ^s .34
6 (J ₂ — E)	= - 3 ^s .12
6 (J ₂ — R C)	= - 2 ^s .98
6 (J ₂ — S D)	= - 2 ^s .98
15 (J ₂ — S)	= - 7 ^s .28
2 (J ₂ — B E)	= - 1 ^s .20

For S.

2 (S — H)	= + 0 ^s .66
14 (S — B)	= + 0 ^s .68
6 (S — W B)	= + 0 ^s .68
7 (S — W)	= + 0 ^s .72
18 (S — J S)	= + 6 ^s .30
11 (S — E)	= + 0 ^s .43

For S.--continued.		For B E.--continued.	
8 (S - R C)	= + 0 ^s .86	2 (B E - H F)	= + 0 ^s .22
10 (S - S D)	= - 0 ^s .14	4 (B E - W)	= + 0 ^s .32
4 (S - J ₁)	= + 1 ^s .92	14 (B E - J S)	= + 5 ^s .74
15 (S - J ₂)	= + 7 ^s .28	2 (B E - W S)	= - 0 ^s .24
4 (S - B E)	= - 0 ^s .26	4 (B E - E)	= - 0 ^s .18
For B E.		4 (B E - R C)	= + 0 ^s .68
2 (B E - B)	= + 0 ^s .34	2 (B E - S D)	= - 0 ^s .16
2 (B E - W B)	= + 0 ^s .52	2 (B E - J ₂)	= + 1 ^s .20
		4 (B E - S)	= + 0 ^s .26

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

4 D-2 S D-2 J ₁	= - 0 ^s .38
4 H-2 J ₁ -2 S	= - 0 ^s .18
93 B-2 C D-6 W-29 J S-4 W S-6 R C-20 S D-10 J ₁ -14 S-2 B E	= + 10 ^s .72
14 C D-2 B-2 W-4 J S-2 S D-4 J ₁	= + 1 ^s .48
36 W B-4 W-6 J S-8 E-2 R C-2 S D-6 J ₂ -6 S-2 B E	= + 0 ^s .60
18 H F-8 J S-4 E-2 S D-2 J ₁ -2 B E	= + 1 ^s .26
91 W-6 B-2 C D-4 W B-24 J S-2 W S-4 E-6 R C-14 S D-10 J ₁ -8 J ₂ -7 S-4 B E	= + 11 ^s .02
221 J S-29 B-4 C D-6 W B-8 H F-24 W-10 W S-2 P M-20 E-18 R C-45 S D-17 J ₁ -6 J ₂ -18 S-14 B E	= - 67 ^s .43
42 W S-4 B-2 W-10 J S-6 E-4 R C-8 S D-4 J ₁ -2 J ₂ -2 B E	= + 10 ^s .82
4 P M-2 J S-2 S D	= + 0 ^s .58
81 E-8 W B-4 H F-4 W-20 J S-6 W S-4 R C-10 S D-4 J ₁ -6 J ₂ -11 S-4 B E	= + 10 ^s .45
82 R C-6 B-2 W B-6 W-18 J S-4 W S-4 E-18 S D-6 J ₁ -6 J ₂ -8 S-4 B E	= + 6 ^s .92
163 S D-2 D-20 B-2 C D-2 W B-2 H F-14 W-45 J S-8 W S-2 P M-10 E-18 R C-20 J ₁ -6 J ₂ -10 S-2 B E	= + 32 ^s .37
85 J ₁ -2 D-2 H-10 B-4 C D-2 H F-10 W-17 J S-4 W S-4 E-6 R C-20 S D-4 S	= - 20 ^s .56
57 J ₂ -6 W B-8 W-6 J S-2 W S-6 E-6 R C-6 S D-15 S-2 B E	= - 25 ^s .50
99 S-2 H-14 B-6 W B-7 W-18 J S-11 E-8 R C-10 S D-4 J ₁ -15 J ₂ -4 B E	= + 19 ^s .13
42 B E-2 B-2 W B-2 H F-4 W-14 J S-2 W S-4 E-4 R C-2 S D-2 J ₂ -4 S	= + 8 ^s .70

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Solving these equations by successive approximations, that is, by first substituting in each equation the approximately known values for all the personal equations except that which has the largest coefficient, 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:—

$$\begin{array}{lll}
 B - D = + 0.22 & B - W = + 0.03 & B - RC = + 0.02 \\
 B - H = + 0.18 & B - JS = + 0.33 & B - SD = - 0.05 \\
 B - CD = + 0.07 & B - WS = - 0.14 & B - J_1 = + 0.31 \\
 B - WB = + 0.11 & B - PM = - 0.01 & B - J_2 = + 0.48 \\
 B - HF = + 0.10 & B - E = - 0.01 & B - S = - 0.04 \\
 & & B - BE = - 0.07
 \end{array}$$

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.

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 1905:—

Date of Observation, 1905.	Excess of Clock Slow by Eye-and-Ear Observer.	Date of Observation, 1905.	Excess of Clock Slow by Eye-and-Ear Observer.	Date of Observation, 1905.	Excess of Clock Slow by Eye-and-Ear Observer.
<i>Observer B.</i>		<i>Observer B—continued.</i>		<i>Observer B—continued.</i>	
d h	s	d h	s	d h	s
Mar. 14. 7	+ 0.09	June 14. 11	— 0.07	Dec. 31. 5	+ 0.04
22. 6	+ 0.06	18. 14	— 0.03		
30. 7	+ 0.09	21. 16	— 0.02	Mean.....	+ 0.01
				<i>Observer W.</i>	
Apr. 13. 7	+ 0.09	July 4. 11	— 0.03	Mar. 15. 7	+ 0.02
19. 8	— 0.06	12. 9	— 0.02	Aug. 8. 11	+ 0.07
28. 7	+ 0.01	19. 8	+ 0.02	Nov. 5. 23	+ 0.04
		26. 7	+ 0.01	Mean.....	+ 0.04
May 5. 7	0.00	Aug. 13. 11	— 0.02		
23. 16	— 0.01				

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Observations for Personal Equations—Eye-and-Ear—continued.

Date of Observation, 1905.	Excess of Clock Slow by Eye-and-Ear Observer.	Date of Observation, 1905.	Excess of Clock Slow by Eye-and-Ear Observer.	Date of Observation, 1905.	Excess of Clock Slow by Eye-and-Ear Observer.
<i>Observer J S.</i>		<i>Observer J S—continued.</i>		<i>Observer R C—continued.</i>	
d h	s	d h	s	d h	s
Mar. 24. 8	+ 0.07	Dec. 30. 7	- 0.08	June 22. 14	- 0.03
Apr. 1. 5	- 0.08	31. 9	+ 0.07	27. 14	- 0.02
29. 6	- 0.04	Mean	- 0.06	July 13. 13	+ 0.05
May 5. 7	- 0.05	<i>Observer W S.</i>		25. 14	+ 0.04
15. 10	- 0.05	May 17. 9	+ 0.23	Aug. 1. 14	+ 0.08
June 19. 14	+ 0.04	June 28. 10	+ 0.13	8. 14	+ 0.02
22. 7	- 0.01	Nov. 20. 8	+ 0.24	18. 15	- 0.04
24. 8	- 0.07	Dec. 9. 7	+ 0.14	Sept. 14. 13	- 0.07
28. 7	- 0.07	Mean.....	+ 0.19	Mean.....	+ 0.02
Sept. 13. 6	- 0.01	<i>Observer E.</i>		<i>Observer S D.</i>	
14. 6	- 0.08	June 13. 9	- 0.08	June 23. 11	+ 0.16
16. 6	- 0.11	July 7. 11	- 0.06	<i>Observer J.</i>	
Oct. 17. 6	+ 0.02	11. 11	+ 0.03	June 26. 10	- 0.15
19. 7	- 0.07	15. 9	- 0.01	July 24. 15	- 0.05
25. 9	0.00	Oct. 27. 10	- 0.11	Oct. 18. 10	- 0.10
28. 5	- 0.06	Mean.....	- 0.05	Mean.....	- 0.10
30. 7	- 0.07	<i>Observer R C.</i>		<i>Observer S.</i>	
Nov. 6. 6	- 0.16	Mar. 18. 14	+ 0.14	Sept. 20. 11	+ 0.04
7. 6	- 0.11	May 17. 14	+ 0.04		
15. 8	+ 0.05				
22. 4	- 0.12				
24. 17	- 0.13				
27. 4	- 0.08				
29. 4	- 0.11				
Dec. 2. 8	- 0.10				
9. 5	- 0.15				
19. 6	- 0.18				
25. 6	- 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:—

$B_0 - B = - 0.01$	$B_0 - W S = - 0.19$	$B_0 - S D = - 0.16$
$B_0 - W = - 0.04$	$B_0 - E = + 0.05$	$B_0 - J = + 0.10$
$B_0 - J S = + 0.06$	$B_0 - R C = - 0.02$	$B_0 - S = - 0.04$

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

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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 $0^{\circ}.30'$ 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 above table of division-errors is a slight modification of that published and used in the second *Ten Year Catalogue*, 1890, owing to the incorporation at a later date of the results of a special examination of the single degree divisions for five degrees on either side of the pole corresponding to pointer readings 14° – 24° .

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 $89^{\circ}.30'$ 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 $0^{\circ}.30'$ and $1^{\circ}.30'$ —was considered to be the correction for all pointer readings between 0° and 1° , and so on. An account of the determination of the errors is given in the *Introduction* for 1897, and also tables of the differences of the values now used (resulting from the determinations in 1851, 1856, and 1898) and the values adopted in previous years.

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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° to 29° , are given in the *Transit-Circle Tables* for 1896. The micrometer is never used beyond these limits and rarely outside 16° and 24° .

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 $1^{\text{rev}} = 37''\cdot05$.

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}	
$\cdot 0$	+ $''39$	+ $''25$	+ $''13$	+ $''98$	+ $''80$	+ $''52$	+ $''35$	+ $''16$	$''00$	$\cdot 0$
$\cdot 1$	+ $1'38$	+ $1'24$	+ $1'12$	+ $0'96$	+ $0'77$	+ $0'51$	+ $0'33$	+ $0'15$	$0'00$	$\cdot 1$
$\cdot 2$	+ $1'36$	+ $1'23$	+ $1'10$	+ $0'94$	+ $0'74$	+ $0'49$	+ $0'31$	+ $0'14$	$0'00$	$\cdot 2$
$\cdot 3$	+ $1'35$	+ $1'21$	+ $1'08$	+ $0'93$	+ $0'72$	+ $0'48$	+ $0'29$	+ $0'12$	$0'00$	$\cdot 3$
$\cdot 4$	+ $1'33$	+ $1'20$	+ $1'07$	+ $0'91$	+ $0'69$	+ $0'46$	+ $0'27$	+ $0'11$	$0'00$	$\cdot 4$
$\cdot 5$	+ $1'32$	+ $1'19$	+ $1'05$	+ $0'89$	+ $0'66$	+ $0'45$	+ $0'25$	+ $0'10$	$0'00$	$\cdot 5$
$\cdot 6$	+ $1'30$	+ $1'18$	+ $1'04$	+ $0'87$	+ $0'63$	+ $0'43$	+ $0'23$	+ $0'08$	$0'00$	$\cdot 6$
$\cdot 7$	+ $1'29$	+ $1'17$	+ $1'02$	+ $0'85$	+ $0'60$	+ $0'41$	+ $0'21$	+ $0'06$	$0'00$	$\cdot 7$
$\cdot 8$	+ $1'27$	+ $1'15$	+ $1'01$	+ $0'84$	+ $0'58$	+ $0'39$	+ $0'20$	+ $0'04$	$0'00$	$\cdot 8$
$\cdot 9$	+ $1'26$	+ $1'14$	+ $0'99$	+ $0'82$	+ $0'55$	+ $0'37$	+ $0'18$	+ $0'02$	$0'00$	$\cdot 9$
	21^{rev}	22^{rev}	23^{rev}	24^{rev}	25^{rev}	26^{rev}	27^{rev}	28^{rev}		
$\cdot 0$	+ $''02$	+ $''07$	+ $''20$	+ $''32$	+ $''44$	+ $''65$	+ $''86$	+ $1'10$		$\cdot 0$
$\cdot 1$	+ $0'02$	+ $0'08$	+ $0'21$	+ $0'33$	+ $0'46$	+ $0'67$	+ $0'88$	+ $1'12$		$\cdot 1$
$\cdot 2$	+ $0'03$	+ $0'09$	+ $0'22$	+ $0'34$	+ $0'48$	+ $0'69$	+ $0'91$	+ $1'14$		$\cdot 2$
$\cdot 3$	+ $0'03$	+ $0'11$	+ $0'24$	+ $0'36$	+ $0'51$	+ $0'72$	+ $0'93$	+ $1'16$		$\cdot 3$
$\cdot 4$	+ $0'04$	+ $0'12$	+ $0'25$	+ $0'37$	+ $0'53$	+ $0'74$	+ $0'95$	+ $1'18$		$\cdot 4$
$\cdot 5$	+ $0'04$	+ $0'13$	+ $0'26$	+ $0'38$	+ $0'55$	+ $0'76$	+ $0'98$	+ $1'20$		$\cdot 5$
$\cdot 6$	+ $0'05$	+ $0'14$	+ $0'27$	+ $0'39$	+ $0'57$	+ $0'78$	+ $1'00$	+ $1'22$		$\cdot 6$
$\cdot 7$	+ $0'05$	+ $0'16$	+ $0'28$	+ $0'40$	+ $0'59$	+ $0'80$	+ $1'03$	+ $1'24$		$\cdot 7$
$\cdot 8$	+ $0'06$	+ $0'17$	+ $0'30$	+ $0'42$	+ $0'61$	+ $0'82$	+ $1'05$	+ $1'26$		$\cdot 8$
$\cdot 9$	+ $0'06$	+ $0'19$	+ $0'31$	+ $0'43$	+ $0'63$	+ $0'84$	+ $1'07$	+ $1'28$		$\cdot 9$

TRANSIT-CIRCLE TABLES.

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*Excess of Reflexion Results above Direct Results, for Observations of
Zenith-Distances with the Transit-Circle, 1905.*

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.
ϵ Cassiopeiæ S.P.	h m 1. 47	- 26. 8	- 1' 13"	1	1	ζ Ursæ Minoris S.P. ...	h m 15. 47	- 11. 9	+ 0' 44"	1	1
Lalande F. 4249 S.P.	22. 39	- 25. 1	- 2' 70"	1	1	Groombridge 1735 S.P. ...	11. 2	- 11. 7	+ 1' 67"	1	1
Lalande F. 1744 S.P.	10. 42	- 24. 4	+ 0' 08"	1	1	Bradley 117 S.P.	1. 4	- 10. 8	+ 2' 55"	1	1
16 Cassiopeiæ S.P.	0. 27	- 23. 8	+ 0' 59"	1	1	Groombridge 471 S.P.	2. 12	- 10. 7	+ 0' 60"	1	1
α Camelopardi S.P.	4. 45	- 23. 8	- 0' 81"	1	1	Groombridge 2066 S.P. ...	13. 51	- 10. 5	- 2' 10"	1	1
38 Ursæ Majoris S.P.	10. 36	- 23. 8	+ 0' 37"	1	1	Piazzi VII. 187 S.P. ...	7. 50	- 10. 3	- 2' 06"	1	1
σ^1 Ursæ Majoris S.P.	9. 0	- 22. 7	+ 0' 07"	2	2	Bradley 2749 S.P. ...	20. 51	- 9. 8	+ 0' 11"	3	3
						Lalande F. 320-1 S.P.	1. 56	- 9. 8	- 0' 90"	1	1
						Piazzi III. 160 S.P.	3. 54	- 9. 6	- 0' 68"	1	1
Groombridge 904 S.P.	4. 55	- 21. 2	+ 0' 15"	1	1	Lalande 41621 S.P. ...	21. 10	- 9. 4	- 0' 32"	1	1
Groombridge 1669 S.P. ...	10. 35	- 21. 1	- 1' 59"	1	1	Bradley 1458 S.P.	10. 34	- 9. 1	- 0' 72"	1	1
Oeltz. Arg. (N.) 10936 S.P.	10. 29	- 20. 6	- 1' 30"	1	1	Bradley 344 S.P.	2. 34	- 9. 0	- 0' 44"	1	1
Oeltz. Arg. (N.) 22715 S.P.	21. 37	- 20. 0	+ 0' 29"	1	1	76 Draconis S.P.	20. 48	- 7. 8	+ 0' 72"	3	3
ϵ Draconis S.P.	19. 48	- 20. 0	+ 0' 71"	1	1	Groombridge 1391 S.P. ...	8. 6	- 7. 3	+ 1' 55"	1	1
Lalande F. 3355-6 S.P. ...	19. 58	- 19. 9	+ 0' 93"	1	1	Groombridge 774 S.P.	4. 9	- 6. 9	- 1' 20"	1	1
Groombridge 834 S.P.	4. 24	- 19. 9	- 0' 27"	1	1	Lalande F. 3616-7 S.P.	20. 39	- 6. 7	- 1' 07"	1	1
Groombridge 786 S.P.	4. 6	- 19. 8	- 2' 50"	1	1	Groombridge 1359 S.P. ...	7. 55	- 5. 7	- 0' 60"	1	1
Lalande F. 1937 S.P.	11. 39	- 19. 5	- 1' 58"	1	1	Groombridge 2213 S.P. ...	15. 1	- 5. 7	- 1' 10"	1	1
Oeltz. Arg. (N.) 13034 S.P. ...	1. 11	- 18. 1	- 1' 23"	1	1						
Lalande F. 2207 S.P.	13. 4	- 18. 1	- 0' 61"	1	1	Groombridge 750 S.P.	4. 6	- 4. 7	- 0' 21"	2	2
						2 Ursæ Minoris S.P. ...	0. 55	- 4. 4	- 1' 36"	1	1
27 Ursæ Majoris S.P.	9. 35	- 17. 3	- 0' 37"	2	2	Groombridge 3548 S.P. ...	21. 18	- 3. 4	- 0' 33"	1	1
Bradley 471 S.P.	2. 24	- 17. 0	- 0' 65"	1	1	Cephei 51 S.P.	6. 56	- 2. 8	- 0' 16"	1	1
Lalande F. 389-90-1 S.P.	2. 18	- 16. 7	+ 0' 03"	1	1	Groombridge 2283 S.P. ...	15. 7	- 2. 4	+ 0' 95"	1	1
Piazzi IV. 254 S.P.	5. 0	- 16. 2	- 1' 88"	1	1						
Lalande F. 3645-6 S.P. ...	20. 52	- 15. 7	+ 0' 07"	1	1	Polaris S.P.	1. 24	- 1. 2	+ 0' 37"	2	2
73 Draconis S.P.	20. 32	- 15. 4	+ 0' 08"	1	1	Groombridge 1119 S.P. ...	8. 3	- 1. 1	- 0' 19"	1	1
Groombridge 3857 S.P. ...	22. 35	- 15. 1	+ 0' 48"	1	1	λ Ursæ Minoris S.P. ...	19. 16	- 1. 0	+ 1' 87"	1	1
3 Ursæ Minoris S.P.	14. 6	- 15. 0	+ 0' 57"	1	1	λ Ursæ Minoris S.P.	19. 16	- 1. 0	- 0' 72"	1	1
Oeltz. Arg. (N.) 5355 S.P.	4. 57	- 14. 5	- 0' 93"	1	1	Polaris.	1. 24	- 1. 2	- 0' 83"	1	1
Groombridge 861 S.P.	4. 40	- 14. 5	- 1' 01"	1	1	Bradley 1672.	12. 14	- 1. 8	+ 0' 66"	2	2
Bradley 1446 S.P. ...	10. 26	- 13. 8	- 0' 52"	1	1						
						Cephei 51.	6. 56	- 2. 8	- 0' 35"	1	1
Groombridge 3479 S.P. ...	21. 23	- 13. 3	- 0' 44"	1	1	Bradley 3147.	23. 27	- 3. 2	- 0' 19"	1	1
77 Draconis S.P.	21. 7	- 12. 3	- 0' 79"	1	1	Groombridge 3548. ...	21. 18	- 3. 3	- 0' 59"	1	1
Lalande 7461 S.P.	4. 6	- 12. 2	+ 0' 81"	1	1	Lalande F. 1781.	11. 3	- 3. 8	+ 0' 27"	1	1
						Bradley 2993.	22. 21	- 4. 3	- 0' 62"	1	1

*Excess of Reflexion Results above Direct Results, for Observations of
Zenith-Distances with the Transit-Circle, 1905—continued.*

