GREENWICH
ASTRONOMICAL OBSERVATIONS,
1906.

INTRODUCTION.

I. *Personal Establishment and Arrangement.*

At the beginning of the year 1906 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.

Mr. Dyson, having been appointed Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh, resigned on January 13. Mr. A. S. Eddington, B.A., M.Sc., was appointed a Chief Assistant on February 19 to fill the vacancy.

Mr. E. V. Vagg was appointed Established Computer on February 21. He died on April 11, after a very short illness.

Mr. R. T. Cullen was appointed Established Computer on October 11.

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

Mr. W. W. Bryant, Superintendent of the Magnetic and Meteorological Branch, and Mr. D. J. R. Edney, Established Computer in that branch, have also taken part in the Astronomical Observations.

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

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

Mr. Thackeray is charged with the deduction of the results of the meridian observations, and with the general superintendence of the Computers of the Astronomical Reductions Branch, by whom the great mass of calculations and of reading proof-sheets is effected.

Mr. 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. Witchell, Mr. Storey, Mr. Evans, and Mr. Cullen. 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 were generally made by the observer on duty with the transit-circle.

Observations with the reflex zenith-tube were made by Mr. Witchell, Mr. Storey, Mr. Evans and Mr. Cullen.

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

Observations with the Altazimuth were made by Mr. Crommelin, Mr. Furner, Mr. Vagg, or by one the Computers.

Photographs with the astrographic equatorial were generally taken by Mr. Hollis, or Mr. Stevens.

Photographs with the Thompson Equatorial (26-inch refractor and 30-inch reflector) were generally taken by 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 1906:—

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

II. *Instruments.*

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

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

The 25-foot zenith-sector was dismounted, and its tube was divided (at its joints) into several parts, in May 1848; and the separate portions of the instrument are stored away in frames constructed to hold them. The object-glass was removed from the tube in 1850, to be used for the collimator of the 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. It was again repolished 1906 January 9–February 9, but as it was found that the figure had been affected, the aperture was reduced to six inches from February 9 to April 2, when the object-glass was taken away to be refigured by Mr. Simms and returned on April 26, after remedying the defect of figure in the outer portion. Since that date the full aperture of eight inches has been used in all observations, including those of the Sun. The power of the eyepiece ordinarily employed is 195, and of that used for observations of the Sun 180. The axis of the instrument is of cast-iron, in two similar pieces, the length between the extremities of the pivots being 6 feet. The mould of the pivot was made of iron, for the purpose of hardening it by the process technically called *chilling*; the moulds for the other parts were sand. The two halves are connected by bolts through flanges at the junction-plane in the middle of the cube. The two portions of the telescope-tube (also of cast-iron, with the exception of the object-glass cell and the eyepiece-work) are bolted on the central cube. The pivots are of "chilled" iron and their diameter is 6 inches, the bearing of each being upon two portions of a concave cylinder, forming the Y. The Y's are firmly screwed down to the massive piers between which the instrument is mounted.

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. During 1905 October 31 to November 18, 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, Micrometer Head to Left.	Vertical Error, Micrometer Head Below.	N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Left.	Vertical Error, Micrometer Head Below.	N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Left.	Vertical Error, Micrometer Head Below.	N. P. D. Pointer Reading.	Horizontal Error, Micrometer Head to Left.	Vertical Error, Micrometer Head Below.
°	"	"	°	"	"	°	"	"	°	"	"
5	−0·07	−0·10	95	−0·10	−0·13	185	+0·05	+0·05	275	−0·13	+0·31
15	−0·05	−0·08	105	−0·16	+0·03	195	+0·13	0·00	285	−0·18	+0·39
25	−0·05	0·00	115	−0·05	+0·08	205	+0·18	+0·05	295	−0·18	+0·28
35	+0·03	−0·10	125	+0·08	0·00	215	+0·13	−0·03	305	−0·13	+0·18
45	+0·10	−0·13	135	+0·03	0·00	225	+0·13	+0·05	315	−0·08	−0·05
55	+0·03	−0·21	145	+0·16	+0·08	235	+0·08	+0·13	325	−0·03	−0·08
65	0·00	−0·23	155	+0·18	+0·03	245	0·00	+0·16	335	−0·05	−0·16
75	−0·10	−0·23	165	+0·16	−0·05	255	+0·03	+0·13	345	0·00	−0·08
85	−0·08	−0·18	175	+0·13	−0·05	265	0·00	+0·21	355	−0·03	−0·21

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 $2\frac{3}{4}°$, and two other parallel wires at right angles to the former, and therefore inclined to the horizontal line at the same angle (the intersection of this pair with the former producing a square). For adjustment of the collimators accurately on each other, the plates carrying the wires are moveable by micrometer-screws: that of the south collimator in altitude only, and that of the north collimator in azimuth only. In order to view either collimator by the transit-circle telescope, it is only necessary to direct the transit-circle telescope towards that collimator; but in order to view one collimator by the other, it is necessary to place the transit telescope vertical, and to uncover the perforations in the opposite sides of its central cube, which permit one collimator to view the other through eight holes of sector-form. The opposite sides of the central cube were pierced with these perforations in August and September 1865. This arrangement was brought into use on 1866 December 17, when the collimators of 7 inches aperture were mounted in place of those of 4 inches aperture, used up to that time. To obtain a somewhat more perfect view of one collimator by the other, it is necessary to raise the transit-circle so far that there shall be no impediment to a direct view, by means of a mechanical apparatus provided for the purpose.

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

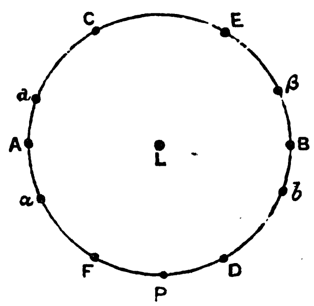
The process of adjusting the collimators, and of using them for determining the line of collimation of the transit-circle telescope, is as follows :—

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

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

The 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 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, 1896, and 1906. The observations are given in the *Transit-Circle Tables* at the end of the *Introductions* for 1894, 1896, and 1906. They show that the wear of the screws is small, and its effect almost entirely eliminated by the reversal of three of the screws.

There are two clamps attached to the eastern pier, at the same height as the centre of the circle (one on the north side, the other on the south side), which can take hold of the clamping circle of the instrument; but they have no slow motion. The eye-piece of the telescope contains only one horizontal wire, moveable by a micrometer, with which all observations of zenith-distance are made. For reducing every observation, therefore, it is necessary to combine the value of the reading of the telescope-micrometer with that of the mean of readings of the microscope-micrometers. When the telescope points vertically upwards, the head of the telescope-micrometer is on the north side; and the telescope-micrometer-readings increase as the wire is moved towards the head. The reading $20^{rev.}$ corresponds nearly to the centre of the field of view. A new screw was applied to the micrometer by Messrs. Troughton and Simms in 1906 July. Its pitch is the same as that of the right ascension micrometer.

Observations for the determination of the value of $1^{rev.}$ of the old 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.*

Observations for determination of the value of one revolution of the new telescope-micrometer screw and of its errors are given in the *Transit Circle Tables.* The observations show that the new screw is sensibly uniform, and no corrections for its errors are applied.

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

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

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

For star-observing generally, the telescope is directed approximately towards the object by the indications of the N.P.D. pointer, and, the telescope being moved by hand till the star is brought near the horizontal micrometer-wire at or near the reading of $20^{rev.}$, the clamping circle is fastened. The transit of the star is then observed over the vertical wires in the usual way. 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. The practice of observing very faint stars in a perfectly dark field with the wires illuminated has been discontinued.

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.

A detailed account of the chronograph used with the Transit-Circle 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 used except for the Sun, when it is reduced to 6 inches. 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 ($=0^{s}\cdot15$) E. and 166 feet ($=1''\cdot67$) 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 1½ feet north of the transit-circle. The mounting, particulars of which are given in the *Introductions* to the *Greenwich Observations* for former years, is similar in general form to that known as the "German equatorial," and was constructed by the late Mr. T. Grubb, of Dublin. Besides several negative eyepieces unfurnished with wires, this telescope has a wire micrometer, and a comet eyepiece with thick wires and position circle, which was supplied on 1890 November 10. On 1892 November 18 a new set of wires was mounted in this eyepiece, as the wires were found to be bent.

The Great Equatorial.—This instrument now carries an object-glass of 28 inches aperture and 28 feet focal length on the mounting which was originally designed for the Merz object-glass of 12·8 inches aperture and 17 ft. 10 in. focal length. This mounting was constructed by Messrs. Ransomes and Sims (as engineers), and the late Mr. William Simms (as instrument-maker), and a complete description of it, with engravings, is attached as *Appendix* to *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 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. A secondary magnifier is sometimes used with this instrument for photographing sun spots and other objects on an enlarged scale.

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 xxii) 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 $0^{m}\cdot33$, or $13^{in}\cdot0$, and $10^{in}\cdot0$ respectively, and the focal lengths of both telescopes $3^{m}\cdot43$ or $135^{in}\cdot1$, so that $1^{mm}\cdot0$ on the plate corresponds to $1'\cdot0$. [The focal length of the photographic telescope is more exactly $3^{m}\cdot441$ or $135^{in}\cdot4$, so that $1^{mm\cdot}$ represents $0'\cdot9990$.] 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 $16^{cm\cdot}$ 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 o 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 $0^{s}\cdot3$ for an increase of 1 inch of barometer reading.

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

Galvanic contact for registration of the clock-beats is made by a wheel of 30 teeth on the escape-wheel arbor, a tooth of which at every beat of the clock presses together two light springs. Another pair of springs is also pressed together at the beginning of each minute by an arm on the same arbor, and a supplementary signal is thus sent through a galvanometer as a check on the numeration of seconds. This arrangement was substituted in the latter part of 1881 for that formerly employed (in which a pin on the pendulum was used to press together the contact springs) in order to avoid any effect on the pendulum, contact being made in the part of the beat when the pendulum is quite detached from the clock-train, after the impulse has been given. The currents obtained from the Sidereal Standard at every alternate second are used to drive a relay, from which three independent circuits are derived. One of these is appropriated to the seconds-magnet of the chronograph; another 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.

The clock "Dent 2" has been fitted with springs and placed in the Record Room for use when the Sidereal Standard is under repair. 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 in the place of Hardy; 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 electro-magnetic clocks in different parts of the Observatory are driven synchronously with the Mean Solar clock. Arrangements are made so that in the case of failure of the clock "Dent 2012," the circuit can be readily shunted on to the electrical clock "Shepherd."

One of the synchronous clocks has a large dial exposed to public view on the east boundary wall of the Observatory; 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 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 $1^h. 0^m. 39^s{\cdot}0$, and the Portsmouth clock at $1^h. 0^m. 20^s{\cdot}0$, to serve as a test of the accuracy with which the local clocks have been corrected.

The following clocks are also in use in the Observatory as Mean Solar Clocks:—

"Mudge and Dutton," with a gridiron pendulum, in the upper chronometer room; "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* 1906.

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, continuous observation is maintained of all stars in Prof. Newcomb's *Catalogue of Fundamental Stars* visible in this latitude.

The other stars observed are, since the beginning of this year, taken from a new working catalogue of stars of magnitude 9·0 and brighter between the limits + 24° to + 32° of N. declination, serving as reference stars for the Oxford Astrographic Zones.

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.

A series of measures of the equatorial and polar diameters of Jupiter has also been made.

The Thompson Equatorial has been used for taking photographs of Neptune and its satellite with the 26-inch refractor, and of Comets *a* 1906, *b* 1906, *d* 1906, *e* 1906, and *g* 1906, 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.*

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* 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 No. in Auwers's edition of Mayer's Catalogue.
4. The hour and No. in Piazzi's Catalogue, edition 1814.
5. The No. in Groombridge's Catalogue.
6. The No. in Baily's edition of Flamsteed's Catalogue, referred to as "B.F."
7. 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.
8. 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.
9. The No. in Lacaille's Catalogue of Southern Stars, published by the British Association.
10. The No. in Oeltzen's two Catalogues of Argelander's Zone Observations, referred to as "Oeltz. Arg. (N.)" or "(S.)" respectively.
11. The No. in the First Radcliffe Catalogue (1845).
12. The No. in Carrington's Red Hill Catalogue.
13. The Zone and No. in Argelander's Bonn *Durchmusterung* or in Schönfeld's continuation of the *Durchmusterung* (Bonn Catalogue, Sections I., II., III., and IV.; Bonn Observations, Vols. III., IV., V., and VIII.), referred to as "B.D."
14. The No. in the Greenwich Catalogues; in the British Association Catalogue, referred to as B.A.C.; in the Cape Catalogue for 1880; or in the 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 have been investigated. The results of the most recent investigation of these errors are given in the *Transit-Circle Tables* at the end of this *Introduction*. It is considered that the errors are too small to necessitate correction, and this is confirmed by comparing the times of transit of circumpolar stars for intervals of successive revolutions.

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

In observing by eye-and-ear, it is the practice to take a second from the clock-face before the transit over the first wire, and to preserve the counting by listening to the beats of the clock, and not to look again at the clock-face till the transit is completed. The fraction of the second is estimated by remarking the place at which the object is seen at the successive beats of the clock. Errors in the hours and minutes are seldom alluded to in the notes of the printed observations; but every alteration of the seconds is carefully recorded. Stars very near the pole are sometimes observed by the eye-and-ear method over the wires intended for the galvanic transits, but more generally over wire T (the middle wire) set to a series of 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 unsynmetrical 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

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

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

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

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

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

$$\text{Duration of passage of semidiameter} \times \text{versed sine } \theta.$$

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

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

Error of Collimation.

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

The method of determining the position of the line of collimation by means of the north and south collimators has been fully explained above 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 $+\ 0^{r}{\cdot}011$ 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 a fixed 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. To the excess thus converted into arc is then applied $-0''\cdot19$ for diurnal aberration; and the result is the quantity which is given in the sixteenth column of the *Transits* as the error of collimation, and 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. The mean of the results is adopted 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 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 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 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 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

$$\text{Azimuth error} = -n \text{ cosec. colat.} + l \text{ cot colat.}$$
$$15\,m = -n \text{ cot colat.} + l \text{ cosec. colat.}$$

The corrections are applied by the formula $\frac{1}{15}n$ cot 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.

From the beginning of 1906, the right ascensions are deduced from the *Standard Mean Right Ascensions for* 1900·0 *based on* 12-*hour groups,* which will be printed in the Introduction to the *Second Nine Year Catalogue for* 1900. The values of the precession and proper motions are taken from Prof. Newcomb's *Catalogue of Fundamental Stars.* 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). In the *Transit-Circle Tables,* at the end of this *Introduction,* are given the adopted mean right ascensions for 1906·0 of all the stars which have been used for determining clock-errors or azimuth-errors, together with the corrections to the mean right ascensions given in the Nautical Almanac.

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

The *twentieth* column contains the adopted losing rate and the adopted error of the clock at 0^h sidereal, as found by the following process. The observations are divided into groups, defined by bars across this column (in all instances the same as the limits of the observations of each observer). The mean of the clock-errors given by all the clock-stars in each group is then taken, and this is considered to be the clock-error corresponding to the mean of all the times of transit of those stars. 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 1906 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 1906. But those used in the adoption of clock-rate as explained on page xxxvi, referred to Mr. Bryant as standard, have been deduced from the observations in 1905. 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:—

	s		s
Mr. Eddington	-0.04_{6}	Mr. Cullen	-0.01_{10}
Mr. Bryant	0.00_{3}	Mr. Daniels	$+0.04_{5}$
Mr. Witchell	-0.02_{23}	Mr. James	-0.03_{5}
Mr. Storey	-0.07_{20}	Mr. Shepperd	$+0.02_{7}$
Mr. Evans	$+0.01_{16}$		

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

$$+ 0\overset{s}{.}026 + 0.027 \times \text{tabular duration of passage of semidiameter.}$$

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, 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 vii and xxxiii). The means of the readings for the separate collimators are set down in the second and third columns. The mean of these gives, after the application of a correction " $+ 0{\cdot}16 \times$ 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 $+0^{r}{\cdot}011$ 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 $-0''{\cdot}19$ 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. ix and xxxiv). 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. xxxv. 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.

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

§ 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 xii. 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 x). These readings in the observing books are placed in the order $\frac{\text{A, C, E}}{\text{B, D, F}}$; from which form they are easily changed into the order of printing. Each pair of adjacent readings, therefore, is the pair of readings at the opposite ends of a diameter. The 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 $29^{r}\cdot3$. Now, if the correction, by the addition of which each revolution of a micrometer may be converted into a minute of arc, were exactly $\frac{1}{50}$ part of the reading, then the sum of the runs would be $\frac{50}{51} \times 30^{r}\cdot000$, or $29^{r}\cdot4118$. If the sum of the runs is not exactly equal to this quantity, there will be a variable correction after adding $\frac{1}{50}$ part of the mean of the readings of the microscopes. To determine this quantity, let the sum of the runs be $29^{r}\cdot412 - x$. Then the true reading in seconds of space, corresponding to a nominal reading of r'' (including the value both of the nominal minutes and of the subdivisions of the nominal minute) will be

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

or

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

Hence the correction, after adding $\frac{1}{50}$ part of the mean of readings, will be $+ r \cdot x \times 0''\cdot03468$. When the four supplementary microscopes are used these rules are modified.

CORRECTIONS FOR ERROR OF DIVISION.—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°. They are printed in the *Transit Circle Tables.*

FLEXURE AND R—D DISCORDANCE.—The observations for determination of the horizontal astronomical flexure of the transit-circle telescope are given in the *Transit*

Circle Tables 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.

The investigation of the discordance of direct and reflexion observations is given in the *Transit-Circle Tables.*

From 1906 January 1, a constant flexure term of $+0''\cdot60$ sin Z.D. has been adopted to include the effects of astronomical flexure and the discordance of direct and reflexion observations; but this correction is not applied in this section or in the *Ledgers,* being deferred until the results are collected in the *Catalogue* (§ 6).

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

During the years 1895 to 1898 a new series of observations were made with a view to 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.

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 $20^{r.}$ 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 1906 July a new steel screw was applied to the micrometer by Messrs. Troughton & Simms. Observations for the determination of the value of $1^{rev.}$ of this screw are given in the *Transit-Circle Tables*, the resulting value being $36''\cdot93$. The errors of the screw were also investigated and found to be insensible.

The value of $1^{rev.}$ of the old screw, in use until July 13, and its errors were re-determined from 1896 December to 1897 February. The resulting value of $1^{rev.}$ was found to be $37''\cdot05$. The screw was found to have worn considerably, and corrections were obtained to the equivalents of the micrometer-readings belonging to a uniform screw with $1^{rev.} = 37''\cdot05$. 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 $14^{s}\cdot8$ for transit of an equatorial star; and the central or 4th wire is so nearly in the meridian as to prevent the necessity of any correction to the observed circle-reading when the body is observed at the passage over that wire. In that case, the only corrections which are required to the mean of the microscope-micrometer-readings (when converted into arc and combined with the equivalent for the telescope-micrometer-reading) are those arising from errors of division of the graduated circle, and from astronomical flexure of the telescope.

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

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

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

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

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

SECONDS OF CONCLUDED MERIDIAN CIRCLE-READING.—The numbers in this column are found by adding together the mean of the microscope-readings corrected for runs, the 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 was applied to nadir-observations for discordance between the results of this observation and the mean of reflexion observations of north and south stars. From 1897 January 1 a correction of $-0''{\cdot}25$ has been applied to the nadir-observations in forming the adopted zenith-point, when there are no reflexion observations of north and south stars; but when the observation of nadir is combined with reflexion observations of stars no correction is applied. From observations in former years a connexion was traced between this discordance and the errors of the screws of the microscope-micrometers, and it was hoped that the application of the new steel screws (one of each pair being reversed) would remove the discordance. This was found to be the case till 1892, the mean apparent correction to the nadir-observation as found from reflexion observations of stars since 1886 being as follows:—

1886	− 0″·09	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	1906	− 0·40

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 and 1906 confirm these results. These observations are given in the *Transit-Circle Tables* for 1896 and 1906.

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 1906 respectively:—

	21h.—3h. G.M.T.	3h.—9h. G.M.T.	9h.—15h. 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
1906	+ 0·19	0·00	− 0·01	40

The + sign indicates a greater circle-reading.

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 $\pm 0''\cdot 11$.

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

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

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

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

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

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

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

Then $$\text{Tan}\ \delta_1 = \text{Tan}\ \delta_m .\ \text{Cos}\ M\,P\,S_1.$$

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

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

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

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

From which θ is found.

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

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

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 θ; and therefore if ϕ be the apparent angular distance of the Sun from that plane as seen from the planet, the value of ϕ is determined by the equation

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

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

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

In cases where the "centre" of Mercury is observed, a correction of 0·4 × 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.

1906 May 16.

Temperature.	Error.
32°·2	+0°·2
50·2	+0·2
66·3	+0·3
73·9	+0·3
86·6	+0·2
95·7	+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.

The following are the results of comparisons with the Standard Thermometer made on 1906 May 16.

Temperature.	Error.
°	°
32·6	+0·6
50·7	+0·7
64·1	+0·8
70·3	+0·9
87·2	+0·8
95·9	+0·5

A correction of $-0^\circ{\cdot}5$ has been applied to the readings of the Interior Thermometer from 1889 March 15 to 1894 December 31, and of $-0^\circ{\cdot}6$ 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.—From the beginning of 1906, Pulkowa refractions have been used. Tables of these refractions are given in an Appendix to the *Greenwich Observations*, 1898.

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 $\frac{1}{300}$ and the value of the solar parallax $8''{\cdot}80$.

For the planets the formula is :—

$$\text{log. parallax} = \text{log. sin (Z.D.} - 11'.12'') + \text{ar. co. log. distance} + 0{\cdot}94360.$$

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

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

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

The correction tabulated above is the sum of two corrections, 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. Eddington	$+0''\cdot21_{7}$	Mr. Cullen	$-0''\cdot60_{10}$
Mr. Bryant	$-0\cdot20_{8}$	Mr. Daniels	$+0\cdot45_{6}$
Mr. Witchell	$-0\cdot14_{26}$	Mr. James	$-0\cdot38_{5}$
Mr. Storey	$-1\cdot21_{21}$	Mr. Shepperd	$+0\cdot42_{7}$
Mr. Evans	$0\cdot00_{16}$		

For Venus the correction + 0″·392 + 0·027 × 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°.31′.21″·80.

§ 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 $\frac{50}{51} \times 30^{r}\cdot000$, or to $29^{r}\cdot4118$; 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 $29^{r}\cdot4118$, is computed in the way that has been explained (page xliii).

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 xlvi. 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 reflexion 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 adopted value $0''\cdot600$ sin Z.D. of the R—D discordance.

From 1897 January 1 a correction of $-0''\cdot25$ has been applied to observations of the nadir, in forming the zenith-point on those days when no reflexion observations of stars were obtained. (See p. xlvi.)

§ 5. *Ledgers of Mean Right Ascensions and Mean North Polar Distances for* 1910·0 *of Stars observed in* 1906.

These ledgers are divided into two parts. Part I. contains Fundamental and Zodiacal stars; Part II. contains the stars of the Oxford Astrographic Zone.

The apparent right ascensions and north polar distances (obtained as explained in §§ 1 and 3) are reduced to mean place for the epoch 1910·0, with Newcomb's constants of precession. Since 1902 a further correction for latitude variation has been applied to the north polar distances. This correction is taken from provisional results sent by Professor Albrecht.

For stars in the lists of the national ephemerides, the correction to reduce to 1910·0 is found by subtracting the apparent R.A. or N.P.D. given in those ephemerides from the mean R.A. and N.P.D. for 1910·0 in the same ephemerides.