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.
Groombridge 1418 ...	h m 8. 26	° 4. 6	—0"39	2	2	Oeltz. Arg. (N.) 9335.	h m 8. 46	° 15. 6	—0"51	1	1
Groombridge 1359....	7. 55	5. 7	+0"57	1	1	Lalande F. 39-40....	6. 40	15. 7	—1"56	1	1
Bradley 1731.....	12. 48	6. 1	+0"53	1	1	Groombridge 1342 ...	7. 37	15. 7	—1"27	1	1
						Piazzi IV. 191.....	4. 50	15. 9	+0"24	2	2
						Groombridge 2388 ...	16. 44	15. 9	+0"74	1	1
						Groombridge 1446 ...	8. 28	16. 0	—0"68	1	1
						Groombridge 2719 ...	18. 48	16. 0	+0"45	2	2
Lalande F. 1347.....	8. 45	6. 9	—0"38	1	1	Bradley 3085	23. 11	16. 3	+0"94	1	1
ε Ursæ Minoris.....	16. 55	7. 8	—0"79	1	1	Bradley 282	2. 4	16. 4	—1"14	1	1
Bradley 48	0. 32	8. 0	+1"15	1	1	Groombridge 2418 ...	17. 2	16. 6	+1"61	1	1
Groombridge 1782 ...	11. 25	8. 3	—0"42	1	1	Lalande F. 389-90-1...	2. 18	16. 7	—0"23	2	2
Groombridge 1845....	11. 55	8. 6	—0"08	1	1	Oeltz. Arg. (N.) 16536	16. 42	17. 1	+0"97	1	1
Groombridge 1909....	12. 31	9. 2	—0"21	1	1	62 Draconis.....	19. 47	17. 8	—1"07	1	1
Piazzi III. 160.....	3. 54	9. 5	+0"85	1	1	Groombridge 1369...	7. 46	17. 9	+1"87	1	1
B. D. + 80°, 395....	12. 42	9. 5	—0"28	1	1	B. D. + 71° 483.....	8. 48	18. 2	+2"12	1	1
B. D. + 79°, 69.....	2. 15	9. 8	+1"78	1	1	Oeltz. Arg. (N.) 22261	21. 21	18. 3	+0"34	1	1
Groombridge 3667 ...	21. 55	10. 1	—1"83	1	1						
Piazzi VII. 187.....	7. 50	10. 2	—1"08	1	1						
Oeltz. Arg. (N.) 18532	18. 32	10. 4	—2"34	1	1						
						φ Cygni	19. 37	60. 0	+1"63	2	2
						ζ Cygni	21. 8	60. 1	—0"70	3	3
						η Pegasi.....	22. 38	60. 2	—1"42	1	1
Lalande 39139-47...	20. 7	10. 6	—0"31	1	1	υ Coronæ.....	16. 12	60. 6	—0"12	2	2
Lalande F. 1288.....	8. 17	11. 4	—1"96	1	1	53 Aurigæ.....	6. 32	60. 9	—0"15	1	1
Bradley 1634	12. 7	11. 8	+0"06	1	1	α Trianguli.....	1. 47	60. 9	—0"62	1	1
Lalande 37669.....	19. 33	11. 9	—2"17	1	1	W. B. (2) V. 207....	5. 10	61. 2	+1"12	1	1
Lalande 44676.....	22. 42	12. 0	+0"23	1	1	Pollux.....	7. 39	61. 7	+1"14	2	2
Groombridge 2378 ...	16. 37	12. 1	+1"24	1	1	6 Cancri.....	7. 57	61. 9	—0"27	1	1
Lalande 42764-74...	21. 46	12. 2	+0"54	2	2	ι Geminorum.....	7. 19	62. 0	—0"10	1	1
Oeltz. Arg. (N.) 9605	9. 6	12. 5	—0"06	1	1	32 Vulpeculæ.....	20. 50	62. 3	+1"02	1	1
Lalande F. 701.....	4. 40	12. 6	—0"59	1	1						
κ Cephei.....	20. 12	12. 6	—1"99	1	1						
Bradley 2440	19. 2	13. 1	+0"34	1	1						
Oeltz. Arg. (N.) 15911-2	16. 0	13. 6	—0"40	1	1						
5 Ursæ Minoris	14. 27	13. 9	+0"39	2	2						
19 Ursæ Minoris.....	16. 13	13. 9	—0"36	1	1	ψ Boötis.....	15. 0	62. 6	—0"09	1	1
17 Ursæ Minoris.....	15. 56	14. 1	+2"27	1	1	φ Tauri.....	4. 14	62. 8	+0"83	1	1
Lalande 41565.....	21. 13	14. 1	+1"32	1	1	α Coronæ.....	15. 30	62. 9	+0"76	1	1
Piazzi IV. 112	4. 36	14. 2	—1"63	1	1	41 Arietis.....	2. 44	63. 1	—0"04	1	1
						ρ Tauri.....	4. 5	63. 8	—0"27	1	1
						ω ¹ Cancri.....	7. 55	64. 3	—0"33	1	1
						16 Pegasi.....	21. 48	64. 5	—0"72	1	1
						A Geminorum.....	7. 17	64. 7	+0"55	1	1
50 Draconis	18. 49	14. 7	—0"63	1	1	ι Pegasi.....	22. 2	65. 1	+1"08	1	1
3 Ursæ Minoris ...	14. 6	14. 9	+1"23	1	1	ε Leonis.....	9. 40	65. 8	+0"03	1	1
β Ursæ Minoris.....	14. 50	15. 4	—0"18	1	1	μ Pegasi.....	22. 45	65. 9	+1"83	2	2

TRANSIT-CIRCLE TABLES.

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*Excess of Reflexion Results above Direct Results, for Observations of
Zenith-Distances with the Transit-Circle, 1905—continued.*

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.
23 Comæ.....	h m 12. 30	66. 8	-1'07	1	1	ε Virginis.....	h m 12. 57	78. 5	+0'86	2	2
W.B. (2) IV. 941....	2. 41	67. 4	-0'52	1	1	ω Aquilæ.....	19. 13	78. 5	+0'71	1	1
δ Geminorum.....	7. 14	67. 8	+0'16	3	3	l Leonis.....	10. 44	78. 9	+0'68	1	1
γ Cancri.....	8. 37	68. 2	-1'47	1	1	δ Serpentis.....	15. 30	79. 1	+0'25	1	1
109 Herculis.....	18. 19	68. 2	+0'48	1	1	ρ Virginis.....	12. 37	79. 2	+0'49	1	1
δ Leonis.....	11. 9	68. 9	-0'78	1	1	κ Ophiuchi.....	16. 53	80. 4	+0'58	2	2
η Cancri.....	8. 27	69. 2	+0'22	1	1	β Cancri.....	8. 11	80. 5	-0'82	1	1
110 Herculis.....	18. 41	69. 5	+0'27	1	1	49 Leonis.....	10. 30	80. 8	-0'18	1	1
Piazzi V. 125.....	5. 28	69. 6	+0'78	1	1	α Aquilæ.....	19. 46	81. 3	+1'79	1	1
γ ¹ Leonis.....	10. 14	69. 6	+0'49	1	1	31 Boötis.....	14. 36	81. 4	-0'19	1	1
β Arietis.....	1. 49	69. 6	+0'69	1	1	π Leonis.....	9. 55	81. 5	+0'23	1	1
47 Arietis.....	2. 52	69. 7	+0'92	1	1						
85 Geminorum.....	7. 50	69. 8	+0'94	1	1						
f Boötis.....	14. 22	70. 3	+0'58	1	1						
Arcturus.....	14. 11	70. 3	+0'83	2	2						
μ Arietis.....	2. 37	70. 4	+1'52	1	1						
						π Virginis.....	11. 56	82. 8	+0'71	1	1
						μ Aquilæ.....	19. 29	82. 8	+2'22	1	1
						ε Hydræ.....	8. 41	83. 2	-0'37	1	1
ω ¹ Tauri.....	4. 3	70. 6	-0'78	1	1	α Serpentis.....	15. 39	83. 2	+0'73	1	1
γ Herculis.....	16. 17	70. 6	-0'77	2	2	B.F. 1402.....	9. 48	83. 6	+1'10	1	1
16 Herculis.....	16. 11	70. 9	-0'78	1	1	δ Hydræ.....	8. 32	83. 9	-0'11	2	2
40 Pegasi.....	22. 33	70. 9	-0'20	1	1	ν Ceti.....	2. 30	84. 8	-0'22	1	1
15 Arietis.....	2. 5	70. 9	-0'63	1	1	ε Serpentis.....	15. 46	85. 2	+0'01	2	2
η Boötis.....	13. 50	71. 1	+0'26	1	1	35 Virginis.....	12. 43	85. 9	+0'33	1	1
g Geminorum.....	7. 40	71. 2	-0'48	1	1	δ Virginis.....	12. 50	86. 0	+0'08	1	1
α ¹ Cancri.....	8. 17	71. 3	-0'89	1	1	η Hydræ.....	8. 38	86. 2	+0'32	2	2
Piazzi IV. 179.....	4. 40	71. 4	-0'38	1	1						
δ Sagittæ.....	19. 43	71. 7	-0'73	1	1						
83 Cancri.....	9. 13	71. 9	+0'05	1	1						
τ Boötis.....	13. 42	72. 0	-1'05	1	1	γ Piscium.....	23. 12	87. 2	+1'64	3	3
W.B. (2) VI. 655....	6. 25	73. 0	+2'60	1	1	λ Ophiuchi.....	16. 26	87. 8	+0'68	2	2
γ Serpentis.....	15. 52	74. 0	+1'33	1	1	η Virginis.....	12. 15	90. 1	+0'44	1	1
β Leonis.....	11. 44	74. 9	+0'02	1	1						
γ Pegasi.....	0. 8	75. 3	+0'25	3	3	η Aquarii.....	22. 30	90. 6	-1'80	1	1
α Pegasi.....	23. 0	75. 3	+0'52	2	2	α Aquarii.....	22. 0	90. 7	+0'28	1	1
α ¹ Herculis.....	17. 10	75. 5	+0'76	1	1	θ Aquilæ.....	20. 6	91. 1	+1'63	1	1
23 Leonis.....	9. 45	76. 5	+0'29	1	1	46 Virginis.....	12. 55	92. 8	-0'18	1	1
B.F. 2318.....	16. 45	76. 5	+0'39	2	2	14 Hydræ.....	8. 44	93. 0	+1'23	2	2
ε Geminorum.....	6. 39	77. 0	+0'47	1	1	k Virginis.....	12. 54	93. 3	+0'60	1	1
α Ophiuchi.....	17. 30	77. 3	-0'60	1	1	δ Ophiuchi.....	16. 9	93. 4	+0'85	3	3
34 Virginis.....	12. 42	77. 5	+1'66	1	1	30 Ophiuchi.....	16. 56	94. 0	+1'03	1	1
Piazzi I. 223.....	1. 54	78. 1	+1'19	2	2	ε Ophiuchi.....	16. 13	94. 4	+0'80	1	1

GREENWICH OBSERVATIONS, 1905.

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*Excess of Reflexion Results above Direct Results, for Observations of
Zenith-Distances with the Transit-Circle, 1905—continued.*

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.
Piazzi XII. 111	^h 12. 36 ^m		94. 5 + 0".25	1	1	ψ Scorpii.....	^h 16. 6 ^m	99. 8	— 0".33	1	1
θ Virginis	13. 5		95. 0 + 0".21	3	3	20 Ophiuchi.....	16. 44	100. 6	+ 0".77	1	1
f Virginis.....	12. 31		95. 3 + 1".73	1	1	σ Aquarii	22. 25	101. 1	— 0".44	1	1
44 Aquarii.....	22. 12		95. 8 + 1".20	1	1	6 Hydræ	8. 35	102. 1	+ 1".17	1	1
β Aquarii.....	21. 26		95. 9 + 0".52	3	3						
φ Aquarii.....	23. 9		96. 5 + 1".27	2	2						
Piazzi XXII. 81	22. 18		97. 6 + 2".32	1	1						
θ Aquarii	22. 11		98. 2 + 0".56	1	1						
1 Aquilæ	18. 30		98. 3 + 0".79	1	1						
γ Monocerotis.....	7. 36		99. 3 — 0".40	1	1	ν ² Hydræ	10. 0	102. 6	+ 0".26	1	1
ε Ceti	0. 14		99. 3 — 0".01	2	2	β Capricorni.....	20. 15	105. 0	+ 1".76	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_0 for the probable systematic error affecting all observations of the same star, the weight to be given to that star is proportional to $\frac{mn}{me^2 + ne^2 + 2mne_0^2}$; or assuming $e_0^2 = \frac{1}{10}e^2$, which would make $e_0 = 0''.16$, the weight becomes $\frac{4mn}{m + n + \frac{1}{5}mn}$, which has been adopted. When $m = n$, the weight is proportional to $\frac{m}{10 + n}$, and $\frac{11m}{10 + m}$, the most convenient multiple of this, has been adopted.

TRANSIT-CIRCLE TABLES.

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*Excess of Reflexion Results above Direct Results from Groups of Stars
observed with the Transit-Circle.*

Extent of Group, 1905.	Weight.	Mean N.P.D.	Mean Z.D. South.	Mean Value of R—D, cor- rected for Inclination of Verticals.	R—D computed by the Formula $+ 0''.110$ $+ 0''.620 \times$ $\sin Z.D.$	Apparent Error of Formula.
ϵ Cassiopeiae S.P.	1	—26. 8	—65. 3	— 1.28	— 0.45	+ 0.83
Lalande F. 4249 S.P. to α^1 Ursæ Majoris S.P.	7	—23. 8	—62. 3	— 0.47	— 0.44	+ 0.03
Groombridge 904 S.P. to Lalande F. 2207 S.P.	11	—19. 8	—58. 3	— 0.78	— 0.42	+ 0.36
27 Ursæ Majoris S.P. to Bradley 1446 S.P.	12	—15. 7	—54. 2	— 0.51	— 0.39	+ 0.12
Groombridge 3479 S.P. to Piazzì III. 160 S.P.	14	—10. 9	—49. 4	— 0.16	— 0.36	— 0.20
Lalande 41621 S.P. to Groombridge 2213 S.P.	11	— 7. 6	—46. 1	— 0.28	— 0.34	— 0.06
Groombridge 750 S.P. to Groombridge 2283 S.P.	6	— 3. 7	—42. 2	— 0.33	— 0.31	+ 0.02
Polaris S.P. to Bradley 1672 Cephei 51 to Bradley 1731 Lalande F. 1347 to Oeltz. Arg. (N.) 18532 Lalande 39139-47 to Piazzì IV. 112 50 Draconis to Oeltz. Arg. (N.) 22261 ϕ Cygni to 32 Vulpeculæ ψ Boötis to μ Pegasi 23 Comæ to μ Arietis ω^1 Tauri to γ Serpentis β Leonis to Piazzì I. 223 ϵ Virginis to π Leonis π Virginis to η Hydræ γ Piscium to η Virginis η Aquarii to ϵ Ophiuchi Piazzì XII. 111 to 1 Aquilæ γ Monocerotis to 6 Hydræ α^2 Hydræ to β Capric	8 9 12 19 22 16 12 19 15 15 13 14 6 12 14 7 2	0. 3 4. 3 9. 0 12. 8 16. 3 60. 9 64. 3 69. 0 71. 5 76. 3 79. 9 84. 5 87. 9 92. 8 96. 1 100. 2 103. 8	—38. 2 —34. 2 —29. 5 —25. 7 —22. 2 22. 4 25. 8 30. 5 33. 0 37. 8 41. 4 46. 0 49. 4 54. 3 57. 6 61. 7 65. 3	+ 0.17 — 0.22 — 0.38 — 0.18 + 0.11 + 0.23 + 0.53 + 0.35 — 0.12 + 0.45 + 0.60 + 0.56 + 0.43 + 1.24 + 0.74 + 0.96 + 0.25 + 1.15	— 0.27 — 0.24 — 0.20 — 0.16 — 0.12 + 0.35 + 0.38 + 0.43 + 0.45 + 0.49 + 0.52 + 0.56 + 0.58 + 0.61 + 0.63 + 0.66 + 0.67	— 0.44 — 0.02 + 0.19 + 0.02 — 0.23 + 0.12 — 0.15 + 0.08 + 0.57 — 0.11 — 0.04 + 0.13 — 0.66 — 0.13 — 0.33 + 0.41 — 0.48

In forming the mean values of R—D for groups in the last column but two of the above table, a correction of $+ 0''.16 \sin Z.D.$ 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

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

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:—

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For direct observations,

$$+ 0''.055 + 0''.310 \sin Z.D.$$

For reflexion observations,

$$- 0''.055 - 0''.310 \sin Z.D. + 0''.16 \sin Z.D.$$

or
$$- 0''.055 - 0''.150 \sin Z.D.$$

For use, these formulæ have been tabulated as follows; and the corrections have been applied to the mean results for N.P.D. of the 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	- 0.25	+ 0.09
40	- 0.25	+ 0.09
30	- 0.23	+ 0.09
20	- 0.21	+ 0.07
- 10	- 0.18	+ 0.06
0	- 0.14	+ 0.04
+ 10	- 0.09	+ 0.02
20	- 0.04	- 0.01
30	+ 0.01	- 0.03
40	+ 0.06	- 0.06
50	+ 0.12	- 0.09
60	+ 0.17	- 0.11
70	+ 0.22	- 0.13
80	+ 0.26	- 0.15
90	+ 0.30	- 0.17
100	+ 0.33	- 0.19
110	+ 0.35	- 0.20
120	+ 0.36	- 0.20
+ 125	+ 0.36	- 0.21

No correction for flexure has been applied since April 1879.

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INTRODUCTION TO GREENWICH ASTRONOMICAL OBSERVATIONS, 1905.

Simultaneous Readings at Apparent Noon of the Transit-Circle Exterior Thermometer and Meteorological Standard Thermometer—continued.

Date, 1905.	Meteoro- logical Standard Thermom.	Excess of Transit- Circle Exterior Thermometer.	Date, 1905.	Meteoro- logical Standard Thermom.	Excess of Transit- Circle Exterior Thermometer.	Date, 1905.	Meteoro- logical Standard Thermom.	Excess of Transit- Circle Exterior Thermometer.
Oct. d h	°	°	Nov. d h	°	°	Dec. d h	°	°
14. 0	45°2	- 0°04	6. 0	50°2	+ 0°3	2. 0	45°2	- 0°7
16. 0	45°3	+ 0°03	10. 0	50°4	- 0°6	6. 0	46°6	0°0
17. 0	43°6	- 0°03	12. 0	48°8	+ 1°4	9. 0	46°7	- 0°2
18. 0	51°3	- 0°03	20. 0	41°0	- 1°5	11. 0	32°3	+ 3°2
19. 0	49°3	- 0°08	21. 0	35°8	+ 1°2	12. 0	32°6	+ 1°9
20. 0	46°8	- 0°08	22. 0	43°7	- 0°2	19. 0	49°2	- 0°4
23. 0	46°8	- 0°09	24. 0	45°3	- 0°4	30. 0	39°5	- 0°3
27. 0	51°6	- 0°06	27. 0	44°2	+ 0°1	31. 0	30°6	- 0°3
31. 0	51°3	+ 0°01						

Means of Simultaneous Readings at Apparent Noon of the Meteorological Standard Thermometer and Transit-Circle Exterior Thermometer.

1905.	January.	February.	March.	April.	May.	June.	Mean for Year.
Meteorological Standard..	41°3 ₁₃	48°1 ₇	52°4 ₁₁	54°1 ₉	63°1 ₂₀	68°8 ₁₄	
Excess of Exterior.	0°0	- 0°9	+ 0°2	+ 0°6	+ 0°8	+ 1°1	
1905.	July.	August.	September.	October.	November.	December.	Mean for Year.
Meteorological Standard..	73°7 ₂₂	69°7 ₁₅	63°1 ₉	47°9 ₉	44°9 ₈	40°3 ₈	
Excess of Exterior.	+ 0°9	+ 0°1	0°0	- 0°4	0°0	+ 0°4	

TRANSIT-CIRCLE TABLES.

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Correction to Assumed Colatitude, $38^{\circ} 31' 21'' 90$,
from Observations in the Year 1905.

(Using Bessel's Refractions, as given in the *Tabulae Regiomontanae*.)

Corrections for Variation of Latitude supplied by Prof. Albrecht have been applied in forming this Table (see p. {2}
of the section "Ledgers of Mean Right Ascensions and North Polar Distances").

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of R.A. above Pole.	Excess of N.P.D. above Pole.	No. of Ob- servations.		Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of R.A. above Pole.	Excess of N.P.D. above Pole.	No. of Ob- servations.		Weight.
					Above Pole.	Below Pole.							Above Pole.	Below Pole.	
λ Ursæ Minoris	h m	° ' "	° ' "	° ' "				Oeltz. Arg. (N.) 24565	h m	° ' "	° ' "	° ' "			
Polaris	19. 17	1. 0	+0° 68	+0° 29	4	4	10	Oeltz. Arg. (N.) 25968	22. 38	16. 7	-0° 60	+0° 39	1	1	3
Bradley 1672	1. 25	1. 12	-1° 09	+0° 94	20	19	26	Oeltz. Arg. (N.) 13...	23. 39	16. 31	-1° 26	-1° 26	1	1	3
Groombridge 2283	12. 14	1. 46	-1° 10	-0° 36	7	6	14	Oeltz. Arg. (N.) 1320-1	0. 4	17. 31	+0° 26	-3° 82	1	1	3
Cephei 51	15. 8	2. 24	-0° 34	-1° 15	1	6	5	Oeltz. Arg. (N.) 2600	1. 13	17. 45	-0° 34	-0° 09	1	1	3
Bradley 3147	6. 56	2. 48	+0° 23	-0° 10	4	4	10	Groombridge 558.....	1. 31	17. 43	+0° 55	+4° 21	1	1	3
Groombridge 3548	23. 28	3. 13	-0° 06	+0° 68	3	1	4	Oeltz. Arg. (N.) 562(S*)	2. 14	17. 1	-0° 37	+3° 14	1	1	3
δ Ursæ Minoris	21. 18	3. 21	-0° 19	-1° 25	5	2	8	Groombridge 562(N*)	2. 46	17. 30	+0° 12	+3° 52	1	1	3
Groombridge 1359	18. 3	3. 23	+0° 31	-0° 09	7	1	5	Oeltz. Arg. (N.) 4534	2. 47	17. 30	+0° 59	+0° 07	1	1	3
Piazzi III. 160	7. 53	5. 40		+0° 60	2	2	6	Oeltz. Arg. (N.) 15055	2. 47	17. 30	+0° 66	-0° 74	1	1	3
Piazzi VII. 187	3. 54	9. 34		-0° 28	2	2	6	Oeltz. Arg. (N.) 15055	4. 8	17. 46	+0° 06	+0° 94	1	1	3
B. D. + 78°, 627	7. 49	10. 16		+0° 48	2	2	5	B. D. + 72°, 672.....	14. 58	17. 8	-0° 62	-1° 50	1	1	3
γ Ursæ Minoris	18. 8	11. 39		+3° 02	1	1	3	Oeltz. Arg. (N.) 22534	15. 9	17. 11	-0° 02	-1° 37	1	1	3
Oeltz. Arg. (N.) 1581-2.	14. 6	14. 57	+0° 14	+0° 77	2	2	5	B. D. + 72°, 1019...	21. 30	17. 21	+1° 06	+1° 06	1	1	3
B. D. + 74°, 467	1. 26	15. 52	-1° 21	-0° 83	2	1	4	Oeltz. Arg. (N.) 25078	22. 8	17. 3	-0° 03	+0° 41	1	1	3
β Ursæ Minoris	11. 32	15. 44		-1° 82	2	1	3	Oeltz. Arg. (N.) 1607-8	22. 59	17. 9	-0° 30	+1° 45	1	1	3
B. D. + 74°, 616	14. 51	15. 27	-0° 35	+0° 02	4	2	6	B. D. + 71°, 253.....	1. 27	18. 38	-0° 20	+0° 31	2	1	3
Oeltz. Arg. (N.) 15723	15. 25	15. 43	-0° 43	+1° 51	1	1	3	Oeltz. Arg. (N.) 5040..	4. 18	18. 12	+0° 85	-0° 64	2	1	3
Oeltz. Arg. (N.) 15744	15. 47	15. 46	-0° 51	+0° 39	3	1	4	B. D. + 71°, 349.....	4. 38	18. 58	-0° 09	-1° 55	1	1	3
Oeltz. Arg. (N.) 15755-6.	15. 49	15. 46	-0° 57	+2° 04	2	1	3	Oeltz. Arg. (N.) 11873	6. 7	18. 59	+0° 64	-0° 54	2	1	3
Groombridge 2410	15. 50	15. 17	-0° 48	-0° 20	1	1	3	B. D. + 71°, 577.....	11. 30	18. 40	-0° 07	-3° 55	2	2	5
Oeltz. Arg. (N.) 16988-9	16. 57	15. 22	+0° 21					*	11. 30	18. 32	-0° 22	-2° 18	2	1	3
Groombridge 3857	17. 10	15. 23	+0° 69					Oeltz. Arg. (N.) 12461	11. 31	18. 33	+0° 30	-1° 41	1	1	3
Oeltz. Arg. (N.) 714...	22. 35	15. 7		+0° 08	1	2	4	B. D. + 71°, 707.....	12. 7	18. 42	-0° 01	+2° 79	1	1	3
B. D. + 73°, 113	0. 41	16. 2	-0° 08	+0° 15	1	1	3	Oeltz. Arg. (N.) 15248	15. 1	18. 31	-0° 09	+2° 93	1	1	3
Lalande F. 389-0-1..	1. 58	16. 17	-0° 10	+1° 51	1	1	3	Lalande F. 2624.....	15. 11	18. 38	-0° 49	-0° 81	1	1	3
B. D. + 72°, 141	2. 19	16. 43	+0° 54	+0° 23	4	2	6	B. D. + 71°, 720.....	15. 13	18. 18	+0° 20	+1° 64	1	1	3
B. D. + 73°, 159	2. 29	16. 50	+0° 18	-0° 31	1	1	3	Oeltz. Arg. (N.) 15372	15. 15	18. 21	+0° 27	+0° 71	1	1	3
Oeltz. Arg. (N.) 11916	2. 46	16. 4	-0° 17	+4° 56	1	1	3	Oeltz. Arg. (N.) 15689	15. 21	18. 59	-0° 60	+0° 01	3	1	4
Oeltz. Arg. (N.) 12584-5	11. 33	16. 57	-0° 39	+2° 23	1	2	4	B. D. + 71°, 951.....	15. 45	18. 29	-0° 40	+1° 52	1	2	4
B. D. + 73°, 609	12. 18	16. 14		-1° 62	1	1	3	Oeltz. Arg. (N.) 23772	19. 24	18. 17	+0° 12	-2° 73	1	1	3
Lalande F. 2403	13. 55	16. 40		+1° 91	1	1	3	Oeltz. Arg. (N.) 23834	22. 12	18. 26	-0° 28	-0° 24	2	1	3
Oeltz. Arg. (N.) 15156	14. 0	16. 24	+0° 12	+0° 98	1	1	3	Oeltz. Arg. (N.) 1551	22. 14	18. 48	-0° 97	+0° 69	1	1	3
B. D. + 73°, 660	15. 4	16. 33	-0° 24	+1° 38	1	1	3	Oeltz. Arg. (N.) 1870	1. 24	19. 22	-0° 22	-0° 95	1	1	3
Oeltz. Arg. (N.) 15283	15. 7	16. 38	+0° 70	+2° 49	1	1	3	B. D. + 70°, 235.....	1. 38	19. 26	+0° 29	+3° 15	1	2	4
B. D. + 74°, 615	15. 13	16. 31	-0° 05	+1° 85	2	1	3	B. D. + 70°, 301.....	1. 58	19. 58	+0° 28	-0° 07	1	1	3
Oeltz. Arg. (N.) 15668	15. 25	16. 5		+2° 15	1	1	3	B. D. + 70°, 364.....	3. 8	19. 27	+0° 09	+1° 16	1	1	3
Oeltz. Arg. (N.) 16309	15. 43	16. 14	-0° 17	-0° 24	2	1	3	Groombridge 1713.....	4. 21	19. 45	+0° 02	+0° 64	1	1	3
B. D. + 73°, 729	16. 27	16. 16	-0° 72	-0° 86	1	1	3	Oeltz. Arg. (N.) 11283	5. 32	19. 35	+0° 42	+1° 95	1	3	5
Lalande 32150	16. 34	16. 11	+0° 06	+4° 43	1	2	4	Oeltz. Arg. (N.) 12089	6. 4	19. 19	+0° 28	-0° 75	1	2	4
Oeltz. Arg. (N.) 17496	17. 26	16. 59	-0° 60					B. D. + 71°, 685.....	10. 52	19. 41	+0° 40	+2° 41	1	1	3
Groombridge 2752	17. 41	16. 59		+0° 91	1	1	3	Oeltz. Arg. (N.) 15448	10. 53	19. 43	+0° 08				
Oeltz. Arg. (N.) 19955	18. 55	16. 2		+0° 12	1	1	3		11. 45	19. 26					
Lalande 43685	19. 58	16. 39							14. 22	19. 6					
	22. 15	16. 22							15. 27	19. 24					

Correction to Assumed Colatitude—continued.

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of R.A. above Pole.	Excess of N.P.D. above Pole.	No. of Observations.		Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of R.A. above Pole.	Excess of N.P.D. above Pole.	No. of Observations.		Weight.
					Above Pole.	Below Pole.							Above Pole.	Below Pole.	
Oeltz. Arg. (N.) 15970	h m 16. 5	° 19. 29	' -0° 07	" +1° 32	2	1	3	Oeltz. Arg. (N.) 16383	h m 16. 33	° 21. 47	' +0° 31	" "			
Oeltz. Arg. (N.) 18303	18. 24	19. 50		-3° 34	1	1	3	Oeltz. Arg. (N.) 17010	17. 13	21. 14		-1° 23	1	1	2
Oeltz. Arg. (N.) 19439	19. 31	19. 15	-0° 15					Lalande 32239.....	17. 30	21. 8	-0° 05	-1° 14	1	1	2
ε Draconis.....	19. 48	19. 58		+0° 46	1	2	4	Oeltz. Arg. (N.) 17742	17. 56	21. 29	-0° 14	+1° 87	1	1	2
Oeltz. Arg. (N.) 25002	22. 56	19. 5	+0° 07	+0° 04	1	1	3	Oeltz. Arg. (N.) 17791	17. 58	21. 57		+5° 07	1	1	2
Lalande 3771.....	2. 0	20. 34	+0° 34	+2° 45	2	1	3	Oeltz. Arg. (N.) 20116	20. 4	21. 8		+0° 51	1	1	2
B. D. + 69°, 260.....	4. 23	20. 4	-0° 21	-1° 33	2	1	3	B. D. + 68°, 1195...	21. 15	21. 29	-0° 32	+0° 05	1	1	2
Oeltz. Arg. (N.) 5483	5. 2	20. 5	+0° 18	-0° 04	1	1	2	Lalande F. 3882.....	21. 37	21. 40	+0° 29	+0° 67	1	1	2
Oeltz. Arg. (N.) 5954	5. 30	20. 5	+0° 18	-0° 32	1	1	2	B. D. + 68°, 1258...	21. 52	21. 39	+0° 44	-1° 08	1	1	2
Piazzi V. 326.....	6. 7	20. 30	+0° 21	+0° 77	2	1	3	B. D. + 68°, 1266...	21. 59	21. 21	+0° 26	+0° 01	1	1	2
Oeltz. Arg. (N.) 9416	8. 51	20. 35	+0° 43					Oeltz. Arg. (N.) 24257	22. 27	21. 8	+0° 10	+0° 07	1	1	2
Oeltz. Arg. (N.) 10060	9. 33	20. 16	+0° 35	-2° 12	1	1	2	B. D. + 68°, 1349...	22. 58	21. 18	-0° 66	-0° 25	1	1	2
Oeltz. Arg. (N.) 11895	11. 31	20. 12	+0° 08	+0° 60	4	1	3	Oeltz. Arg. (N.) 297..	0. 19	22. 35	+0° 12	+0° 02	1	1	2
B. D. + 69°, 783.....	15. 4	20. 21	-0° 13	+0° 64	1	1	2	B. D. + 66°, 303....	3. 58	22. 59	+0° 20	+1° 19	1	1	2
B. D. + 69°, 786.....	15. 12	20. 19	-0° 11	+0° 58	1	1	2	B. D. + 67°, 380.....	5. 13	22. 32	+0° 22	+0° 70	1	1	2
B. D. + 69°, 787.....	15. 13	20. 51	-0° 16	+0° 31	2	1	3	Oeltz. Arg. (N.) 9888	9. 22	22. 27	-0° 32	-0° 86	4	1	3
Oeltz. Arg. (N.) 15375-6	15. 22	20. 55	-0° 04	+1° 21	1	1	2	Oeltz. Arg. (N.) 9890	9. 22	22. 25	+0° 01	+2° 08	4	1	3
Oeltz. Arg. (N.) 15578	15. 37	20. 23	-2° 93		1	1	2	Oeltz. Arg. (N.) 10347-8	9. 50	22. 47	+0° 44	+0° 52	1	1	2
B. D. + 69°, 817.....	15. 49	20. 37	-0° 23	+1° 96	1	1	2	B. D. + 67°, 711....	11. 34	22. 57	-0° 13	-1° 89	2	1	3
B. D. + 69°, 967.....	18. 8	20. 16	-0° 62		1	1	2	Oeltz. Arg. (N.) 12251	11. 56	22. 55		-0° 50	2	1	3
B. D. + 69°, 1061...	19. 38	20. 45	+0° 33	+1° 05	1	1	2	B. D. + 67°, 736....	12. 9	22. 59	-0° 34	-3° 59	1	1	2
B. D. + 69°, 1086...	20. 0	20. 51	-0° 16	+1° 01	2	1	3	B. D. + 67°, 776....	13. 7	22. 59		-4° 40	1	1	2
B. D. + 69°, 1160...	21. 18	20. 32	-0° 37	-0° 22	1	1	2	Lalande F. 2225.....	13. 10	22. 13	-0° 12				
Oeltz. Arg. (N.) 22167	21. 19	20. 53	-0° 12	+0° 42	1	1	2	Oeltz. Arg. (N.) 13974	13. 42	22. 1	+0° 61	+1° 23	2	1	3
Lalande F. 3802-3...	21. 23	20. 25	-0° 37	-0° 03	1	1	2	Oeltz. Arg. (N.) 14927	14. 48	22. 3	+0° 13	+0° 66	4	1	3
Oeltz. Arg. (N.) 22505	21. 31	20. 14	-0° 09	-2° 25	1	1	2	B. D. + 68°, 824....	15. 10	22. 1	-0° 66	+2° 58	1	1	2
Oeltz. Arg. (N.) 23583	22. 6	20. 55	-0° 77	-0° 87	1	1	2	Oeltz. Arg. (N.) 15259	15. 13	22. 47	+0° 19	+2° 57	1	1	2
B. D. + 69°, 1308...	23. 5	20. 25	-0° 17	+1° 30	1	1	2	Oeltz. Arg. (N.) 15507	15. 32	22. 38	+0° 19	+0° 79	1	2	4
Oeltz. Arg. (N.) 25928	23. 37	20. 8	-0° 35	+2° 19	2	1	3	B. D. + 67°, 915....	15. 43	22. 12	-0° 25	+0° 10	1	1	2
B. D. + 67°, 89.....	0. 56	21. 50	+0° 01	+3° 12	1	1	2	Lalande 29723.....	16. 9	22. 23		+1° 35	1	1	2
Oeltz. Arg. (N.) 7635	7. 8	21. 6	0° 00	-1° 84	5	1	3	Lalande 29965.....	16. 8	22. 31	+0° 33	+0° 61	1	1	2
Oeltz. Arg. (N.) 8009	7. 29	21. 21	-0° 38		1	1	2	B. D. + 67°, 1032...	17. 43	22. 28	+0° 60				
Oeltz. Arg. (N.) 8284	7. 44	21. 27	-0° 35	+0° 92	2	1	3	Oeltz. Arg. (N.) 18049	18. 11	22. 50	+0° 04	-3° 75	1	1	2
Oeltz. Arg. (N.) 9892	9. 22	21. 58	+0° 08	+0° 26	1	2	4	B. D. + 67°, 1132...	19. 14	22. 15	-0° 41	+0° 82	1	1	2
B. D. + 68°, 598.....	10. 13	21. 23	+3° 82		3	1	3	B. D. + 67°, 1133...	19. 14	22. 16	-0° 09	+1° 60	1	1	2
B. D. + 68°, 599.....	10. 13	21. 19	+3° 67		2	1	3	Oeltz. Arg. (N.) 23050	21. 51	22. 39	-0° 03	+0° 34	1	1	2
Oeltz. Arg. (N.) 10916	10. 28	21. 6	-1° 13		2	1	3	B. D. + 67°, 1491...	22. 57	22. 17	-0° 36	+0° 26	1	1	2
Oeltz. Arg. (N.) 11839	11. 27	21. 47	-0° 68	-0° 19	1	1	2	B. D. + 67°, 1500...	23. 4	22. 36	-0° 25	+0° 04	1	1	2
Oeltz. Arg. (N.) 11970	11. 36	21. 1	-0° 13	+2° 85	1	1	2	B. D. + 66°, 1592...	23. 8	22. 55	-0° 33	-3° 04	1	1	2
Oeltz. Arg. (N.) 12006	11. 38	21. 53	+0° 24	-2° 04	1	1	2	Lalande F. 4530.....	23. 33	22. 36	-0° 14	-1° 66	1	2	4
Oeltz. Arg. (N.) 12080	11. 43	21. 30	-0° 26	+1° 00	1	1	2	Oeltz. Arg. (N.) 26404	0. 2	23. 15	+0° 05	+1° 75	1	1	2
B. D. + 69°, 637....	11. 57	21. 11	-0° 20	+2° 77	2	2	5	Oeltz. Arg. (N.) 18...	0. 4	23. 37	-0° 03	+0° 03	1	1	2
Oeltz. Arg. (N.) 14901	14. 46	21. 39	+0° 28	-0° 60	3	1	3	B. D. + 66°, 10.....	0. 8	23. 30	+0° 08	-0° 26	1	1	2
Oeltz. Arg. (N.) 15409	15. 24	21. 35	-0° 50	+1° 94	1	1	2	B. D. + 65°, 52.....	0. 21	23. 44	+0° 11	-2° 72	2	1	3
Oeltz. Arg. (N.) 15523	15. 33	21. 38	-0° 48	+2° 49	1	1	2	Oeltz. Arg. (N.) 1491	1. 20	23. 25	+0° 06	+2° 17	1	1	2
Oeltz. Arg. (N.) 15531	15. 34	21. 50	+0° 24	+3° 56	2	1	3	Christiana 266.....	1. 20	23. 32	-0° 51	+0° 20	1	1	2
Oeltz. Arg. (N.) 15567	15. 37	21. 4	-0° 31	+0° 19	2	1	3	Groombridge 521.....	2. 26	23. 0	+0° 43	+0° 12	1	1	2
Oeltz. Arg. (N.) 15575	15. 37	21. 28	-0° 18	-1° 71	1	1	2	B. D. + 65°, 313....	2. 53	23. 48	-0° 39	+3° 36	1	1	2
Oeltz. Arg. (N.) 15591	15. 38	21. 19	-0° 49	+0° 80	3	1	3	Lalande F. 504.....	3. 1	23. 27	-0° 26	+0° 03	1	1	2
B. D. + 68°, 850....	15. 45	21. 33	-0° 13	+2° 30	2	1	3	Lalande F. 522.....	3. 11	23. 7	+0° 28	+1° 25	1	1	2
Oeltz. Arg. (N.) 16030	16. 10	21. 15	-0° 36	-0° 25	1	1	2	B. D. + 66°, 377....	5. 2	23. 40	+0° 01	+0° 48	1	1	2

TRANSIT-CIRCLE TABLES.

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Correction to Assumed Colatitude—continued.

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of R.A. above Pole.	Excess of N.P.D. above Pole.	No. of Observations.		Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of R.A. above Pole.	Excess of N.P.D. above Pole.	No. of Observations.		Weight.
					Above Pole.	Below Pole.							Above Pole.	Below Pole.	
Oeltz. Arg. (N.) 7526	h m	°	'	"	3	1	3	Lalande F. 3788	h m	°	'	"	2	1	3
Lalande F. 1257	7. 1	23. 35	-0.07	-0.45	1	1	2	Lalande F. 3794	21. 21	24. 14	-0.50	+0.21	2	1	3
Oeltz. Arg. (N.) 11849	8. 5	23. 28	+0.44	+2.46	4	1	3	B. D. + 65°, 1599	21. 22	24. 16	-0.25	+0.22	2	1	3
B. D. + 66°, 828	11. 28	23. 10	-0.34	-2.80	1	1	2	Oeltz. Arg. (N.) 22577	21. 31	24. 18	-0.19	+1.16	1	1	2
Oeltz. Arg. (N.) 14625	13. 58	23. 28	-0.03	+0.78	1	1	2	Oeltz. Arg. (N.) 22588	21. 34	24. 41	+0.13	-4.34	1	1	2
Oeltz. Arg. (N.) 14687-9	14. 26	23. 14	-0.04	+2.42	1	1	2	Oeltz. Arg. (N.) 24948	21. 34	24. 47	-0.32	-0.93	1	1	2
Oeltz. Arg. (N.) 14830	14. 30	23. 7	+0.14	+2.57	1	1	2	B. D. + 65°, 1899	22. 54	24. 27	-0.08	-0.55	1	1	2
B. D. + 67°, 852	14. 40	23. 28	-0.62	-0.62	3	1	3	Lalande 2933	23. 25	24. 25	-0.66	+0.47	1	1	2
Oeltz. Arg. (N.) 15256	14. 47	23. 0	-0.14	+0.75	2	1	3	Lalande 3134	1. 33	25. 20	-0.19	+0.54	1	1	2
B. D. + 66°, 901	15. 12	23. 3	+0.12	+1.90	2	1	3	Lalande 6011	1. 39	25. 44	-0.27	+1.07	1	1	2
B. D. + 67°, 946	15. 18	23. 23	+0.06	+1.14	1	1	2	Lalande 8192	3. 14	25. 12	-0.03	+0.13	1	1	2
Oeltz. Arg. (N.) 16905	16. 31	23. 5	+0.12	+2.50	1	1	2	B. D. + 64°, 531	4. 22	25. 9	-0.04	+0.07	1	1	2
Lalande 31526-7	17. 7	23. 36	+0.90	+0.90	1	1	2	B. D. + 64°, 699	5. 20	25. 29	+0.05	+0.57	2	1	3
Oeltz. Arg. (N.) 17386-7	17. 11	23. 38	+0.09	+0.70	1	1	2	B. D. + 65°, 717	8. 32	25. 54	-0.21	+0.57	3	1	3
B. D. + 66°, 1362	17. 36	23. 11	-0.15	+1.04	1	1	2	Oeltz. Arg. (N.) 10535	9. 21	25. 6	+0.10	-1.45	3	1	3
B. D. + 65°, 1485	20. 29	23. 35	-0.01	-2.08	1	1	2	B. D. + 64°, 827	10. 2	25. 5	+0.10	+1.63	3	1	3
B. D. + 66°, 1395	20. 36	23. 58	-0.43	-0.17	1	1	2	B. D. + 65°, 836	10. 57	25. 18	+0.14	+1.42	1	1	2
B. D. + 65°, 1654	21. 21	23. 20	-0.62	-0.62	1	1	2	Groombridge 1801	11. 30	25. 10	+0.15	-1.79	3	1	3
B. D. + 66°, 1447	21. 46	23. 54	-0.07	+1.65	1	2	4	Oeltz. Arg. (N.) 11894	11. 30	25. 9	-0.61	+2.65	2	2	4
Lalande F. 4021	21. 50	23. 36	-0.02	+2.19	1	1	2	Oeltz. Arg. (N.) 11945	11. 31	25. 13	+0.05	+3.14	3	1	3
Oeltz. Arg. (N.) 24915	22. 3	23. 41	+0.13	+1.38	2	2	5	Lalande F. 2337	11. 34	25. 24	+0.40	+0.56	1	1	2
Oeltz. Arg. (N.) 25158	22. 52	23. 47	+0.36	+0.36	2	1	3	Oeltz. Arg. (N.) 14160	12. 25	25. 55	+0.50	+0.98	2	1	3
B. D. + 65°, 1917	23. 3	23. 13	+0.02	-0.16	1	1	2	B. D. + 64°, 1027	13. 41	25. 48	-0.06	+0.86	1	1	2
B. D. + 65°, 1944	23. 32	23. 58	-0.13	+0.84	1	1	2	Oeltz. Arg. (N.) 14913	13. 55	25. 45	-0.41	+0.98	2	1	3
Oeltz. Arg. (N.) 26041	23. 43	23. 56	+0.17	+0.96	1	1	2	B. D. + 64°, 1034	14. 2	25. 10	+0.10	+0.37	4	1	3
Oeltz. Arg. (N.) 160	23. 44	23. 53	+0.16	+0.42	1	1	2	Oeltz. Arg. (N.) 15210	14. 44	25. 52	-0.28	+2.62	1	1	2
Lalande 2633	0. 11	24. 34	-0.27	+0.91	1	1	2	B. D. + 64°, 1416	14. 47	25. 1	-0.18	+1.86	1	1	2
Oeltz. Arg. (N.) 2073 (1st star)	1. 24	24. 15	-0.33	+0.82	1	1	2	Groombridge 2252	14. 50	25. 51	-0.18	-0.34	2	1	3
Oeltz. Arg. (N.) 2073 (2nd star)	2. 33	24. 46	+0.11	-2.36	1	1	2	Oeltz. Arg. (N.) 15547	15. 9	25. 46	+0.11	-0.81	1	1	2
Oeltz. Arg. (N.) 3483	2. 33	24. 45	-0.15	+0.77	1	1	2	Oeltz. Arg. (N.) 15831	15. 29	25. 32	+0.33	+1.67	1	1	2
Lalande 7028	3. 4	24. 29	+0.07	+0.22	1	1	2	Oeltz. Arg. (N.) 16374	15. 36	25. 15	-0.43	+0.43	1	1	2
Oeltz. Arg. (N.) 4408	3. 47	24. 52	-0.07	+0.44	1	1	2	Oeltz. Arg. (N.) 16764	15. 57	25. 54	-0.43	+0.83	1	1	2
Oeltz. Arg. (N.) 4797	3. 59	24. 24	-0.33	+0.67	1	1	2	B. D. + 64°, 1300	16. 33	25. 35	-0.55	+1.18	2	1	3
Oeltz. Arg. (N.) 7421	4. 21	24. 19	-0.32	+0.33	1	1	2	Oeltz. Arg. (N.) 19705	16. 59	25. 9	-0.76	+0.27	1	1	2
Groombridge 1345	6. 54	24. 18	-0.16	+0.84	3	1	3	B. D. + 64°, 1416	18. 53	25. 20	-0.03	-0.41	1	1	2
Oeltz. Arg. (N.) 8648	7. 35	24. 20	+0.03	-0.81	1	1	2	Oeltz. Arg. (N.) 21983	19. 46	25. 33	+0.23	+0.25	1	1	2
B. D. + 65°, 852	8. 5	24. 38	+0.38	+2.17	2	1	3	B. D. + 64°, 1546	20. 7	25. 41	+0.38	-0.84	1	1	2
Oeltz. Arg. (N.) 12987-8	11. 42	24. 18	-0.13	-3.49	1	2	4	Oeltz. Arg. (N.) 22548	21. 13	25. 35	-0.15	-0.63	1	1	2
Oeltz. Arg. (N.) 13299	12. 42	24. 30	-0.17	+0.50	2	1	3	B. D. + 63°, 1754	21. 24	25. 9	+0.12	-0.22	1	2	3
Oeltz. Arg. (N.) 14190	13. 1	24. 54	-0.52	+0.50	2	1	3	B. D. + 64°, 1656	21. 32	25. 27	+0.02	+0.96	1	1	2
Oeltz. Arg. (N.) 14248	13. 57	24. 51	-0.21	+1.76	1	1	2	Lalande F. 4648	21. 34	25. 53	-0.30	+0.12	1	1	2
Oeltz. Arg. (N.) 14446	14. 1	24. 49	+0.18	+1.40	2	1	3	B. D. + 63°, 209	22. 14	25. 46	+0.21	+0.61	2	1	3
Oeltz. Arg. (N.) 14462	14. 13	24. 57	+0.43	+0.62	2	1	3	Oeltz. Arg. (N.) 11838	22. 21	25. 17	-0.32	+1.24	2	1	3
B. D. + 65°, 1017	14. 15	24. 57	+0.13	-1.92	1	1	2	Lalande 32132	23. 59	25. 23	-0.09	+0.93	1	1	2
B. D. + 65°, 1045	14. 47	24. 29	+0.03	-0.71	1	1	2	Oeltz. Arg. (N.) 22326	26. 1	26. 0	-0.14	+0.48	1	1	2
Lalande 28583	15. 32	24. 29	-0.22	+4.13	1	1	2	53 Camelopardi	11. 27	26. 1	-0.02	+1.06	1	1	2
B. D. + 65°, 1072	15. 41	24. 19	-0.12	-1.41	2	1	3	β Cassiopeiæ	17. 29	26. 3	-0.04	+0.70	2	1	2
Oeltz. Arg. (N.) 15618	15. 53	24. 57	-0.30	+2.49	1	1	2	ε Ursæ Majoris	18. 31	26. 5	+0.15	+0.70	2	1	2
Oeltz. Arg. (N.) 15849	15. 59	24. 59	-0.25	-1.15	2	1	3		21. 25	26. 0	-0.14	+0.86	1	1	2
Oeltz. Arg. (N.) 17176	17. 24	24. 11	-1.78		1	1	2		7. 54	29. 25	-0.02	+0.48	1	3	4

GREENWICH OBSERVATIONS, 1905.