For the remaining stars of Part I. and for all the stars of Part II., star constants are formed for 1910·0, 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 use of logarithms.

The logarithms of the day numbers, with Newcomb's constants, are given in the Nautical Almanac for mean midnight of each day 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 has only been taken into account for those stars for which apparent places are given in the ephemerides for every day of the year.

The places for 1910·0 are not corrected for secular variation during the interval between the date of observation and 1910·0 (except in the case of stars contained in the ephemerides, which have been reduced as explained above). It is intended ultimately to apply mean corrections for secular variation when the annual results are collected in the *Greenwich Catalogue for* 1910.

Corrections for the proper motion in the interval between the time of observation and the epoch 1910·0 are applied to the stars of Part I. but *not* to those of Part II. The proper motion adopted in the former case is given in the *Catalogue of Mean R.A. and N.P.D.* (§ 6).

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

Half weight has been given to a result for right ascension when the transit was observed at two or three wires only, observations at a single wire being rejected. A reflexion and direct observation at the same transit are considered as separate observations with full weight.

In Part I. the rules for the nomenclature of stars are the same as those in the section *Transits observed*, detailed on page xxix. In Part II. the Zone and No. in the *Bonn Durchmusterung* are used.

§ 6. *Catalogue of Mean R.A. and N.P.D. for* 1910·0 *of Fundamental and Zodiacal Stars observed in* 1906.

The results of observations of stars included in Part I. only of the ledgers are given in this catalogue.

The right ascensions in the catalogue are the means of the separate determinations for each star, and are identical with the means printed in the ledgers.

The north polar distances in the catalogue are obtained from the results in the ledgers by applying corrections for the 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.

A constant flexure term of the R—D discordance, namely $+0''{\cdot}60 \sin$ Z.D., has been adopted. This is sensibly the same as the mean values used in the 1880, 1890 and 1900 Catalogues.

For the circumpolar stars the following weights are assigned to the observations below pole—

N.P.D. not exceeding 15°				weight 1
N.P.D.	15°	to	36°	weight $\frac{2}{3}$
N.P.D.	36°	to	41°	weight $\frac{1}{2}$

Beyond N.P.D. 41° the observations are not combined. Direct and reflexion observations are treated as having equal weights.

As already explained Poulkowa refractions and an adopted colatitude 38° 31′ 21″·80 have been used in the reductions, Newcomb's constants of precession have been adopted, and the results have been corrected for latitude variation.

§ 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 113 measures of the value of this error made during the year is $+0^{s}{\cdot}036$. The values obtained by the several observers are given on p. xxxviii.

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 124 measures of the value of this error made during the year is $+0''{\cdot}36$. The values obtained by the several observers are given on p. lii.

For the duration of the passage of the Moon's diameter, the correction for defect of illumination is investigated as on p. xxxii. The mean of three determinations of the error of the Moon's tabular duration of passage made in this year is $+0^{s}{\cdot}050$.

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 xlviii). The mean of 12 determinations of the error of the Moon's tabular vertical diameter made during the year is $+0''\cdot45$.

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 xlix. 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 xxxviii. 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 :—

	SE	W	JS	E	RC	SD	J	S	Other Observers.
	s	s	s	s	s	s	s	s	s
1906	$0\cdot00_{5}$	$-0\cdot02_{28}$	$-0\cdot05_{18}$	$0\cdot00_{14}$	$-0\cdot05_{11}$	$-0\cdot08_{5}$	$+0\cdot07_{5}$	$-0\cdot01_{7}$	$-0\cdot02_{16}$

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 corrections for discordance of direct and reflexion results and (since 1902) for latitude variation being applied. As has been previously explained, Pulkowa refractions and assumed colatitude 38°.31'.21''·80 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 :—

	SE	W	JS	E	RC	SD	J	S	Other Observers.
	"	"	"	"	"	"	"	"	"
1906	$+0.53_{8}$	$+0.17_{26}$	-0.22_{21}	$+0.16_{17}$	-0.55_{10}	$+0.49_{4}$	$+0.06_{5}$	-0.12_{7}	$+0.02_{18}$

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

The tabular right ascension of the Moon's centre is found by applying to the right ascension of the limb (given in the section, *Moon-culminating Stars*, of the *Nautical Almanac*) the sidereal duration of passage of semidiameter, which is given in the same section of the *Nautical Almanac*.

The 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 :—

	SE	W	JS	E	RC	HA	Other Observers.
				Moon 1 L.			
	s.	s.	s.	s.	s.	s.	s.
1906	-0.62_{5}	-0.49_{12}	-0.61_{9}	-0.50_{13}	-0.52_{8}	-0.34_{4}	-0.49_{8}
				Moon 2 L.			
1906	...	-0.19_{8}	-0.28_{10}	-0.33_{4}	-0.43_{2}	-0.04_{1}	-0.19_{7}

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.

	SE	W	JS	E	RC	HA	Other Observers.
	″	″	″	″	″	″	″
1906	$-2{\cdot}27_2$	$+0{\cdot}42_{11}$	$-3{\cdot}14_7$	$-2{\cdot}30_9$	$-3{\cdot}83_4$	...	$-0{\cdot}61_7$

Moon S. L.

	SE	W	JS	E	RC	HA	Other Observers.
1906	$+2{\cdot}66_1$	$+2{\cdot}44_7$	$+1{\cdot}08_9$	$+1{\cdot}35_6$	$+0{\cdot}52_5$	$+2{\cdot}33_3$	$-0{\cdot}66_4$

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.

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 daily errors in each month of the R.A. and N.P.D. of the sun is taken to be the error for the day which is nearest to the mean of all the days of observation. When the same day is not found for R.A. and for N.P.D., an alteration of a unit or more has sometimes been made. From these, the error in the ecliptic polar distance is obtained by means of the factors R and S in the tables forming the second part of the *Appendix* to the *Greenwich Observations*, 1836. Supposing these errors to arise from an erroneous position of the ecliptic assumed in the *Nautical Almanac*, they may be expressed by the formula $x \cos l + y \sin l + z$, where l is the Sun's longitude. Weights are then assigned proportional to the number of observations of N.P.D., and the equations solved by the ordinary method of least squares. This method has been used since 1888, instead of the method of weighting and grouping the observations previously adopted.

For the *Mean Errors of the Tabular Geocentric Places of the Sun and Planets*, the observations have been collected into groups rarely exceeding a month in duration, and the mean of all the errors in each group, for R.A. and for N.P.D., giving half weight to observations of a single limb of the Sun in either element, is supposed to be the error for the day which is nearest to the mean of all the days of observation in the group, an alteration of a unit or more being sometimes made, in order to refer R.A. and N.P.D. to the same day. The errors in longitude and E.P.D. are formed by the use of the numbers P, Q, R, S in the *Appendix* to the *Greenwich Observations*, 1836. For any of the four small planets, Ceres, Pallas, Juno, and Vesta, whose latitude exceeds the limits of the tables, the longitude and E.P.D. are computed, 1st, from the R.A. and N.P.D. of the *Nautical Almanac*; 2nd, from these quantities affected with the errors in R.A. and N.P.D.; and the difference between these results gives the errors in longitude and E.P.D.

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

For the small planets, Ceres, Pallas, Juno, and Vesta.

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

Then,

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

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

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

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

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

For the other planets, the following are used :—

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

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

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

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

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

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 moon's limbs is given on pp. {*84*} and {*85*}.

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 xiv, 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

where

$$\cos(Z+\theta) = \sec\gamma_0 \cos\Delta$$
$$\sin\gamma_0 = \sin\gamma \sin A$$
$$\tan\theta = \tan\gamma \cos A$$

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 :—

$$\cos (T - \alpha + \phi) = \tan \gamma_0 \cot \Delta$$

where

$$\tan \phi = \sec \gamma \cot A$$

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 $15\, m \cot S \operatorname{cosec} Z$.

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.

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″·09 to Struve's dark limb value 15′ 32″·65. 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

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

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

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

F = log. sin star's hour-angle + log. seconds of corrected eq. hor. parallax + 9·4942268.

G = log. sin star's N.P.D. + log. sin star's hour-angle + log. seconds of corrected eq. hor. parallax + 9·8913966.

(The former numerical constant is the logarithm of half the distance of Greenwich from the Earth's axis, and the latter is the logarithm of the distance of Greenwich from the plane of the equator; supposing the Earth's ellipticity = $\frac{1}{300}$).

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

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

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

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

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

In the first trials, the log. $\frac{\text{arc}}{\text{sine}}$, &c. are omitted. The convergence of these approximations is extremely rapid.

When δ' and θ' are found accurately, the distance of the corresponding point from the Moon's centre is thus found, by means of a subsidiary angle ψ :—

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

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

The coefficients of small variations of the north polar distance and of the difference of right ascension (in the expression for distance) are computed by the formulæ :—

log. 1^{st} number = 2 log. diff. R.A. + log. sine (sum of N.P.D.) − log. dist. + 4·0835.
log. 2^{nd} number = log. diff. N.P.D. − log. distance.
Coefficient of variation of greater N.P.D. = 1^{st} number + 2^{nd} number.
Coefficient of variation of smaller N.P.D. = 1^{st} number − 2^{nd} number.
Log. coefficient of variation of diff. R.A. =
log. diff. R.A. + log. sin δ' + log. sin Moon's N.P.D. − log. distance.

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

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

2nd. The alteration of the horizontal equatorial parallax in the proportion of $1 : 1 + \frac{m}{1000}$ 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 $\frac{m}{1000}$ × correction for parallax in R.A.

3rd. The alteration in the position of the Moon, with regard to the meridian depending on the alteration of time t^s, will introduce an alteration in the correction for parallax. It is computed by the following formula:—

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

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

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

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

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

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

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

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

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

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

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

§ 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 $12''\cdot06$. 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 year* 1906.

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 1906·0 are given in separate tables.

§ 16. *Observations of the Sixth and Seventh Satellites of Jupiter from Photographs taken with the* 30-*inch Reflector during the oppostion* 1905–6.

The photographs were taken and measured as described in the preceding paragraph with this variation. To eliminate the distortion of the reflector, the positions of the satellites were measured on the photographs taken with the reflector, with reference to 3 or 4 faint comparison stars (of eleventh to twelfth magnitude) symmetrically distributed about the satellites. The positions of these stars were then measured relatively to the reference stars (of eighth to ninth magnitude) in the Astronomische Gesellschaft Catalogue on photographs (with two exposures of 20 minutes each) taken with the Astrographic 13-inch refractor, and, *viâ* the comparison stars, the positions of the satellites were projected on the Astrographic plate, and Right Ascensions and Declinations deduced as described (in § 15). The field, sensibly free from distortion, being much larger with the Astrographic Refractor than with the reflector, from 15 to 20 reference stars were available on each plate.

As Jupiter moved slowly, it was possible to make each reference plate serve for several photographs which were each referred to it.

To eliminate the error of the Tabular Place of Jupiter (for comparison with the R.A. and Dec. of the satellites deduced as above), and also that arising from any systematic error of the catalogues employed, a series of photographs of Jupiter was taken with the Astrographic 13-inch refractor, with exposures only just long enough to give good measurable images of the known stars, *viz.* 30 seconds. Four images each of Jupiter and of about twelve stars were measured on each plate, the positions of the stars being derived from the Astronomische Gesellschaft Catalogue. The deduced positions of Jupiter are thus affected by any systematic errors of the catalogue, but as the positions of the satellites, deduced in the same manner, are affected by the same errors, it follows that this is the proper place of Jupiter with which the positions of the satellites should be compared.

The corrections to the Tabular Place of Jupiter thus obtained have been applied in forming the columns Satellite VI—Jupiter and Satellite VII—Jupiter in the printed observations.

§ 17. *Observations of the Satellite of Neptune from Photographs taken with the 26-inch Refractor of the Thompson Equatorial during the opposition* 1905–6.

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. Davidson and Mr. Edney, the means of the measures being taken.

Corrections for refraction have not been applied separately to the distances or angles. These will in all cases be less than 0″·01. 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

$+ 0''{\cdot}042$ to $+ 0''{\cdot}105$, and for aberration from $+ 0''{\cdot}006$ to $- 0''{\cdot}014$. A mean total correction of $+ 0''{\cdot}07$ has been adopted, giving the *réseau* interval $= 150''{\cdot}98$. 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.

§ 18. *Measures of Photographs of the Sun.*

The results of the measures of positions and areas of sun-spots and faculæ made on photographs of the sun are not printed as usual in the present volume. This is owing to the circumstance that, on the completion of the reduction of the measures of the photographs taken during the year 1906, the photographs taken at Dehra Dûn were seen to be affected by serious errors in the orientation of the wires upon them. In former years in the use of the photoheliograph at Dehra Dûn the position-circle of the instrument has always been set to the zero as determined, by allowing the diurnal motion to carry a spot on the sun's limb along the horizontal wire, and the accuracy of the adjustment has been tested at short intervals. It appeared, however, on inquiry, that the photoheliograph at Dehra Dûn had been allowed to get much out of adjustment, and that this had been its condition for a long time. This will necessitate a thorough reexamination of all the photographs taken at Dehra Dûn throughout the year 1906, in order, if possible, to determine the error of orientation of the wires for each; after which all the Dehra Dûn photographs would have to be again reduced. It is proposed to publish these corrected results for 1906 together with those for 1907 in the volume of the Greenwich Observations for 1907.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich,
1908 *May* 6.

TRANSIT-CIRCLE TABLES,

1906.

ROYAL OBSERVATORY, GREENWICH.

TRANSIT-CIRCLE TABLES, 1906.

Equatorial Intervals of the Transit Wires.

The following are the intervals from the middle wire determined from measures with the transit-micrometer on the North and South Collimators respectively, which were in use to January 8 (adopted value of 1^rev. of Transit-micrometer = 37″·10):—

			s				s
For Wire M	=	+	44·65	For Wire T	=		0·00
N	=	+	29·82	U	=	−	7·16
O	=	+	14·92	V	=	−	9·68
P	=	+	12·50	W	=	−	12·11
Q	=	+	10·10	X	=	−	14·58
R	=	+	4·93	Y	=	−	29·39
S	=	+	2·62	Z	=	−	44·42

January 9 to February 11, the object-glass was away for repolishing, and wires P, Q, and R were renewed. The following are the intervals from the middle wire determined from observations of close polar stars combined with equatorial stars, which were in use to April 1 (adopted value of 1^rev. of the Transit-micrometer = 37″·06) :—

			s				s
For Wire M	=	+	44·54	For Wire T	=		0·00
N	=	+	29·69	U	=	−	7·23
O	=	+	14·92	V	=	−	9·76
P	=	+	12·50	W	=	−	12·20
Q	=	+	10·06	X	=	−	14·66
R	=	+	4·98	Y	=	−	29·45
S	=	+	2·53	Z	=	−	44·47

April 2 to April 26, the object-glass was away for refiguring. The following are the intervals from the middle wire determined from observations of close polar stars, combined with equatorial stars, which were in use to November 14 (adopted value of $1^{rev.}$ of the Transit-micrometer = 36″·97) :—

For Wire M	=	+	44·43 s	For Wire T	=		0·00 s
N	=	+	29·62	U	=	−	7·21
O	=	+	14·88	V	=	−	9·74
P	=	+	12·47	W	=	−	12·17
Q	=	+	10·04	X	=	−	14·62
R	=	+	4·97	Y	=	−	29·38
S	=	+	2·52	Z	=	−	44·36

November 15 to November 22, all the wires were renewed, new slots being cut in the wire frame. The following are the intervals from the middle wire, determined from observations of close polar stars, which were in use from November 22 to the end of the year (adopted value of $1^{rev.}$ of the Transit-micrometer = 36″·97) :—

For Wire M	=	+	44·34 s	For Wire T	=		0·00 s
N	=	+	29·75	U	=	−	7·35
O	=	+	14·91	V	=	−	9·83
P	=	+	12·43	W	=	−	12·31
Q	=	+	9·99	X	=	−	14·74
R	=	+	4·87	Y	=	−	29·56
S	=	+	2·42	Z	=	−	44·25

Determination of the value of one revolution of the Right Ascension Micrometer-Screw.

On 1906 April 26, the object-glass having been repolished and refigured, was finally returned from Messrs. Troughton and Simms, and it became necessary to determine the value of the screw. This was done in two ways :—

A. The eye-end of the transit-circle having been rotated through a right angle, the lengths of the screw from 44^r to 36^r and 36^r to 28^r, which are approximately 5′, were measured on the circle with the instrument directed to the Nadir. The results were corrected for division-error of the circle, and altogether 24 observations of each part of the screw were made.

B. By transits of Polar stars. The micrometer was set at tenths of a revolution (omitting ·5), and the observations were grouped together in sets of nine about each zero.

Those for λ Ursæ Minoris extended from $29^r \cdot 6 - 42^r \cdot 4$.
„ „ Groombridge 1119 S.P. „ „ $44^r \cdot 4 - 42^r \cdot 6$ and $29^r \cdot 4 - 27^r \cdot 6$.
„ „ Bradley 3147 „ „ $27^r \cdot 6 - 44^r \cdot 4$.

The value of $1^{rev.}$ was obtained by combining the values of 8, 7, 6, 5, 4, 2, revolutions before the centre with 8, 7, 6, 5, 4, 2 revolutions after the centre.

Date.	Values obtained from.	Value of $1^{rev.}$
May 3	Microscope readings on the Nadir from 28^r to 36^r	36″·95
	„ „ „ 36^r to 44^r	37·00
September 26	Transit of λ Ursæ Minoris	36·96
	„ Groombridge 1119 S.P.	36·97
	„ Bradley 3147	36·98
	Adopted value of $1^{rev.} = 36''\cdot97$.	

Investigation of the Errors of the Right Ascension Micrometer-Screw.

The value of this screw was determined in 1891, and was found sensibly uniform throughout the range at which it is generally used. A redetermination of the errors was made during 1906 by the following methods.

A. The lengths of the screw from $44^r - 36^r$, $36^r - 28^r$, which are approximately 5′, were measured on the circle, the instrument being directed to the North Collimator. The intervals between the divisions of the circle were corrected for division-error.

B. Concluded circle readings of the observation of the Nadir at intervals of $1^{rev.}$ of the screw from $44^r - 28^r$.

C. The intervals of the screw $29^r - 32^r$, $32^r - 35^r$, $35^r - 38^r$, and $38^r - 41^r$, were compared with a definite length on the South Collimator screw. The intervals $28^r - 29^r$, $29^r - 30^r$, etc., were similarly compared with definite lengths on the South Collimator screw.

D. By observations of Polar Stars. The micrometer was set at tenths of a revolution (omitting ·5), and observations were grouped together in sets of nine about each zero.

A.

1. Concluded circle readings on the North Collimator using the divisions 269°.30′, 35′, and 40′, corresponding to readings of the Right Ascension micrometer at about 44ʳ, 36ʳ, 28ʳ respectively :—

OCTOBER 1.

	44ʳ	36ʳ	28ʳ
	25″·94	27″·19	27″·01
	27·15	27·29	26·87
	26·77	27·12	26·47
	27·37	27·03	26·92
	26·96	27·63	26·53
Mean	26·84	27·25	26·76

Assuming the correction to the value of 36ʳ· = 0″·00, the apparent corrections to the adopted value are :—

+0″·41	0″·00	+0″·49

OCTOBER 2.

	26″·70	26″·82	26″·10
	27·31	26·98	26·20
	26·75	26·83	26·64
	26·48	26·93	25·90
	27·25	27·54	26·53
	27·01	26·53	26·60
	26·83	26·95	26·26
	27·72	26·75	26·36
	27·29	27·63	26·67
	26·91	26·98	26·53
	26·86	27·49	26·65
	26·84	26·80	26·58
	27·21	27·05	25·97
	26·46	26·85	26·22
	26·58	27·46	26·75
	26·62	26·80	26·23
	26·87	26·86	26·73
	26·72	27·13	26·88
	26·61	27·49	26·79
	26·55	26·90	26·86
Mean	26·88	27·04	26·47

Assuming the correction to the value of 36ʳ· = 0″·00, the apparent corrections to the adopted value are :—

+0″·16	0″·00	+0″·57

2. Similar observations, using divisions 269°.25′, 30′, and 35′ :—

	44^r	36^r	28^r
	58″·18	58″·26	57″·57
	58·01	58·88	58·05
	58·17	58·26	57·85
	58·53	58·16	57·63
	57·93	57·97	57·55
	58·06	58·17	57·95
	58·19	58·59	57·48
	58·31	58·33	57·39
	57·85	58·88	57·30
	58·53	58·65	57·54
Mean	58·18	58·42	57·63

Assuming the correction to the value of $36^r = 0''·00$, the apparent corrections to the adopted value are :—

+0″·24	0″·00	+0″·79

3. Similar observations, using divisions 269°.40′, 45′, and 50′ :—

	44^r	36^r	28^r
	24″·77	24″·45	24″·48
	24·12	24·94	24·32
	24·59	24·19	24·08
	24·09	24·31	24·27
	24·48	24·56	24·16
	24·49	24·95	24·42
	24·71	24·93	24·41
	24·13	24·50	24·11
	24·24	24·83	24·35
	24·52	24·37	24·44
Mean	24·41	24·60	24·30

Assuming the correction to the value of $36^r = 0''·00$, the apparent corrections to the adopted value are :—

+0″·19	0″·00	+0″·30

Summary of the observations of the Concluded Circle readings on the Collimator.

The apparent corrections to the adopted value are :—

	44^r	36^r	28^r	No. of Obs.
Oct. 1	+0″·41	0″·00	+0″·49	5
2	+0·16	0·00	+0·57	20
2	+0·24	0·00	+0·79	10
2	+0·19	0·00	+0·30	10
Mean	+0·21	0·00	+0·55	

B.

4. Concluded Circle readings of the observation of the Nadir at intervals of 1^{rev}. of the Right Ascension micrometer from 44^r to 28^r.

44^r.	43^r.	42^r.	41^r.	40^r.	39^r.	38^r.	37^r.	36^r.	35^r.	34^r.	33^r.	32^r.	31^r.	30^r.	29^r.	28^r.
43″·61	44″·04	44″·23	43″·92	44″·36	44″·62	44″·53	44″·50	44″·63	45″·13	44″·58	44″·91	44″·41	44″·03	44″·30	44″·67	44″·11
43·68	43·71	43·18	44·06	43·85	44·39	43·53	44·03	44·20	44·52	44·04	44·29	43·77	43·85	43·84	44·16	44·10
43·74	43·89	43·87	43·97	43·70	44·07	44·18	45·04	44·49	44·25	44·62	44·75	43·77	44·34	44·11	43·96	44·29
44·09	43·45	43·92	43·45	43·63	43·46	44·21	44·26	44·16	44·64	44·89	43·87	43·90	44·32	43·53	43·94	43·94
43·97	44·00	44·99	44·44	44·32	44·22	44·10	44·33	44·87	44·78	44·51	44·49	44·29	44·06	43·92	44·11	43·75
44·39	44·05	43·47	44·20	43·96	44·34	43·99	44·15	44·38	44·05	44·35	44·44	44·33	44·17	43·72	43·41	44·26
44·68	44·54	44·75	45·12	44·79	44·27	44·40	44·34	44·79	44·69	44·60	44·56	44·25	44·24	44·23	43·79	44·14
44·93	43·55	44·84	44·79	44·37	43·92	44·39	44·70	44·78	44·80	44·83	44·51	44·14	43·74	44·15	43·57	43·67
44·32	44·14	45·06	45·19	45·12	44·67	44·55	44·81	44·40	44·70	44·91	45·11	44·71	44·16	44·22	44·32	43·66
Mean 44·16	43·93	44·26	44·35	44·23	44·22	44·21	44·46	44·52	44·62	44·59	44·55	44·17	44·10	44·00	43·99	43·99

Assuming the correction to the value of $36^r = 0''\cdot00$, the apparent corrections to the adopted value are :—

+0·36	+0·59	+0·26	+0·17	+0·29	+0·30	+0·31	+0·06	0·00	−0·10	−0·07	−0·03	+0·35	+0·42	+0·52	+0·53	+0·53

C.

Intervals corresponding to $4^r\cdot600$ *of the South Collimator Micrometer.*

(About 3^r of the Right Ascension Micrometer).

29^r–32^r.	32^r–35^r.	35^r–38^r.	38^r–41^r.	No. of Readings.
2·994	3·011	2·995	2·996	5
2·998	3·009	3·005	2·997	5
2·996	3·010	3·000	2·997	...

These quantities referred to the general mean $3^r\cdot001$ and converted into arc with the adopted value of $1^r = 36''\cdot97$, assuming, in this case, the correction to $35^r = 0''\cdot00$, give the following apparent corrections :—

29^r.	32^r.	35^r.	38^r.	41^r.
+0″·15	+0″·33	0″·00	+0″·04	+0″·19

Intervals corresponding to 1r·540 *of the South Collimator Micrometer.*

(About 1r of the Right Ascension Micrometer).

28r–29r.	29r–30r.	30r–31r.	31r–32r.	32r–33r.	33r–34r.	34r–35r.	35r–36r.	No. of Readings.
r	r	r	r	r	r	r	r	
...	1·012	1·003	1·004	0·997	1·006	1·010	1·006	5
...	1·012	1·012	1·007	1·007	1·015	1·005	1·015	5
1·004	1·009	1·009	1·009	1·008	1·006	1·008	1·004	20
1·004	1·010	1·008	1·007	1·005	1·008	1·008	1·007	...

36r–37r.	37r–38r.	38r–39r.	39r–40r.	40r–41r.	41r–42r.	42r–43r.	43r–44r.	No. of Readings.
r	r	r	r	r	r	r	r	
1·003	1·004	1·006	1·009	1·001	...	...	...	5
1·002	0·999	1·011	1·004	1·001	...	...	...	5
1·005	1·007	1·005	1·004	1·002	1·002	1·005	1·007	20
1·004	1·004	1·007	1·005	1·002	1·002	1·005	1·007	...

These quantities referred to the general mean 1r·006 and converted into arc with the adopted value of 1r = 36″·97, assuming the correction to 36r = 0″·00, give the following apparent corrections :—

28r.	29r.	30r.	31r.	32r.	33r.	34r.	35r.	36r.
+0″·33	+0″·40	+0″·25	+0″·18	+0″·14	+0″·18	+0″·11	+0″·04	0″·00
37r.	**38r.**	**39r.**	**40r.**	**41r.**	**42r.**	**43r.**	**44r.**	
+0″·07	+0″·14	+0″·10	+0″·14	+0″·29	+0″·44	+0″·48	+0″·44	

D.

From Polar Stars. Assuming the correction to the value of $36^r = 0''·00$, the apparent corrections to the adopted value are :—

Name of Star.	28r.	29r.	30r.	31r.	32r.	33r.	34r.	35r.	36r.	37r.	38r.	39r.	40r.	41r.	42r.	43r.	44r.
λ Ursæ Minoris.....	″ ...	″ ...	″ 0·00	″ +0·10	″ +0·08	″ +0·24	″ −0·10	″ −0·30	″ 0·00	″ −0·17	″ −0·08	″ +0·18	″ −0·08	″ +0·05	″ +0·18	″ ...	″ ...
Groomb. 1119 S.P.	0·00	−0·21	...	...	...	...	...	...	0·00	−0·32	−0·20	−0·30	−0·40	−0·35	−0·24	−0·28	0·00
Bradley 3147.........	+0·32	+0·35	+0·30	−0·25	0·00	−0·09	+0·08	+0·30	0·00	−0·19	−0·34	−0·12	+0·16	+0·15	+0·18	+0·21	+0·08
Mean............	+0·16	+0·07	+0·15	−0·08	+0·04	+0·07	−0·01	0·00	0·00	−0·23	−0·21	−0·08	−0·11	−0·05	+0·04	−0·04	+0·04

Table of corrections to the adopted value of the Right Ascension Micrometer-Screw on the assumption that the screw is uniform and $1^r = 36''·97$, *derived from the preceding results.*

Method.	28r.	29r.	30r.	31r.	32r.	33r.	34r.	35r.	36r.	37r.	38r.	39r.	40r.	41r.	42r.	43r.	44r.
A.	″ +0·55	″ ...	″ ...	″ ...	″ ...	″ ...	″ ...	″ ...	″ 0·00	″ ...	″ ...	″ ...	″ ...	″ ...	″ ...	″ ...	″ +0·21
B.	+0·53	+0·53	+0·52	+0·42	+0·35	−0·03	−0·07	−0·10	0·00	+0·06	+0·31	+0·30	+0·29	+0·17	+0·26	+0·59	+0·36
C.	+0·33	+0·40	+0·25	+0·18	+0·14	+0·18	+0·11	+0·04	0·00	+0·07	+0·14	+0·10	+0·14	+0·29	+0·44	+0·48	+0·44
D.	+0·16	+0·07	+0·15	−0·08	+0·04	+0·07	−0·01	0·00	0·00	−0·23	−0·21	−0·08	−0·11	−0·05	+0·04	−0·04	+0·04

In view of the fact that the equivalent value of the screw is mainly required for reducing observations of circumpolar stars, special importance is attached to the results of method *D.*

Accordingly no correction for Error of Screw has been applied.

Apparent Correction to adopted Level-Errors, deduced from a Comparison of Reflexion and Direct Observations of Right Ascension, made in the Year 1906.

Name of Star.	Approx. N.P.D.	Approx. R.A.	Seconds of		R. – D.	Deduced Correction to Level-Error.	Number of Observations.		Weight.
			R.	D.			R.	D.	
	° ′	h m	s	s	s	″			
α Draconis S.P.	–25. 11	14. 1	57·170	57·110	+0·060	–0·42	1	2	1
Piazzi XI. 43 S.P.	–25. 10	11. 17	31·350	30·925	+0·425	–3·00	1	2	1
4 Ursæ Minoris S.P.	–12. 1	14. 9	10·420	11·335	–0·915	+2·22	1	2	1
Bradley 1634 S.P.	–11. 53	12. 7	59·510	59·830	–0·320	+0·76	1	2	1
Groombridge 1374	15. 50	7. 49	26·220	26·260	–0·040	–0·09	1	1	2
μ Herculis	62. 13	17. 42	56·070	56·149	–0·079	–0·57	1	9	3
υ Geminorum	62. 54	7. 30	22·660	22·695	–0·035	–0·26	1	2	2
α Coronæ	62. 58	15. 30	52·670	52·663	+0·007	+0·06	1	9	3
89 Herculis	63. 56	17. 51	47·300	47·350	–0·050	–0·37	1	2	2
110 Herculis	69. 32	18. 41	47·320	47·340	–0·020	–0·15	1	2	2
α Delphini	74. 24	20. 35	27·510	27·500	+0·010	+0·09	1	4	2
ζ Aquilæ	76. 16	19. 1	16·440	16·448	–0·008	–0·07	1	4	2
α Ophiuchi	77. 22	17. 30	45·350	45·390	–0·040	–0·37	1	4	2
μ Ceti	80. 15	2. 40	4·570	4·550	+0·020	+0·20	1	1	1
o Piscium	81. 17	1. 40	38·340	38·330	+0·010	+0·10	1	5	2
α Orionis	82. 36	5. 50	17·990	17·930	+0·060	+0·61	1	4	2
ν Piscium	84. 58	1. 36	44·740	44·800	–0·060	–0·64	1	5	2
β Ophiuchi	85. 23	17. 39	1·460	1·573	–0·113	–1·24	1	9	2
θ Serpentis	85. 54	18. 51	44·800	44·660	+0·140	+1·55	1	1	1
c Serpentis	92. 2	18. 24	59·970	59·970	0·000	0·00	1	2	1
δ Ophiuchi	93. 27	16. 9	37·800	37·683	+0·117	+1·55	1	3	2
6 Sextantis	93. 49	9. 46	42·120	41·950	+0·170	+2·45	1	1	1
2 Aquilæ	99. 8	18. 37	20·840	20·818	+0·022	+0·33	2	5	2
ε Aquarii	99. 49	20. 42	48·350	48·357	–0·007	–0·12	1	3	1
κ Orionis	99. 41	5. 43	29·285	29·150	+0·135	+2·14	2	1	1
δ Crateris	104. 17	11. 14	50·450	50·500	–0·050	–0·87	1	1	1

The weights used have been determined as follows:—

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

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

From 21 South Stars, Mean Correction to Level-Error + 0″·08, Weight 37.
„ 5 North Stars, „ „ „ – 0″·10, „ 6.

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

Factors for Instrumental-Errors—continued.

N.P.D.	Collimation.	Level.	Azimuth.	N.P.D.	Collimation.	Level.	Azimuth.
	$\frac{1}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Cos Z.D.}}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Sin Z.D.}}{15 \text{ Sin N.P.D.}}$		$\frac{1}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Cos Z.D.}}{15 \text{ Sin N.P.D.}}$	$\frac{\text{Sin Z.D.}}{15 \text{ Sin N.P.D.}}$
° ′				° ′			
35. 0	+0·116	+0·116	−0·007	81. 0	+0·067	+0·050	+0·045
36. 0	+0·113	+0·113	−0·005	82. 0	+0·067	+0·049	+0·046
37. 0	+0·111	+0·111	−0·003	83. 0	+0·067	+0·048	+0·047
38. 0	+0·108	+0·108	−0·001	84. 0	+0·067	+0·047	+0·048
39. 0	+0·106	+0·106	+0·001	85. 0	+0·067	+0·046	+0·048
40. 0	+0·104	+0·104	+0·003	86. 0	+0·067	+0·045	+0·049
41. 0	+0·102	+0·101	+0·004	87. 0	+0·067	+0·044	+0·050
42. 0	+0·100	+0·099	+0·006	88. 0	+0·067	+0·043	+0·051
43. 0	+0·098	+0·097	+0·007	89. 0	+0·067	+0·042	+0·052
44. 0	+0·096	+0·096	+0·009	90. 0	+0·067	+0·041	+0·052
45. 0	+0·094	+0·094	+0·011	91. 0	+0·067	+0·040	+0·053
46. 0	+0·093	+0·092	+0·012	92. 0	+0·067	+0·040	+0·054
47. 0	+0·091	+0·090	+0·013	93. 0	+0·067	+0·039	+0·054
48. 0	+0·090	+0·088	+0·015	94. 0	+0·067	+0·038	+0·055
49. 0	+0·088	+0·087	+0·016	95. 0	+0·067	+0·037	+0·056
50. 0	+0·087	+0·085	+0·017	96. 0	+0·067	+0·036	+0·057
51. 0	+0·086	+0·084	+0·018	97. 0	+0·067	+0·035	+0·057
52. 0	+0·085	+0·082	+0·020	98. 0	+0·067	+0·034	+0·058
53. 0	+0·083	+0·081	+0·021	99. 0	+0·067	+0·033	+0·059
54. 0	+0·082	+0·080	+0·022	100. 0	+0·068	+0·032	+0·060
55. 0	+0·081	+0·078	+0·023	101. 0	+0·068	+0·031	+0·060
56. 0	+0·080	+0·077	+0·024	102. 0	+0·068	+0·030	+0·061
57. 0	+0·080	+0·075	+0·025	103. 0	+0·068	+0·029	+0·062
58. 0	+0·079	+0·074	+0·026	104. 0	+0·069	+0·028	+0·063
59. 0	+0·078	+0·073	+0·027	105. 0	+0·069	+0·027	+0·063
60. 0	+0·077	+0·072	+0·028	106. 0	+0·069	+0·027	+0·064
61. 0	+0·076	+0·070	+0·029	107. 0	+0·070	+0·026	+0·065
62. 0	+0·076	+0·069	+0·030	108. 0	+0·070	+0·025	+0·066
63. 0	+0·075	+0·068	+0·031	109. 0	+0·071	+0·024	+0·066
64. 0	+0·074	+0·067	+0·032	110. 0	+0·071	+0·023	+0·067
65. 0	+0·073	+0·066	+0·033	111. 0	+0·072	+0·022	+0·068
66. 0	+0·073	+0·065	+0·034	112. 0	+0·072	+0·021	+0·069
67. 0	+0·072	+0·064	+0·035	113. 0	+0·073	+0·020	+0·070
68. 0	+0·072	+0·063	+0·035	114. 0	+0·073	+0·018	+0·071
69. 0	+0·071	+0·061	+0·036	115. 0	+0·074	+0·017	+0·072
70. 0	+0·071	+0·060	+0·037	116. 0	+0·075	+0·016	+0·072
71. 0	+0·071	+0·059	+0·038	117. 0	+0·075	+0·015	+0·073
72. 0	+0·070	+0·058	+0·039	118. 0	+0·076	+0·014	+0·074
73. 0	+0·070	+0·057	+0·039	119. 0	+0·076	+0·013	+0·075
74. 0	+0·069	+0·056	+0·040	120. 0	+0·077	+0·012	+0·076
75. 0	+0·069	+0·055	+0·041	121. 0	+0·078	+0·011	+0·077
76. 0	+0·069	+0·054	+0·042	122. 0	+0·079	+0·009	+0·078
77. 0	+0·068	+0·053	+0·043	123. 0	+0·080	+0·008	+0·079
78. 0	+0·068	+0·053	+0·043	124. 0	+0·080	+0·007	+0·080
79. 0	+0·068	+0·052	+0·044	125. 0	+0·081	+0·005	+0·081
80. 0	+0·068	+0·051	+0·045	126. 0	+0·082	+0·004	+0·082
81. 0	+0·067	+0·050	+0·045				

Assumed Mean Right Ascensions of Clock Stars and Circumpolar Stars, with the Corrections to the R.A. of the Nautical Almanac, for 1906·0.

Star's Name.	Mag.	Assumed Mean R.A. 1906·0.	Correction to N.A.	Approx. N.P.D.	Star's Name.	Mag.	Assumed Mean R.A. 1906·0.	Correction to N.A.	Approx. N.P.D.
		h m s	s	° ′			h m s	s	° ′
α Andromedæ	2·1	0. 3. 31·579	− 0·014	61. 26	α Orionis	1·4	5. 50. 4·965	+ 0·008	82. 37
γ Pegasi	3·0	0. 8. 23·647	+ 0·001	75. 20	1 Geminorum	4·3	5. 58. 24·369	− 0·015	66. 44
ι Ceti	3·6	0. 14. 38·324	− 0·007	99. 21	ν Orionis	4·4	6. 2. 12·273	− 0·048	75. 13
44 Piscium	5·8	0. 20. 35·016	− 0·003	88. 35	η Geminorum	3·2	6. 9. 12·210	− 0·039	67. 28
12 Ceti	6·2	0. 25. 14·501	− 0·011	94. 29	μ Geminorum	3·2	6. 17. 16·430	− 0·018	67. 26
ε Andromedæ	4·6	0. 33. 35·122	− 0·031	61. 12	β Canis Majoris	2·0	6. 18. 33·586	− 0·012	107. 55
β Ceti	2·1	0. 38. 52·311	+ 0·006	108. 30	ν Geminorum	4·0	6. 23. 22·920	+ 0·008	69. 44
δ Piscium	4·6	0. 43. 48·252	− 0·011	82. 56	γ Geminorum	2·0	6. 32. 16·927	+ 0·002	73. 31
20 Ceti	5·0	0. 48. 12·208	+ 0·037	91. 39	ξ Geminorum	3·4	6. 40. 0·829	− 0·014	77. 0
μ Andromedæ	3·9	0. 51. 31·895	− 0·045	52. 1	θ Canis Majoris	4·2	6. 49. 49·337	− 0·043	101. 55
ε Piscium	4·5	0. 58. 3·811	+ 0·001	82. 37	ε Canis Majoris	1·5	6. 54. 55·871	− 0·015	118. 51
β Andromedæ	2·2	1. 4. 27·917	+ 0·002	54. 53	Cephei 51	5·3	6. 56. 41·793	+ 0·394	2. 48
ζ^1 Piscium	4·2	1. 8. 49·117	− 0·033	82. 55	ζ Geminorum	3·7	6. 58. 32·051	− 0·028	69. 17
θ Ceti	3·8	1. 19. 19·472	+ 0·003	98. 40	γ Canis Majoris	4·1	6. 59. 30·326	− 0·031	105. 30
Polaris	2·2	1. 25. 8·364	+ 0·147	1. 12	51 Geminorum	5·4	7. 7. 58·454	− 0·033	73. 41
η Piscium	3·7	1. 26. 27·073	− 0·004	75. 8	δ Geminorum	3·2	7. 14. 30·596	− 0·035	67. 51
ν Piscium	4·7	1. 36. 32·285	− 0·019	84. 59	β Canis Minoris	3·1	7. 22. 3·229	− 0·009	81. 31
ο Piscium	4·4	1. 40. 25·698	− 0·008	81. 19	Castor	2·7	7. 28. 36·253	+ 0·021	57. 54
β Arietis	2·8	1. 49. 26·700	+ 0·027	69. 39	Procyon	0·5	7. 34. 22·926	+ 0·020	84. 32
α Arietis	2·0	2. 1. 52·307	+ 0·007	66. 59	Pollux	1·1	7. 39. 33·940	+ 0·009	61. 45
ξ^1 Ceti	4·4	2. 8. 0·952	− 0·016	81. 36	ξ Argûs	3·4	7. 45. 20·431	− 0·026	114. 37
67 Ceti	5·5	2. 12. 17·648	+ 0·010	96. 51	6 Cancri	5·0	7. 57. 44·794	− 0·046	61. 57
ξ^2 Ceti	4·4	2. 23. 9·574	+ 0·003	81. 58	ρ Argûs	2·9	8. 3. 32·437	+ 0·001	114. 2
ν Ceti	4·9	2. 30. 56·396	+ 0·022	84. 49	Groomb. 1119	7·1	8. 4. 29·416	− 0·213	1. 5
δ Ceti	4·1	2. 34. 39·784	− 0·022	90. 5	β Cancri	3·8	8. 11. 25·112	+ 0·012	80. 31
γ^2 Ceti	3·0	2. 38. 25·731	+ 0·016	87. 10	d^1 Cancri	5·9	8. 17. 58·976	− 0·006	71. 22
σ Arietis	5·5	2. 46. 18·044	− 0·001	75. 18	η Cancri	5·5	8. 27. 16·477	− 0·009	69. 14
ε Arietis	4·6	2. 53. 50·063	0·000	69. 2	γ Cancri	4·8	8. 37. 50·898	− 0·006	68. 12
α Ceti	2·7	2. 57. 21·862	+ 0·001	86. 17	ε Hydræ	3·8	8. 41. 47·953	− 0·008	83. 14
δ Arietis	4·5	3. 6. 15·085	− 0·023	70. 38	α Cancri	4·3	8. 53. 20·846	− 0·013	77. 47
τ^1 Arietis	5·2	3. 15. 47·869	− 0·014	69. 11	κ Cancri	5·0	9. 2. 39·423	− 0·018	78. 57
ο Tauri	3·8	3. 19. 45·186	− 0·002	81. 18	83 Cancri	6·6	9. 13. 44·202	− 0·035	71. 54
f Tauri	4·3	3. 25. 40·878	− 0·032	77. 23	α Hydræ	2·0	9. 22. 58·117	+ 0·002	98. 15
ε Eridani	3·7	3. 28. 30·051	− 0·015	99. 47	ξ Leonis	5·2	9. 26. 52·838	+ 0·001	78. 17
11 Tauri	6·5	3. 35. 9·296	− 0·014	64. 58	ο Leonis	3·8	9. 36. 8·103	− 0·008	79. 41
δ Eridani	3·7	3. 38. 44·658	− 0·036	100. 5	ε Leonis	3·1	9. 40. 31·074	+ 0·008	65. 48
η Tauri	3·0	3. 41. 53·674	+ 0·002	66. 11	μ Leonis	4·1	9. 47. 25·212	+ 0·052	63. 33
γ^1 Eridani	3·0	3. 53. 38·587	− 0·021	103. 47	π Leonis	5·0	9. 55. 14·822	0·000	81. 30
A^1 Tauri	4·4	3. 59. 8·146	− 0·023	68. 10	Regulus	1·4	10. 3. 22·057	+ 0·020	77. 34
ω^1 Tauri	5·8	4. 3. 41·241	− 0·051	70. 38	γ^1 Leonis	2·0	10. 14. 47·533	+ 0·028	69. 41
o^1 Eridani	4·1	4. 7. 16·548	− 0·043	97. 5	μ Hydræ	4·1	10. 21. 32·610	− 0·022	106. 21
γ Tauri	3·9	4. 14. 26·539	− 0·015	74. 36	ρ Leonis	4·0	10. 27. 51·774	− 0·004	80. 13
ε Tauri	3·7	4. 23. 7·566	− 0·017	71. 2	34 Sextantis	6·9	10. 37. 46·285	− 0·013	85. 56
Aldebaran	1·0	4. 30. 31·537	+ 0·014	73. 41	*l* Leonis	5·3	10. 44. 19·051	− 0·011	78. 57
τ Tauri	4·4	4. 36. 36·097	− 0·015	67. 13	*d* Leonis	5·0	10. 55. 42·410	+ 0·022	85. 53
μ Eridani	4·3	4. 40. 48·070	− 0·037	93. 26	χ Leonis	4·7	11. 0. 10·138	− 0·008	82. 9
ι Aurigæ	2·7	4. 50. 52·204	− 0·015	56. 59	δ Leonis	2·8	11. 9. 6·656	− 0·015	68. 58
ε Leporis	3·3	5. 1. 28·878	− 0·012	112. 30	δ Crateris	3·9	11. 14. 38·419	+ 0·012	104. 16
Rigel	0·3	5. 10. 1·198	+ 0·010	98. 19	τ Leonis	5·1	11. 23. 6·212	0·000	86. 38
β Tauri	1·9	5. 20. 20·931	− 0·003	61. 28	υ Leonis	4·5	11. 32. 8·150	− 0·004	90. 18
δ Orionis	2·4	5. 27. 12·233	+ 0·001	90. 22	β Leonis	2·2	11. 44. 15·961	− 0·003	74. 54
α Leporis	2·7	5. 28. 35·004	− 0·051	107. 53	β Virginis	3·7	11. 45. 47·937	+ 0·003	87. 42
ε Orionis	1·8	5. 31. 26·588	− 0·010	91. 16	π Virginis	4·4	11. 56. 3·389	+ 0·026	82. 52
α Columbæ	2·7	5. 36. 14·683	− 0·030	124. 7	ο Virginis	4·3	12. 0. 25·290	+ 0·011	80. 45
κ Orionis	2·2	5. 43. 17·879	− 0·014	99. 42	ε Corvi	3·1	12. 5. 17·317	− 0·002	112. 6

NOTE.—The Right Ascensions are deduced from the "Standard Mean Right Ascensions of Clock Stars for 1900·0 based on Twelve-hour Groups" which will be printed at the end of the *Introduction to the Second Nine-Year Catalogue* for 1900. The values of the Precession and Proper Motions are taken from Prof. Newcomb's *Catalogue of Fundamental Stars.*

Assumed Mean Right Ascensions of Clock Stars and Circumpolar Stars, with the Corrections to the R.A. of the Nautical Almanac, for 1906·0—continued.