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The weights used in the above tables 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 234. 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 $\frac{2nn_1}{n_1e^2 + ne_1^2 + 2nn_1e_0^2}$; or assuming $e_0^2 = \frac{1}{10} e_1^2$, which would make $e_0 = 0''.16$, the weight becomes $\frac{2nn_1}{n_1e^2 + ne_1^2 + \frac{1}{5}nn_1e_1^2}$, which has been adopted in the investigation.

If z be the correction to the assumed colatitude $38^\circ. 31'. 21''.90$, $2z +$ the algebraic sum of determinations ought to be equal to 0. Combining the whole with the weights above attached to them, $z = - 0''.200$.

The colatitude determined from the observations of 1905 is therefore $38^\circ. 31'. 21''.70$.

ALTAZIMUTH TABLES, 1905.

ROYAL OBSERVATORY, GREENWICH.

ALTAZIMUTH TABLES, 1905.

Equatorial Intervals of the Transit Wires.

The following are the intervals from the middle wire determined from measures with the transit-micrometer and the position micrometer, combined with star transits. A star transits the wires in the order of numeration of the wires in position 0° , d or 180° , r; in the reverse order in position 0° , r or 180° , d. In each case, the order is reversed below the pole.

One revolution of transit-micrometer = $21''.636$

Wire.		Wire.	
	$\begin{matrix} r & s \\ + & - \end{matrix}$		$\begin{matrix} r & s \\ - & + \end{matrix}$
1	+ 30.067 = + 43.368	15	- 2.030 = - 2.928
2	+ 23.046 = + 33.241	16	- 3.030 = - 4.371
3	+ 20.990 = + 30.276	17	- 4.045 = - 5.835
4	+ 18.971 = + 27.363	18	- 5.058 = - 7.296
5	+ 16.842 = + 24.293	19	- 6.051 = - 8.728
6	+ 15.021 = + 21.666	20	- 8.090 = - 11.668
7	+ 10.024 = + 14.459	21	- 10.047 = - 14.491
8	+ 7.912 = + 11.412	22	- 15.067 = - 21.732
9	+ 5.968 = + 8.609	23	- 17.102 = - 24.666
10	+ 5.026 = + 7.250	24	- 19.092 = - 27.536
11	+ 4.020 = + 5.799	25	- 21.130 = - 30.477
12	+ 2.935 = + 4.234	26	- 23.162 = - 33.408
13	+ 1.988 = + 2.867	27	- 30.197 = - 43.556
14	0.000 + 0.000		

Intervals of the Zenith Distance Wires on the Prime Vertical.

The following are the intervals from the middle wire, determined from measures with the telescope-micrometer and the position-micrometer, combined with star transits.

A star transits the wires in the order of numeration of the wires when the Fixed Circle is south, *i.e.*, in positions 0° , d, to 180° , d, or 180° , r, to 360° , r.

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One revolution of telescope-micrometer = $21''\cdot707$.

Wire.		Wire.	
	$\begin{matrix} r & s \end{matrix}$		$\begin{matrix} r & s \end{matrix}$
I.	+ 15'950 = + 37'059	XII.	- 2'037 = - 4'733
II.	+ 14'963 = + 34'767	XIII.	- 2'997 = - 6'964
III.	+ 13'976 = + 32'474	XIV.	- 4'009 = - 9'315
IV.	+ 12'972 = + 30'141	XV.	- 4'991 = - 11'597
V.	+ 12'045 = + 27'987	XVI.	- 5'998 = - 13'936
VI.	+ 6'036 = + 14'025	XVII.	- 11'961 = - 27'791
VII.	+ 5'025 = + 11'676	XVIII.	- 12'977 = - 30'150
VIII.	+ 4'037 = + 9'380	XIX.	- 13'984 = - 32'492
IX.	+ 2'998 = + 6'966	XX.	- 15'013 = - 34'883
X.	+ 1'954 = + 4'540	XXI.	- 16'033 = - 37'252
XI.	0'000 = 0'000		

The following factors must be used to obtain the time intervals of the wires in other azimuths. Az. $80^\circ, 100^\circ, 1\cdot01543$; Az. $70^\circ, 110^\circ, 1\cdot06418$; Az. $60^\circ, 120^\circ, 1\cdot15470$; Az. $45^\circ, 135^\circ, 1\cdot41421$; Az. $30^\circ, 150^\circ, 2\cdot00000$.

Apparent Correction to Adopted Level-Errors.

Apparent Correction to Adopted Level-Errors, deduced from a Comparison of Reflexion and Direct Observations of Right Ascensions, made in the Year 1905.

Name of Star.	Approx. N.P.D.	Approx. R.A.	Seconds of R.A.		R.—D.	Deduced Correction to Level-Error.	No. of Obs.		Weight.
			R.	D.			R.	D.	
	$^\circ \quad '$	$^h \quad m$	s	s	s	$''$			
ν Ursæ Majoris S.P...	- 30. 30	9. 44	14'640	14'400	+ 0'240	- 2'52	$\frac{1}{2}$	1	1
β Ursæ Majoris S.P...	- 26. 31	9. 24	2'850	2'840	+ 0'010	- 0'08	$\frac{1}{2}$	2	1
ι Draconis S.P.....	- 24. 48	13. 48	39'420	39'260	+ 0'160	- 1'10	1	2	1
ϵ Cephei S.P.....	- 24. 17	22. 46	17'720	17'815	- 0'095	+ 0'64	1	2	1
ϵ Draconis S.P.....	- 19. 58	19. 48	30'140	29'770	+ 0'370	- 1'79	1	1	1
Groomb. 2930 S.P.....	- 15. 50	19. 37	10'130	9'580	+ 0'550	- 1'90	1	1	1
π Cephei S.P.....	- 15. 7	23. 4	52'470	52'900	- 0'430	+ 1'40	1	1	1
θ Draconis S.P.....	- 13. 46	20. 2	17'000	17'040	- 0'040	+ 0'11	1	2	1
Cephei 47 S.P.....	- 10. 57	2. 53	25'120	25'635	- 0'515	+ 1'12	1	2	1
24 Cephei.....	18. 7	22. 7	58'960	58'780	+ 0'180	+ 0'44	1	1	1
ζ Cygni.....	60. 9	21. 8	53'520	53'550	- 0'030	- 0'21	1	2	2
ϵ Leonis.....	65. 47	9. 40	27'620	27'630	- 0'010	- 0'08	1	3	3
Arcturus.....	70. 19	14. 11	19'630	19'647	- 0'017	- 0'15	1	3	3
η Boötis.....	71. 7	13. 50	9'510	9'677	- 0'167	- 1'41	1	3	3
γ Pegasi.....	75. 20	0. 8	20'500	20'513	- 0'013	- 0'13	1	$\frac{1}{2}$	2
σ Leonis.....	83. 26	11. 16	14'390	14'340	+ 0'050	+ 0'52	1	1	1
ω Piscium.....	83. 39	23. 54	25'870	26'010	- 0'140	- 1'46	1	$\frac{1}{2}$	1
e Piscium.....	84. 51	1. 3	28'400	28'510	- 0'110	- 1'18	1	2	1
ν Piscium.....	84. 59	1. 36	29'160	29'225	- 0'065	- 0'70	1	2	1

Apparent Correction to Adopted Level-Errors—continued.

Name of Star.	Approx. N.P.D.	Approx. R.A.	Seconds of R.A.		R. — D.	Deducted Correction to Level-Error.	No. of Obs.		Weight.
			R.	D.			R.	D.	
	° ' "	h m	s	s	s	"			
Piazzi 0 189.....	85. 12	0. 43	23° 9' 0	23° 8' 7	— 0° 0' 17	— 0° 2' 0	1 2	1 2	1
f Piscium.....	86. 53	1. 12	53° 9' 10	53° 8' 05	+ 0° 1' 05	+ 1° 1' 7	1	2	1
η Serpentis.....	92. 55	18. 16	23° 6' 20	23° 6' 50	— 0° 0' 30	— 0° 3' 8	1	3	1
δ Ophiuchi.....	93. 27	16. 9	21° 8' 90	21° 8' 0	— 0° 0' 90	— 1° 1' 6	1	1	1
13 Ceti.....	94. 6	0. 30	21° 4' 80	21° 4' 17	+ 0° 0' 63	+ 0° 8' 3	1 2	1 2	1
κ Virginis.....	99. 49	14. 7	49° 6' 30	49° 5' 83	+ 0° 0' 47	+ 0° 7' 2	2	3	2
θ Capricorni.....	107. 36	21. 0	36° 6' 00	36° 5' 50	+ 0° 0' 50	+ 0° 9' 8	1	2	1

From 16 South Stars, Mean Correction to Level-Error, = $-0''.23$.

From 10 North " " " " " = - 0''·37.

Corrections for Errors of Division of the Altazimuth. (In use from 1899.)

Pointer.	Fixed Circle.	Movable Circle.	Pointer.	Fixed Circle.	Movable Circle.	Pointer.	Fixed Circle.	Movable Circle.
0	0°00	0°00	31	+ 0°26	+ 0°14	61	+ 0°68	+ 0°66
1	— 0°15	+ 0°03	32	+ 0°28	+ 0°22	62	+ 0°76	+ 0°71
2	— 0°21	+ 0°02	33	+ 0°35	+ 0°26	63	+ 0°86	+ 0°74
3	— 0°20	+ 0°03	34	+ 0°43	+ 0°33	64	+ 0°86	+ 0°78
4	— 0°18	+ 0°03	35	+ 0°44	+ 0°48	65	+ 0°72	+ 0°77
5	— 0°17	+ 0°01	36	+ 0°47	+ 0°61	66	+ 0°61	+ 0°68
6	— 0°18	+ 0°02	37	+ 0°53	+ 0°62	67	+ 0°61	+ 0°64
7	— 0°17	+ 0°03	38	+ 0°60	+ 0°52	68	+ 0°64	+ 0°61
8	— 0°11	+ 0°02	39	+ 0°67	+ 0°43	69	+ 0°63	+ 0°55
9	— 0°05	+ 0°07	40	+ 0°72	+ 0°44	70	+ 0°61	+ 0°50
10	— 0°06	+ 0°09	41	+ 0°80	+ 0°44	71	+ 0°64	+ 0°39
11	— 0°12	+ 0°02	42	+ 0°88	+ 0°33	72	+ 0°69	+ 0°35
12	— 0°10	— 0°01	43	+ 0°86	+ 0°30	73	+ 0°74	+ 0°35
13	— 0°04	+ 0°04	44	+ 0°77	+ 0°37	74	+ 0°77	+ 0°24
14	— 0°03	+ 0°06	45	+ 0°69	+ 0°48	75	+ 0°82	+ 0°13
15	— 0°08	+ 0°03	46	+ 0°61	+ 0°56	76	+ 0°89	+ 0°17
16	— 0°09	+ 0°04	47	+ 0°64	+ 0°51	77	+ 0°91	+ 0°18
17	0°00	+ 0°08	48	+ 0°82	+ 0°54	78	+ 0°88	+ 0°09
18	+ 0°06	+ 0°11	49	+ 0°92	+ 0°62	79	+ 0°85	+ 0°02
19	+ 0°11	+ 0°09	50	+ 0°89	+ 0°54	80	+ 0°83	— 0°08
20	+ 0°14	+ 0°03	51	+ 0°89	+ 0°47	81	+ 0°79	— 0°12
21	+ 0°14	+ 0°05	52	+ 0°89	+ 0°48	82	+ 0°67	— 0°07
22	+ 0°21	+ 0°13	53	+ 0°89	+ 0°47	83	+ 0°49	— 0°05
23	+ 0°29	+ 0°15	54	+ 0°88	+ 0°49	84	+ 0°35	— 0°05
24	+ 0°33	+ 0°07	55	+ 0°75	+ 0°61	85	+ 0°31	+ 0°03
25	+ 0°34	+ 0°02	56	+ 0°67	+ 0°66	86	+ 0°32	+ 0°11
26	+ 0°36	0°00	57	+ 0°70	+ 0°63	87	+ 0°27	+ 0°07
27	+ 0°35	— 0°02	58	+ 0°71	+ 0°64	88	+ 0°19	+ 0°03
28	+ 0°34	— 0°03	59	+ 0°65	+ 0°65	89	+ 0°12	+ 0°01
29	+ 0°31	— 0°01	60	+ 0°63	+ 0°62	90	0°00	0°00
30	+ 0°27	+ 0°05						

The signs given in the table are for positions d ; they are to be reversed for positions r.

The Division Errors are repeated after 90° . Thus for Pointer 91° , 181° , 271° , the Error is the same as for Pointer 1° , and so on.

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Observations to determine the Astronomical Flexure of the Altazimuth, 1905.

Date.	Mean Concluded Circle Reading.				Resulting Correction for Astronomical Horizontal Flexure.		Reading of Interior Thermometer.		
	North Collimator.		South Collimator.		Fixed Circle.	Movable Circle.	Upper.	Lower.	
	Fixed Circle.	Movable Circle.	Fixed Circle.	Movable Circle.					
Position 0°, d.									
Mar.	21	90° 0' 34".95	31".65	270° 0' 33".78	29".45	- 0".58	- 1".10	E 54°.0	53°.4
								W 55°.0	54°.5
	24	36".32	31".02	35".85	30".14	- 0".22	- 0".44	E 59°.4	57°.3
								W 59°.9	58°.0
Position 180°, d.									
July	24	269 57 50.85	36.60	89 57 51.26	37.00	- 0.20	- 0.20	E 74.6	72.6
								W 74.5	73.1
Position 0°, r.									
Sept.	12	90 4 34.08	60.77	270 4 34.44	60.45	+ 0.18	- 0.16	E 63.7	62.6
								W 64.9	63.0
	19	32.21	57.37	31.89	56.68	- 0.16	- 0.34	E 64.2	62.6
								W 65.1	62.7
	29	28.19	57.37	26.70	55.44	- 0.75	- 0.97	E 54.0	53.9
								W 53.0	53.2
Oct.	17	22.25	50.12	22.00	49.43	- 0.13	- 0.35	E 45.9	45.1
								W 46.3	45.1
Position 0°, d.									
Nov.	17	90 0 58.76	26.25	270 0 57.26	24.04	- 0.75	- 1.11	E 37.4	37.8
								W 37.3	37.3
	27	56.52	22.98	56.02	21.77	- 0.25	- 0.61	E 45.6	45.0
								W 45.5	44.8
Dec.	6	56.04	15.12	55.19	13.79	- 0.43	- 0.67	E 47.8	47.3
								W 48.0	47.1
	18	66.88	25.51	65.81	23.56	- 0.74	- 0.97	E 42.4	42.4
								W 42.4	42.1
	22	68.49	26.57	67.77	24.76	- 0.36	- 0.91	E 42.9	43.1
								W 42.6	42.7

The column "Resulting Correction for Astronomical Horizontal Flexure," is in all cases $\frac{1}{2}$ (Circle Reading at Pointer 270°—Circle Reading at Pointer 90°); it thus gives the correction for Flexure to an observed Zenith-Distance of 90° with its proper sign.

Each result is usually the mean of five determinations, the collimators being read for coincidence of their horizontal wires through the openings in the central cube of the telescope before and after each determination, and a correction being applied for the change in the Collimator Readings before and after.

No Correction for Astronomical Flexure has been applied to the observations.

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Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1905.

In these tables 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.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
Position 0° , r. January, February.					
	h m	$^{\circ}$ ' "	"		
θ Draconis S.P.....	16. 0	— 31. 11	+ 2'23	1	1
α Draconis S.P.....	14. 1	— 25. 10	— 0'09	1	1
β Draconis S.P.....	17. 53	— 13. 1	+ 0'61	1	1
ζ Ursæ Minoris S.P.....	15. 47	— 11. 55	+ 1'08	1	1
Groombridge 993.....	5. 37	14. 19	+ 0'02	1	1
Lalande F. 430-1.....	2. 37	14. 59	— 2'28	1	1
B. D. + 73', 285.....	5. 13	16. 23	+ 0'79	1	1
ι Tauri.....	4. 57	68. 33	— 2'52	1	1
β Arietis.....	1. 49	69. 39	— 4'08	1	1
ν Piscium.....	1. 36	85. 0	— 1'75	1	1
μ Eridani.....	4. 40	93. 26	+ 1'12	1	1
σ^2 Eridani.....	4. 10	97. 48	+ 0'65	1	1
κ Orionis.....	5. 43	99. 42	— 0'84	1	1
α Leporis.....	5. 28	107. 53	— 0'96	1	1
Position 0° , d. March, April.					
ϵ Draconis S.P.....	19. 48	— 19. 58	+ 3'15	1	1
Groombridge 2930 S.P.....	19. 37	— 15. 50	+ 1'59	1	1
69 Draconis S.P.....	20. 2	— 13. 47	+ 1'76	1	1
Groombridge 1463.....	8. 42	9. 37	+ 1'73	1	1
Lalande F. 1338.....	8. 33	16. 30	+ 1'50	1	1
ϵ Leonis.....	9. 40	65. 47	— 0'13	1	1
λ Geminorum.....	7. 12	73. 17	+ 0'92	1	1
ν Leonis.....	9. 53	77. 6	— 1'20	1	1
β Canis Minoris.....	7. 22	81. 31	— 0'36	1	1
δ Hydræ.....	8. 32	83. 58	+ 2'26	1	1
Position 180° , d. May, June.					
Piazzi III. 51 S.P.....	3. 21	— 30. 23	— 0'84	1	1
Piazzi III. 94 S.P.....	3. 33	— 27. 5	— 2'48	1	1
ι Cephei S.P.....	22. 46	— 24. 18	— 1'10	1	1
ι Cassiopeiae S.P.....	2. 21	— 23. 1	— 0'72	1	1

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Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1905—contd.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
Position 180°, d. May, June— <i>continued</i> .					
	h m	° '	"		
Bradley 366 S.P.	2. 37	— 22. 35	— 1'67	1	1
π Cephei S.P.	23. 4	— 15. 8	— 1'18	1	1
Cephei 47 S.P.	2. 53	— 10. 57	(+ 4'85)	(1)	(1)
Bradley 1730	12. 48	6. 4	— 0'20	1	1
Bradley 1731	12. 48	6. 4	— 0'49	1	1
5 Ursæ Minoris	14. 27	13. 53	— 1'51	1	1
20 Comæ	12. 24	68. 34	+ 0'73	1	1
Arcturus	14. 11	70. 19	— 0'14	1	1
η Boötis	13. 50	71. 7	— 0'21	1	1
σ Leonis	11. 16	83. 27	— 1'95	1	1
ε Serpentis	15. 46	85. 14	— 1'77	1	1
δ Ophiuchi	16. 9	93. 27	— 1'24	1	1
κ Virginis	14. 7	99. 50	— 0'50	2	2
ζ Crateris	11. 39	107. 49	— 3'04	1	1
Position 0°, r. September, October.					
υ Ursæ Majoris S.P.	9. 43	— 30. 31	+ 0'63	1	1
h Ursæ Majoris S.P.	9. 24	— 26. 31	— 0'13	2	2
Piazzi XL 43 S.P.	11. 17	— 25. 9	+ 0'63	1	1
10 Draconis S.P.	13. 49	— 24. 48	— 0'67	1	1
Cephei 51 S.P.	6. 56	— 2. 48	— 1'59	1	1
Groombridge 1119 S.P.	8. 3	— 1. 5	+ 2'37	1	1
Polaris	1. 24	1. 12	— 0'29	1	1
Bradley 3147	23. 27	3. 13	— 0'09	1	1
Groombridge 3548	21. 18	3. 21	— 0'89	1	1
50 Draconis	18. 49	14. 41	— 2'17	1	1
Groombridge 3241	20. 30	17. 47	+ 1'08	1	1
ζ Cygni	21. 8	60. 10	— 1'02	1	1
32 Vulpeculæ	20. 50	62. 18	— 3'05	1	1
γ Pegasi	0. 8	75. 21	— 1'17	1	1
ω Piscium	23. 54	83. 40	— 2'64	1	1
ε Piscium	1. 3	84. 51	— 3'38	1	1
Piazzi O 189	0. 43	85. 12	— 3'36	1	1