Star's Name.	Mag.	Assumed Mean R.A. 1906·0.	Correction to N.A.	Approx. N.P.D.	Star's Name.	Mag.	Assumed Mean R.A. 1906·0.	Correction to N.A.	Approx. N.P.D.
		h m s	s	° ′			h m s	s	° ′
Bradley 1672....	6·3	12. 14. 25·187	+ 0·460	1. 47	λ Sagittarii	3·1	18. 22. 10·162	− 0·019	115. 28
η Virginis.........	4·0	12. 15. 5·792	− 0·014	90. 9	α Lyræ...........	0·2	18. 33. 45·331	− 0·019	51. 18
δ^2 Corvi	3·0	12. 24. 59·923	− 0·034	106. 0	2 Aquilæ.........	4·8	18. 37. 7·633	− 0·031	99. 9
β Corvi...........	2·8	12. 29. 26·839	+ 0·027	112. 53	β^1 Lyræ..........	3·4	18. 46. 36·570	+ 0·013	56. 45
ρ Virginis.........	5·1	12. 37. 7·624	− 0·015	79. 15	ε Aquilæ	4·1	18. 55. 21·378	+ 0·019	75. 4
35 Virginis	6·9	12. 43. 4·230	− 0·004	85. 55	ζ Aquilæ	3·1	19. 1. 5·397	+ 0·025	76. 17
31 Comæ.........	5·0	12. 47. 7·264	+ 0·024	61. 57	ψ Sagittarii	5·2	19. 9. 46·674	+ 0·030	115. 25
δ Virginis.........	3·7	12. 50. 52·093	+ 0·012	86. 6	ω Aquilæ.........	5·1	19. 13. 24·272	+ 0·011	78. 34
ε Virginis.........	3·0	12. 57. 29·875	+ 0·013	78. 32	λ Ursæ Minoris..	6·5	19. 15. 38·324	+ 0·434	1. 0
θ Virginis.........	4·4	13. 5. 4·902	− 0·001	95. 2	δ Aquilæ	3·5	19. 20. 45·559	+ 0·015	87. 4
Spica	1·2	13. 20. 14·379	+ 0·012	100. 40	α Vulpeculæ......	4·7	19. 24. 47·649	+ 0·025	65. 32
ζ Virginis	3·5	13. 29. 54·155	+ 0·017	90. 7	μ Aquilæ..........	4·7	19. 29. 29·860	− 0·010	82. 49
m Virginis........	5·3	13. 36. 40·620	+ 0·012	98. 14	h^2 Sagittarii......	4·6	19. 30. 59·311	+ 0·040	115. 5
τ Boötis...........	4·5	13. 42. 47·733	+ 0·022	72. 4	e^1 Sagittarii	5·6	19. 35. 20·341	+ 0·003	106. 31
η Boötis...........	2·9	13. 50. 12·540	− 0·004	71. 8	γ Aquilæ.........	2·8	19. 41. 47·464	+ 0·018	79. 37
τ Virginis.........	4·4	13. 56. 51·699	− 0·007	88. 0	α Aquilæ.........	1·0	19. 46. 11·836	+ 0·011	81. 23
94 Virginis	6·8	14. 1. 19·020	+ 0·016	98. 27	β Aquilæ.........	4·0	19. 50. 41·770	+ 0·010	83. 50
κ Virginis.........	4·3	14. 7. 52·784	− 0·011	99. 50	c Sagittarii	4·7	19. 56. 52·803	+ 0·024	117. 58
Arcturus	0·0	14. 11. 22·423	+ 0·012	70. 20	θ Aquilæ	3·4	20. 6. 27·330	+ 0·016	91. 6
f Boötis...........	5·4	14. 22. 5·013	+ 0·001	70. 21	α^2 Capricorni.....	3·8	20. 12. 50·414	+ 0·006	102. 50
ρ Boötis...........	3·6	14. 27. 46·755	− 0·001	59. 13	β Capricorni.....	3·4	20. 15. 43·876	− 0·013	105. 5
ϵ^2 Boötis..........	3·0	14. 40. 52·930	+ 0·018	62. 32	ρ Capricorni......	5·0	20. 23. 30·027	+ 0·012	108. 7
α Libræ...........	3·0	14. 45. 40·556	− 0·006	105. 39	ε Delphini........	4·1	20. 28. 43·338	− 0·008	79. 1
ξ^2 Libræ..........	5·8	14. 51. 39·946	+ 0·016	101. 2	α Delphini	4·0	20. 35. 16·320	− 0·013	74. 25
ψ Boötis..........	4·5	15. 0. 25·071	+ 0·010	62. 41	ε Aquarii.........	3·8	20. 42. 35·330	+ 0·021	99. 50
ι^1 Libræ	4·9	15. 6. 51·637	− 0·007	109. 26	μ Aquarii	4·8	20. 47. 35·096	+ 0·009	99. 20
Groomb. 2283 ...	7·1	15. 7. 18·539	− 0·075	2. 24	32 Vulpeculæ....	5·1	20. 50. 33·223	+ 0·003	62. 18
β Libræ	2·7	15. 11. 56·817	− 0·008	99. 2	θ Capricorni......	4·3	21. 0. 39·873	+ 0·005	107. 36
o^2 Libræ	6·3	15. 17. 47·092	− 0·001	104. 48	ζ Cygni	3·5	21. 8. 56·119	+ 0·014	60. 10
ζ^1 Libræ..........	6·2	15. 22. 57·186	− 0·008	106. 23	α Equulei.........	4·1	21. 11. 7·520	+ 0·007	85. 8
α Coronæ	2·4	15. 30. 42·472	+ 0·013	62. 58	ι Capricorni	4·4	21. 17. 0·840	− 0·021	107. 14
α Serpentis	2·7	15. 39. 38·241	+ 0·020	83. 17	Groomb. 3548 ...	7·4	21. 18. 25·669	..	3. 21
ε Serpentis.......	3·7	15. 46. 7·763	+ 0·008	85. 14	β Aquarii.........	3·1	21. 26. 36·691	+ 0·010	95. 59
γ Serpentis.......	4·0	15. 52. 6·633	− 0·009	74. 2	ξ Aquarii.........	4·8	21. 32. 44·925	− 0·009	98. 17
β^1 Scorpii..........	2·0	15. 59. 58·148	+ 0·021	109. 33	ε Pegasi...........	2·4	21. 39. 34·168	+ 0·023	80. 33
δ Ophiuchi.......	2·8	16. 9. 25·095	− 0·008	93. 27	δ Capricorni......	3·0	21. 41. 51·248	+ 0·010	106. 33
γ Herculis........	3·8	16. 17. 46·382	+ 0·004	70. 38	16 Pegasi.........	5·0	21. 48. 47·071	− 0·001	64. 31
Antares...........	1·1	16. 23. 38·506	− 0·007	116. 13	α Aquarii	3·2	22. 0. 57·401	+ 0·010	90. 47
λ Ophiuchi.......	4·0	16. 26. 10·281	− 0·013	87. 49	ι Pegasi...........	4·0	22. 2. 38·066	− 0·007	65. 7
ζ Ophiuchi.......	2·8	16. 31. 58·884	− 0·005	100. 23	θ Aquarii.........	4·3	22. 11. 52·477	+ 0·024	98. 15
ζ Herculis	3·1	16. 37. 44·570	+ 0·026	58. 14	γ Aquarii.........	4·1	22. 16. 48·102	+ 0·008	91. 52
κ Ophiuchi.......	3·4	16. 53. 13·104	+ 0·008	80. 29	σ Aquarii.........	4·8	22. 25. 40·404	− 0·035	101. 10
ε Herculis........	4·0	16. 56. 41·569	+ 0·004	58. 56	η Aquarii	4·2	22. 30. 31·593	+ 0·006	90. 36
η Ophiuchi.......	2·6	17. 4. 59·158	+ 0·017	105. 37	ζ Pegasi	3·6	22. 36. 46·413	− 0·008	79. 40
α^1 Herculis	3·1	17. 10. 21·651	− 0·001	75. 30	μ Pegasi..........	3·7	22. 45. 27·917	− 0·010	65. 54
θ Ophiuchi	3·4	17. 16. 14·139	+ 0·015	114. 54	λ Aquarii	3·8	22. 47. 42·681	+ 0·011	98. 5
σ Ophiuchi	4·4	17. 21. 51·023	+ 0·001	85. 47	Fomalhaut	1·3	22. 52. 27·547	+ 0·036	120. 7
α Ophiuchi.......	2·2	17. 30. 34·242	+ 0·005	77. 22	α Pegasi..........	2·6	23. 0. 4·666	+ 0·011	75. 18
β Ophiuchi	2·9	17. 38. 49·717	− 0·005	85. 24	γ Piscium.........	3·8	23. 12. 17·540	+ 0·011	87. 14
μ Herculis........	3·5	17. 42. 46·744	− 0·013	62. 13	κ Piscium.........	5·0	23. 22. 6·819	− 0·013	89. 16
89 Herculis......	5·6	17. 51. 37·643	− 0·041	63. 56	Bradley 3147 ...	5·6	23. 27. 47·674	+ 0·950	3. 13
δ Ursæ Minoris..	4·3	18. 2. 36·170	+ 0·396	3. 23	ι Piscium.........	4·3	23. 35. 6·908	+ 0·010	84. 53
72 Ophiuchi......	3·8	18. 2. 53·595	+ 0·023	80. 27	δ Sculptoris.......	4·6	23. 44. 1·911	+ 0·082	118. 39
μ Sagittarii.......	4·1	18. 8. 8·507	+ 0·021	111. 5	ω Piscium.........	4·2	23. 54. 29·025	0·000	83. 39
η Serpentis.......	3·4	18. 16. 26·743	+ 0·025	92. 55	2 Ceti	4·6	23. 58. 55·521	+ 0·013	107. 52

The correction to the R.A. of Procyon for the effect of orbital motion from 1900 (the epoch of the *Nine-Year Catalogue*) to 1906·0 is −0s·059. This correction is derived from Prof. Auwers' "Elements" (*Astronomische Nachrichten*, Nos. 1371, 1372, 1373).

The Right Ascensions of the *Nautical Almanac* for 1906·0 are derived from Prof. Newcomb's *Catalogue of Fundamental Stars.*

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

The Observers, in order of seniority, are :—

S E, A C, B, W B, H F, W, J S, W S, P M, E, R C, S D, J, S, B E, H A, G C.

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, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Sept.	29	3	B	S E	+ 0·06
Dec.	5	1	B	S E	+ 0·11
May	29	3	W	S E	− 0·15
May	4	0	J S	S E	− 0·34
June	7	2	J S	S E	− 0·34
,,	11	2	J S	S E	− 0·33
,,	18	4	J S	S E	− 0·29*
,,	25	1	S E	J S	− 0·26
July	5	1	J S	S E	− 0·26
Sept.	29	2	J S	S E	− 0·19
Oct.	8	10	S E	J S	− 0·19
Nov.	5	8	S E	J S	− 0·28
Mar.	29	4	R C	S E	− 0·02
Dec.	5	7	S E	R C	+ 0·16
Sept.	25	2	S E	J	− 0·46*
June	7	3	S E	S	+ 0·20
Sept.	25	4	S E	S	+ 0·28*
June	7	2	S E	B E	+ 0·05
July	5	0	S E	B E	+ 0·03
May	29	0	S E	H A	− 0·23
June	7	1	H A	S E	− 0·08
July	31	4	H A	S E	− 0·21

Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Nov.	5	3	H A	S E	− 0·22
July	5	4	G C	S E	− 0·16
June	6	3	W	B	0·00
Aug.	1	3	W	B	− 0·11
Sept.	5	6	B	W	− 0·08
,,	27	0	W	B	− 0·11
,,	28	4	B	W	− 0·06
Mar.	7	0	B	J S	− 0·24
May	13	8	B	J S	− 0·24
June	20	0	J S	B	− 0·32
Sept.	5	2	J S	B	− 0·19
,,	26	2	J S	B	− 0·21
,,	29	1	B	J S	− 0·25
Oct.	24	3	B	J S	− 0·26
Oct.	24	1	B	P M	+ 0·01
June	6	6	B	E	+ 0·16
Sept.	28	2	B	E	+ 0·04
Nov.	27	0	E	B	+ 0·06
Sept.	5	4	R C	B	+ 0·04
Dec.	5	9	B	R C	+ 0·05
June	26	2	B	S D	+ 0·02
Aug.	8	2	S D	B	+ 0·02

Observations for Personal Equations—Chronographic—continued.

Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Oct.	10	10	B	S D	+ 0·07
Sept.	27	2	S	B	− 0·01
June	6	0	H A	B	− 0·10
,,	20	1	B	H A	− 0·15
Oct.	10	1	B	G C	− 0·04
Aug.	3	0	W	W B	+ 0·10
May	8	0	W B	J S	− 0·17
Dec.	4	0	W B	P M	+ 0·15*
May	8	4	W B	S D	+ 0·12
Aug.	2	7	S D	W B	+ 0·17
Aug.	3	2	W B	J	− 0·37
,,	7	2	W B	J	− 0·44
May	8	4	S	W B	+ 0·10
Aug.	7	2	H A	W B	− 0·14
Apr.	27	1	J S	H F	− 0·17
Dec.	7	1	J	H F	− 0·35
May	12	8	J S	W	− 0·15*
Sept.	5	8	J S	W	− 0·11
Dec.	3	11	W	J S	− 0·27*
Feb.	14	8	W	E	+ 0·08
Mar.	6	3	W	E	+ 0·04
June	6	8	W	E	+ 0·16
Aug.	31	2	E	W	+ 0·09
Sept.	22	1	E	W	+ 0·04
,,	28	2	E	W	+ 0·10
Sept.	5	11	R C	W	+ 0·12

Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Oct.	25	1	W	R C	+ 0·06
Feb.	12	4	W	S D	+ 0·02
Aug.	3	2	W	J	− 0·47
May	12	5	S	W	+ 0·14
Aug.	29	1	W	S	+ 0·05
Sept	27	1	S	W	+ 0·10
Oct.	25	1	S	W	+ 0·18
May	29	4	W	H A	− 0·08
June	6	2	W	H A	− 0·10
,,	30	2	H A	W	− 0·24
Aug.	29	1	W	H A	− 0·18
July	16	3	G C	W	− 0·12
Mar.	31	0	J S	P M	+ 0·32
June	22	2	P M	J S	+ 0·25
Oct.	24	2	P M	J S	+ 0·27
Oct.	19	1	J S	W S	+ 0·43
,,	27	3	J S	W S	+ 0·45
Nov.	2	0	W S	J S	+ 0·35*
Dec.	21	7	W S	J S	+ 0·39
Jan.	4	0	J S	E	+ 0·26*
May	3	6	E	J S	+ 0·38
Dec.	21	4	E	J S	+ 0·39
Mar.	5	1	R C	J S	+ 0·22
,,	21	1	R C	J S	+ 0·29
May	28	1	J S	R C	+ 0·36
June	5	1	R C	J S	+ 0·31

Observations for Personal Equations—Chronographic—continued.

Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
Sept.	5	3	R C	J S	+ 0·23
,,	10	11	R C	J S	+ 0·23
Oct.	11	2	R C	J S	+ 0·23
,,	17	1	J S	R C	+ 0·33
,,	19	3	R C	J S	+ 0·29
,,	23	0	R C	J S	+ 0·25
,,	27	5	J S	R C	+ 0·33
Nov.	22	4	R C	J S	+ 0·21
Dec.	10	0	R C	J S	+ 0·29
,,	12	7	J S	R C	+ 0·26
,,	14	2	J S	R C	+ 0·30
,,	21	8	J S	R C	+ 0·31
Jan.	8	3	S D	J S	+ 0·36
May	8	4	J S	S D	+ 0·29
Mar.	9	2	J S	J	− 0·24*
May	11	8	J S	J	− 0·35
Sept.	6	8	J	J S	− 0·22
May	8	4	S	J S	+ 0·27
,,	11	0	S	J S	+ 0·20
,,	12	3	J S	S	+ 0·29*
,,	28	1	J S	S	+ 0·42
June	7	5	J S	S	+ 0·54
Oct.	23	0	S	J S	+ 0·38*
Nov.	10	9	J S	S	+ 0·20
Mar.	17	1	J S	B E	+ 0·32
May	11	1	J S	B E	+ 0·30
June	7	4	J S	B E	+ 0·39
July	5	1	J S	B E	+ 0·29
Aug.	28	0	B E	J S	+ 0·34
June	5	4	H A	J S	+ 0·13
,,	7	1	J S	H A	+ 0·26

Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s
June	12	1	J S	H A	+ 0·13
,,	20	1	J S	H A	+ 0·17
,,	22	2	H A	J S	+ 0·15
,,	27	0	H A	J S	+ 0·10
July	3	0	H A	J S	+ 0·08
Aug.	30	2	H A	J S	+ 0·05
Sept.	1	1	H A	J S	+ 0·11
,,	3	9	J S	H A	+ 0·12
Oct.	19	1	J S	H A	+ 0·10
Nov.	5	11	H A	J S	+ 0·06
,,	22	2	H A	J S	− 0·02
Dec.	12	2	H A	J S	− 0·05
,,	14	0	H A	J S	− 0·05
,,	21	3	H A	J S	− 0·02
July	3	3	J S	G C	+ 0·20
,,	5	3	G C	J S	+ 0·10
,,	17	3	G C	J S	+ 0·20
Dec.	21	3	W S	E	0·00
Oct.	19	4	R C	W S	− 0·14
,,	27	1	W S	R C	− 0·12
Oct.	19	0	H A	W S	− 0·33
Dec.	21	4	W S	H A	− 0·41
Mar.	28	0	E	P M	+ 0·15
June	22	0	H A	P M	− 0·10
July	25	3	P M	G C	− 0·03
May	7	3	S	E	− 0·09
July	4	4	S	E	− 0·05
Nov.	10	12	S	E	− 0·11
Sept.	7	8	B E	E	− 0·08
May	31	3	H A	E	− 0·28

Observations for Personal Equations—Chronographic—continued.

Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.	Day, 1906.		Interval between Mean of Groups of Clock Stars.	Observers.		Excess of Clock Slow by Junior Observer.
		h			s			h			s
June	6	6	H A	E	− 0·26	May	11	8	S	J	+ 0·55
July	4	2	H A	E	− 0·19	Aug.	16	6	J	S	+ 0·58
Dec.	1	3	H A	E	− 0·42	Sept.	25	2	J	S	+ 0·74
,,	21	1	E	H A	− 0·41						
						May	11	6	B E	J	+ 0·65
July	18	4	G C	E	− 0·18						
						Aug.	7	4	H A	J	+ 0·30
May	28	1	R C	S	+ 0·06						
						July	23	1	J	G C	+ 0·35
Aug.	14	3	S	R C	0·00*						
						Apr.	28	3	S	B E	− 0·05*
Oct.	23	0	S	R C	+ 0·13*						
,,	25	2	S	R C	+ 0·12	May	11	2	S	B E	+ 0·10
June	5	2	H A	R C	− 0·18	June	7	1	B E	S	− 0·15
Oct.	19	3	R C	H A	− 0·19	June	7	4	H A	S	− 0·28
Nov.	22	1	R C	H A	− 0·23	July	4	3	S	H A	− 0·14
Dec.	12	9	H A	R C	− 0·31	Aug.	15	1	H A	S	− 0·33
,,	14	3	H A	R C	− 0·35	,,	29	0	H A	S	− 0·23
,,	21	11	H A	R C	− 0·33						
						Aug.	4	0	G C	S	− 0·14
May	8	8	S	S D	− 0·02						
						June	7	3	H A	B E	− 0·13
Aug.	15	3	S	S D	+ 0·05						
						July	5	5	G C	B E	− 0·19
Aug.	15	4	H A	S D	− 0·28						
						July	3	3	H A	G C	+ 0·12
Oct.	10	9	G C	S D	− 0·11	,,	14	3	G C	H A	− 0·02

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 S E.

		s
4 (S E − B)	= −	0·34
2 (S E − W)	= +	0·30
17 (S E − J S)	= +	4·67
4 (S E − R C)	= −	0·28
1 (S E − J)	= +	0·46
3 (S E − S)	= −	0·68
4 (S E − B E)	= −	0·16
8 (S E − H A)	= +	1·48
2 (S E − G C)	= +	0·32

For A C.

		s
1 (A C − E)	= +	0·13

For B.

		s
4 (B − S E)	= +	0·34
10 (B − W)	= +	0·72
14 (B − J S)	= +	3·42
2 (B − P M)	= −	0·02
6 (B − E)	= −	0·52
2 (B − R C)	= −	0·18
6 (B − S D)	= −	0·22
2 (B − S)	= +	0·02
4 (B − H A)	= +	0·50
2 (B − G C)	= +	0·08

For W B.

		s
2 (W B − W)	= −	0·20
2 (W B − J S)	= +	0·34
1 (W B − P M)	= −	0·15
4 (W B − S D)	= −	0·58
4 (W B − J)	= +	1·62
2 (W B − S)	= −	0·20
2 (W B − H A)	= +	0·28

For H F.

		s
2 (H F − J S)	= +	0·34
2 (H F − J)	= +	0·70

For W.

		s
2 (W − S E)	= −	0·30
10 (W − B)	= −	0·72
2 (W − W B)	= +	0·20
4 (W − J S)	= +	0·64
12 (W − E)	= −	1·02
4 (W − R C)	= −	0·36
2 (W − S D)	= −	0·04
2 (W − J)	= +	0·94
8 (W − S)	= −	0·94
8 (W − H A)	= +	1·20
2 (W − G C)	= +	0·24

For J S.

		s
17 (J S − S E)	= −	4·67
14 (J S − B)	= −	3·42
2 (J S − W B)	= −	0·34
2 (J S − H F)	= −	0·34
4 (J S − W)	= −	0·64
7 (J S − W S)	= −	2·89
6 (J S − P M)	= −	1·68
5 (J S − E)	= −	1·80
32 (J S − R C)	= −	8·88
4 (J S − S D)	= −	1·30
5 (J S − J)	= +	1·38
12 (J S − S)	= −	3·93
10 (J S − B E)	= −	3·28
32 (J S − H A)	= −	2·64
6 (J S − G C)	= −	1·00

For W S.

		s
7 (W S − J S)	= +	2·89
2 (W S − E)	=	0·00
4 (W S − R C)	= +	0·52
4 (W S − H A)	= +	1·48

For P M.

		s
2 (P M − B)	= +	0·02
1 (P M − W)	= +	0·15
6 (P M − J S)	= +	1·68
2 (P M − E)	= −	0·30
2 (P M − H A)	= +	0·20
2 (P M − G C)	= +	0·06

For E.

6 (E – B)	= +	s 0·52
12 (E – W)	= +	1·02
5 (E – J S)	= +	1·80
2 (E – W S)	=	0·00
2 (E – P M)	= +	0·30
6 (E – S)	= +	0·50
2 (E – B E)	= +	0·16
10 (E – H A)	= +	3·12
2 (E – G C)	= +	0·36

For R C.

4 (R C – S E)	= +	s 0·28
2 (R C – B)	= +	0·18
4 (R C – W)	= +	0·36
32 (R C – J S)	= +	8·88
4 (R C – W S)	= –	0·52
6 (R C – S)	= –	0·49
12 (R C – H A)	= +	3·18

For S D.

6 (S D – B)	= +	s 0·22
4 (S D – W B)	= +	0·58
2 (S D – W)	= +	0·04
4 (S D – J S)	= +	1·30
4 (S D – S)	= –	0·06
2 (S D – H A)	= +	0·56
2 (S D – G C)	= +	0·22

For J.

1 (J – S E)	= –	s 0·46
4 (J – W B)	= –	1·62
2 (J – H F)	= –	0·70
2 (J – W)	= –	0·94
5 (J – J S)	= –	1·38
6 (J – S)	= –	3·74
2 (J – B E)	= –	1·30
2 (J – H A)	= –	0·60
2 (J – G C)	= –	0·70

For S.

3 (S – S E)	= +	s 0·68
2 (S – B)	= –	0·02
2 (S – W B)	= +	0·20
8 (S – W)	= +	0·94
12 (S – J S)	= +	3·93

For S.—*continued.*

6 (S – E)	= –	s 0·50
6 (S – R C)	= +	0·49
4 (S – S D)	= +	0·06
6 (S – J)	= +	3·74
5 (S – B E)	= +	0·15
8 (S – H A)	= +	1·96
2 (S – G C)	= +	0·28

For B E.

4 (B E – S E)	= +	s 0·16
10 (B E – J S)	= +	3·28
2 (B E – E)	= –	0·16
2 (B E – J)	= +	1·30
5 (B E – S)	= –	0·15
2 (B E – H A)	= +	0·26
2 (B E – G C)	= +	0·38

For H A.

8 (H A – S E)	= –	s 1·48
4 (H A – B)	= –	0·50
2 (H A – W B)	= –	0·28
8 (H A – W)	= –	1·20
32 (H A – J S)	= +	2·64
4 (H A – W S)	= –	1·48
4 (H A – P M)	= –	0·20
10 (H A – E)	= –	3·12
12 (H A – R C)	= –	3·18
2 (H A – S D)	= –	0·56
2 (H A – J)	= +	0·60
8 (H A – S)	= –	1·96
2 (H A – B E)	= –	0·26
4 (H A – G C)	= –	0·20

For G C.

2 (G C – S E)	= –	s 0·32
2 (G C – B)	= –	0·08
2 (G C – W)	= –	0·24
6 (G C – J S)	= +	1·00
2 (G C – P M)	= –	0·06
2 (G C – E)	= –	0·36
2 (G C – S D)	= –	0·22
2 (G C – J)	= +	0·70
2 (G C – S)	= –	0·28
2 (G C – B E)	= –	0·38
4 (G C – H A)	= +	0·20

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

	s
45 S E − 4 B − 2 W − 17 J S − 4 R C − J − 3 S − 4 B E − 8 H A − 2 G C	= + 5·77
52 B − 4 S E − 10 W − 14 J S − 2 P M − 6 E − 2 R C − 6 S D − 2 S − 4 H A − 2 G C	= + 4·14
17 W B − 2 W − 2 J S − P M − 4 S D − 4 J − 2 S − 2 H A	= + 1·11
4 H F − 2 J S − 2 J	= + 1·04
56 W − 2 S E − 10 B − 2 W B − 4 J S − 12 E − 4 R C − 2 S D − 2 J − 8 S − 8 H A − 2 G C	= − 0·16
158 J S − 17 S E − 14 B − 2 W B − 2 H F − 4 W − 7 W S − 6 P M − 5 E − 32 R C − 4 S D − 5 J − 12 S − 10 B E − 32 H A − 6 G C	= −35·43
17 W S − 7 J S − 2 E − 4 R C − 4 H A	= + 4·89
15 P M − 2 B − W − 6 J S − 2 E − 2 H A − 2 G C	= + 1·81
47 E − 6 B − 12 W − 5 J S − 2 W S − 2 P M − 6 S − 2 B E − 10 H A − 2 G C	= + 7·78
64 R C − 4 S E − 2 B − 4 W − 32 J S − 4 W S − 6 S − 12 H A	= +11·87
24 S D − 6 B − 4 W B − 2 W − 4 J S − 4 S − 2 H A − 2 G C	= + 2·86
26 J − S E − 4 W B − 2 H F − 2 W − 5 J S − 6 S − 2 B E − 2 H A − 2 G C	= −11·44
64 S − 3 S E − 2 B − 2 W B − 8 W − 12 J S − 6 E − 6 R C − 4 S D − 6 J − 5 B E − 8 H A − 2 G C	= +11·91
27 B E − 4 S E − 10 J S − 2 E − 2 J − 5 S − 2 H A − 2 G C	= + 5·07
102 H A − 8 S E − 4 B − 2 W B − 8 W − 32 J S − 4 W S − 4 P M − 10 E − 12 R C − 2 S D − 2 J − 8 S − 2 B E − 4 G C	= −11·18
28 G C − 2 S E − 2 B − 2 W − 6 J S − 2 P M − 2 E − 2 S D − 2 J − 2 S − 2 B E − 4 H A	= − 0·04

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:—

W − J S = + 0·23 s	W − B = − 0·04 s	W − B E = − 0·09 s	W − W S = − 0·19 s
W − H A = + 0·15	W − E = − 0·14	W − J = + 0·48	W − P M = − 0·03
W − R C = − 0·07	W − S E = − 0·03	W − S D = − 0·08	W − H F = + 0·09
W − S = − 0·11	W − G C = + 0·07	W − W B = + 0·06	

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. Witchell, by applying the personal equations for chronographic transits found from the observations of 1906 :—

Date of Observation, 1906.		Excess of Clock Slow by Eye-and-Ear Observer.
Observer S E.		
	d h	s
July	26. 11	+ 0·09
Observer W.		
Feb.	21. 8	+ 0·06
Mar.	2. 11	− 0·02
	6. 7	+ 0·11
	22. 4	+ 0·11
July	20. 12	0·00
	24. 11	+ 0·10
Aug.	31. 12	+ 0·07
Sept.	27. 11	− 0·02
	28. 10	+ 0·03
Oct.	25. 13	+ 0·02
Dec.	27. 10	+ 0·06
	31. 13	+ 0·09
Mean........		+ 0·05

Date of Observation, 1906.		Excess of Clock Slow by Eye-and-Ear Observer.
Observer J S.		
	d h	s
Jan.	4. 4	+ 0·13
	8. 13	+ 0·07
Feb.	23. 9	+ 0·05
Mar.	3. 8	− 0·10
	5. 10	+ 0·04
	7. 7	+ 0·01
	11. 13	+ 0·08
	19. 8	+ 0·12
	21. 9	+ 0·08
	23. 7	+ 0·09
	27. 10	+ 0·06
	31. 9	+ 0·07
May	8. 8	+ 0·08
	12. 9	+ 0·08
June	7. 14	+ 0·08
	12. 8	+ 0·25
	20. 7	+ 0·07
	22. 9	+ 0·09
	27. 10	+ 0·20
July	3. 11	− 0·05
	17. 10	+ 0·28

Date of Observation, 1906.		Excess of Clock Slow by Eye-and-Ear Observer.
Observer J S.—continued.		
	d h	s
Aug.	30. 12	+ 0·10
Sept.	15. 11	+ 0·07
	26. 10	+ 0·03
Oct.	13. 7	+ 0·14
	17. 7	+ 0·21
	24. 12	+ 0·11
Nov.	2. 8	+ 0·07
Dec.	12. 7	+ 0·12
	14. 5	+ 0·08
Mean		+ 0·09
Observer P M.		
July	25. 9	+ 0·14
Oct.	24. 7	+ 0·14
Mean.........		+ 0·14

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

Date of Observation, 1906.	Excess of Clock Slow by Eye-and-Ear Observer.	Date of Observation, 1906.	Excess of Clock Slow by Eye-and-Ear Observer.	Date of Observation, 1906.	Excess of Clock Slow by Eye-and-Ear Observer.
Observer E.		*Observer* R C.		*Observer* S D—continued.	
d h	s	d h	s	d h	s
Feb. 20. 11	+ 0·03	Mar. 29. 12	+ 0·22	June 26. 13	+ 0·16
Mar. 6. 11	+ 0·16	Apr. 30. 13	+ 0·09	July 27. 12	+ 0·19
12. 10	+ 0·17	June 5. 13	+ 0·09	Mean.........	+ 0·18
May 7. 13	+ 0·11	Aug. 14. 13	+ 0·15	*Observer* J.	
19. 13	+ 0·23	22. 13	+ 0·26	Mar. 9. 13	− 0·15
31. 9	+ 0·10	Sept. 10. 13	+ 0·15	*Observer* G C.	
June 19. 12	+ 0·14	Oct. 23. 8	+ 0·18	July 25. 10	− 0·02
July 18. 13	+ 0·17	27. 13	+ 0·18	Oct. 10. 9	+ 0·02
Aug. 27. 12	+ 0·02	Dec. 10. 13	+ 0·22	10. 10	+ 0·02
Sept. 7. 16	+ 0·07	Mean.........	+ 0·17	Mean.........	+ 0·01
28. 12	+ 0·07	*Observer* S D.			
Nov. 27. 9	+ 0·10	Jan. 8. 10	+ 0·09		
Dec. 1. 11	+ 0·13				
21. 12	+ 0·16				
Mean.........	+ 0·12				

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 :—

W_0 − S E = − 0·09 s	W_0 − P M = − 0·14 s	W_0 − S D = − 0·18 s
W_0 − W = − 0·05	W_0 − E = − 0·12	W_0 − J = + 0·15
W_0 − J S = − 0·09	W_0 − R C = − 0·17	W_0 − G C = − 0·01

Errors of Division.

In use from 1897.

The following table contains the adopted result for errors of division for every degree. The errors are always considered in the nature of reading too much. $1^r = 61''\cdot4$ nearly.

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

Division-Correction.

Applicable to Observations made with the six Microscopes.

(*Always Additive.*)

In use from 1897.

The corrections recur after every 60° of pointer reading.

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

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

The 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 the ten degrees near 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°.30′ instead of 90°, as it had till then been assumed to be, what had been taken as the correction for 1°—that was, for all pointer readings between 0°.30′ and 1°·30′—was considered to be the correction for all pointer readings between 0° and 1°, and so on. 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.

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

Observations to determine the Astronomical Flexure of the Transit Circle, 1905–6.

Date.	Observer.	Reader of Micro-scopes.	Mean Concluded Circle-Reading.		Resulting Correction for Astronomical Horizontal Flexure.	Temperature.
			North Collimator.	South Collimator.		
1905. d h			° ′ ″	° ′ ″	″	°
November 29. 3	W	SD	269 37 11·30	89 37 12·02	−0·36	45·1
29. 23	W	J	11·99	12·57	−0·29	42·1
30. 23	W	SD	10·86	11·30	−0·22	43·5
December 1. 23	W	J	12·11	13·37	−0·63	42·1
5. 0	W	SD	12·15	12·70	−0·28	41·6
6. 3	W	SD	11·74	11·85	−0·06	46·4
7. 1	W	J	11·20	11·31	−0·06	50·7
8. 1	JS	J	9·66	9·93	−0·14	51·1
9. 0	JS	SD	10·47	10·34	+0·07	46·9
10. 23	JS	SD	11·57	11·47	+0·05	37·4
12. 2	W	J	12·19	12·86	−0·34	37·5
14. 22	JS	SD	10·86	11·04	−0·09	42·6
16. 0	W	J	11·82	12·79	−0·49	41·4
18. 1	W	SD	10·17	11·05	−0·44	43·2
19. 0	JS	J	12·05	11·83	+0·12	46·4
20. 0	W	J	9·83	10·36	−0·27	44·7
20. 23	JS	SD	9·05	8·65	+0·20	46·8
29. 0	W	SD	11·19	11·27	−0·04	44·9
29. 23	JS	J	11·43	12·38	−0·50	41·8
1906.						
December 31. 3	W	HA	269 37 6·52	89 37 5·52	+0·50	38·4
31. 23	W	HA	6·26	5·26	+0·50	40·6

In 1905, the mean of these observations gives the value of $-0''\cdot20$ for the Astronomical horizontal flexure; the mean of the corresponding temperatures being $44^\circ\cdot0$, and in 1906 a value of $+0''\cdot50$ and mean temperature of $39^\circ\cdot5$.

The observations for coincidence of north and south collimators were in every case made through the openings in the central cube of the Transit Circle.

No correction for flexure has been applied since April 1879.

Errors of the old Zenith Distance Micrometer-Screw in use up to 1906 *July* 12.

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

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

Corrections for Errors of Zenith Distance Micrometer-Screw.

	12^{rev}	13^{rev}	14^{rev}	15^{rev}	16^{rev}	17^{rev}	18^{rev}	19^{rev}	20^{rev}	
·0	+ 1″·39	+ 1″·25	+ 1″·13	+ 0″·98	+ 0″·80	+ 0″·52	+ 0″·35	+ 0″·16	0″·00	·0
·1	+ 1·38	+ 1·24	+ 1·12	+ 0·96	+ 0·77	+ 0·51	+ 0·33	+ 0·15	0·00	·1
·2	+ 1·36	+ 1·23	+ 1·10	+ 0·94	+ 0·74	+ 0·49	+ 0·31	+ 0·14	0·00	·2
·3	+ 1·35	+ 1·21	+ 1·08	+ 0·93	+ 0·72	+ 0·48	+ 0·29	+ 0·12	0·00	·3
·4	+ 1·33	+ 1·20	+ 1·07	+ 0·91	+ 0·69	+ 0·46	+ 0·27	+ 0·11	0·00	·4
·5	+ 1·32	+ 1·19	+ 1·05	+ 0·89	+ 0·66	+ 0·45	+ 0·25	+ 0·10	0·00	·5
·6	+ 1·30	+ 1·18	+ 1·04	+ 0·87	+ 0·63	+ 0·43	+ 0·23	+ 0·08	0·00	·6
·7	+ 1·29	+ 1·17	+ 1·02	+ 0·85	+ 0·60	+ 0·41	+ 0·21	+ 0·06	0·00	·7
·8	+ 1·27	+ 1·15	+ 1·01	+ 0·84	+ 0·58	+ 0·39	+ 0·20	+ 0·04	0·00	·8
·9	+ 1·26	+ 1·14	+ 0·99	+ 0·82	+ 0·55	+ 0·37	+ 0·18	+ 0·02	0·00	·9

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

Determinations of the Value of One Revolution of the new Zenith Distance Micrometer-Screw inserted 1906 *July* 13.

Date.	Value obtained from	Value of 1rev.	Part of Screw determined.	No. of Obs.
August 29. 3 (d h)	Microscope Readings on the Nadir . .	36″·94	8r to 16r	12
		36·94	16 to 24	12
		36·91	24 to 32	12
August 24. 0	Microscope Readings on the Nadir . .	36·86	12 to 20	12
September 6. 0		36·90	12 to 20	12
August 24. 0	Microscope Readings on the Nadir . .	36·96	20 to 28	12
September 6. 0		36·97	20 to 28	12
August 27. 3	Eye-and-Ear Observations of Polaris S.P.	36·92	8 to 32	17
Adopted Value for 1rev. of micrometer = 36″·93.				

Investigation of the Errors of the new Zenith Distance Micrometer-Screw inserted 1906 *July* 13.

Observations were made by Mr Witchell and Mr Storey, assisted by Mr James and Mr Shepperd on various dates between September 4 and November 28, and were of two kinds :—

(*a*) Comparisons of successive intervals of the Zenith Distance Micrometer Screw with a fixed interval of the South Collimator Screw, varying lengths being investigated.

(*b*) Observations of the Nadir and of a fixed wire in the North Collimator with different parts of the Micrometer Screw, using the Adopted Mean Value 1rev. = 36″·93 so as to exhibit the Apparent Error of the Screw at each point in terms of the microscope-micrometers, the error at 20r·000 being taken as zero.

(*a*) Successive intervals of about 4rev., 2rev. and 1rev. of the Zenith Distance Micrometer Screw were measured by means of fixed intervals of the South Collimator Screw.

The South Collimator Screw having been set to read 0r·000, the Transit Circle Telescope was pointed on it and clamped. Five readings were then taken for coincidence of wires in the two telescopes. The South Collimator Micrometer was then set to 6r·100 (the interval corresponding to 4rev. of the telescope-micrometer) and five more readings of the latter were taken for coincidence.

These observations were repeated so as to compare each successive interval of about $4^{revs.}$ of the telescope-micrometer with the same interval of $6^{r}{\cdot}100$ of the South Collimator Micrometer. The whole process was then repeated, giving ten determinations of each measure in any particular set of observations.

Similar observations were made for measuring the successive intervals corresponding to $3^{r}{\cdot}100$ and $1^{r}{\cdot}500$ of the South Collimator Micrometer ($2^{r}{\cdot}0$ and $1^{r}{\cdot}0$ nearly, of the telescope-micrometer).

$1^{rev.}$ of telescope-micrometer $= 36''{\cdot}93$.

Date.	Readings of South Collimator Micrometer.	Mean Reading of Telescope-micrometer.	Interval.	Mean Reading of Telescope-micrometer.	Interval.
	r	r	r	r	r
Sept. 4–6	0·000	8·001	$3{\cdot}987_{10}$	20·020	$3{\cdot}983_{30}$
	6·100	11·988		24·003	
	0·000	12·024	$3{\cdot}992_{30}$	24·023	$3{\cdot}985_{30}$
	6·100	16·016		28·008	
	0·000	16·018	$3{\cdot}990_{30}$	28·042	$3{\cdot}984_{10}$
	6·100	20·008		32·026	
	r	r	r	r	r
Sept. 4–6 and Nov. 27	0·000	12·013	$2{\cdot}028_{50}$	20·013	$2{\cdot}023_{50}$
	3·100	14·041		22·036	
	0·000	14·001	$2{\cdot}029_{50}$	21·996	$2{\cdot}024_{50}$
	3·100	16·030		24·020	
	0·000	16·009	$2{\cdot}028_{50}$	24·004	$2{\cdot}023_{50}$
	3·100	18·037		26·027	
	0·000	17·988	$2{\cdot}028_{50}$	25·985	$2{\cdot}028_{50}$
	3·100	20·016		28·013	
	r	r	r	r	r
Sept. 4–6 and Nov. 28	0·000	16·023	$0{\cdot}983_{20}$	21·042	$0{\cdot}980_{40}$
	1·500	17·006		22·022	
	0·000	17·037	$0{\cdot}981_{20}$	22·018	$0{\cdot}980_{40}$
	1·500	18·018		22·998	
	0·000	18·014	$0{\cdot}980_{40}$	23·038	$0{\cdot}980_{40}$
	1·500	18·994		24·018	
	0·000	19·042	$0{\cdot}982_{40}$	24·029	$0{\cdot}979_{20}$
	1·500	20·024		25·008	
	0·000	20·015	$0{\cdot}979_{40}$	25·036	$0{\cdot}983_{20}$
	1·500	20·994		26·019	

The suffixes in columns 4 and 6 denote the number of measurements on which the mean value of the interval depends.

(*b*) Comparisons with the microscope-micrometers from observations of the Nadir and of the North Collimator.

The telescope-micrometer was made to read about 16$^{revs.}$, and the horizontal wire was set on one of the sides of the square of the collimator or its own reflected image in the mercury; the instrument was then clamped, six readings of the telescope-micrometer made, and the microscopes read. Then the instrument was unclamped, and the telescope-micrometer was moved as nearly as possible 1$^{rev.}$; the horizontal wire was again set on the side of the square of the collimator (or its reflected image in the mercury), the instrument was clamped, and a similar observation made.

(1) Concluded Circle readings of the Nadir at intervals of 1$^{rev.}$ of the telescope-micrometer from 16$^{revs.}$ to 24$^{revs.}$.

Adopted value of 1$^{rev.}$ of the telescope-micrometer = 36″·93.

Date.	16^r.	17^r.	18^r.	19^r.	20^r.	21^r.	22^r.	23^r.	24^r.
d h	° ′ ″	″	″	″	″	″	″	″	″
October 8. 3	179. 59. 49·60$_6$	49·64$_6$	49·38$_6$	49·47$_6$	49·48$_6$	49·05$_6$	49·22$_6$	49·37$_6$	48·90$_6$
8. 22	49·22$_6$	49·46$_6$	49·26$_6$	49·40$_6$	49·33$_6$	48·90$_6$	48·78$_6$	49·12$_6$	48·85$_6$
15. 22	49·24$_6$	49·24$_6$	49·41$_6$	49·18$_6$	49·31$_6$	48·98$_6$	49·14$_6$	49·27$_6$	49·21$_6$
Mean	49·35	49·45	49·35	49·35	49·37	48·98	49·05	49·25	48·99

The suffixes denote the number of separate observations.

Assuming the correction to the value of 20$^{revs.}$ = 0″·00, the apparent corrections to the adopted value are:—

16^r	17^r	18^r	19^r	20^r	21^r	22	23^r	24^r
+0″·02	−0″·08	+0″·02	+0″·02	0″·00	+0″·39	+0″·32	+0″·12	+0″·38

(2) Concluded Circle readings of the observations on the North Collimator at intervals of 1$^{rev.}$ of the telescope-micrometer from 16$^{revs.}$ to 24$^{revs.}$.

Adopted value of 1$^{rev.}$ of the telescope-micrometer = 36″·93.

Date.	16^r.	17^r.	18^r.	19^r.	20^r.	21^r.	22^r.	23^r.	24^r.
d h	° ′ ″	″	″	″	″	″	″	″	″
October 12. 0	269. 57. 45·79$_6$	45·91$_6$	45·55$_6$	45·61$_6$	45·65$_6$	45·92$_6$	45·88$_6$	45·89$_6$	45·79$_6$

The suffixes denote as before the number of separate observations.

Assuming the correction to the value of $20^{revs.} = 0''{\cdot}00$, the apparent corrections to adopted value are :—

16^r	17^r	18^r	19^r	20^r	21^r	22^r	23^r	24^r
$-0''{\cdot}14$	$-0''{\cdot}26$	$+0''{\cdot}10$	$+0''{\cdot}04$	$0''{\cdot}00$	$-0''{\cdot}27$	$-0''{\cdot}23$	$-0''{\cdot}24$	$-0''{\cdot}14$

Combination of the various results shows that the corrections are practically insensible.

No correction for Error of Screw has therefore been applied.

Investigation of the Errors of the Microscope-Micrometer Screws of the Transit-Circle.

For the purpose of this investigation two horizontal wires, parallel to those already existing, were inserted in the South Collimator as nearly as possible $2\frac{1}{2}$ minutes of arc on each side of the lower wire of the square; and an additional wire, parallel to and about $2\frac{1}{2}$ minutes from the lower existing horizontal wire, was inserted in the North Collimator.

Making use of the interval in the North Collimator as a fixed gauge, the small inequality of the two South Collimator intervals was measured by means of the South Collimator micrometer, the Transit-Circle having been raised during the observations. Since the value of one revolution of the South Collimator micrometer-screw was only required for converting this small inequality into arc, no appreciable error would be introduced by an uncertainty in the value of its revolution.

The telescope-micrometer of the Transit-Circle was now set to such a position, that when the telescope was pointed to the middle wire in the South Collimator the circle divisions fell under the microscope-micrometers at $2{\cdot}5^{revs.}$ The telescope was then clamped and the circle read, and the reading of the telescope-micrometer for coincidence of wires observed. Keeping the telescope-micrometer at approximately the same reading, each of the other two wires was observed in the same manner, the same divisions of the circle falling under the microscope-micrometers near $0^r{\cdot}0$ and $5^r{\cdot}0$ respectively in the two cases. Settings of the telescope-micrometer were found corresponding to three consecutive 5′ divisions on the circle, and four sets of six readings taken.

The two intervals on the South Collimator were thus measured by each microscope-micrometer. The microscope-micrometers may be considered to read correctly at $0^r{\cdot}0$ and at $5^r{\cdot}0$, as the value of a revolution (or the "Correction for Runs") is determined from this interval; accordingly by comparing the difference of the two intervals as measured by the microscope-micrometers with its known value measured by the South Collimator Screw, the errors of the microscope-micrometers at $2^{r}\cdot5$ can be deduced.