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Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1905—contd.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
Position 0° , r. September, October— <i>continued</i> .					
	h m	$^{\circ}$ '	"		
η Serpentis.....	18. 16	92. 55	— 1'14	1	1
3 Aquarii.....	20. 43	95. 23	+ 1'72	1	1
2 Aquilæ.....	18. 36	99. 9	— 1'67	1	1
δ Capricorni.....	21. 41	106. 33	— 1'82	1	1
γ Capricorni.....	21. 34	107. 5	— 3'40	1	1
θ Capricorni.....	21. 0	107. 37	— 0'88	1	1
Position 0° , d. November, December.					
Piazzi XIII. 110 S.P.....	13. 24	— 29. 34	+ 4'74	1	1
10 Draconis S.P.....	13. 49	— 24. 48	+ 3'08	1	1
Groombridge 2029 S.P.....	13. 35	— 18. 16	+ 0'84	2	2
Bradley 1508 S.P.....	10. 52	— 11. 43	+ 1'05	1	1
Bradley 1399 S.P.....	10. 15	— 5. 16	+ 3'35	1	1
Polaris.....	1. 24	1. 12	+ 0'70	2	2
Bradley 3147.....	23. 27	3. 13	— 0'41	1	1
γ Cephei.....	23. 35	12. 54	— 0'32	1	1
π Cephei.....	23. 4	15. 8	+ 0'74	2	2
24 Cephei.....	22. 7	18. 8	+ 0'46	1	1
η Pegasi.....	22. 38	60. 17	+ 1'24	1	1
35 Arietis.....	2. 37	62. 42	+ 0'11	1	1
θ Arietis.....	2. 13	70. 32	— 1'33	2	2
α Pegasi.....	23. 0	75. 18	— 1'54	1	1
ϵ Pegasi.....	21. 39	80. 34	+ 0'34	1	1
ξ^2 Ceti.....	2. 23	81. 58	+ 1'42	1	1
e Piscium.....	1. 3	84. 51	+ 0'95	1	1
Piazzi 0 189.....	0. 43	85. 12	+ 1'46	1	1
f Piscium.....	1. 12	86. 53	— 1'20	1	1
η Aquarii.....	22. 30	90. 36	+ 0'90	1	1
13 Ceti.....	0. 30	94. 7	+ 1'20	1	1
ϕ Aquarii.....	23. 9	96. 34	— 1'51	1	1
μ Capricorni.....	21. 48	104. 0	+ 1'33	1	1

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*Excess of Reflexion Results above Direct Results from Groups of Stars
observed with the Altazimuth.*

Extent of Group 1905.	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.	Apparent Error of the Formula.
Position 0°, r. January, February.						
θ Draconis S. P. to ζ Ursæ Minoris S.P.	4	— 20. 19	— 58. 50	+ 0.86	— 0.24	— 1.10
Groombridge 993 to B. D. + 73° 285	3	15. 14	— 23. 17	— 0.54	— 0.55	— 0.01
ϵ Tauri to β Arietis.....	2	69. 6	30. 35	— 3.24	— 1.17	+ 2.07
ν Piscium to μ Eridani.....	2	89. 13	50. 42	— 0.23	— 1.35	— 1.12
α^2 Eridani to α Leporis.....	3	101. 48	63. 17	— 0.27	— 1.43	— 1.16
Position 0°, d. March, April.						
ϵ Draconis S.P. to 69 Draconis S.P....	3	— 16. 32	— 55. 3	+ 2.07	+ 1.38	— 0.69
Groombridge 1463 to Lalande F. 1338	2	13. 4	— 25. 27	+ 1.57	+ 1.11	— 0.46
ϵ Leonis to ν Leonis.....	3	72. 3	33. 32	— 0.07	+ 0.44	+ 0.51
β Canis Minoris to δ Hydræ.....	2	82. 45	44. 14	+ 1.03	+ 0.35	— 0.68
Position 180°, d. May, June.						
Piazzi III. 51 S.P. to ϵ Cassiop. S.P....	4	— 26. 12	— 64. 43	— 1.40	— 0.21	+ 1.19
Bradley 366 S.P. to Cephei 47 S.P....	2	— 18. 52	— 57. 23	— 1.53	— 0.25	+ 1.28
Bradley 1730 to 5 Ursæ Minoris.....	3	8. 40	— 29. 51	— 0.78	— 0.48	+ 0.30
20 Comæ to η Boötis.....	3	70. 0	31. 29	+ 0.19	— 1.17	— 1.36
σ Leonis to δ Ophiuchi.....	3	87. 23	48. 52	— 1.56	— 1.33	+ 0.23
κ Virginis to ζ Crateris.....	3	102. 30	63. 59	— 1.23	— 1.43	— 0.20
Position 0°, r. September, October.						
ν Ursæ Majoris S.P. to 10 Draconis S.P.	5	— 26. 42	— 65. 13	— 0.04	— 0.20	— 0.16
Cephei 51 S.P. to Groombridge 3548..	5	0. 47	— 37. 44	— 0.17	— 0.40	— 0.23
50 Draconis to Groombridge 3241.....	2	16. 14	— 22. 17	— 0.59	— 0.56	+ 0.03
ζ Cygni to 32 Vulpeculæ.....	2	61. 14	22. 43	— 2.01	— 1.08	+ 0.93
γ Pegasi to Piazzi O. 189.....	4	82. 16	43. 45	— 2.58	— 1.29	+ 1.29
η Serpentis to 2 Aquilæ.....	3	95. 49	57. 18	— 0.26	— 1.39	— 1.13
δ Capricorni to θ Capricorni.....	3	107. 5	68. 34	— 1.92	— 1.45	+ 0.47
Position 0°, d. November, December.						
Piazzi XIII. 110 S.P. to Groomb. 2029 S.P.	4	— 22. 41	— 61. 12	+ 2.27	+ 1.42	— 0.85
Bradley 1508 S.P. to Bradley 1399 S.P.	2	— 8. 30	— 47. 0	+ 1.95	+ 1.32	— 0.63
Polaris to Bradley 3147.....	3	1. 52	— 36. 39	+ 0.26	+ 1.23	+ 0.97
γ Cephei to 24 Cephei.....	4	15. 20	— 23. 11	+ 0.35	+ 1.09	+ 0.74
η Pegasi to 35 Arietis.....	2	61. 30	23. 0	+ 0.73	+ 0.55	— 0.18
θ Arietis to α Pegasi.....	3	72. 7	33. 36	— 1.34	+ 0.44	+ 1.78
ϵ Pegasi to f Piscium.....	5	83. 54	45. 23	+ 0.68	+ 0.34	— 0.34
η Aquarii to μ Capricorni.....	4	96. 19	57. 48	+ 0.58	+ 0.24	— 0.34

In forming the mean values of $R-D$ for groups in the fifth column of the above table, a correction of $+0''.12 \sin Z.D.$ 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 instrument, the centre of the mercury trough being assumed to describe a circle of 6 feet radius.

Assuming that the $R-D$ discordance can be represented by

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

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 :—

*Observed $R-D$ Discordance for Different Positions of the Altazimuth,
in the Year 1905.*

Position of Instrument.	$R-D$ Discordance.	
	"	"
0° , r (Jan., Feb.).	-0.38	$-0.98 \sin Z.$
0° , d (Mar., Apr.).	$+1.08$	$-1.18 \sin Z.$
180° , d (May, June).	-1.04	$+0.24 \sin Z.$
180° , r (July, Aug.).	Instrument under repair.	
0° , r (Sept., Oct.).	-0.94	$-1.08 \sin Z.$
0° , d (Nov., Dec.).	$+0.70$	$-0.72 \sin Z.$

Assuming the formulæ for the four positions as

$$+ a + b \sin Z.D. \text{ for the positions } 0^\circ \text{ d and } 180^\circ \text{ r,}$$

and

$$- a + b \sin Z.D. \quad ,, \quad ,, \quad 0^\circ \text{ r and } 180^\circ \text{ d,}$$

the $R-D$ discordance for applying to the four positions may be taken as

$$\pm 0''.82 - 0''.68 \sin Z.D.$$

ALTAZIMUTH TABLES, 1905.

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Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1905, with those of Newcomb's Fundamental Catalogue.

Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.
R.A.	N.P.D.				R.A.	N.P.D.				R.A.	N.P.D.			
Position 0° , r. January, February.					Position 0° , r. Jan., Feb.—contd.					Position 0° , r. Jan., Feb.—contd.				
h	m	$^{\circ}$	"		h	m	$^{\circ}$	"		h	m	$^{\circ}$	"	
15. 55	—	35.0	+ 1.63	1	3. 21	30.4	+ 0.05	1	1	9. 40	65.8	— 0.54	1	1
16. 22	—	34.6	+ 1.61	1	9. 44	30.5	+ 0.08	1	1	3. 39	66.2	— 0.05	1	1
18. 22	—	31.3	— 0.31	1	4. 40	33.4	+ 0.79	2	2	3. 41	66.2	+ 0.97	1	1
16. 0	—	31.2	+ 1.02	4	2. 43	34.5	+ 2.75	1	1	2. 1	67.0	— 0.40	1	1
15. 22	—	30.7	— 0.42	1	4. 24	36.3	+ 0.10	2	2	6. 9	67.5	— 0.29	1	1
					2. 57	36.9	— 0.60	2	2	9. 3	67.6	— 0.76	1	1
20. 43	—	28.5	+ 1.36	1						8. 37	68.2	— 0.60	1	1
15. 45	—	27.1	+ 0.76	2	3. 17	40.5	+ 0.02	3	3	2. 33	68.4	— 0.02	1	1
18. 13	—	25.6	— 0.39	1	3. 2	40.7	+ 0.82	2	2	4. 57	68.5	+ 0.30	1	1
14. 1	—	25.2	— 0.32	1	4. 8	41.8	+ 0.08	1	1	3. 15	69.2	— 0.75	1	1
14. 56	—	23.7	+ 0.56	1	3. 36	42.5	+ 0.03	1	1	1. 49	69.7	— 1.11	1	1
15. 13	—	22.3	— 0.23	2	4. 1	42.5	+ 0.40	1	1					
16. 6	—	22.0	+ 0.39	1	5. 52	45.1	+ 0.30	1	1	14. 47	70.5	+ 0.64	1	1
16. 28	—	21.0	+ 2.23	1	4. 55	46.3	+ 1.87	1	1	13. 50	71.1	+ 0.06	1	1
					10. 16	48.0	— 0.60	1	1	4. 45	71.3	— 0.18	1	1
21. 27	—	19.9	+ 0.50	1	6. 44	48.1	— 0.66	1	1	8. 26	71.6	+ 0.18	1	1
15. 20	—	17.8	+ 0.83	1	13. 11	48.6	+ 1.41	1	1	4. 20	72.3	— 0.84	2	2
19. 17	—	16.8	— 0.87	1	3. 1	49.4	+ 1.78	1	1	2. 25	72.7	— 0.37	1	1
14. 50	—	15.5	+ 0.59	1	5. 12	50.0	+ 0.73	1	1	4. 17	72.7	+ 0.87	1	1
14. 27	—	13.9	+ 1.27	3						7. 12	73.3	— 0.42	1	1
17. 53	—	13.0	+ 0.52	1	3. 51	50.3	+ 0.48	4	3	6. 32	73.5	— 2.60	1	1
14. 9	—	12.0	+ 0.48	2	2. 59	51.5	+ 0.56	1	1	4. 30	73.7	— 0.71	1	1
15. 47	—	11.9	+ 0.58	2	0. 51	52.0	+ 0.37	1	1	4. 14	74.6	— 0.92	1	1
19. 27	—	10.6	— 0.24	1	2. 3	55.5	+ 0.34	1	1	4. 24	74.6	— 2.37	1	1
					4. 14	55.7	+ 0.24	1	1	4. 59	74.7	— 0.64	1	1
15. 7	—	2.4	+ 1.08	1	6. 46	55.9	— 0.66	1	1	4. 28	75.4	— 0.68	1	1
0. 56	—	1.5	+ 0.39	1	2. 11	56.6	+ 0.01	1	1	6. 7	75.8	— 0.05	1	1
1. 24	—	1.2	+ 1.95	2	3. 38	58.0	— 0.15	3	3	17. 30	77.0	— 0.56	1	1
19. 16	—	1.0	— 0.58	1	3. 48	58.4	+ 0.17	2	2	3. 55	77.8	— 0.07	1	1
					14. 27	59.2	+ 0.45	1	1	8. 53	77.8	— 0.60	1	1
1. 24	1.2	+ 1.16	1	1	14. 30	59.8	— 0.61	1	1	3. 25	79.0	— 0.52	2	2
6. 56	2.8	+ 0.22	1	1						2. 19	79.8	+ 0.50	1	1
23. 27	3.2	+ 1.99	1	1	8. 41	60.9	+ 0.24	1	1					
18. 4	3.4	+ 0.35	1	1	0. 33	61.2	+ 0.25	1	1	6. 35	80.0	— 0.42	1	1
7. 11	7.4	+ 0.12	1	1	8. 47	61.3	— 0.49	3	3	2. 39	80.3	+ 0.50	1	1
					1. 15	61.8	+ 2.15	1	1	3. 19	81.3	— 0.02	1	1
2. 53	11.0	+ 1.67	1	1	17. 42	62.2	— 0.37	1	1	9. 55	81.5	— 0.64	1	1
3. 8	12.6	+ 0.49	1	1	2. 37	62.7	— 0.30	1	1	2. 54	81.5	— 0.53	2	2
8. 29	16.0	+ 0.30	1	1	15. 0	62.7	— 0.29	1	1	2. 23	82.0	+ 0.34	1	1
9. 49	16.7	+ 1.29	1	1	7. 30	62.9	— 1.32	1	1	6. 27	82.6	— 0.10	1	1
3. 40	19.0	+ 1.23	1	1	2. 44	63.1	— 1.66	2	2	2. 30	83.6	— 0.04	2	2
					4. 5	63.8	— 0.26	1	1	3. 58	84.3	+ 2.05	1	1
2. 36	22.6	+ 0.80	1	1	17. 27	63.8	+ 0.29	1	1	4. 46	84.5	+ 0.39	1	1
2. 21	23.0	+ 1.17	1	1	6. 38	64.8	— 0.81	1	1	1. 36	85.0	— 0.53	1	1
10. 11	24.4	+ 1.51	1	1	4. 52	65.1	+ 1.32	1	1	3. 15	85.2	— 0.86	1	1
3. 33	27.1	+ 0.39	3	3	8. 57	65.2	— 0.47	1	1	6. 18	85.4	— 0.50	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1905, with those of Newcomb's Fundamental Catalogue—continued.

Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.
R.A.	N.P.D.				R.A.	N.P.D.				R.A.	N.P.D.			
Position $^{\circ}$, r. Jan., Feb.— <i>contd.</i>					Position $^{\circ}$, d. March, April.					Position $^{\circ}$, d. Mar., Apr.— <i>contd.</i>				
h	m	"	"		h	m	"	"		h	m	"	"	
17. 38	85'4	- 1'04	1	1	23. 8	- 33'4	+ 0'57	1	1	9. 28	53'2	+ 0'11	1	1
17. 21	85'8	- 0'33	1	1	20. 43	- 32'8	+ 1'41	1	1	13. 1	53'7	+ 1'08	1	1
3. 15	87'0	- 0'01	2	2	22. 7	- 32'3	- 1'53	1	1	7. 32	55'2	+ 1'60	1	1
6. 42	87'5	- 0'24	1	1	18. 49	- 30'7	+ 2'59	1	1	9. 15	55'2	+ 0'73	2	2
4. 49	87'7	- 0'71	1	1						10. 48	55'3	+ 0'35	1	1
11. 45	87'7	- 0'55	1	1	20. 43	- 28'5	+ 1'65	1	1	6. 46	55'9	- 0'35	1	1
13. 56	88'0	+ 0'47	1	1	21. 16	- 27'8	- 0'40	1	1	7. 41	56'4	+ 0'23	1	1
					22. 46	- 24'3	+ 1'18	1	1	11. 13	56'4	+ 0'15	1	1
2. 34	90'1	+ 0'60	1	1	19. 48	- 20'0	- 0'45	2	2	18. 46	56'7	- 0'61	1	1
12. 36	90'9	- 1'17	1	1	20. 32	- 15'4	- 0'24	1	1	7. 23	58'0	- 0'62	1	1
12. 36	90'9	- 2'10	1	1	19. 27	- 10'6	+ 0'61	1	1	10. 40	58'8	- 0'41	4	3
0. 48	91'7	- 0'60	1	1						8. 40	60'9	+ 0'22	1	1
2. 14	93'4	+ 0'96	2	2	21. 18	- 3'4	+ 0'99	3	3	12. 47	61'9	+ 1'44	2	2
4. 40	93'4	+ 0'75	1	1	1. 24	- 1'2	+ 0'26	1	1	17. 42	62'2	+ 1'04	1	1
					19. 16	- 1'0	+ 0'40	3	3	8. 14	62'5	+ 0'34	2	2
13. 5	95'0	+ 0'05	1	1	8. 3	1'1	+ 0'67	2	2	7. 30	62'9	+ 0'60	3	3
5. 3	95'2	+ 0'64	1	1	6. 56	2'8	- 0'38	1	1	7. 55	64'3	+ 0'38	1	1
					18. 2	3'4	+ 0'86	1	1	7. 38	65'4	+ 0'84	3	3
4. 10	97'8	+ 1'10	4	3	7. 11	7'4	- 0'99	1	1	9. 40	65'8	+ 0'55	3	3
1. 9	98'4	+ 2'56	1	1	9. 23	8'3	+ 0'94	1	1	10. 11	66'1	- 0'45	2	2
14. 1	98'4	+ 0'50	1	1						5. 58	66'7	+ 0'25	1	1
3. 11	99'2	- 1'32	1	1	8. 7	14'0	+ 1'40	1	1	9. 3	67'6	- 0'22	1	1
7. 36	99'3	+ 2'54	1	1	9. 49	16'7	0'00	2	2	8. 2	68'1	+ 1'01	1	1
5. 43	99'7	- 0'29	1	1	9. 26	19'8	+ 0'26	1	1	8. 37	68'2	+ 0'80	1	1
14. 7	99'8	+ 0'36	1	1	6. 8	20'6	+ 0'54	1	1	8. 27	69'2	- 0'35	1	1
13. 20	100'7	- 1'42	1	1	7. 21	21'3	+ 1'43	1	1	6. 58	69'3	+ 0'39	1	1
6. 49	101'9	+ 0'25	1	1	10. 17	24'0	- 0'10	1	1	18. 41	69'5	+ 1'23	1	1
10. 5	101'9	- 0'65	1	1	12. 51	24'0	+ 0'84	1	1	6. 23	69'7	- 0'56	1	1
10. 0	102'6	+ 0'66	1	1	9. 24	26'5	+ 1'52	1	1					
7. 47	103'6	- 1'82	1	1						8. 17	71'4	+ 0'48	2	2
2. 39	104'3	+ 0'45	1	1	9. 44	30'5	- 0'38	1	1	8. 39	71'5	+ 0'48	2	2
5. 8	106'3	+ 0'21	1	1	7. 15	34'5	+ 0'58	1	1	13. 42	72'0	+ 1'02	1	1
10. 21	106'4	+ 0'64	1	1	8. 57	35'3	+ 0'19	1	1	8. 6	72'1	- 0'63	2	2
5. 28	107'9	+ 0'75	1	1	8. 1	38'2	+ 0'33	1	1	7. 12	73'3	+ 0'62	2	2
										8. 23	75'5	+ 0'85	2	2
2. 46	111'4	- 0'74	2	2	5. 38	40'2	+ 0'04	1	1	17. 10	75'5	+ 0'90	1	1
6. 31	112'9	- 2'91	1	1	8. 54	47'8	+ 1'34	1	1	19. 1	76'3	+ 0'93	2	2
12. 29	112'9	+ 0'49	1	1	13. 11	48'6	+ 1'19	1	1	6. 39	77'0	- 0'57	1	1
2. 18	114'2	+ 1'61	1	1	5. 44	50'9	+ 0'16	1	1	9. 53	77'1	- 0'06	3	3
3. 43	114'2	- 0'40	2	2	13. 5	51'0	+ 0'54	1	1	17. 1	77'1	+ 0'75	1	1
7. 4	116'2	- 0'15	1	1	9. 0	51'2	+ 1'22	3	3	10. 3	77'6	+ 0'67	1	1
					18. 33	51'3	+ 0'80	1	1	6. 11	77'7	- 0'08	1	1
6. 16	120'0	+ 0'46	1	1	17. 14	52'6	+ 0'61	1	1	7. 24	77'8	+ 0'81	2	2
					10. 22	52'8	+ 0'81	1	1	12. 57	78'5	+ 0'32	2	2
										12. 37	79'2	+ 0'27	1	1
										19. 41	79'6	+ 0'05	1	1
										9. 36	79'7	- 0'31	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1905, with those of Newcomb's Fundamental Catalogue—continued.

Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D. - Observed N.P.D.	No. of Obs.	Weight.
R.A.	N.P.D.				R.A.	N.P.D.				R.A.	N.P.D.			
Position 0°, d. Mar., Apr.— <i>contd.</i>					Position 180°, d. May, June.					Position 180°, d. May, June— <i>contd.</i>				
h	m	°	"		h	m	°	"		h	m	°	"	
6. 35	80°0	+ 0°02	1	1	1. 1	— 35°5	— 0°72	1	1	15. 0	62°7	— 0°14	1	1
8. 11	80°5	+ 1°22	2	2	0. 4	— 31°4	— 0°76	1	1	19. 39	64°5	— 0°42	1	1
21. 39	80°6	— 0°04	1	1	3. 21	— 30°4	— 0°68	1	1	15. 3	64°8	— 0°60	1	1
19. 45	81°4	— 0°16	1	1	1. 19	— 30°3	— 0°13	1	1	17. 11	65°0	— 0°66	1	1
7. 22	81°5	+ 1°41	1	1						22. 2	65°1	— 1°46	1	1
12. 40	81°8	+ 1°56	1	1	0. 27	— 27°6	— 1°08	1	1	22. 41	66°9	— 0°42	1	1
10. 29	82°5	+ 0°79	1	1	3. 33	— 27°1	— 2°14	1	1	12. 24	68°6	+ 0°12	1	1
6. 27	82°6	+ 0°49	1	1	22. 46	— 24°3	— 1°11	1	1					
16. 45	82°6	0°00	1	1	2. 21	— 23°1	— 2°26	1	1	14. 11	70°3	— 0°21	1	1
9. 32	82°7	+ 0°63	2	2	2. 36	— 22°6	— 1°25	1	1	14. 47	70°5	— 0°55	1	1
15. 39	83°3	+ 0°10	1	1						13. 50	71°1	+ 0°18	2	2
8. 50	83°7	— 0°20	1	1	23. 50	— 16°1	— 1°10	1	1	19. 32	73°8	— 0°56	1	1
8. 32	84°0	+ 0°68	2	2	23. 4	— 15°1	— 1°25	1	1	20. 35	74°4	— 1°74	1	1
9. 0	84°5	— 0°46	1	1	4. 36	— 14°2	— 1°43	1	1	21. 56	77°3	— 1°18	1	1
15. 46	85°2	— 0°60	1	1	23. 35	— 12°9	— 0°41	1	1	20. 28	79°0	— 0°42	2	2
17. 38	85°4	+ 0°09	1	1	2. 53	— 11°0	— 0°83	2	2	22. 36	79°7	+ 0°31	1	1
10. 55	85°9	+ 0°32	1	1										
12. 43	85°9	+ 0°21	2	2	0. 55	— 4°3	— 1°26	1	1	12. 0	80°7	+ 0°63	2	2
6. 42	87°5	— 1°03	1	1	23. 27	— 3°2	— 0°70	1	1	19. 46	81°4	+ 0°17	1	1
11. 2	87°5	+ 0°53	1	1	1. 24	— 1°2	— 0°83	4	3	7. 22	81°5	— 0°79	1	1
										12. 40	81°8	+ 0°19	1	1
9. 35	90°7	+ 0°18	1	1	19. 16	1°0	— 0°30	1	1	5. 50	82°6	0°00	2	2
12. 36	90°9	+ 0°03	1	1	1. 24	1°2	— 1°12	2	2	15. 39	83°3	— 1°10	1	1
12. 36	90°9	— 0°18	1	1	12. 14	1°8	— 0°98	3	3	11. 16	83°4	— 0°71	1	1
10. 36	91°2	— 1°06	1	1	15. 7	2°4	— 1°16	2	2	19. 50	83°8	— 0°02	1	1
5. 35	92°0	— 0°54	1	1	12. 48	6°1	— 0°67	1	1	7. 34	84°5	— 0°88	1	1
8. 20	93°6	+ 0°34	2	2						15. 45	85°2	— 1°57	2	2
9. 46	93°8	— 0°14	1	1	12. 7	11°9	— 0°58	1	1	11. 54	85°8	— 0°36	1	1
13. 20	94°7	+ 0°34	1	1	14. 27	13°9	— 2°16	1	1	11. 45	87°7	— 0°72	1	1
5. 30	96°0	— 1°00	1	1						14. 41	87°7	— 0°46	1	1
12. 34	97°5	+ 0°51	1	1	16. 28	21°0	— 1°07	1	1					
18. 30	98°3	+ 0°68	1	1	13. 48	24°8	— 0°72	1	1	12. 15	90°1	— 0°49	1	1
15. 11	99°0	+ 0°57	1	1	0. 27	27°6	+ 0°30	1	1	13. 29	90°1	— 0°51	4	3
18. 37	99°1	+ 1°44	1	1	13. 24	29°6	— 0°46	1	1	22. 30	90°6	+ 0°20	2	2
7. 36	99°3	+ 1°32	1	1	16. 43	33°0	— 0°87	1	1	12. 36	90°9	— 0°69	1	1
										20. 6	91°1	— 0°23	1	1
6. 49	101°9	— 1°62	1	1	13. 11	48°6	— 0°27	1	1	5. 31	91°3	+ 0°16	1	1
13. 21	102°2	+ 0°19	1	1	12. 21	50°5	— 1°42	1	1	14. 23	91°8	— 0°48	1	1
10. 0	102°6	+ 0°41	1	1	7. 28	57°9	— 0°70	1	1	22. 16	91°9	— 0°62	2	2
5. 42	104°9	+ 0°14	1	1						12. 59	93°2	— 0°55	1	1
17. 4	105°6	+ 0°19	1	1	0. 3	61°4	— 0°59	1	1	16. 9	93°5	— 1°26	1	1
12. 24	106°0	+ 0°02	1	1	5. 20	61°5	— 0°37	1	1	13. 5	95°0	+ 0°41	2	2
16. 36	107°6	+ 0°38	1	1	13. 7	61°6	— 1°23	2	2	12. 32	95°3	— 1°47	1	1
					7. 39	61°7	— 0°48	1	1	23. 57	96°5	— 1°47	1	1
7. 4	116°2	— 0°15	2	2	12. 21	62°2	— 1°14	1	1	14. 55	98°1	— 0°75	1	1
6. 54	118°9	— 1°48	1	1	19. 26	62°2	— 0°92	1	1	13. 36	98°2	+ 0°67	2	2
										5. 9	98°3	+ 1°78	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1905, with those of Newcomb's Fundamental Catalogue—continued.

Approximate		Newcomb N.P.D. -Observed N.P.D.	No. of Obs.	Weight	Approximate		Newcomb N.P.D. -Observed N.P.D.	No. of Obs.	Weight	Approximate		Newcomb N.P.D. -Observed N.P.D.	No. of Obs.	Weight			
R.A.	N.P.D.				R.A.	N.P.D.				R.A.	N.P.D.						
Position 180°, d. May, June.— <i>contd.</i>					Position 0°, r. Sept., Oct.— <i>contd.</i>					Position 0°, r. Sept., Oct.— <i>contd.</i>							
h	m	°	"		h	m	°	"		h	m	°	"				
15.	11	99°0	— 0°62	1	1	6.	29	— 28°4	+ 0°07	1	1	2.	3	55°5	— 0°55	1	1
14.	7	99°8	+ 0°24	2	2	12.	37	— 26°8	— 1°19	1	1	4.	14	55°7	+ 1°00	1	1
20.	42	99°8	+ 0°13	1	1	9.	24	— 26°5	+ 0°27	2	2	12.	11	56°6	+ 0°04	1	1
14.	51	101°0	— 0°58	1	1	11.	17	— 25°1	— 0°43	1	1	4.	50	57°0	+ 1°42	1	1
14.	49	101°5	+ 0°01	1	1	13.	48	— 24°8	— 0°24	1	1	7.	28	57°9	— 0°59	1	1
20.	15	105°1	— 0°79	1	1	10.	11	— 24°4	+ 0°11	1	1	3.	48	58°4	+ 0°58	1	1
14.	45	105°6	— 0°42	1	1	17.	8	— 24°2	— 0°25	1	1	19.	8	58°9	— 0°95	1	1
17.	4	105°6	— 0°41	1	1	10.	17	— 24°0	— 0°19	1	1						
12.	24	106°0	+ 1°23	1	1	11.	37	— 22°7	— 4°49	1	1	21.	8	60°2	— 0°03	2	2
21.	0	107°6	+ 0°58	1	1	12.	29	— 19°7	— 1°69	1	1	22.	38	60°3	+ 1°97	1	1
11.	39	107°8	— 0°71	2	2							0.	33	61°2	— 0°83	2	2
13.	13	107°8	— 0°25	1	1	18.	3	— 3°4	+ 0°13	1	1	1.	15	61°8	— 0°20	1	1
20.	23	108°1	— 0°65	1	1	6.	56	— 2°8	+ 0°12	4	3	17.	42	62°2	— 0°32	1	1
0.	38	108°5	— 1°23	1	1	12.	14	— 1°8	— 0°18	2	2	20.	50	62°3	— 0°94	1	1
15.	6	109°4	— 0°20	1	1	8.	3	— 1°1	+ 1°02	1	1	15.	30	63°0	— 0°37	1	1
19.	40	110°0	— 0°29	1	1							19.	24	65°5	+ 0°13	2	2
						19.	16	1°0	+ 0°02	2	2	3.	41	66°2	— 1°32	1	1
12.	5	112°1	— 0°79	1	1	1.	24	1°2	— 0°58	3	3	0.	42	66°3	— 1°77	1	1
13.	13	112°7	+ 0°52	2	2	23.	29	3°2	— 1°01	2	2	18.	18	66°8	— 1°20	1	1
18.	22	115°5	+ 0°23	1	1	18.	2	3°4	+ 1°04	1	1	23.	16	66°8	— 1°64	1	1
						21.	18	3°4	— 0°34	1	1	22.	41	66°9	+ 0°84	1	1
						0.	55	4°3	— 1°24	1	1	4.	36	67°2	— 0°02	1	1
Position 180°, r. August.					Position 0°, r. Sept., Oct.— <i>contd.</i>					Position 0°, r. Sept., Oct.— <i>contd.</i>							
						18.	49	14°7	+ 0°31	1	1	6.	9	67°5	— 0°99	1	1
						23.	50	16°1	— 0°85	1	1	6.	58	69°3	— 0°58	1	1
23.	27	3°2	+ 0°87	1	1	21.	51	16°7	+ 0°14	1	1	6.	23	69°7	— 1°47	1	1
22.	39	48°7	+ 1°33	1	1	20.	30	17°8	+ 0°62	1	1	14.	11	70°3	— 0°46	1	1
22.	59	62°4	+ 1°71	1	1							4.	3	70°6	— 0°89	1	1
22.	45	65°9	+ 1°26	1	1	23.	43	22°7	— 0°83	1	1	19.	44	71°1	+ 0°20	1	1
22.	54	78°8	+ 2°60	1	1							4.	45	71°3	+ 0°73	2	2
23.	6	81°8	+ 0°56	1	1	22.	7	32°3	— 0°28	1	1	4.	19	72°3	+ 0°57	1	1
23.	12	87°2	+ 0°33	1	1	2.	43	34°5	+ 0°28	1	1	6.	32	73°5	— 1°54	1	1
23.	22	89°3	+ 0°36	1	1	1.	1	35°5	— 2°27	1	1	4.	30	73°7	+ 0°41	1	1
						2.	47	37°6	+ 0°04	1	1	20.	35	74°4	— 1°11	1	1
22.	49	106°3	+ 0°37	1	1	19.	53	37°8	+ 0°57	1	1	4.	14	74°6	— 0°65	1	1
												4.	24	74°6	— 0°25	1	1
						22.	27	40°2	+ 0°50	1	1	0.	8	75°3	— 0°20	1	1
						0.	39	42°2	— 0°22	1	1	3.	25	77°4	— 0°53	1	1
						18.	12	47°9	— 0°56	1	1	17.	30	77°4	— 0°22	1	1
						1.	58	48°1	— 0°67	1	1	22.	16	78°3	— 0°59	1	1
						22.	39	48°7	— 0°61	1	1	19.	13	78°6	— 0°85	1	1
						0.	44	49°4	— 0°09	1	1	2.	19	79°8	+ 0°01	1	1
Position 0°, r. September, October.					Position 0°, r. Sept., Oct.— <i>contd.</i>					Position 0°, r. Sept., Oct.— <i>contd.</i>							
10.	24	— 33°5	— 1°63	1	1	18.	33	51°3	— 0°15	1	1	18.	2	80°4	— 0°24	1	1
9.	43	— 30°5	+ 0°40	1	1	0.	51	52°0	— 1°41	1	1	2.	7	81°6	+ 0°13	2	2
						19.	3	54°0	+ 0°36	1	1	2.	23	82°0	— 0°07	1	1
												5.	50	82°6	+ 0°26	1	1

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Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1905, with those of Newcomb's Fundamental Catalogue—continued.

Approximate		Newcomb N.P.D.	- Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D.	- Observed N.P.D.	No. of Obs.	Weight.	Approximate		Newcomb N.P.D.	- Observed N.P.D.	No. of Obs.	Weight.	
R.A.	N.P.D.					R.A.	N.P.D.					R.A.	N.P.D.					
Position 0°, r. Sept., Oct.— <i>contd.</i>						Position 0°, r. Sept., Oct.— <i>contd.</i>						Position 0°, d. Nov., Dec.— <i>contd.</i>						
h	m	°	"			h	m	°	"			h	m	°	"			
1. 8	82.9	—	0.75	2	2	5. 28	107.9	+	0.06	1	1	22. 38	60.3	+	0.92	1	1	
23. 54	83.7	—	1.61	1	1	0. 38	108.5	—	0.23	1	1	2. 37	62.7	+	0.87	1	1	
1. 25	84.3	—	1.07	1	1	5. 24	110.8	+	0.25	1	1	23. 15	66.8	+	0.82	1	1	
2. 30	84.8	—	0.11	1	1	18. 52	110.8	+	0.90	2	2	2. 1	67.0	+	1.05	2	2	
1. 3	84.9	—	1.89	1	1	18. 8	111.0	—	0.84	1	1	3. 15	69.2	+	0.24	1	1	
0. 43	85.2	—	2.53	1	1	5. 1	112.5	—	0.01	2	2	1. 49	69.7	+	0.69	1	1	
17. 38	85.4	—	0.80	1	1	19. 9	115.4	+	0.75	2	2							
1. 12	86.9	+	0.45	1	1	18. 39	117.1	+	2.77	1	1	2. 12	70.5	+	0.64	3	3	
2. 38	87.2	—	0.25	1	1							23. 0	75.3	—	0.67	1	1	
22. 20	89.1	—	0.89	1	1							2. 19	79.8	+	1.30	1	1	
23. 22	89.3	—	2.16	1	1	Position 0°, d. Nov., Dec.						21. 39	80.6	+	0.06	1	1	
												2. 8	81.6	+	0.46	1	1	
2. 34	90.1	—	0.68	1	1	13. 43	—	40.2	—	1.59	1	1	23. 6	81.8	+	0.18	1	1
0. 48	91.7	—	0.67	3	3							2. 23	82.0	+	0.49	3	3	
22. 16	91.9	—	0.44	1	1	10. 56	—	33.1	+	1.41	1	1	2. 30	84.8	—	0.07	1	1
18. 24	92.0	—	0.50	1	1							23. 35	84.9	+	0.74	1	1	
21. 58	92.6	—	0.82	1	1	13. 24	—	29.6	+	1.23	1	1	1. 3	84.9	—	0.74	2	2
5. 33	92.7	+	0.54	1	1	13. 48	—	24.8	+	1.69	1	1	0. 43	85.2	+	0.97	1	1
18. 16	92.9	—	0.77	1	1							1. 12	86.9	+	0.64	1	1	
2. 14	93.4	+	0.25	1	1	13. 34	—	18.3	—	0.05	2	2	23. 12	87.2	—	0.24	1	1
4. 40	93.4	—	0.49	1	1	10. 52	—	11.7	+	0.65	1	1	23. 48	88.4	+	0.22	1	1
0. 30	94.1	—	0.35	1	1							23. 22	89.3	+	0.95	1	1	
0. 25	94.5	—	0.89	1	1	10. 15	—	5.3	+	1.69	1	1						
22. 32	94.7	—	0.85	1	1	12. 14	—	1.8	+	1.60	1	1	22. 30	90.6	+	0.50	1	1
20. 43	95.4	+	0.78	1	1	1. 24	—	1.2	+	3.26	1	1	0. 48	91.7	—	0.53	1	1
23. 57	96.5	—	0.50	1	1							0. 3	93.0	—	1.87	1	1	
4. 7	97.1	—	1.30	1	1	1. 24	1.2	+	0.61	3	3	2. 14	93.4	+	0.43	1	1	
19. 31	97.2	+	0.17	1	1	23. 27	3.2	+	1.12	1	1	0. 30	94.1	+	0.65	1	1	
5. 9	98.3	+	0.20	1	1							21. 26	96.0	—	0.26	1	1	
22. 11	98.3	0.00		2	2	23. 35	12.9	+	0.15	1	1	23. 57	96.5	+	0.50	1	1	
22. 15	98.3	+	0.77	1	1	23. 4	15.1	+	0.88	2	2	23. 9	96.6	—	0.23	1	1	
19. 3	98.7	—	1.41	3	3	22. 7	18.1	+	0.79	1	1	22. 11	98.3	—	0.15	1	1	
18. 37	99.1	—	0.11	2	2							20. 42	99.8	+	0.52	1	1	
0. 14	99.4	+	1.01	1	1	2. 36	22.6	+	0.54	1	1							
20. 42	99.8	—	0.34	1	1	1. 55	26.1	+	1.26	1	1	21. 48	104.0	+	0.89	1	1	
22. 25	101.2	—	0.65	1	1							21. 0	107.6	+	0.52	1	1	
3. 53	103.8	—	0.27	2	2	2. 7	39.4	+	1.00	1	1	20. 21	108.5	+	0.05	1	1	
1. 39	106.5	—	2.55	1	1							23. 39	108.8	—	0.16	1	1	
19. 35	106.5	+	0.76	2	2	3. 1	49.4	—	0.39	1	1							
21. 41	106.6	—	1.72	1	1							23. 18	110.6	+	0.43	1	1	
21. 34	107.1	—	1.68	1	1	1. 4	54.9	+	0.72	1	1	23. 4	111.7	—	0.37	1	1	
21. 0	107.6	—	0.26	1	1													

The results obtained in the above tables were divided into groups for each 10° of N.P.D., the divisions of the groups being indicated by the spaces. They were combined according to the following system of weights:—

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No. of Observations.	Weight.	No. of Observations.	Weight.
1	1	5 or 6	4
2	2	7, 8 or 9	5
3 or 4	3	10 to 14	6

and the resulting means with their weights are given in the following table :—

*Comparison of North Polar Distances observed with the Altazimuth, in 1905,
with Newcomb's Fundamental Catalogue.*

Mean N.P.D. of Group.	Mean Tabular —Observed.	Weight.	Mean N.P.D. of Group.	Mean Tabular —Observed.	Weight.	Mean N.P.D. of Group.	Mean Tabular —Observed.	Weight.
Position 0° , r. Jan., Feb.			Position 180° , d. May, June.			Position 0° , r. Sept., Oct.		
— $32^{\circ}2$	+ $0^{\circ}80$	7	— $31^{\circ}9$	— $0^{\circ}57$	4	— $32^{\circ}0$	— $0^{\circ}62$	2
— $24^{\circ}5$	+ $0^{\circ}41$	10	— $24^{\circ}9$	— $1^{\circ}57$	5	— $25^{\circ}3$	— $0^{\circ}61$	10
— $14^{\circ}1$	+ $0^{\circ}69$	13	— $15^{\circ}1$	— $0^{\circ}98$	6	— $19^{\circ}7$	— $1^{\circ}68$	1
— $1^{\circ}5$	+ $0^{\circ}96$	5	— $3^{\circ}4$	— $0^{\circ}89$	5	— $2^{\circ}3$	+ $0^{\circ}16$	7
— $3^{\circ}6$	+ $0^{\circ}77$	5	— $2^{\circ}2$	— $0^{\circ}94$	9	— $2^{\circ}3$	— $0^{\circ}43$	10
— $15^{\circ}1$	+ $1^{\circ}00$	5	— $12^{\circ}9$	— $1^{\circ}37$	2	— $16^{\circ}3$	+ $0^{\circ}06$	4
— $25^{\circ}2$	+ $0^{\circ}77$	6	— $25^{\circ}8$	— $0^{\circ}49$	4	— $22^{\circ}7$	— $0^{\circ}83$	1
— $33^{\circ}2$	+ $0^{\circ}38$	9	— $33^{\circ}0$	— $0^{\circ}87$	1	— $35^{\circ}5$	— $0^{\circ}33$	5
— $44^{\circ}3$	+ $0^{\circ}47$	15	— $48^{\circ}6$	— $0^{\circ}27$	1	— $46^{\circ}1$	— $0^{\circ}28$	6
— $55^{\circ}5$	+ $0^{\circ}13$	16	— $54^{\circ}2$	— $1^{\circ}06$	2	— $55^{\circ}6$	— $0^{\circ}03$	10
— $64^{\circ}7$	— $0^{\circ}27$	28	— $63^{\circ}6$	— $0^{\circ}68$	14	— $64^{\circ}5$	— $0^{\circ}41$	20
— $74^{\circ}2$	— $0^{\circ}48$	22	— $74^{\circ}6$	— $0^{\circ}42$	10	— $74^{\circ}4$	— $0^{\circ}27$	17
— $84^{\circ}3$	— $0^{\circ}15$	23	— $83^{\circ}6$	— $0^{\circ}41$	16	— $84^{\circ}4$	— $0^{\circ}72$	17
— $95^{\circ}7$	+ $0^{\circ}43$	18	— $94^{\circ}2$	— $0^{\circ}22$	26	— $95^{\circ}5$	— $0^{\circ}40$	29
— $104^{\circ}0$	— $0^{\circ}10$	9	— $106^{\circ}5$	— $0^{\circ}24$	14	— $106^{\circ}0$	— $0^{\circ}55$	11
— $113^{\circ}4$	— $0^{\circ}41$	8	— $113^{\circ}3$	+ $0^{\circ}12$	4	— $112^{\circ}9$	+ $0^{\circ}61$	9
— $120^{\circ}0$	+ $0^{\circ}46$	1						
Position 0° , d. March, April.			Position 180° , r. August.			Position 0° , d. Nov., Dec.		
— $32^{\circ}3$	+ $0^{\circ}76$	4	— $3^{\circ}2$	+ $0^{\circ}87$	1	— $40^{\circ}2$	— $1^{\circ}59$	1
— $26^{\circ}9$	+ $0^{\circ}81$	3	— $48^{\circ}7$	+ $1^{\circ}33$	1	— $33^{\circ}1$	+ $1^{\circ}41$	1
— $16^{\circ}5$	— $0^{\circ}13$	4	— $64^{\circ}2$	+ $1^{\circ}49$	2	— $27^{\circ}2$	+ $0^{\circ}73$	2
— $2^{\circ}1$	+ $0^{\circ}63$	7	— $78^{\circ}8$	+ $2^{\circ}60$	1	— $16^{\circ}1$	+ $0^{\circ}18$	3
— $4^{\circ}0$	+ $0^{\circ}30$	6	— $86^{\circ}1$	+ $0^{\circ}42$	3	— $2^{\circ}8$	+ $2^{\circ}18$	3
— $16^{\circ}8$	+ $0^{\circ}42$	4	— $106^{\circ}3$	+ $0^{\circ}37$	1	— $1^{\circ}7$	+ $0^{\circ}74$	4
— $23^{\circ}3$	+ $0^{\circ}85$	5				— $15^{\circ}3$	+ $0^{\circ}68$	4
— $34^{\circ}6$	+ $0^{\circ}18$	4				— $24^{\circ}4$	+ $0^{\circ}90$	2
— $45^{\circ}5$	+ $0^{\circ}86$	3				— $39^{\circ}4$	+ $1^{\circ}00$	1
— $56^{\circ}9$	+ $0^{\circ}41$	22				— $49^{\circ}4$	— $0^{\circ}39$	1
— $69^{\circ}9$	+ $0^{\circ}49$	26				— $54^{\circ}9$	+ $0^{\circ}72$	1
— $73^{\circ}9$	+ $0^{\circ}36$	28				— $66^{\circ}1$	+ $0^{\circ}81$	7
— $83^{\circ}4$	+ $0^{\circ}32$	24				— $73^{\circ}3$	+ $0^{\circ}51$	5
— $94^{\circ}7$	+ $0^{\circ}19$	15				— $84^{\circ}4$	+ $0^{\circ}26$	15
— $104^{\circ}4$	— $0^{\circ}04$	7				— $95^{\circ}0$	— $0^{\circ}04$	10
— $117^{\circ}1$	— $0^{\circ}59$	3				— $107^{\circ}2$	+ $0^{\circ}33$	4
						— $111^{\circ}2$	+ $0^{\circ}03$	2

Assuming the differences "Tabular—Observed" to be represented by the formula

$$a + b \sin Z.D.,$$

a solution by the method of least squares gave the results :—

Newcomb — Altazimuth.