Denoting the three wires in the South Collimator by the letters K, L, M, and the wires in the North Collimator by G, H, the following readings of the South Collimator micrometer were obtained from the means of twenty bisections :—

Coincidence of	G and K	H and L	G and L	H and M.
	$0^{r}\cdot816$	$1^{r}\cdot125$	$7^{r}\cdot493$	$7^{r}\cdot542$,

from which we deduce—

Excess of interval GK over interval KL = $0^{r}\cdot309$
" " " GK " " LM = $0^{r}\cdot049$.
Error of L from mean of K and M = $\frac{1}{2}(0^{r}\cdot309 - 0^{r}\cdot049) = 0^{r}\cdot130 = 3''\cdot14$.

Determination of Apparent Error of Position of Middle Wire by Readings of the Microscope-Micrometers.

Microscope.	Concluded Circle Reading for Coincidence with			$\frac{1}{2}$(K+M)—L.	Apparent Error of Screw at $2^{r}\cdot5$.
	Wire K.	Wire L.	Wire M.		
	° ′ ″	° ′ ″	° ′ ″	″	″
A	89 40 7·60	89 42 39·87	89 45 17·87	$2\cdot87_{24}$	− 0·27
B	21·13	52·66	31·51	$3\cdot66_{24}$	+ 0·52
C	18·81	50·29	26·96	$2\cdot60_{24}$	− 0·54
D	17·64	48·80	26·88	$3\cdot46_{24}$	+ 0·32
E	19·27	50·71	28·79	$3\cdot32_{24}$	+ 0·18
F	17·57	48·82	25·39	$2\cdot66_{24}$	− 0·48
Mean of Six Microscopes.	89 40 17·00	89 42 48·53	89 45 26·23	$3\cdot10_{24}$	− 0·04

The fifth column gives the apparent error of position of the middle wire L, compared with the mean of the two extreme wires K and M, as measured with the respective microscopes. The sixth column is obtained by subtracting $3''\cdot14$, which is the true value of this error of position, determined above. The difference is the error of the microscope-micrometer reading when L is observed, *i.e.* at $2^{r}\cdot5$, the errors when K and M are observed (at $0^{r}\cdot0$ and $5^{r}\cdot0$) being taken as zero.

The screws of microscopes A, C, and F are reversed as compared with B, D, and E.

Excess of Reflexion Results above Direct Results, for Observations of Zenith-Distances with the Transit-Circle, 1906.

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

Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.	Star's Name.	Approx. R.A.	Approx. N.P.D.	R—D.	No. of Obs. R. and D.	Weight.
	h m	°	″				h m	°	″		
4 Cassiopeiæ S.P....	23. 21	−28. 2	−0·86	1	1	Groombridge 1852 S.P...	12. 1	−12. 6	−1·38	1	1
20 Cephei S.P.........	22. 2	−27. 7	−1·39	1	1	4 Ursæ Minoris S.P..	14. 9	−12. 0	−1·11	4	3
κ Cassiopeiæ S.P.....	0. 28	−27. 6	+0·13	1	1	Bradley 1634 S.P.....	12. 8	−11. 9	−0·12	1	1
θ Cephei S.P.........	20. 28	−27. 3	+0·85	1	1	Bradley 1508 S.P.....	10. 53	−11. 7	+0·19	1	1
Piazzi III. 94 S.P....	3. 34	−27. 1	−1·06	1	1	Piazzi IV. 269 S.P...	5. 8	−10. 9	−0·28	2	2
17 Camelopardi S.P..	5. 22	−27. 0	−2·36	1	1						
76 Ursæ Majoris S.P.	12. 38	−26. 8	−1·41	1	1						
36 Draconis S.P.......	18. 13	−25. 6	+0·42	1	1	Piazzi VI. 292 S.P...	7. 12	− 7. 4	−0·06	2	2
						Piazzi X. 22 S.P......	10. 20	− 6. 9	−1·05	1	1
α Draconis S.P........	14. 2	−25. 2	−3·57	1	1	Bradley 1399 S.P....	10. 17	− 5. 2	+0·53	1	1
Piazzi XI. 43 S.P.....	11. 18	−25. 1	−0·17	1	1	Groombridge 750 S.P.	4. 8	− 4. 7	−2·26	1	1
ι Draconis S.P.......	13. 49	−24. 8	+0·22	1	1	Groombridge 1418 S.P..	8. 28	− 4. 6	−2·01	1	1
32 Ursæ Majoris S.P.	10. 12	−24. 4	−0·01	1	1	Groombridge 1850 S.P...	12. 0	− 3. 9	−0·31	1	1
α Camelopardi S.P..	4. 45	−23. 8	+0·22	1	1	δ Ursæ Minoris S.P..	18. 1	− 3. 4	−0·30	2	2
Piazzi V. 253 S.P....	5. 53	−23. 1	−1·99	1	1	Groombridge 3548 S.P...	21. 18	− 3. 4	−0·12	3	3
Bradley 366 S.P......	2. 37	−22. 6	−0·27	1	1	Groombridge 1004 S.P...	6. 12	− 3. 3	+0·04	2	2
δ Draconis S.P.........	19. 13	−22. 5	−0·23	1	1	Bradley 3147 S.P....	23. 28	− 3. 2	−1·92	1	1
σ^2 Ursæ Majoris S.P.	9. 2	−22. 5	−2·56	1	1	Cephei 51 S.P.........	6. 59	− 2. 8	−1·61	1	1
ρ Ursæ Majoris S.P.	8. 54	−22. 0	−0·52	1	1	Bradley 1672 S.P.....	12. 14	− 1. 8	−0·62	2	2
Piazzi VII. 67 S.P...	7. 22	−21. 3	−0·83	1	1	Polaris S.P............	1. 27	− 1. 2	−0·22	3	3
55 Camelopardi S.P...	8. 4	−21. 2	+0·64	2	2	Groombridge 1119 S.P..	8. 9	− 1. 1	−0·32	3	3
Piazzi V. 335 S.P.....	6. 9	−20. 6	−0·24	2	2	λ Ursæ Minoris S.P...	19. 11	− 1. 0	+0·18	1	1
Piazzi X. 126 S.P.....	10. 37	−20. 4	+0·07	1	1	λ Ursæ Minoris.......	19. 11	1. 0	−0·58	2	2
κ Draconis S.P.	12. 30	−19. 7	−0·17	1	1	Polaris..................	1. 27	1. 2	−0·49	1	1
υ Draconis S.P.	18. 55	−18. 8	−0·50	1	1	Bradley 1672..........	12. 14	1. 8	+0·82	1	1
Groombridge 2039 S.P...	13. 35	−18. 3	+2·02	1	1	Groombridge 2283...	15. 6	2. 4	−0·90	2	2
24 Cephei S.P.........	22. 8	−18. 1	−0·82	1	1						
						Bradley 3147	23. 28	3. 2	−0·74	1	1
						δ Ursæ Minoris.......	18. 1	3. 4	+0·06	9	5
χ Draconis S.P.	18. 23	−17. 3	−0·80	1	1	Groombridge 944.....	5. 33	4. 8	−0·63	1	1
Piazzi XIII. 109 S.P.	13. 24	−17. 1	−1·53	1	1	Bradley 1399.........	10. 17	5. 3	−1·31	1	1
Piazzi IV. 207 S.P...	4. 53	−16. 1	−1·41	1	1	Bradley 3058	22. 55	6. 1	−0·43	1	1
Groombridge 1446 S.P...	8. 30	−16. 0	−1·92	1	1						
Groombridge 966 S.P.	5. 28	−15. 0	+0·57	1	1						
50 Draconis S.P.......	18. 49	−14. 7	−2·04	1	1						
Piazzi IV. 112 S.P....	4. 37	−14. 2	+0·34	2	2	Piazzi X. 22..........	10. 20	6. 9	−1·35	2	2
5 Ursæ Minoris S.P..	14. 28	−13. 9	+0·17	3	3	Piazzi VI. 292........	7. 12	7. 4	+0·34	1	1
Bradley 1147 S.P. ...	8. 8	−13. 9	+1·30	1	1	76 Draconis............	20. 49	7. 8	+0·45	2	2

Excess of Reflexion Results above Direct Results, for Observations of Zenith-Distances with the Transit-Circle, 1906—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.
	h m	°	″				h m	°	″		
Piazzi IX. 37	9. 24	8. 2	+0·44	1	1	κ Pegasi	21. 41	64. 7	+1·22	1	1
Bradley 2749	20. 52	9. 8	+0·06	1	1	ε Leonis	9. 41	65. 8	−0·43	1	1
Piazzi VI. 75	6. 31	10. 3	+0·34	2	2	μ Pegasi	22. 46	65. 9	+0·49	1	1
						17 Tauri	3. 40	66. 1	+0·30	1	1
ζ Ursæ Minoris	15. 47	11. 9	−0·03	1	1	1 Geminorum	5. 59	66. 7	+0·50	2	2
4 Ursæ Minoris	14. 9	12. 0	+0·04	3	3	λ Pegasi	22. 42	67. 0	+0·93	1	1
77 Draconis	21. 7	12. 2	−0·72	1	1	β Herculis	16. 26	68. 3	+0·70	1	1
κ Cephei	20. 12	12. 6	+1·24	1	1	110 Herculis	18. 42	69. 5	−0·43	2	2
Piazzi VI. 201	6. 47	12. 9	−1·27	1	1	γ^1 Leonis	10. 15	69. 6	+0·19	1	1
35 Draconis	17. 53	13. 0	−0·49	2	2	Arcturus	14. 12	70. 3	+0·55	2	2
Bradley 1446	10. 27	13. 8	+0·98	2	2	*f* Boötis	14. 22	70. 3	+0·45	2	2
β Ursæ Minoris	14. 51	15. 3	+1·56	2	2	θ Arietis	2. 13	70. 5	+1·12	1	1
Groombridge 1374	7. 49	15. 8	+0·12	2	2	γ Sagittæ	19. 55	70. 7	+2·02	1	1
Groombridge 1446	8. 30	16. 0	+0·27	2	2	15 Arietis	2. 6	70. 9	−0·35	1	1
16 Cephei	21. 58	17. 2	+0·51	1	1	η Boötis	13. 50	71. 1	−0·33	1	1
Bradley 348	2. 29	17. 6	+1·40	1	1	111 Herculis	18. 43	71. 9	+0·82	1	1
50 Cassiopeiæ	1. 56	18. 0	+0·23	1	1	τ Boötis	13. 43	72. 0	−0·10	1	1
						Radcliffe 3896	18. 19	72. 2	+1·47	1	1
						η Leonis	10. 2	72. 7	−0·21	1	1
						κ Herculis	16. 4	72. 7	+1·24	1	1
ρ Boötis	14. 28	59. 2	−0·46	1	1	π Boötis (1st star)	14. 36	73. 1	+2·31	1	1
Piazzi IX. 221	9. 54	59. 9	+2·68	1	1	θ Leonis	11. 10	74. 0	+1·00	1	1
B. D. + 29°4038	20. 23	59. 9	−0·72	1	1	γ Serpentis	15. 52	74. 0	+0·61	1	1
ζ Cygni	21. 9	60. 1	−0·16	1	1	τ^1 Serpentis	15. 22	74. 2	+1·02	1	1
β Tauri	5. 21	61. 4	+0·15	1	1	α Delphini	20. 35	74. 4	+0·55	1	1
h Piscium	0. 53	61. 5	+0·49	1	1						
Pollux	7. 40	61. 7	+0·29	1	1						
β Cygni	19. 27	62. 2	+0·43	1	1						
μ Herculis	17. 43	62. 2	+0·17	3	3	δ Delphini	20. 39	75. 2	+1·06	3	3
32 Vulpeculæ	20. 51	62. 3	−0·31	1	1	σ Arietis	2. 47	75. 3	+0·53	1	1
						ω Herculis	16. 21	75. 7	+0·78	1	1
						β Delphini	20. 33	75. 7	+0·15	2	2
						ζ Aquilæ	19. 1	76. 2	−0·21	1	1
ϵ^2 Boötis	14. 41	62. 5	+0·95	2	2	α Ophiuchi	17. 31	77. 3	+0·75	3	3
ψ Boötis	15. 1	62. 7	−0·50	1	1	*f* Tauri	3. 26	77. 3	+0·75	1	1
υ Geminorum	7. 30	62. 9	+0·16	1	1	Regulus	10. 4	77. 5	+0·74	2	2
α Coronæ	15. 31	62. 9	+0·71	2	2						
47 Geminorum	7. 6	63. 0	−0·73	3	3						
μ Leonis	9. 48	63. 5	+1·20	1	1						
89 Herculis	17. 52	63. 9	−1·85	1	1	52 Pegasi	22. 55	78. 7	−0·38	1	1
ω^1 Cancri	7. 55	64. 3	+1·24	1	1	κ Cancri	9. 3	78. 9	+2·52	1	1
87 Herculis	17. 45	64. 3	+0·07	1	1	ρ Virginis	12. 37	79. 2	−0·11	1	1
10 Vulpeculæ	19. 40	64. 4	+0·67	1	1	54 Ceti	1. 46	79. 4	+0·54	1	1

Excess of Reflexion Results above Direct Results, for Observations of Zenith-Distances with the Transit-Circle, 1906—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.
	h m	°	″				h m	°	″		
γ Aquilæ	19.42	79.6	+1·05	1	1	η Aquarii	22.31	90.6	−0·39	1	1
ξ Arietis	2.20	79.8	+0·76	1	1	φ Virginis	14.24	91.8	+0·31	1	1
κ Delphini	20.35	80.2	+0·67	1	1	c Serpentis	18.25	92.0	+1·01	2	2
μ Ceti	2.40	80.2	+1·22	1	1	14 Hydræ	8.45	93.1	+0·51	1	1
55 Pegasi	23. 2	81.1	+0·09	1	1	δ Ophiuchi	16.10	93.4	+1·16	2	2
α Aquilæ	19.46	81.3	+0·91	1	1	6 Sextantis	9.47	93.8	+1·47	1	1
ο Piscium	1.41	81.3	+0·48	1	1	25 Monocerotis	7.33	93.9	−0·19	1	1
57 Pegasi	23. 5	81.8	−0·57	1	1	13 Ceti	0.31	94.1	+0·71	1	1
α Orionis	5.50	82.6	+0·01	1	1	β Aquarii	21.27	95.9	+1·67	1	1
τ Aquilæ	20. 0	82.9	−1·04	1	1	67 Aquarii	22.39	97.4	+0·82	1	1
α Serpentis	15.40	83.2	+0·53	1	1	ρ Aquarii	22.15	98.2	−0·60	1	1
σ Virginis	13.13	84.0	+2·02	1	1	1 Aquilæ	18.30	98.3	+0·82	1	1
ω Hydræ	9. 1	84.5	+0·58	1	1	37 Ceti	1.10	98.4	+1·52	1	1
ν Piscium	1.37	84.9	+1·28	1	1						
β Ophiuchi	17.39	85.4	+1·37	3	3						
σ Ophiuchi	17.22	85.7	+1·24	1	1	ψ Virginis	12.50	99.0	+0·19	1	1
d Leonis	10.56	85.8	−0·89	1	1	2 Aquilæ	18.37	99.1	+1·67	2	2
θ Serpentis	18.52	85.9	+1·11	2	2	η Eridani	2.52	99.2	+0·19	1	1
α Ceti	2.58	86.2	+1·48	1	1	κ Orionis	5.43	99.7	+1·74	2	2
						ε Aquarii	20.43	99.8	+0·65	2	2
						σ Aquarii	22.26	101.1	+2·21	1	1
β Piscium	22.59	86.6	+1·77	1	1	θ Canis Majoris	6.50	101.9	+1·06	1	1
f Piscium	1.13	86.8	−0·35	1	1	6 Hydræ	8.36	102.1	−1·19	1	1
δ Aquilæ	19.21	87.0	+0·21	1	1						
γ Ophiuchi	17.43	87.2	+0·56	1	1						
p^3 Leonis	11. 2	87.5	+1·83	1	1	ρ Ceti	2.22	102.7	−0·96	1	1
λ Ophiuchi	16.26	87.7	+1·85	1	1	ο Serpentis	17.36	102.8	−1·36	1	1
21 Aquilæ	19. 9	87.8	+0·09	1	1	δ Crateris	11.15	104.2	+3·60	1	1
44 Piscium	0.21	88.5	−0·03	2	2	π Ceti	2.40	104.2	+4·09	1	1
δ Orionis	5.27	90.3	+0·59	1	1	Bradley 2313	18.24	104.6	+1·33	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 $\frac{mn}{me^2 + ne^2 + 2\,mne_0^{\,2}}$; or assuming $e_0^{\,2} = \frac{1}{10}e^2$, which would make $e_0 = 0''{\cdot}16$, the weight becomes $\frac{4\,mn}{m + n + \frac{1}{5}mn}$, which has been adopted. When $m = n$, the weight is proportional to $\frac{m}{10 + n}$, and $\frac{11\,m}{10 + m}$, the most convenient multiple of this, has been adopted.

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

Extent of Group, 1906.	Weight.	Mean N.P.D.	Mean Z.D. South.	Mean Value of R—D, corrected for Inclination of Verticals.	R—D computed by the Formula $+0''\cdot177 + 0''\cdot943 \times \sin$ Z.D.	Apparent Error of Formula.
		°	°	″	″	″
4 Cassiopeiæ S.P. to 36 Draconis S.P.	8	−27.2	−65.7	−0·86	−0·68	+0·18
α Draconis S.P. to ρ Ursæ Majoris S.P.	10	−23.6	−62.1	−1·03	−0·66	+0·37
Piazzi VII. 67 S.P. to 24 Cephei S.P.	10	−20.0	−58.5	−0·08	−0·63	−0·55
χ Draconis S.P. to Bradley 1147 S.P.	12	−15.0	−53.5	−0·52	−0·58	−0·06
Groombridge 1852 S.P. to Piazzi IV. 269 S.P.	8	−11.8	−50.3	−0·77	−0·55	+0·22
Piazzi VI. 292 S.P. to Piazzi X. 22 S.P.	3	−7.3	−45.8	−0·50	−0·50	0·00
Bradley 1399 S.P. to Bradley 1672 S.P.	15	−3.4	−41.9	−0·76	−0·45	+0·31
Polaris S.P. to Groombridge 2283	13	0.1	−38.4	−0·41	−0·41	0·00
Bradley 3147 to Bradley 3058	9	4.0	−34.5	−0·40	−0·36	+0·04
Piazzi X. 22 to Piazzi VI. 75	9	8.4	−30.1	−0·11	−0·30	−0·19
ζ Ursæ Minoris to Bradley 1446	11	12.7	−25.8	−0·04	−0·23	−0·19
β Ursæ Minoris to 50 Cassiopeiæ	8	16.2	−22.3	+0·61	−0·18	−0·79
ρ Boötis to 32 Vulpeculæ	12	61.2	22.7	+0·30	+0·54	+0·24
ϵ^2 Boötis to 17 Tauri	18	63.8	25.3	+0·28	+0·58	+0·30
1 Geminorum to *f* Boötis	11	69.0	30.5	+0·44	+0·66	+0·22
θ Arietis to α Delphini	14	72.5	34.0	+0·89	+0·70	−0·19
δ Delphini to Regulus	14	76.4	37.9	+0·75	+0·76	+0·01
52 Pegasi to 57 Pegasi	12	80.1	41.6	+0·71	+0·80	+0·09
α Orionis to α Ceti	14	84.8	46.3	+0·94	+0·86	−0·08
β Piscium to δ Orionis	10	87.8	49.3	+0·77	+0·89	+0·12
η Aquarii to 13 Ceti	10	92.8	54.3	+0·80	+0·94	+0·14
β Aquarii to 37 Ceti	5	97.6	59.1	+0·99	+0·99	0·00
ψ Virginis to 6 Hydræ	11	100.0	61.5	+1·10	+1·01	−0·09
ρ Ceti to Bradley 2313	5	103.7	65.2	+1·88	+1·03	−0·85

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

Assuming that the R—D correction can be represented by

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

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

For direct observations,

$$+ 0''\cdot089 + 0''\cdot472 \sin \text{Z.D.}$$

For reflexion observations,

$$- 0''\cdot089 - 0''\cdot472 \sin \text{Z.D.} + 0''\cdot16 \sin \text{Z.D.}$$

or

$$- 0''\cdot089 - 0''\cdot312 \sin \text{Z.D.}$$

Beginning with 1906, the corrections for the R—D discordance have been found by using the value of x from the observations made during the year, and by assuming a constant value of $+0''\cdot600$ for y (practically the value adopted for the 1880, 1890, and 1900 Catalogues), giving :—

For direct observations,

$$+ 0''\cdot089 + 0''\cdot600 \sin \text{Z.D.}$$

For reflexion observations,

$$- 0''\cdot089 - 0''\cdot440 \sin \text{Z.D.}$$

For use, these formulæ have been tabulated as follows, and the corrections have been applied to the mean results for N.P.D. of 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	− 0·51	+ 0·35
40	− 0·50	+ 0·34
30	− 0·47	+ 0·32
20	− 0·42	+ 0·29
− 10	− 0·36	+ 0·24
0	− 0·29	+ 0·19
+ 10	− 0·20	+ 0·12
20	− 0·10	+ 0·05
30	0·00	− 0·02
40	+ 0·11	− 0·10
50	+ 0·21	− 0·18
60	+ 0·31	− 0·25
70	+ 0·40	− 0·32
80	+ 0·49	− 0·38
90	+ 0·56	− 0·43
100	+ 0·62	− 0·48
110	+ 0·66	− 0·51
120	+ 0·68	− 0·52
+ 125	+ 0·69	− 0·53

No correction for flexure has been applied since April 1879.