Position of Altazimuth.

0°, r (Jan., Feb.).	+0".30	—0".63 sin Z.
0°, d (Mar., Apr.).	+0".41	—0".13 sin Z.
180°, d (May, June).	—0".67	+0".44 sin Z.
180°, r (August).	Insufficient material.	
0°, r (Sept., Oct.).	—0".35	+0".02 sin Z.
0°, d (Nov., Dec.).	+0".56	—0".36 sin Z.

Assuming the formula for the four positions as

$$+ a + b \sin Z.D. \text{ for the positions } 0^\circ \text{ d and } 180^\circ \text{ r,}$$

and

$$- a + b \sin Z.D. \text{ „ „ } 0^\circ \text{ r and } 180^\circ \text{ d,}$$

the differences "Newcomb — Altazimuth" may be represented by the formula

$$\pm 0''.31 - 0''.35 \sin Z.D.$$

Taking the coefficient of $\sin Z.D.$ from the results of the reflexion observations as $-0''.34$, the values found for the a term in the different positions are given below.

Position of Instrument.	Difference of N.P.D. Newcomb — Altazimuth.	Weight.
Value of a .		
0°, r (Jan., Feb.).	+0".23	200
0°, d (Mar., Apr.).	+0".48	165
180°, d (May, June).	—0".43	123
180°, r (August).	Insufficient material.	
0°, r (Sept., Oct.).	—0".26	159
0°, d (Nov., Dec.).	+0".56	66

The weighted mean is $\pm 0''.30$, but the formula $\pm 0''.31 - 0''.34 \sin Z.D.$ was adopted as a correction to the direct observations. Subtracting from this the R—D discordance, we have $\mp 0''.51 + 0''.34 \sin Z.D.$ as a correction to the R. observation, to which $+0''.12 \sin Z.D.$ is to be added for inclination of the verticals. The correction $\mp 0''.51 + 0''.46 \sin Z.D.$ was adopted for the reflexion observations.

It should be remarked that the above corrections reduce the observations to what would be the mean of the four positions of the instrument, and that Newcomb's Fundamental Catalogue is simply used as a convenient method of effecting the comparison of the direct observations in the four positions.

Adopted Corrections to North Polar Distances of the Altazimuth, 1905.

N.P.D.	Corrections to Results of Direct Observations.		Corrections to Results of Reflexion Observations.	
	o° d. 180° r.	o° r. 180° d.	o° d. 180° r.	o° r. 180° d.
- 45	+ 0"65	+ 0"03	- 0"97	+ 0"05
- 40	+ 0"64	+ 0"02	- 0"96	+ 0"06
- 30	+ 0"63	+ 0"01	- 0"94	+ 0"08
- 20	+ 0"60	- 0"01	- 0"90	+ 0"12
- 10	+ 0"57	- 0"05	- 0"86	+ 0"16
0	+ 0"52	- 0"10	- 0"80	+ 0"22
+ 10	+ 0"47	- 0"15	- 0"73	+ 0"29
20	+ 0"42	- 0"20	- 0"66	+ 0"36
30	+ 0"36	- 0"26	- 0"58	+ 0"44
40	+ 0"30	- 0"31	- 0"50	+ 0"52
50	+ 0"24	- 0"38	- 0"42	+ 0"60
60	+ 0"18	- 0"44	- 0"34	+ 0"68
70	+ 0"13	- 0"49	- 0"27	+ 0"75
80	+ 0"09	- 0"53	- 0"21	+ 0"81
90	+ 0"04	- 0"58	- 0"15	+ 0"87
100	+ 0"01	- 0"61	- 0"11	+ 0"91
110	- 0"01	- 0"63	- 0"07	+ 0"95
120	- 0"03	- 0"65	- 0"05	+ 0"97
125	- 0"03	- 0"65	- 0"05	+ 0"97

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*Altazimuth Colatitude Investigation.*Correction to Assumed Colatitude $38^{\circ}.31'.23''.42$ from observations in the Year 1905.

(Using Pulkowa Refractions, computed from the tables given in the Appendix to the Greenwich Observations for 1898.)

Corrections for Variation of Latitude supplied by Prof. Albrecht have been applied in forming this table (see p. {26} of the section "Ledgers of Mean Right Ascensions and North Polar Distances of Stars observed with the Altazimuth"):

Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations		Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations		Weight.
				Above Pole.	Below Pole.						Above Pole.	Below Pole.	
λ Ursæ Minoris.	h m 19. 17	° ' 1. 0	+ 0"20	3	4	9	A Draconis	h m 16. 8	° ' 21. 1	- 1"39	1	1	2
Groomb. 1119...	8. 2	1. 4	+ 0"08	2	2	6	Bradley 366.....	2. 36	22. 34	- 0"11	2	2	5
Polaris.....	1. 24	1. 11	- 0"39	12	8	18	ι Cassiopeiæ.....	2. 21	23. 1	+ 0"55	1	2	4
Bradley 1672....	12. 14	1. 46	+ 0"57	3	3	8	Bradley 1429....	10. 17	23. 57	+ 0"68	1	1	2
Groomb. 2283...	15. 7	2. 24	- 0"12	2	1	4	β Ursæ Majoris	10. 11	24. 25	- 1"85	1	1	2
Cephei 51.....	6. 55	2. 48	- 0"17	2	5	8	γ Draconis.....	13. 48	24. 48	+ 0"31	1	4	5
Bradley 3147...	23. 27	3. 12	+ 0"28	9	1	5	δ Ursæ Majoris.	9. 24	26. 31	- 1"43	1	4	5
Groomb. 3548...	21. 18	3. 21	- 0"50	2	3	7	Piazzi III. 94...	3. 33	27. 5	+ 0"31	3	2	5
δ Ursæ Minoris..	18. 3	3. 23	- 0"46	3	1	4	κ Cassiopeiæ.....	0. 27	27. 35	+ 0"53	1	1	2
ϵ Ursæ Minoris..	0. 55	4. 15	+ 2"30	1	1	3	Piazzi XIII. 110	13. 24	29. 33	+ 1"18	1	2	3
Cephei 47.....	2. 53	10. 57	- 1"05	1	2	4	Piazzi III. 51...	3. 21	30. 23	- 0"01	1	2	3
γ Cephei.....	23. 35	12. 53	- 0"07	2	1	3	ν Ursæ Majoris.	9. 44	30. 30	- 0"07	2	2	4
ϵ Ursæ Minoris..	14. 27	13. 52	+ 0"19	2	3	6	ζ Cephei.....	22. 7	32. 15	+ 2"17	1	1	2
π Cephei	23. 4	15. 7	+ 0"07	4	2	6	μ Cassiopeiæ.....	1. 1	35. 32	+ 2"72	1	1	2
Groomb. 4163...	23. 50	16. 7	+ 1"73	1	1	3							

The weights used in the above tables are the same as those used in the Transit-Circle investigation.

The assumed colatitude $38^{\circ}.31'.23''.42$ was found by applying to the adopted colatitude of the Transit-Circle, with Pulkowa Refractions $38^{\circ}.31'.21''.75$, a correction of $+1''.67$ for geodetic difference of latitude as measured on the plan of the Observatory.

The resulting correction to the assumed colatitude $38^{\circ}.31'.23''.42$ from these results is $-0''.035$. The colatitude determined from the observations of 1905 is, therefore, $38^{\circ}.31'.23''.38$.

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*Factors for Instrumental Errors for Extra-Meridian Observations
with the Altazimuth.*

The Level Factor = $\cos Z.D. \tan \text{Parallactic Angle} \div 15m = \sin N.P.D. \cos Z.D. \times$
(difference H.A. for 1" difference N.P.D.) $\div m$.

Where $m = \sin \text{Colat.} \sin \text{Azimuth.}$ The Azimuth Factor = Level Factor $\times \tan Z.D.$

N.P.D.	Azimuth 90°.		Azimuth 80°.		Azimuth 70°.		Azimuth 60°.		Azimuth 45°.		Azimuth 30°.	
	Lev.	Az.	Lev.	Az.	Lev.	Az.	Lev.	Az.	Lev.	Az.	Lev.	Az.
41	.3118	.0852	.2830	.0462	.2238	.0244	.1780	.0144	.1369	.0081	.1153	.0057
42	.2584	const.	.2439	.0514	.2035	.0299	.1673	.0186	.1319	.0110	.1123	.0078
43	.2243		.2165	.0553	.1874	.0342	.1581	.0222	.1273	.0135	.1094	.0098
44	.1993		.1960	.0581	.1742	.0378	.1502	.0254	.1231	.0159	.1067	.0116
45	.1800		.1795	.0603	.1630	.0409	.1431	.0283	.1191	.0181	.1042	.0134
46	.1645		.1661	.0623	.1535	.0435	.1367	.0308	.1155	.0202	.1018	.0151
47	.1516		.1547	.0638	.1451	.0458	.1309	.0332	.1120	.0221	.0994	.0167
48	.1406		.1448	.0653	.1376	.0478	.1256	.0352	.1088	.0240	.0972	.0172
49	.1312		.1363	.0664	.1308	.0496	.1207	.0372	.1057	.0257	.0950	.0189
50	.1228		.1286	.0674	.1247	.0512	.1162	.0390	.1027	.0273	.0929	.0212
51	.1154		.1218	.0684	.1192	.0527	.1120	.0407	.0999	.0289	.0909	.0226
52	.1087		.1156	.0693	.1141	.0541	.1081	.0422	.0974	.0304	.0890	.0239
53	.1026		.1100	.0700	.1094	.0554	.1045	.0436	.0948	.0318	.0871	.0252
54	.0970		.1047	.0707	.1051	.0566	.1010	.0450	.0923	.0331	.0853	.0264
55	.0919		.0998	.0714	.1010	.0577	.0977	.0463	.0901	.0345	.0836	.0276
56	.0871		.0954	.0721	.0972	.0588	.0946	.0475	.0880	.0357	.0819	.0288
57	.0826		.0912	.0726	.0936	.0598	.0917	.0487	.0858	.0369	.0802	.0299
58	.0784		.0872	.0732	.0902	.0607	.0889	.0499	.0838	.0380	.0786	.0310
59	.0745		.0834	.0737	.0869	.0616	.0862	.0510	.0817	.0392	.0770	.0321
60	.0708		.0799	.0741	.0838	.0624	.0836	.0520	.0798	.0403	.0755	.0331
61	.0673		.0765	.0746	.0808	.0632	.0811	.0530	.0779	.0413	.0740	.0341
62	.0639		.0733	.0751	.0780	.0640	.0787	.0539	.0761	.0423	.0726	.0351
63	.0607		.0703	.0755	.0753	.0647	.0763	.0548	.0744	.0434	.0712	.0361
64	.0576		.0674	.0759	.0726	.0654	.0740	.0557	.0727	.0443	.0698	.0371
65	.0547		.0646	.0763	.0700	.0661	.0719	.0566	.0710	.0452	.0685	.0380
66	.0519		.0618	.0767	.0676	.0668	.0699	.0575	.0693	.0462	.0672	.0389
67	.0492		.0591	.0771	.0653	.0675	.0679	.0583	.0676	.0470	.0659	.0398
68	.0465		.0566	.0774	.0630	.0681	.0659	.0591	.0660	.0479	.0646	.0407
69	.0439		.0541	.0778	.0607	.0688	.0639	.0599	.0646	.0488	.0633	.0416
70	.0414		.0517	.0781	.0585	.0694	.0620	.0606	.0631	.0497	.0621	.0424
71	.0390		.0494	.0784	.0564	.0700	.0601	.0613	.0616	.0505	.0609	.0432
72	.0366		.0471	.0787	.0543	.0705	.0583	.0620	.0602	.0514	.0597	.0441
73	.0343		.0449	.0790	.0523	.0711	.0566	.0627	.0588	.0522	.0585	.0449
74	.0321		.0427	.0793	.0503	.0716	.0549	.0634	.0573	.0529	.0573	.0457
75	.0299		.0405	.0796	.0483	.0721	.0532	.0641	.0559	.0537	.0562	.0465
76	.0277		.0384	.0799	.0464	.0726	.0515	.0648	.0545	.0545	.0551	.0473
77	.0256		.0364	.0802	.0445	.0731	.0498	.0654	.0531	.0552	.0539	.0481
78	.0235		.0344	.0805	.0426	.0736	.0481	.0661	.0518	.0560	.0528	.0489
79	.0214		.0324	.0808	.0408	.0741	.0464	.0667	.0505	.0568	.0516	.0497
80	.0194		.0304	.0811	.0390	.0746	.0448	.0674	.0491	.0575	.0505	.0504
81	.0174		.0284	.0814	.0372	.0751	.0432	.0680	.0479	.0582	.0493	.0511
82	.0154		.0265	.0816	.0354	.0756	.0416	.0687	.0465	.0589	.0484	.0519
83	.0134		.0246	.0819	.0336	.0761	.0400	.0693	.0453	.0597	.0473	.0526
84	.0115	.0852	.0227	.0821	.0319	.0765	.0385	.0699	.0440	.0604	.0462	.0534

ALTAZIMUTH TABLES, 1905.

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*Factors for Instrumental Errors for Extra-Meridian Observations
with the Altazimuth—continued.*

N.P.D.	Azimuth 80°.		Azimuth 70°.		Azimuth 60°.		Azimuth 45°.		Azimuth 30°.		
	Lev.	Az.	Lev.	Az.	Lev.	Az.	Lev.	Az.	Lev.	Az.	
85°	'0208	'0823	'0301	'0770	'0369	'0705	'0427	'0612	'0451	'0541	
86	'0189	'0826	'0284	'0775	'0354	'0712	'0415	'0619	'0441	'0549	
87	'0171	'0829	'0267	'0780	'0339	'0718	'0402	'0626	'0430	'0556	
88	'0153	'0831	'0250	'0784	'0323	'0723	'0389	'0633	'0419	'0563	
89	'0134	'0834	'0233	'0789	'0308	'0730	'0377	'0639	'0408	'0570	
90	'0115	'0837	'0216	'0794	'0293	'0736	'0364	'0646	'0398	'0578	
91	'0097	'0839	'0199	'0799	'0278	'0742	'0351	'0654	'0387	'0585	
92	'0113	'0867	'0182	'0803	'0262	'0747	'0339	'0661	'0376	'0592	78°
93	'0133	'0870	'0164	'0808	'0247	'0755	'0327	'0668	'0366	'0599	77
94	'0153	'0873	'0147	'0812	'0232	'0761	'0314	'0676	'0355	'0606	76
95	'0174	'0876	'0130	'0817	'0216	'0767	'0301	'0683	'0345	'0614	75
96	'0196	'0879	'0113	'0821	'0201	'0772	'0288	'0689	'0334	'0621	74
97	'0218	'0882	'0091	'0877	'0186	'0778	'0275	'0696	'0324	'0629	73
98	'0240	'0885	'0111	'0883	'0170	'0784	'0263	'0704	'0313	'0637	72
99	'0263	'0888	'0132	'0888	'0155	'0790	'0250	'0711	'0302	'0644	71
100	'0286	'0892	'0153	'0893	'0139	'0796	'0237	'0717	'0291	'0652	70
101	'0310	'0895	'0175	'0899	'0124	'0802	'0224	'0726	'0280	'0659	69
102	'0335	'0898	'0197	'0906	'0073	'0881	'0210	'0733	'0269	'0667	68
103	'0361	'0902	'0220	'0912	'0093	'0889	'0196	'0740	'0258	'0675	67
104	'0387	'0906	'0244	'0919	'0113	'0898	'0183	'0749	'0247	'0683	66
105	'0414	'0909	'0269	'0925	'0134	'0905	'0169	'0756	'0235	'0691	65
106	'0442	'0913	'0294	'0932	'0156	'0914	'0156	'0764	'0224	'0699	64
107	'0471	'0917	'0321	'0939	'0178	'0923	'0141	'0773	'0212	'0707	63
108	'0502	'0921	'0348	'0947	'0201	'0933	'0127	'0780	'0200	'0715	62
109	'0534	'0926	'0376	'0955	'0225	'0942	'0112	'0788	'0188	'0723	61
110	'0568	'0931	'0405	'0963	'0250	'0952	'0098	'0797	'0176	'0732	60
111	'0603	'0936	'0436	'0971	'0276	'0962	'0089	'0902	'0164	'0740	59
112	'0641	'0941	'0469	'0980	'0303	'0973	'0109	'0914	'0151	'0749	58
113	'0681	'0946	'0504	'0990	'0332	'0984	'0129	'0925	'0138	'0758	57
114	'0723	'0952	'0540	'1000	'0361	'0995	'0151	'0937	'0125	'0767	56
115	'0767	'0958	'0578	'1010	'0392	'1008	'0173	'0950	'0112	'0775	55
116	'0816	'0965	'0619	'1021	'0424	'1021	'0196	'0962	'0098	'0784	54
	'0868	'0972	'0663	'1032	'0459	'1035	'0220	'0975	'0075	'0903	53
	'0925	'0980	'0710	'1045	'0496	'1050	'0245	'0990	'0093	'0916	52
	'0987	'0989	'0761	'1059	'0535	'1065	'0271	'1006	'0112	'0929	51
	'1055	'0997	'0816	'1074	'0577	'1081	'0298	'1022	'0132	'0943	50
	'1132	'1009	'0876	'1091	'0622	'1100	'0328	'1037	'0153	'0957	49
	'1217	'1022	'0944	'1109	'0670	'1119	'0359	'1054	'0175	'0972	48
	'1316	'1034	'1018	'1130	'0723	'1140	'0391	'1073	'0197	'0988	47
	'1430	'1050	'1103	'1153	'0781	'1162	'0426	'1092	'0221	'1004	46
	'1564	'1068	'1198	'1179	'0845	'1189	'0463	'1113	'0245	'1021	45
	'1729	'1090	'1309	'1209	'0916	'1216	'0502	'1135	'0271	'1039	44
	'1934	'1118	'1442	'1246	'0997	'1248	'0544	'1159	'0298	'1057	43
	'2207	'1156	'1603	'1290	'1088	'1285	'0590	'1184	'0327	'1077	42
	'2598	'1212	'1805	'1345	'1195	'1328	'0640	'1212	'0357	'1098	41
	Azimuth 100°.		Azimuth 110°.		Azimuth 120°.		Azimuth 135°.		Azimuth 150°.		N.P.D.

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Altazimuth Extra-Meridian Tables.

Motion in Zenith Distance in the Standard Azimuths, and Azimuthal Motion in the Prime Vertical.

Motion in Z.D. in units of $0''.01$.

Motion in Z.D. in units of $0''.01$.

Time Inter- val.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Motion.	Time Inter- val.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Motion.
^s 0°01	09	09	09	08	07	05	0°12	^s 0°51	476	469	448	413	337	238	5°99
0°02	19	18	18	16	13	09	0°23	0°52	486	478	457	421	344	243	6°10
0°03	28	28	26	24	20	14	0°35	0°53	495	488	465	429	350	248	6°22
0°04	37	37	35	32	26	19	0°47	0°54	504	497	474	437	357	252	6°34
0°05	47	46	44	40	33	24	0°59	0°55	514	506	483	445	363	257	6°45
0°06	56	55	53	49	40	28	0°70	0°56	523	515	492	453	370	262	6°57
0°07	65	64	61	57	46	33	0°82	0°57	533	524	500	461	377	267	6°69
0°08	75	74	70	65	53	38	0°94	0°58	542	534	508	469	383	271	6°81
0°09	84	83	79	73	59	42	1°06	0°59	551	543	518	477	390	276	6°92
0°10	93	92	88	81	66	47	1°17	0°60	561	552	527	485	396	281	7°04
0°11	103	101	97	89	73	52	1°29	0°61	570	561	535	494	403	285	7°16
0°12	112	110	105	97	79	56	1°41	0°62	579	570	543	502	410	290	7°28
0°13	121	120	114	105	86	61	1°53	0°63	589	580	553	510	416	295	7°39
0°14	131	129	123	113	92	66	1°64	0°64	598	589	562	518	423	299	7°51
0°15	140	138	132	121	99	70	1°76	0°65	607	598	571	526	429	304	7°63
0°16	149	147	140	129	106	75	1°88	0°66	617	607	579	534	436	309	7°75
0°17	159	156	149	138	112	80	2°00	0°67	626	616	588	542	443	313	7°86
0°18	168	166	158	146	119	84	2°11	0°68	635	626	597	550	449	318	7°98
0°19	178	175	167	154	126	89	2°23	0°69	645	635	606	558	456	323	8°10
0°20	187	184	176	162	132	94	2°35	0°70	654	644	615	566	462	327	8°21
0°21	196	193	184	170	139	98	2°46	0°71	663	653	623	574	469	332	8°33
0°22	206	202	193	178	145	103	2°58	0°72	673	662	632	583	476	337	8°45
0°23	215	212	202	186	152	108	2°70	0°73	682	672	641	591	482	341	8°57
0°24	224	221	211	194	159	112	2°82	0°74	691	681	650	599	489	346	8°68
0°25	234	230	219	202	165	117	2°93	0°75	701	690	658	607	495	351	8°80
0°26	243	239	228	210	172	122	3°05	0°76	710	699	667	615	502	355	8°92
0°27	252	248	237	218	178	126	3°17	0°77	719	708	676	623	509	360	9°04
0°28	262	258	246	227	185	131	3°29	0°78	729	718	685	631	515	365	9°15
0°29	271	267	255	235	192	136	3°40	0°79	738	727	694	639	522	369	9°27
0°30	280	276	263	243	198	140	3°52	0°80	747	736	702	647	528	374	9°39
0°31	290	285	272	251	205	145	3°64	0°81	757	745	711	655	535	379	9°51
0°32	299	294	281	259	211	150	3°76	0°82	766	754	720	663	542	383	9°62
0°33	308	304	290	267	218	154	3°87	0°83	775	764	729	672	548	388	9°74
0°34	318	313	298	275	225	159	3°99	0°84	785	773	737	680	555	393	9°86
0°35	327	322	307	283	231	164	4°11	0°85	794	782	746	688	562	397	9°98
0°36	336	331	316	291	238	168	4°22	0°86	803	791	755	696	568	402	10°09
0°37	346	340	325	299	244	173	4°34	0°87	813	800	764	704	575	407	10°21
0°38	355	350	334	307	251	178	4°46	0°88	822	810	773	712	581	411	10°33
0°39	364	359	342	316	258	182	4°58	0°89	831	819	781	720	588	416	10°44
0°40	374	368	351	324	264	187	4°69	0°90	841	828	790	728	595	421	10°56
0°41	383	377	360	332	271	192	4°81	0°91	850	837	799	736	601	425	10°68
0°42	392	386	369	340	277	196	4°93	0°92	860	846	808	744	608	430	10°80
0°43	402	396	377	348	284	201	5°05	0°93	869	856	816	752	614	435	10°91
0°44	411	405	386	356	291	206	5°16	0°94	878	865	825	761	621	439	11°03
0°45	420	414	395	364	297	210	5°28	0°95	888	874	834	769	628	444	11°15
0°46	430	423	404	372	304	215	5°40	0°96	897	883	843	777	634	449	11°27
0°47	439	432	413	380	310	220	5°52	0°97	906	892	852	785	641	453	11°38
0°48	448	442	421	388	317	224	5°63	0°98	916	902	860	793	647	458	11°50
0°49	458	451	430	396	324	229	5°75	0°99	925	911	869	802	654	463	11°62
0°50	467	460	439	405	330	234	5°87	1°00	934	920	878	809	661	467	11°74

ALTAZIMUTH TABLES, 1905.

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Altazimuth Extra-Meridian Tables—continued.

Motion in Zenith Distance in the Standard Azimuths, and Azimuthal Motion in the Prime Vertical.

Motion in Z.D. in units of $0''.01$.Motion in Z.D. in units of $0''.01$.

Time Interval.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Motion.	Time Interval.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Motion.
s							"	s							"
1'01	944	929	887	817	667	472	11'85	1'51	1411	1389	1326	1222	998	706	17'72
1'02	953	938	895	825	674	477	11'97	1'52	1420	1398	1334	1230	1004	710	17'84
1'03	962	948	904	833	680	481	12'09	1'53	1429	1408	1343	1238	1011	715	17'96
1'04	972	957	913	841	687	486	12'20	1'54	1439	1417	1352	1246	1017	720	18'07
1'05	981	966	922	850	694	491	12'32	1'55	1448	1426	1361	1254	1024	724	18'19
1'06	990	975	931	858	700	495	12'44	1'56	1457	1435	1370	1262	1031	729	18'31
1'07	1000	984	939	866	707	500	12'56	1'57	1467	1444	1378	1270	1037	734	18'42
1'08	1009	994	948	874	713	505	12'67	1'58	1476	1454	1387	1278	1044	738	18'54
1'09	1018	1003	957	882	720	509	12'79	1'59	1485	1463	1396	1286	1050	743	18'66
1'10	1028	1012	966	890	727	514	12'91	1'60	1495	1472	1405	1295	1057	748	18'78
1'11	1037	1021	974	898	733	519	13'03	1'61	1504	1481	1413	1303	1064	752	18'89
1'12	1046	1030	983	906	740	523	13'14	1'62	1513	1490	1422	1311	1070	757	19'01
1'13	1056	1040	992	914	746	528	13'26	1'63	1523	1500	1431	1319	1077	762	19'13
1'14	1065	1049	1001	922	753	533	13'38	1'64	1532	1509	1440	1327	1083	766	19'25
1'15	1074	1058	1010	930	760	537	13'50	1'65	1542	1518	1449	1335	1090	771	19'36
1'16	1084	1067	1018	939	766	542	13'61	1'66	1551	1527	1457	1343	1097	776	19'48
1'17	1093	1076	1027	947	773	547	13'73	1'67	1560	1536	1466	1351	1103	780	19'60
1'18	1102	1086	1036	955	780	551	13'85	1'68	1570	1546	1475	1359	1110	785	19'72
1'19	1112	1095	1045	963	786	556	13'97	1'69	1579	1555	1484	1367	1116	790	19'83
1'20	1121	1104	1053	971	793	561	14'08	1'70	1588	1564	1492	1375	1123	794	19'95
1'21	1130	1113	1062	979	799	565	14'20	1'71	1598	1573	1501	1384	1130	799	20'07
1'22	1140	1122	1071	987	806	570	14'32	1'72	1607	1582	1510	1392	1136	804	20'18
1'23	1149	1132	1080	995	813	575	14'43	1'73	1616	1592	1519	1400	1143	808	20'30
1'24	1158	1141	1089	1003	819	579	14'55	1'74	1626	1601	1528	1408	1149	813	20'42
1'25	1168	1150	1097	1011	826	584	14'67	1'75	1635	1610	1536	1416	1156	818	20'54
1'26	1177	1159	1106	1019	832	589	14'79	1'76	1644	1619	1545	1424	1163	822	20'65
1'27	1186	1168	1115	1028	839	593	14'90	1'77	1654	1628	1554	1432	1169	827	20'77
1'28	1196	1178	1124	1036	846	598	15'02	1'78	1663	1638	1563	1440	1176	832	20'89
1'29	1205	1187	1132	1044	852	603	15'14	1'79	1672	1647	1571	1448	1182	836	21'01
1'30	1215	1196	1141	1052	859	608	15'26	1'80	1682	1656	1580	1456	1189	841	21'12
1'31	1224	1205	1150	1060	865	612	15'37	1'81	1691	1665	1589	1464	1196	846	21'24
1'32	1233	1214	1159	1068	872	617	15'49	1'82	1700	1674	1598	1473	1202	850	21'36
1'33	1243	1224	1168	1076	879	622	15'61	1'83	1710	1684	1607	1481	1209	855	21'48
1'34	1252	1233	1176	1084	885	626	15'73	1'84	1719	1693	1615	1489	1216	860	21'59
1'35	1261	1242	1185	1092	892	632	15'84	1'85	1728	1702	1624	1497	1222	864	21'71
1'36	1271	1251	1194	1100	898	636	15'96	1'86	1738	1711	1633	1505	1229	869	21'83
1'37	1280	1260	1203	1108	905	640	16'08	1'87	1747	1721	1642	1513	1235	874	21'95
1'38	1289	1270	1212	1117	912	645	16'19	1'88	1756	1730	1650	1521	1242	878	22'06
1'39	1299	1279	1220	1125	918	650	16'31	1'89	1766	1739	1659	1529	1249	883	22'18
1'40	1308	1288	1229	1133	925	654	16'43	1'90	1775	1748	1668	1537	1255	888	22'30
1'41	1317	1297	1238	1141	931	659	16'55	1'91	1784	1757	1677	1545	1262	892	22'41
1'42	1327	1306	1247	1149	938	664	16'66	1'92	1794	1767	1686	1553	1268	897	22'53
1'43	1336	1316	1255	1157	945	668	16'78	1'93	1803	1776	1694	1562	1275	902	22'65
1'44	1345	1325	1264	1165	951	673	16'90	1'94	1812	1785	1703	1570	1282	906	22'77
1'45	1355	1334	1273	1173	958	678	17'02	1'95	1822	1794	1712	1578	1288	911	22'88
1'46	1364	1343	1282	1181	964	682	17'13	1'96	1831	1803	1721	1586	1295	916	23'00
1'47	1373	1352	1291	1189	971	687	17'25	1'97	1840	1813	1729	1594	1301	920	23'12
1'48	1383	1362	1299	1197	978	692	17'37	1'98	1850	1822	1738	1601	1308	925	23'24
1'49	1392	1371	1308	1206	984	696	17'49	1'99	1859	1831	1747	1610	1315	930	23'35
1'50	1401	1380	1317	1214	991	702	17'60	2'00	1868	1840	1756	1618	1321	934	23'47

GREENWICH OBSERVATIONS, 1905.

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cxxxviii INTRODUCTION TO GREENWICH ASTRONOMICAL OBSERVATIONS, 1905.

Altazimuth Extra-Meridian Tables—continued.

Motion in Zenith Distance in the Standard Azimuths, and Azimuthal Motion in the Prime Vertical.

Motion in Z.D. in units of $0''.01$.Motion in Z.D. in units of $0''.01$.

Time Interval.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Motion.	Time Interval.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Motion.
2°01	1878	1849	1765	1626	1328	939	23°59	2°51	2345	2309	2204	2031	1658	1173	29°46
2°02	1887	1859	1773	1634	1334	944	23°71	2°52	2354	2319	2212	2039	1665	1177	29°57
2°03	1897	1868	1782	1642	1341	949	23°82	2°53	2364	2328	2221	2047	1671	1182	29°69
2°04	1906	1877	1791	1651	1348	953	23°94	2°54	2373	2337	2230	2055	1678	1187	29°81
2°05	1915	1886	1800	1659	1354	958	24°06	2°55	2382	2346	2239	2063	1685	1191	29°93
2°06	1925	1895	1808	1667	1361	963	24°17	2°56	2392	2355	2247	2071	1691	1196	30°04
2°07	1934	1905	1817	1675	1367	967	24°29	2°57	2401	2365	2256	2079	1698	1201	30°16
2°08	1943	1914	1826	1683	1374	972	24°41	2°58	2410	2374	2265	2087	1704	1205	30°28
2°09	1953	1923	1835	1691	1381	977	24°53	2°59	2420	2383	2274	2096	1711	1210	30°39
2°10	1962	1932	1844	1699	1387	981	24°64	2°60	2429	2392	2283	2104	1718	1215	30°51
2°11	1971	1941	1852	1707	1394	986	24°76	2°61	2438	2401	2291	2112	1724	1219	30°63
2°12	1981	1951	1861	1715	1400	991	24°88	2°62	2448	2411	2300	2120	1731	1224	30°75
2°13	1990	1960	1870	1723	1407	995	25°00	2°63	2457	2420	2309	2128	1737	1229	30°86
2°14	1999	1969	1879	1731	1414	1000	25°11	2°64	2466	2429	2318	2136	1744	1233	30°98
2°15	2009	1978	1887	1740	1420	1005	25°23	2°65	2476	2438	2326	2144	1751	1238	31°10
2°16	2018	1987	1896	1748	1427	1009	25°35	2°66	2485	2447	2335	2152	1757	1243	31°22
2°17	2027	1997	1905	1756	1434	1014	25°47	2°67	2494	2457	2344	2160	1764	1247	31°33
2°18	2037	2006	1914	1764	1440	1019	25°58	2°68	2504	2466	2353	2168	1770	1252	31°45
2°19	2046	2015	1923	1772	1447	1023	25°70	2°69	2513	2475	2362	2176	1777	1257	31°57
2°20	2055	2024	1931	1780	1453	1028	25°82	2°70	2522	2484	2370	2185	1784	1261	31°69
2°21	2065	2033	1940	1788	1460	1033	25°94	2°71	2532	2493	2379	2193	1790	1266	31°80
2°22	2074	2043	1949	1796	1467	1037	26°05	2°72	2541	2503	2388	2201	1797	1271	31°92
2°23	2083	2052	1958	1804	1473	1042	26°17	2°73	2550	2512	2397	2209	1803	1275	32°04
2°24	2093	2061	1967	1812	1480	1047	26°29	2°74	2560	2521	2405	2217	1810	1280	32°15
2°25	2102	2070	1975	1820	1486	1051	26°40	2°75	2569	2530	2414	2225	1817	1285	32°27
2°26	2111	2079	1984	1829	1493	1056	26°52	2°76	2579	2539	2423	2233	1823	1290	32°39
2°27	2121	2089	1993	1837	1500	1061	26°64	2°77	2588	2549	2432	2241	1830	1294	32°51
2°28	2130	2098	2002	1845	1506	1065	26°76	2°78	2597	2558	2441	2249	1837	1299	32°62
2°29	2139	2107	2010	1853	1513	1070	26°87	2°79	2607	2567	2449	2257	1843	1304	32°74
2°30	2149	2116	2019	1861	1519	1075	26°99	2°80	2616	2576	2458	2265	1850	1308	32°86
2°31	2158	2125	2028	1869	1526	1079	27°11	2°81	2625	2585	2467	2274	1856	1313	32°98
2°32	2167	2135	2037	1877	1533	1084	27°23	2°82	2635	2595	2476	2282	1863	1318	33°09
2°33	2177	2144	2046	1885	1539	1088	27°34	2°83	2644	2604	2484	2290	1870	1322	33°21
2°34	2186	2153	2054	1893	1546	1093	27°46	2°84	2653	2613	2493	2298	1876	1327	33°33
2°35	2195	2162	2063	1901	1552	1098	27°58	2°85	2663	2622	2502	2306	1883	1332	33°45
2°36	2205	2171	2072	1909	1559	1103	27°70	2°86	2672	2631	2511	2314	1889	1336	33°56
2°37	2214	2181	2081	1918	1566	1107	27°81	2°87	2681	2641	2520	2322	1896	1341	33°68
2°38	2224	2190	2089	1926	1572	1112	27°93	2°88	2691	2650	2528	2330	1903	1346	33°80
2°39	2232	2199	2098	1934	1579	1116	28°05	2°89	2700	2659	2537	2338	1909	1350	33°92
2°40	2242	2208	2107	1942	1585	1121	28°16	2°90	2709	2668	2546	2346	1916	1355	34°03
2°41	2252	2217	2116	1950	1592	1126	28°28	2°91	2719	2677	2555	2354	1922	1359	34°15
2°42	2261	2227	2125	1958	1599	1131	28°40	2°92	2728	2687	2563	2363	1929	1364	34°27
2°43	2270	2236	2133	1966	1605	1135	28°52	2°93	2737	2696	2572	2371	1936	1369	34°38
2°44	2280	2245	2142	1974	1612	1140	28°63	2°94	2747	2705	2581	2379	1942	1374	34°50
2°45	2289	2254	2151	1982	1618	1145	28°75	2°95	2756	2714	2590	2387	1949	1378	34°62
2°46	2298	2263	2160	1990	1625	1149	28°87	2°96	2765	2723	2599	2395	1955	1383	34°74
2°47	2308	2273	2168	1998	1632	1154	28°99	2°97	2775	2733	2607	2403	1962	1388	34°85
2°48	2317	2282	2177	2007	1638	1159	29°10	2°98	2784	2742	2616	2411	1969	1392	34°97
2°49	2326	2291	2186	2015	1645	1163	29°22	2°99	2793	2751	2625	2419	1975	1397	35°09
2°50	2336	2300	2195	2023	1652	1168	29°34	3°00	2803	2760	2634	2427	1982	1402	35°21

ALTAZIMUTH TABLES, 1905.

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Altazimuth Extra-Meridian Tables—continued.

Motion in Zenith Distance in the Standard Azimuths, and Azimuthal Motion in the Prime Vertical.

Motion in Z.D. in units of $0''.01$.Motion in Z.D. in units of $0''.01$.

Time Inter- val.	Az. 90°.	Az. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Az. Motion.	Time Inter- val.	Az. 90°.	As. 80°.	Az. 70°.	Az. 60°.	Az. 45°.	Az. 30°.	Az. 90°. Az. Motion.
^s							^s								
3'01	2812	2769	2642	2435	1988	1406	35'32	3'51	3279	3229	3081	2840	2319	1640	41'19
3'02	2821	2779	2651	2443	1995	1411	35'44	3'52	3289	3239	3090	2848	2325	1645	41'31
3'03	2831	2788	2660	2452	2002	1416	35'56	3'53	3298	3248	3099	2856	2332	1649	41'43
3'04	2840	2797	2669	2460	2008	1420	35'68	3'54	3307	3257	3108	2864	2339	1654	41'54
3'05	2849	2806	2678	2468	2015	1425	35'79	3'55	3317	3266	3117	2872	2345	1659	41'66
3'06	2859	2815	2686	2476	2021	1430	35'91	3'56	3326	3275	3125	2880	2352	1663	41'78
3'07	2868	2825	2695	2484	2028	1434	36'03	3'57	3335	3285	3134	2888	2358	1668	41'90
3'08	2877	2834	2704	2492	2035	1439	36'14	3'58	3345	3294	3143	2897	2365	1673	42'01
3'09	2887	2843	2713	2500	2041	1444	36'26	3'59	3354	3303	3152	2905	2372	1677	42'13
3'10	2896	2852	2722	2508	2048	1448	36'38	3'60	3363	3312	3160	2913	2378	1682	42'25
3'11	2906	2861	2730	2516	2055	1453	36'50	3'61	3373	3321	3169	2921	2385	1687	42'36
3'12	2915	2871	2739	2524	2061	1458	36'61	3'62	3382	3331	3178	2929	2391	1691	42'48
3'13	2924	2880	2748	2532	2068	1462	36'73	3'63	3391	3340	3187	2937	2398	1696	42'60
3'14	2934	2889	2757	2541	2074	1467	36'85	3'64	3401	3349	3196	2945	2405	1701	42'72
3'15	2943	2898	2765	2549	2081	1472	36'97	3'65	3410	3358	3204	2953	2411	1705	42'83
3'16	2952	2907	2774	2557	2088	1476	37'08	3'66	3419	3367	3213	2961	2418	1710	42'95
3'17	2962	2917	2783	2565	2094	1481	37'20	3'67	3429	3377	3222	2969	2424	1715	43'07
3'18	2971	2926	2792	2573	2101	1486	37'32	3'68	3438	3386	3231	2977	2431	1719	43'19
3'19	2980	2935	2801	2581	2107	1490	37'44	3'69	3447	3395	3239	2986	2438	1724	43'30
3'20	2990	2944	2809	2589	2114	1495	37'55	3'70	3457	3404	3248	2994	2444	1729	43'42
3'21	2999	2953	2818	2597	2121	1500	37'67	3'71	3466	3413	3257	3002	2451	1733	43'54
3'22	3008	2963	2827	2605	2127	1504	37'79	3'72	3475	3423	3266	3010	2457	1738	43'66
3'23	3018	2972	2836	2613	2134	1509	37'91	3'73	3485	3432	3275	3018	2464	1743	43'77
3'24	3027	2981	2844	2621	2140	1514	38'02	3'74	3494	3441	3283	3026	2471	1747	43'89
3'25	3036	2990	2853	2630	2147	1518	38'14	3'75	3503	3450	3292	3034	2477	1752	44'01
3'26	3046	2999	2862	2638	2154	1523	38'26	3'76	3513	3459	3301	3042	2484	1757	44'12
3'27	3055	3009	2871	2646	2160	1528	38'37	3'77	3522	3469	3310	3050	2491	1761	44'24
3'28	3064	3018	2880	2654	2167	1532	38'49	3'78	3531	3478	3318	3058	2497	1766	44'36
3'29	3074	3027	2888	2662	2173	1537	38'61	3'79	3541	3487	3327	3066	2504	1771	44'48
3'30	3083	3036	2897	2670	2180	1542	38'73	3'80	3550	3496	3336	3075	2510	1775	44'59
3'31	3092	3045	2906	2678	2187	1546	38'84	3'81	3559	3505	3345	3083	2517	1780	44'71
3'32	3102	3055	2915	2686	2193	1551	38'96	3'82	3569	3515	3354	3091	2524	1785	44'83
3'33	3111	3064	2923	2694	2200	1556	39'08	3'83	3578	3524	3362	3099	2530	1789	44'95
3'34	3120	3073	2932	2702	2206	1560	39'20	3'84	3588	3533	3371	3107	2537	1794	45'06
3'35	3130	3082	2941	2710	2213	1565	39'31	3'85	3597	3542	3380	3115	2543	1799	45'18
3'36	3139	3091	2950	2719	2220	1570	39'43	3'86	3606	3551	3389	3123	2550	1803	45'30
3'37	3148	3101	2959	2727	2226	1574	39'55	3'87	3616	3561	3397	3131	2557	1808	45'42
3'38	3158	3110	2967	2735	2233	1579	39'67	3'88	3625	3570	3406	3139	2563	1813	45'53
3'39	3167	3119	2976	2743	2239	1584	39'78	3'89	3634	3579	3415	3147	2570	1817	45'65
3'40	3176	3128	2985	2751	2246	1588	39'90	3'90	3644	3588	3424	3155	2576	1822	45'77
3'41	3186	3137	2994	2759	2253	1593	40'02	3'91	3653	3597	3433	3164	2583	1827	45'89
3'42	3195	3147	3002	2767	2259	1598	40'13	3'92	3662	3607	3441	3172	2590	1831	46'00
3'43	3204	3156	3011	2775	2266	1602	40'25	3'93	3672	3616	3450	3180	2596	1836	46'12
3'44	3214	3165	3020	2783	2273	1607	40'37	3'94	3681	3625	3459	3188	2603	1841	46'24
3'45	3223	3174	3029	2791	2279	1612	40'49	3'95	3690	3634	3468	3196	2609	1845	46'35
3'46	3232	3183	3038	2799	2286	1616	40'60	3'96	3700	3643	3477	3204	2616	1850	46'47
3'47	3242	3193	3046	2808	2292	1621	40'72	3'97	3709	3653	3485	3212	2623	1855	46'59
3'48	3251	3202	3055	2816	2299	1626	40'84	3'98	3718	3662	3494	3220	2629	1859	46'71
3'49	3261	3211	3064	2824	2306	1631	40'96	3'99	3728	3671	3503	3228	2636	1864	46'82
3'50	3270	3220	3073	2832	2312	1635	41'07	4'00	3737	3680	3512	3236	2642	1869	46'94