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

Date, 1906.	Meteorological Standard Thermom.	Excess of Transit-Circle Exterior Thermometer.
d h	°	°
Jan. 4.0	49·1	+ 0·6
7.0	44·5	− 0·5
Feb. 14.0	43·8	− 0·3
20.0	42·6	+ 0·2
21.0	41·7	− 0·9
22.0	41·9	+ 0·6
24.0	39·6	+ 0·8
28.0	40·5	+ 0·2
Mar. 3.0	44·6	+ 0·7
4.0	55·2	+ 0·4
6.0	60·2	+ 0·4
7.0	64·0	− 0·1
14.0	40·9	+ 0·7
17.0	60·9	+ 0·6
20.0	44·8	0·0
22.0	37·9	+ 0·8
25.0	40·7	− 0·2
26.0	38·8	+ 1·2
27.0	39·6	+ 0·3
28.0	43·5	+ 1·1
29.0	45·1	− 0·5
May 5.0	59·6	+ 0·9
8.0	73·2	+ 1·1
13.0	72·6	+ 0·1
14.0	63·8	+ 1·6
16.0	50·6	− 0·6
18.0	55·0	+ 0·5
29.0	67·3	+ 1·5
30.0	64·0	+ 0·9
June 1.0	57·6	+ 1·2
3.0	64·6	+ 1·2
5.0	58·1	+ 1·7
6.0	63·8	+ 2·0
7.0	70·8	− 0·7
8.0	70·4	+ 0·4
9.0	69·7	+ 1·6
10.0	64·3	− 3·0

Date, 1906.	Meteorological Standard Thermom.	Excess of Transit-Circle Exterior Thermometer.
d h	°	°
June 16.0	61·0	+ 0·8
17.0	66·4	+ 0·8
18.0	70·6	+ 1·1
20.0	78·1	− 0·8
21.0	74·2	− 0·4
22.0	77·1	− 0·4
23.0	76·2	+ 1·0
26.0	73·0	− 1·0
27.0	74·6	− 2·1
28.0	70·2	− 0·7
30.0	62·2	− 2·5
July 1.0	63·4	+ 0·4
2.0	68·2	+ 0·4
3.0	69·0	+ 0·4
5.0	74·2	+ 0·9
14.0	71·6	+ 1·2
16.0	70·1	− 1·9
17.0	76·9	+ 0·7
18.0	77·8	+ 0·4
20.0	61·8	+ 0·5
21.0	65·6	+ 0·1
22.0	76·6	− 1·0
23.0	79·0	− 0·2
24.0	69·0	+ 2·0
25.0	71·2	+ 1·9
26.0	71·0	+ 1·0
27.0	74·4	+ 0·2
28.0	73·8	+ 1·3
30.0	75·7	+ 1·4
Aug. 6.0	76·4	+ 0·7
8.0	83·3	+ 1·7
9.0	70·9	+ 0·2
16.0	64·4	+ 0·2
17.0	64·6	+ 0·2
21.0	77·6	− 1·0
22.0	82·7	+ 2·3
23.0	73·6	+ 1·1
25.0	67·6	− 0·4
27.0	75·4	− 0·5
28.0	67·8	+ 2·2
29.0	72·4	+ 1·2

Date, 1906.	Meteorological Standard Thermom.	Excess of Transit-Circle Exterior Thermometer.
d h	°	°
Aug. 30.0	81·4	+ 0·2
31.0	90·2	+ 0·8
Sept. 1.0	90·5	+ 0·7
2.0	90·9	+ 1·0
3.0	89·9	− 0·6
4.0	76·9	+ 0·3
7.0	71·1	+ 0·4
8.0	75·6	+ 1·6
9.0	67·5	+ 0·3
10.0	62·6	0·0
11.0	65·8	+ 1·6
15.0	59·2	+ 1·9
22.0	63·5	+ 0·1
25.0	58·6	+ 1·8
28.0	61·0	− 1·7
29.0	62·7	− 0·7
30.0	64·5	− 0·4
Oct. 5.0	65·2	+ 0·2
6.0	63·5	− 0·7
8.0	63·1	− 1·0
10.0	67·5	+ 0·8
12.0	62·3	+ 0·1
16.0	59·5	− 0·7
19.0	52·6	+ 1·1
20.0	55·9	− 2·2
25.0	54·4	− 0·9
26.0	54·2	+ 1·2
27.0	53·4	− 0·8
29.0	48·8	+ 0·7
Nov. 5.0	51·8	+ 0·4
11.0	46·6	− 0·2
Dec. 1.0	44·0	− 0·2
6.0	44·1	− 1·1
7.0	42·1	− 1·3
10.0	34·8	− 0·5
22.0	35·6	− 0·6
25.0	34·6	− 0·3
27.0	33·2	+ 0·1
29.0	34·6	− 0·4

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

1906.	January.	February.	March.	April.	May.	June.	Mean for Year.
Meteorological Standard..	46°·8 $_{2}$	41°·7 $_{6}$	47°·4 $_{13}$	°	63°·3 $_{8}$	68°·5 $_{19}$	
Excess of Exterior.	0·0	+ 0·1	+ 0·4		+ 0·8	0·0	
1906.	**July.**	**August.**	**September.**	**October.**	**November.**	**December.**	
Meteorological Standard..	71°·6 $_{18}$	74°·9 $_{14}$	70°·7 $_{15}$	58°·4 $_{12}$	49°·2 $_{2}$	37°·9 $_{8}$	62°·1 $_{117}$
Excess of Exterior.	+ 0·5	+ 0·6	+ 0·4	− 0·2	+ 0·1	− 0·5	+ 0·3

Correction to Assumed Colatitude, 38° 31′ 21″·80,

from Observations in the Year 1906.

(Using Pulkowa's Refractions.)

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 Observations. Above Pole.	No. of Observations. Below Pole.	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. Above Pole.	No. of Observations. Below Pole.	Weight.
	h m	° ′	s	″					h m	° ′	s	″			
λ Ursæ Minoris.......	19. 11	1. 0	+0·81	−0·65	21	10	21	24 Cephei..............	22. 10	18. 6		+1·62	1	2	4
Groombridge 1119...	8. 9	1. 6	+0·50	−0·09	11	26	22	δ Draconis	19. 12	22. 30		+0·06	1	2	4
Polaris	1. 27	1. 10	−1·76	+0·46	24	35	28	Bradley 366...........	2. 37	22. 33		+0·13	1	2	4
Bradley 1672..........	12. 14	1. 48	−0·35	+0·21	11	15	20	Piazzi XI. 43	11. 18	25. 11	−0·31	+0·75	1	3	4
Groombridge 2283 ...	15. 6	2. 25		−0·49	19	4	14	α Draconis	14. 2	25. 2	−0·03	+2·22	1	4	5
Cephei 51	6. 59	2. 48	+0·03	−0·34	8	23	20	Piazzi III. 94..........	3. 34	27. 4	−0·13	+0·68	1	2	3
Bradley 3147	23. 28	3. 11	−1·02	+0·52	18	11	21	θ Cephei...............	20. 28	27. 18		−1·13	1	2	3
Groombridge 3548...	21. 18	3. 20	−0·22	+0·44	21	13	22	κ Cassiopeiæ	0. 28	27. 34	+0·06	−0·22	1	2	3
δ Ursæ Minoris.......	18. 1	3. 23	+0·47	+0·63	37	14	24	θ Draconis............	16. 0	31. 12		−0·41	1	1	2
Groombridge 750.....	4. 8	4. 41		+0·63	1	2	4	β Draconis............	17. 28	37. 38	+0·11	+0·12	3	1	2
Bradley 1399..........	10. 17	5. 17		+0·71	2	2	6	γ Draconis.............	17. 55	38. 30	+0·13	+0·82	3	3	5
Piazzi X. 22	10. 20	6. 59		−0·69	4	2	7	Piazzi XI. 19..........	11. 12	40. 2	+0·06	0·00	1	1	1
Piazzi VI. 292.........	7. 10	7. 25		+1·37	2	4	7	o Aurigæ	5. 39	40. 13	−0·14	+0·73	1	1	1
ζ Ursæ Minoris........	15. 47	11. 56	+0·42	−0·13	3	1	4	z Herculis..............	17. 48	41. 35	+0·10	(+1·56)	1	2	
4 Ursæ Minoris.......	14. 9	12. 2		−0·35	6	8	14	σ Persei	3. 24	42. 19		(−1·48)	1	1	
77 Draconis............	21. 7	12. 14		−0·65	2	1	3	δ Persei................	3. 37	42. 30	+0·05	(+1·22)	1	3	
Bradley 1446..........	10. 27	13. 49		+1·60	4	1	4	f^1 Cygni	20. 57	42. 50	−0·02	(−0·06)	1	1	
β Ursæ Minoris.......	14. 51	15. 29	+0·40	+1·36	5	2	7	ρ Cygni.................	21. 31	44. 48	−0·16	(+0·68)	1	2	
Groombridge 1374 ...	7. 49	15. 50	−0·22	+0·49	4	1	4	α Cygni.................	20. 38	45. 2	+0·02	(+1·03)	3	1	
Groombridge 1446 ...	8. 29	16. 3		+0·35	4	2	6	β Persei.................	3. 2	49. 23		(+1·79)	1	1	
χ Draconis.............	18. 22	17. 18		+1·99	1	2	4								

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 $\frac{2\,nn_1}{n_1e^2 + ne_1^2 + 2\,nn_1e_0^2}$; or assuming $e_0^2 = \frac{1}{10}\,e_1^2$, which would make $e_0 = 0''\cdot16$, the weight becomes $\frac{2\,nn_1}{n_1e^2 + ne_1^2 + \frac{1}{5}\,nn_1e^2}$, which has been adopted in the investigation.

If z be the correction to the assumed colatitude 38°. 31′. 21″·80, $2z$ + the algebraic sum of determinations ought to be equal to 0. Combining the whole with the weights above attached to them, $z = -0''\cdot131$.

The colatitude determined from the observations of 1906 is therefore 38°. 31′. 21″·67.

ALTAZIMUTH TABLES, 1906.

ROYAL OBSERVATORY, GREENWICH.

ALTAZIMUTH TABLES, 1906.

Equivalents of the Transit-Micrometer Screw and 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.

From Jan. 1 to Oct. 20 one revolution of transit-micrometer = 21″·636

In October 1906 an entirely new set of wires was inserted. In connection with the determination of their intervals, an investigation was made of the wear of the Transit-Micrometer-Screw. The following are the equivalents (expressed in equatorial time interval) of the revolutions and tenths of a revolution for the portion of the screw that is in general use, taking the equivalent for 12$^{rev.}$ as the Zero.

Parts of Rev.	rev. 12	rev. 13	rev. 14	rev. 15	rev. 16	rev. 17	rev. 18	rev. 19	rev. 20	rev. 21	rev. 22	rev. 23	rev. 24	Parts of Rev.
r	s	s	s	s	s	s	s	s	s	s	s	s	s	r
·0	·000	1·432	2·864	4·298	5·732	7·169	8·606	10·046	11·488	12·933	14·378	15·825	17·271	·0
·1	·143	1·574	3·007	4·441	5·876	7·313	8·750	10·190	11 632	13·077	14·523	15·970	17·416	·1
·2	·286	1·717	3·150	4·584	6·019	7·457	8·894	10·335	11·777	13·222	14·667	16·114	17·560	·2
·3	·430	1·861	3·294	4·728	6·163	7·599	9·038	10·479	11·921	13·366	14·812	16·259	17·705	·3
·4	·573	2·004	3·437	4·871	6·306	7·743	9·182	10·622	12·066	13·510	14·957	16·404	17·850	·4
·5	·716	2·147	3·580	5·015	6·450	7·887	9·326	10·766	12·210	13·655	15·101	16·547	17·994	·5
·6	·859	2·291	3·724	5·158	6·594	8·031	9·470	10·911	12·355	13·800	15·246	16·692	18·139	·6
·7	1·002	2·434	3·867	5·302	6·738	8·175	9·614	11·055	12·499	13·944	15·391	16·837	18·284	·7
·8	1·146	2·578	4·011	5·445	6·882	8·318	9·758	11·199	12·644	14·089	15·536	16·982	18·429	·8
·9	1·289	2·721	4·154	5·589	7·025	8·462	9·902	11·344	12·788	14·233	15·680	17·126	18·573	·9
1·0	1·432	2·864	4·298	5·732	7·169	8·606	10·046	11·488	12·933	14·378	15·825	17·271	18·718	1·0

Wire.	Jan. 1 to Oct. 20.	Oct. 20 to Dec. 31.	Wire.	Jan. 1 to Oct. 20.	Oct. 20 to Dec. 31.
	r s	s		r s	s
1	+ 30·067 = + 43·368	+ 43·481	15	− 2·030 = − 2·928	− 2·868
2	+ 23·046 = + 33·241	+ 33·261	16	− 3·030 = − 4·371	− 4·364
3	+ 20·990 = + 30·276	+ 30·363	17	− 4·045 = − 5·835	− 5·798
4	+ 18·971 = + 27·363	+ 27·434	18	− 5·058 = − 7·296	− 7·249
5	+ 16·842 = + 24·293	+ 24·499	19	− 6·051 = − 8·728	− 8·784
6	+ 15·021 = + 21·666	+ 21·690	20	− 8·090 = − 11·668	− 11·539
7	+ 10·024 = + 14·459	+ 14·497	21	− 10·047 = − 14·491	− 14·495
8	+ 7·912 = + 11·412	+ 11·478	22	− 15·067 = − 21·732	− 21·649
9	+ 5·968 = + 8·609	+ 8·651	23	− 17·102 = − 24·666	− 24·548
10	+ 5·026 = + 7·250	+ 7·210	24	− 19·092 = − 27·536	− 27·445
11	+ 4·020 = + 5·799	+ 5·816	25	− 21·130 = − 30·477	− 30·361
12	+ 2·935 = + 4·234	+ 4·328	26	− 23·162 = − 33·408	− 33·322
13	+ 1·988 = + 2·867	+ 2·809	27	− 30·197 = − 43·556	− 43·417
14	0·000 0·000	0·000			

Equivalents of the Zenith Distance Micrometer-Screw and 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.

From Jan. 1 to Oct. 20 one revolution of telescope-micrometer = 21″·680.

The wear of the Zenith Distance Micrometer-Screw was investigated at the same time as that of the Transit-Micrometer-Screw; and from Oct. 20, the following corrections have been applied for inequality of screw, to the table deduced with the value 21″·680.

Rev.	Correction.	Rev.	Correction.	Rev.	Correction.
	″		″		″
0	+ 0·73	7	+ 0·08	13	+ 0·12
1	+ 0·61	8	+ 0·06	14	+ 0·10
2	+ 0·48	9	+ 0·07	15	+ 0·06
3	+ 0·36	10	+ 0·11	16	0·00
4	+ 0·26	11	+ 0·13		
5	+ 0·18	12	+ 0·13		
6	+ 0·12				

Wire.	Jan. 1 to Oct. 20.	Oct. 20 to Dec. 31.	Wire.	Jan. 1 to Oct. 20.	Oct. 20 to Dec. 31.
	r s	″		r s	″
I.	+ 15·950 = + 37·059	+ 346·67	XII.	− 2·037 = − 4·733	− 346·37
II.	+ 14·963 = + 34·767	+ 325·13	XIII.	− 2·997 = − 6·964	− 326·32
III.	+ 13·976 = + 32·474	+ 303·55	XIV.	− 4·009 = − 9·315	− 304·60
IV.	+ 12·972 = + 30·141	+ 282·03	XV.	− 4·991 = − 11·597	− 281·80
V.	+ 12·045 = + 27·987	+ 259·53	XVI.	− 5·998 = − 13·936	− 260·84
VI.	+ 6·036 = + 14·025	+ 130·05	XVII.	− 11·961 = − 27·791	− 132·04
VII.	+ 5·025 = + 11·676	+ 108·58	XVIII.	− 12·977 = − 30·150	− 108·07
VIII.	+ 4·037 = + 9·380	+ 87·72	XIX.	− 13·984 = − 32·492	− 86·31
IX.	+ 2·998 = + 6·966	+ 64·97	XX.	− 15·013 = − 34·883	− 65·06
X.	+ 1·954 = + 4·540	+ 42·99	XXI.	− 16·033 = − 37·252	− 43·04
XI.	0·000 = 0·000	0·00			

The following factors must be used to obtain the time intervals of the wires in other azimuths. Az. 80°, 100°, 1·01543; Az. 70°, 110°, 1·06418; Az. 60°, 120°, 1·15470; Az. 45°, 135°, 1·41421; Az. 30°, 150°, 2·00000.

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 1906.

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.	
	° ′	h m	s	s	s	″			
36 Draconis S.P.	− 25. 38	18. 13	21·240	21·265	− 0·025	+ 0·19	½	2	1
ζ Draconis S.P.	− 24. 10	17. 8	30·790	30·808	− 0·018	+ 0·12	2	2½	2
O.A.(N.) 20021−2 S.P.	− 18. 21	20. 1	0·600	0·600	0·000	0·00	½	1	1
Lalande 40304 S.P.	− 13. 30	20. 40	3·500	3·370	+ 0·130	− 0·36	1	1	1
ε Ursæ Minoris S.P.	− 7. 48	16. 55	35·070	34·357	+ 0·713	− 1·03	½	3	1
Bradley 2748	14. 26	20. 55	51·870	51·560	+ 0·310	+ 0·63	1	½	1
16 Cephei	17. 16	21. 57	55·090	54·620	+ 0·470	+ 1·10	1	1	1
υ Piscium	63. 13	1. 14	17·790	17·810	− 0·020	− 0·15	1	1	2
μ Cancri	68. 9	8. 2	14·060	14·040	+ 0·020	+ 0·16	1	2	2
τ¹ Arietis	69. 11	3. 16	47·910	47·867	+ 0·043	+ 0·35	1	4	2
δ Arietis	70. 37	3. 6	15·140	15·040	+ 0·100	+ 0·82	½	1	2
γ Tauri	74. 36	4. 14	26·500	26·480	+ 0·020	+ 0·18	1	1	2
f Tauri	77. 23	3. 25	40·880	40·880	0·000	0·00	1	3	2
Regulus	77. 34	10. 3	22·030	22·047	− 0·017	− 0·17	1	4	2
β Cancri	80. 31	8. 11	25·070	25·143	− 0·073	− 0·72	1	3	2
ξ¹ Ceti	81. 36	2. 8	0·970	1·010	− 0·040	− 0·40	½	1	1
ζ Hydræ	83. 42	8. 50	25·610	25·605	+ 0·005	+ 0·06	1	2	1
α² Piscium	87. 41	1. 57	10·920	10·925	− 0·005	− 0·07	½	2	1
ζ Leporis	104. 51	5. 42	41·850	41·810	+ 0·040	+ 0·71	1	2	1

From 12 South Stars, Mean Correction to Level-Error, = + 0″·06.
From 7 North ,, ,, ,, ,, ,, = + 0″·10.

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.

Observations to determine the Astronomical Flexure of the Altazimuth, 1906.

Date.	Mean Concluded Circle Reading. North Collimator. Fixed Circle.	North Collimator. Movable Circle.	South Collimator. Fixed Circle.	South Collimator. Movable Circle.	Resulting Correction for Astronomical Horizontal Flexure. Fixed Circle.	Movable Circle.	Reading of Interior Thermometer. Upper.	Lower.
				Position 180°, r.				
Jan. 2	270° 1′ 23″·38	67″·44	90° 1′ 24″·89	68″·56	− 0″·75	− 0″·56	E 40°·3 W 40·6	40°·0 39·7
Feb. 6	21·77	68·45	23·50	69·92	− 0·87	− 0·74	E 38·9 W 37·7	38·6 38·0
20	23·84	70·93	25·24	72·31	− 0·70	− 0·69	E 44·6 W 44·8	44·0 44·0
23	25·41	70·70	26·77	72·35	− 0·68	− 0·82	E 36·3 W 36·3	36·4 36·3
				Position 180°, d.				
Apr. 6	269 56 92·62	44·71	89 56 93·29	45·69	− 0·33	− 0·49	E 59·0 W 61·5	58·1 59·7
24	86·41	45·27	87·16	46·77	− 0·38	− 0·75	E 41·8 W 41·9	41·9 41·9
25	87·84	46·62	87·66	47·33	+ 0·09	− 0·35	E 47·1 W 47·0	45·2 45·5
				Position 0°, r.				
Aug. 20	90 4 2·92	48·20	270 4 1·15	47·77	− 0·17	− 0·22	E 67·1 W 67·1	66·5 66·2
22	2·07	47·98	1·62	47·23	− 0·23	− 0·38	E 86·9 W 89·7	85·4 86·4
31	6·32	56·34	7·19	56·35	+ 0·43	+ 0·01	E 83·4 W 82·1	80·7 80·4
				Position 180°, r.				
Sept. 6	270 1 2·59	62·63	90 1 2·92	63·64	− 0·17	− 0·51	E 73·4 W 73·0	72·0 72·0
10	4·21	66·22	4·53	66·94	− 0·22	− 0·36	E 65·0 W 66·8	64·5 65·6
				Position 180°, d.				
Nov. 23	269 56 103·17	38·59	89 56 104·14	39·86	− 0·48	− 0·64	E 51·5 W 51·6	51·4 51·4
Dec. 4	128·30	60·84	129·11	62·40	− 0·46	− 0·78	E 52·8 W 52·8	52·4 52·1

The column "Resulting Correction for Astronomical Horizontal Flexure," is in all cases ½ (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 of the Collimator Readings before and after.

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

Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1906.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
	Position 180°, r.	January, February.			
	h m	° ′	″		
Groombridge 2164 S.P.	14. 49	− 30. 20	+ 2·04	1	1
ζ Draconis S.P.	17. 8	− 24. 10	+ 1·60	2	2
A Draconis S.P.	16. 28	− 21. 2	+ 2·62	1	1
γ Ursæ Minoris S.P.	15. 20	− 17. 50	+ 2·89	1	1
ψ Draconis (S. star) S.P.	17. 43	− 17. 48	+ 0·28	1	1
χ Draconis S.P.	18. 22	− 17. 19	+ 2·00	1	1
β Ursæ Minoris S.P.	14. 50	− 15. 28	+ 1·69	2	2
19 Ursæ Minoris S.P.	16. 13	− 13. 53	+ 2·30	1	1
5 Ursæ Minoris S.P.	14. 27	− 13. 53	+ 2·09	1	1
ζ Ursæ Minoris S.P.	15. 47	− 11. 55	− 0·60	1	1
ε Ursæ Minoris S.P.	16. 55	− 7. 49	+ 1·64	2	2
2 Ursæ Minoris	0. 55	4. 14	+ 0·39	1	1
Bradley 473	3. 28	14. 34	+ 1·90	1	1
Lalande F. 724	5. 9	14. 54	+ 0·72	1	1
Piazzi IV. 207	4. 53	16. 4	+ 1·33	1	1
α Trianguli	1. 47	60. 53	+ 0·14	1	1
ν Arietis	2. 33	68. 27	− 1·07	1	1
τ^1 Arietis	3. 15	69. 12	+ 2·05	1	1
δ Arietis	3. 6	70. 38	− 1·06	2	2
ε Tauri	4. 23	71. 2	+ 2·76	1	1
γ Geminorum	6. 32	73. 31	+ 1·04	1	1
γ Tauri	4. 14	74. 36	+ 1·44	1	1
λ Tauri	3. 55	77. 47	+ 0·78	1	1
μ Orionis	5. 57	80. 21	+ 1·47	1	1
ξ^1 Ceti	2. 7	81. 36	+ 1·64	1	1
ξ^2 Ceti	2. 23	81. 58	− 1·94	1	1
α Piscium	1. 57	87. 41	+ 0·62	1	1

Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1906—contd.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
	Position 180°, r.	January, February—*continued.*			
	h m	° ′	″		
ε Eridani	3. 28	99. 47	− 0·11	2	2
ζ Leporis	5. 42	104. 52	− 0·85	1	1
α Leporis	5. 28	107. 54	− 1·29	1	1
	Position 180°, d.	March, April.			
α Cephei S.P.	21. 16	− 27. 49	+ 0·24	1	1
θ Cephei S.P.	20. 27	− 27. 20	+ 0·37	1	1
36 Draconis S.P.	18. 13	− 25. 38	− 0·28	1	1
ε Draconis S.P.	19. 48	− 19. 58	+ 1·00	1	1
O. A. (N.) 20021–2 S.P.	20. 1	− 18. 22	+ 1·15	1	1
Lalande 39736 S.P.	20. 24	− 14. 16	− 1·07	1	1
Lalande 40304–5 S.P.	20. 40	− 13. 30	− 1·25	1	1
35 Draconis S.P.	17. 53	− 13. 2	− 0·72	1	1
Bradley 2777 S.P.	21. 7	− 12. 15	+ 1·72	1	1
δ Ursæ Minoris S.P.	18. 3	− 3. 23	− 0·37	2	2
Groombridge 3548 S.P.	21. 18	− 3. 21	+ 1·83	1	1
Groombridge 1119	8. 3	1. 5	− 2·48	1	1
Piazzi X. 22	10. 19	6. 58	− 0·81	1	1
Piazzi IX. 37	9. 23	8. 15	+ 1·67	1	1
Piazzi VII. 132	7. 41	9. 30	(− 4·40)	1	1
Lalande F. 1647	10. 10	16. 27	− 1·19	1	1
ε Geminorum	6. 38	64. 47	− 2·37	1	1
ξ Cancri	9. 3	67. 35	+ 0·59	1	1
μ Cancri	8. 2	68. 9	(− 2·99)	1	1
η Cancri	8. 27	69. 14	+ 1·46	1	1
δ Cancri	8. 39	71. 30	− 0·44	2	2
ψ Leonis	9. 38	75. 33	− 0·79	2	2
Regulus	10. 3	77. 35	+ 0·14	1	1
α Cancri	8. 53	77. 47	+ 0·57	1	1
β Cancri	8. 11	80. 32	− 0·39	1	1
π Leonis	9. 55	81. 30	− 0·81	1	1
13 Monocerotis	6. 27	82. 36	− 1·11	1	1
ζ Hydræ	8. 50	83. 42	(− 11·91)	1	1
ω Hydræ	9. 1	84. 32	− 2·13	1	1
2 Sextantis	9. 33	84. 56	− 2·00	1	1

Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1906—contd.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
	Position 180°, d.	March, April—*continued.*			
	h m	° ′	″		
δ Orionis	5. 27	90. 22	+ 0·08	1	1
30 Monocerotis	8. 20	93. 36	− 2·67	1	1
κ Orionis	5. 43	99. 42	− 1·74	1	1
20 Puppis	8. 8	105. 31	(− 3·50)	1	1
	Position 0°, d.	May, June.			
55 Cassiopeiæ S.P.	2. 7	− 23. 55	− 0·13	1	1
ι Cassiopeiæ S.P.	2. 21	− 23. 1	+ 0·97	2	2
Groombridge 2283	15. 7	2. 24	+ 0·46	1	1
Groombridge 2066	13. 50	10. 32	+ 2·24	1	1
θ Ursæ Minoris	15. 34	12. 20	(+ 4·80)	1	1
5 Ursæ Minoris	14. 27	13. 53	(− 5·27)	1	1
3 Ursæ Minoris	14. 6	14. 57	+ 1·22	1	1
45 Boötis	16. 3	64. 46	+ 0·12	1	1
β Herculis	16. 26	68. 18	+ 0·67	1	1
γ Herculis	16. 17	70. 37	− 0·22	1	1
η Boötis	13. 50	71. 8	+ 0·25	1	1
τ Boötis	13. 42	72. 4	− 1·16	1	1
Piazzi XIV 221	14. 51	75. 10	+ 0·31	1	1
τ Virginis	13. 56	88. 0	+ 1·19	2	2
	Position 0°, r.	July, August.			
Radcliffe 1707 S.P.	6. 17	− 19. 25	− 0·24	1	1
Piazzi VI. 75 S.P.	6. 30	− 10. 20	− 1·17	1	1
Groombridge 944 S.P.	5. 31	− 4. 51	+ 2·28	1	1
24 Ursæ Minoris	18. 5	3. 0	− 1·86	1	1
δ Ursæ Minoris	18. 3	3. 23	− 2·00	1	1
ζ Ursæ Minoris	15. 47	11. 55	− 2·16	1	1
θ Ursæ Minoris	15. 34	12. 20	− 2·11	1	1
Lalande 40305	20. 40	13. 30	− 0·66	1	1
η Ursæ Minoris	16. 20	14. 1	− 1·96	1	1
Lalande 39736	20. 24	14. 16	− 1·02	1	1
β Ursæ Minoris	14. 50	15. 27	− 1·57	1	1
Bradley 2942	22. 11	17. 9	+ 2·19	1	1
16 Cephei	21. 57	17. 16	+ 0·84	1	1
χ Draconis	18. 23	17. 18	− 1·53	1	1

Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1906—contd.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
		Position 0°, r. July, August—*continued.*			
	h m	° ′	″		
β Coronæ	15. 23	60. 34	− 2·13	1	1
μ Herculis	17. 42	62. 13	− 1·20	1	1
89 Herculis	17. 51	63. 56	− 0·66	1	1
10 Vulpeculæ	19. 39	64. 27	− 3·23	1	1
γ Sagittæ	19. 54	70. 45	− 1·12	1	1
γ Serpentis	15. 52	74. 2	+ 0·51	1	1
β Serpentis	15. 41	74. 17	− 1·79	1	1
ρ Aquilæ	20. 10	75. 5	− 0·78	1	1
α Ophiuchi	17. 30	77. 22	− 1·11	1	1
ω Aquilæ	19. 13	78. 34	− 2·27	1	1
β Ophiuchi	17. 38	85. 23	− 0·14	1	1
θ Serpentis	18. 51	85. 55	(+ 4·55)	1	1
c Serpentis	18. 24	92. 3	− 2·14	1	1
β Libræ	15. 11	99. 2	− 3·36	1	1
		Position 180°, r. September, October.			
Bradley 1429 S.P.	10. 17	− 23. 58	− 0·75	1	1
σ² Ursæ Majoris S.P.	9. 2	− 22. 29	− 0·41	1	1
Groombridge 1374 S.P.	7. 48	− 15. 50	+ 1·10	1	1
λ Ursæ Minoris	19. 24	1. 0	− 0·55	1	1
Bradley 2777	21. 7	12. 15	+ 0·15	1	1
Bradley 2748	20. 56	14. 26	+ 0·80	1	1
Piazzi XXIII. 218	23. 48	14. 58	− 0·62	1	1
Groombridge 3426	21. 10	15. 9	+ 0·86	1	1
Lalande 47031	23. 54	15. 43	+ 0·44	1	1
δ Andromadæ	0. 34	59. 39	− 2·58	1	1
υ Piscium	1. 14	63. 14	+ 0·29	1	1
κ Pegasi	21. 40	64. 47	− 0·36	1	1
ι Pegasi	22. 2	65. 6	− 1·33	1	1
γ Sagittæ	19. 54	70. 45	− 1·60	1	1
ε Pegasi	21. 39	80. 33	− 1·10	1	1
ι Piscium	23. 35	84. 53	+ 0·74	1	1
γ Piscium	23. 12	87. 14	− 0·48	1	1

Excess of Reflexion Results above Direct Results for Observations of Zenith-Distance with the Altazimuth, 1906—contd.

Star's Name.	Approximate R.A.	Approximate N.P.D.	R.—D.	No. of Obs. R. and D.	Weight.
	Position 180°, r.	September, October—*continued*.			
	h m	° ′	″		
θ Aquilæ	20. 6	91. 6	− 0·14	1	1
ξ Aquarii	21. 32	98. 16	− 1·16	1	1
μ Capricorni	21. 48	103. 59	+ 2·34	1	1
ι Aquarii	22. 1	104. 19	+ 3·06	1	1
	Position 180°, d.	November, December.			
A Draconis S.P.	16. 28	− 21. 2	− 1·58	1	1
Bradley 1446 S.P.	10. 27	− 13. 49	+ 1·10	1	1
11 Tauri	3. 35	64. 58	− 0·91	1	1
f Tauri	3. 25	77. 23	+ 0·02	1	1
o² Eridani	4. 10	97. 48	− 0·68	1	1

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

Extent of Group 1906.	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 180°, r.	January, February.			
		° ′	° ′	″	″	″
Groomb. 2164 S.P. to A. Draconis S.P.	4	− 24. 55	− 63. 26	+ 1·85	+ 1·03	− 0·82
γ Ursæ Min. S.P. to ζ Ursæ Min. S.P.	8	− 15. 27	− 53. 58	+ 1·44	+ 0·99	− 0·45
ε Ursæ Minoris S.P.	1	− 7. 49	− 46. 20	+ 1·54	+ 0·95	− 0·49
2 Ursæ Minoris	1	4. 14	− 34. 17	+ 0·32	+ 0·87	+ 0·55
Bradley 473 to Piazzi IV. 207	3	15. 11	− 23. 20	+ 1·27	+ 0·79	− 0·48
α Trianguli to ε Tauri	6	68. 28	29. 57	+ 0·35	+ 0·36	+ 0·01
γ Geminorum to ξ² Ceti	6	78. 18	39. 47	+ 0·82	+ 0·29	− 0·53
α Piscium	1	87. 41	49. 10	+ 0·71	+ 0·24	− 0·47
ε Eridani to α Leporis	4	103. 5	64. 34	− 0·48	+ 0·17	+ 0·65

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

Extent of Group 1906.	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 180°, d. March, April.						
		° ′	° ′	″	″	″
α Cephei S.P. to 36 Draconis S.P.	3	− 26. 56	− 65. 27	0·00	− 0·16	− 0·16
ε Draconis S. P. to Bradley 2777 S.P.	6	− 15. 14	− 53. 45	+ 0·04	− 0·21	− 0·25
δ Ursæ Minoris S.P. to Groomb. 1119.	4	− 2. 16	− 40. 47	− 0·43	− 0·28	+ 0·15
Piazzi X. 22 to Lalande F. 1647	4	10. 33	− 27. 58	− 0·17	− 0·37	− 0·20
ε Geminorum to δ Cancri	6	68. 48	30. 17	− 0·18	− 0·84	− 0·66
ψ Leonis to 2 Sextantis	10	80. 4	41. 33	− 0·73	− 0·92	− 0·19
δ Orionis to κ Orionis	3	94. 33	56. 2	− 1·34	− 1·00	+ 0·34
20 Puppis	1	105. 31	67. 0	− 3·50	− 1·04	+ 2·46
Position 0°, d. May, June.						
55 Cassiopeiæ S.P. to ι Cassiopeiæ S.P.	3	− 23. 19	− 61. 50	+ 0·49	+ 1·02	+ 0·53
Groombridge 2283 to 3 Ursæ Minoris.	3	9. 18	− 29. 13	+ 1·25	+ 0·84	− 0·41
45 Boötis to Piazzi XIV 221	6	70. 21	31. 50	+ 0·06	+ 0·35	+ 0·29
τ Virginis	2	88. 0	49. 29	+ 1·28	+ 0·24	− 1·04
Position 0°, r. July, August.						
Radcliffe 1707 S.P. to Piazzi VI.75 S.P.	2	− 14. 53	− 53. 24	− 0·80	− 0·22	+ 0·58
Groombridge 944 S.P. to δ Ursæ Minoris	3	− 0. 31	− 38. 0	− 0·60	− 0·30	+ 0·30
ζ Ursæ Minoris to χ Draconis	9	14. 54	− 23. 37	− 0·94	− 0·41	+ 0·53
β Coronæ to 10 Vulpeculæ	4	62. 57	24. 26	− 1·75	− 0·80	+ 0·95
γ Sagittæ to α Ophiuchi	5	74. 18	35. 47	− 0·79	− 0·88	− 0·09
ω Aquilæ to θ Serpentis	2	81. 59	43. 28	− 1·12	− 0·93	+ 0·19
c Serpentis to β Libræ	2	95. 33	57. 2	− 2·65	− 1·00	+ 1·65
Position 180°, r. September, October.						
Bradley 1429 S.P. to Groomb. 1374 S.P.	3	− 20. 46	− 59. 17	− 0·12	+ 1·01	+ 1·13
λ Ursæ Minoris	1	1. 0	− 37. 31	− 0·62	+ 0·89	+ 1·51
Bradley 2777 to Lalande 47031	5	14. 30	− 24. 1	+ 0·28	+ 0·80	+ 0·52
δ Andromedæ to ι Pegasi	4	63. 12	24. 41	− 0·95	+ 0·39	+ 1·34
γ Sagittæ	1	70. 45	32. 14	− 1·54	+ 0·35	+ 1·89
ε Pegasi to γ Piscium	3	84. 13	45. 42	− 0·19	+ 0·25	+ 0·44
θ Aquilæ to ξ Aquarii	2	94. 41	56. 10	− 0·55	+ 0·20	+ 0·75
μ Capricorni to ι Aquarii	2	104. 9	65. 38	+ 2·81	+ 0·16	− 2·65
Position 180°, d. November, December.						
A Draconis S.P.	1	− 21. 2	− 59. 33	− 1·68	− 0·19	+ 1·49
Bradley 1446 S.P.	1	− 13. 49	− 52. 20	+ 1·01	− 0·22	− 1·23
11 Tauri	1	64. 58	26. 27	− 0·86	− 0·81	+ 0·05
f Tauri	1	77. 23	38. 52	+ 0·09	− 0·90	− 0·99
o^2 Eridani	1	97. 48	59. 17	− 0·58	− 1·01	− 0·43

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

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

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

Observed R−D Discordance for Different Positions of the Altazimuth, in the Year 1906.

Position of Instrument.	R−D Discordance.	
	″	″
180°, r (Jan., Feb.).	+0·86	−0·80 sin Z.
180°, d (Mar., Apr.).	−0·42	−0·40 sin Z.
0°, d (May, June).	+0·60	−0·40 sin Z.
0°, r (July, Aug.).	−1·12	−0·52 sin Z.
180°, r (Sept., Oct.).	−0·04	−0·14 sin Z.
180°, d (Nov., Dec.).	−0·40	−0·08 sin Z.

Assuming the formulæ for the four positions as

$+ a + b \sin$ Z.D. for the positions 0°, d and 180°, r,

and

$- a + b \sin$ Z.D. „ „ 0° r, and 180°, d,

the R−D discordance for applying the four positions may be taken as

$$\pm 0''\cdot60 - 0''\cdot48 \sin \text{Z.D.}$$

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1906, *with those of Newcomb's Fundamental Catalogue.*

Position 180°, r. January, February.

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
19. 53	− 37·8	+ 0·63	1	1
13. 30	− 34·2	+ 2·22	1	1
14. 49	− 30·3	+ 1·61	1	1
18. 13	− 25·6	+ 0·23	1	1
17. 8	− 24·2	+ 0·42	1	1
16. 6	− 21·9	+ 0·21	1	1
17. 37	− 21·2	+ 1·55	1	1
16. 28	− 21·0	+ 1·30	1	1
18. 22	− 18·7	+ 0·93	1	1
22. 7	− 18·1	+ 0·45	1	1
15. 20	− 17·8	+ 1·13	1	1
17. 43	− 17·8	+ 0·49	1	1
18. 22	− 17·3	+ 1·27	1	1
21. 57	− 17·3	0·00	1	1
19. 17	− 16·8	− 0·05	1	1
14. 50	− 15·5	+ 0·44	2	2
16. 20	− 14·0	+ 0·66	2	2
14. 27	− 13·9	+ 2·80	1	1
16. 13	− 13·9	+ 0·71	3	3
17. 53	− 13·0	+ 1·78	1	1
15. 47	− 11·9	− 0·01	1	1
16. 55	− 7·8	+ 1·15	2	2
18. 3	− 3·4	+ 0·94	5	4
15. 6	− 2·4	+ 1·54	1	1
1. 24	− 1·2	+ 0·38	1	1
19. 16	− 1·0	+ 0·55	1	1
1. 24	1·2	+ 0·58	1	1
6. 54	2·8	+ 0·32	4	3
0. 55	4·2	+ 0·16	1	1
4. 6	4·7	+ 0·67	2	2
7. 11	7·4	+ 0·70	1	1
5. 7	10·9	+ 1·99	1	1
6. 29	28·4	+ 0·57	2	2
3. 49	29·2	+ 1·00	1	1
1. 19	30·3	+ 0·82	1	1
3. 21	30·4	+ 0·55	2	2
6. 49	31·5	+ 0·79	1	1
6. 22	31·8	− 0·05	2	2
0. 35	34·0	+ 0·72	1	1

Position 180°, r. Jan., Feb.—*contd.*

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
5. 38	40·2	+ 1·26	1	1
22. 27	40·2	+ 0·84	1	1
6. 17	40·7	+ 0·08	1	1
7. 47	42·2	+ 0·65	1	1
5. 52	45·1	+ 0·11	1	1
6. 39	46·3	+ 0·15	1	1
4. 26	47·1	+ 1·01	1	1
6. 44	48·1	+ 0·14	2	2
7. 5	50·5	+ 0·25	2	2
12. 21	50·5	− 0·08	1	1
5. 44	50·9	+ 1·49	1	1
18. 33	51·3	− 0·03	3	3
1. 4	54·9	+ 1·34	1	1
4. 14	55·7	+ 0·54	1	1
6. 46	55·9	+ 0·74	3	3
4. 50	57·0	+ 1·28	1	1
7. 28	57·9	− 0·25	1	1
7. 23	58·0	+ 1·24	1	1
1. 47	60·9	+ 0·62	1	1
4. 1	61·3	+ 0·61	1	1
5. 20	61·5	+ 0·57	3	3
7. 39	61·7	+ 0·48	1	1
7. 19	62·0	+ 0·19	1	1
9. 47	63·5	+ 0·59	1	1
7. 55	64·3	+ 0·85	1	1
6. 38	64·8	+ 0·26	1	1
3. 35	65·0	+ 0·49	2	2
9. 40	65·8	+ 0·82	1	1
5. 58	66·7	+ 2·13	1	1
4. 36	67·2	+ 0·48	2	2
6. 17	67·4	+ 1·10	1	1
6. 9	67·5	− 0·01	1	1
8. 2	68·1	+ 0·95	1	1
2. 33	68·4	− 0·05	1	1
3. 15	69·2	+ 0·89	3	3
6. 58	69·3	+ 0·49	2	2
6. 23	69·7	+ 0·24	1	1
10. 14	69·7	+ 0·11	1	1
10. 14	69·7	+ 0·55	1	1
3. 6	70·6	− 0·28	1	1
4. 3	70·6	+ 1·00	1	1
4. 23	71·0	+ 0·96	3	3

Position 180°, r. Jan., Feb.—*contd.*

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
13. 50	71·1	− 0·26	1	1
4. 17	72·7	+ 1·28	1	1
7. 12	73·3	+ 0·64	1	1
6. 32	73·5	+ 0·50	2	2
4. 30	73·7	+ 0·86	3	3
7. 7	73·7	+ 0·44	1	1
7. 2	73·9	+ 0·61	1	1
4. 14	74·6	− 0·28	1	1
4. 59	74·7	+ 1·32	1	1
1. 26	75·1	+ 0·16	1	1
4. 28	75·4	+ 0·72	1	1
6. 6	75·8	+ 1·60	1	1
6. 40	77·0	+ 0·66	1	1
9. 53	77·1	+ 0·08	1	1
3. 25	77·4	+ 1·11	1	1
10. 3	77·6	− 0·13	1	1
6. 11	77·7	+ 1·02	2	2
3. 55	77·8	+ 0·71	2	2
7. 24	77·8	+ 0·52	1	1
6. 35	80·0	− 0·13	2	2
5. 57	80·4	+ 1·87	1	1
12. 0	80·7	+ 1·35	1	1
7. 22	81·5	+ 0·09	1	1
2. 8	81·6	+ 2·38	1	1
2. 23	82·0	− 0·25	1	1
5. 50	82·6	+ 1·16	2	2
6. 27	82·6	+ 0·30	3	3
11. 41	82·9	− 0·16	1	1
3. 58	84·3	+ 0·86	2	2
2. 57	86·3	− 0·98	1	1
6. 42	87·5	+ 0·03	1	1
1. 57	87·7	+ 1·11	1	1
4. 49	87·7	+ 1·24	1	1
5. 27	90·4	+ 0·29	1	1
12. 36	90·9	− 0·78	2	2
12. 36	90·9	− 0·52	2	2
5. 31	91·3	+ 1·37	1	1
5. 19	92·5	+ 1·74	1	1
5. 34	92·7	− 0·10	1	1
4. 40	93·4	+ 0·29	2	2
7. 32	93·9	− 0·14	1	1
5. 3	95·2	− 0·36	1	1
5. 13	97·0	+ 0·69	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1906, *with those of Newcomb's Fundamental Catalogue*—continued.

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 180°, r. Jan., Feb.—*contd.*				
h m	°	″		
5. 10	98·3	+ 0·68	1	1
1. 19	98·7	− 0·46	1	1
7. 36	99·3	+ 0·45	2	2
3. 28	99·8	− 0·25	3	3
6. 49	101·9	+ 0·35	2	2
5. 15	103·3	+ 0·39	2	2
3. 53	103·8	+ 1·49	1	1
4. 33	104·5	− 0·17	1	1
5. 42	104·9	+ 0·97	2	2
12. 24	106·0	+ 0·42	1	1
5. 8	106·3	+ 0·21	1	1
10. 21	106·4	+ 2·48	1	1
6. 41	106·6	+ 1·22	3	3
5. 28	107·9	− 0·69	2	2
6. 18	107·9	+ 0·85	1	1
0. 38	108·5	− 0·55	1	1
5. 24	110·8	+ 1·42	2	2
3. 29	111·9	+ 1·01	1	1
12. 5	112·1	+ 0·73	1	1
5. 1	112·5	+ 1·61	1	1
6. 31	112·9	− 2·69	1	1
12. 29	112·9	+ 0·73	2	2
3. 42	113·5	− 3·42	1	1
6. 54	118·8	+ 1·94	1	1
6. 16	120·0	− 0·32	1	1
Position 180°, d. March, April.				
19. 33	− 40·0	− 2·66	1	1
19. 53	− 37·8	+ 0·22	1	1
21. 49	− 34·2	+ 2·09	1	1
22. 7	− 32·3	+ 0·50	1	1
18. 22	− 31·3	− 0·49	1	1
18. 49	− 30·7	− 0·79	1	1
20. 43	− 28·5	+ 0·94	1	1
21. 16	− 27·8	+ 0·27	1	1
20. 28	− 27·3	− 1·33	1	1
18. 13	− 25·6	− 0·60	1	1
18. 35	− 24·6	− 0·40	1	1

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 0°, d. March, April.				
h m	°	″		
19. 48	− 20·0	− 1·75	2	2
21. 27	− 19·9	+ 0·05	1	1
21. 40	− 19·1	− 0·49	1	1
20. 30	− 17·8	− 2·05	2	2
21. 57	− 17·3	− 1·07	2	2
17. 53	− 13·0	− 0·82	1	1
23. 35	− 12·9	+ 0·26	1	1
21. 7	− 12·3	− 0·78	1	1
18. 3	− 3·4	− 0·49	3	3
21. 18	− 3·4	+ 0·36	4	3
23. 27	− 3·2	− 0·94	1	1
6. 54	− 2·8	+ 0·66	1	1
19. 16	− 1·0	− 0·66	2	2
8. 6	1·1	− 0·92	5	4
1. 24	1·2	− 2·53	2	2
15. 6	2·4	− 1·93	1	1
6. 54	2·8	− 0·39	1	1
18. 3	3·4	+ 0·61	1	1
10. 19	7·0	− 0·18	1	1
9. 23	8·3	+ 0·74	1	1
10. 52	11·7	− 0·90	1	1
7. 48	15·8	− 0·85	1	1
9. 49	16·7	+ 0·20	3	3
10. 36	20·4	0·00	1	1
7. 20	21·3	− 0·20	1	1
11. 37	22·7	− 0·13	1	1
9. 44	30·5	+ 0·82	3	3
6. 49	31·5	− 0·65	1	1
8. 32	37·0	+ 0·29	1	1
8. 1	38·2	− 1·24	2	2
5. 9	44·1	− 0·97	1	1
9. 7	46·4	− 0·52	1	1
10. 16	48·0	− 1·35	1	1
13. 13	48·9	+ 0·10	1	1
10. 54	49·1	− 1·22	1	1
18. 33	51·3	− 1·88	1	1
9. 12	52·8	+ 0·14	1	1
10. 22	52·8	+ 0·71	1	1
13. 1	53·7	+ 0·63	1	1
9. 15	55·2	− 1·00	1	1

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 0°, d. Mar., Apr.—*contd.*				
h m	°	″		
6. 46	55·9	− 1·32	1	1
7. 28	57·9	− 0·64	1	1
7. 28	57·9	+ 0·54	1	1
7. 23	58·0	− 2·43	1	1
8. 48	59·1	− 1·53	1	1
17. 54	60·7	+ 0·14	1	1
13. 7	61·6	− 0·73	1	1
7. 57	61·9	− 0·83	1	1
12. 47	61·9	+ 0·01	1	1
9. 47	63·6	− 1·11	2	2
7. 55	64·3	− 0·51	1	1
6. 38	64·8	− 1·12	1	1
9. 40	65·8	− 0·75	2	2
5. 58	66·7	− 0·90	1	1
4. 36	67·2	− 1·70	1	1
9. 3	67·6	− 0·10	2	2
8. 2	68·1	− 0·73	1	1
8. 37	68·2	− 0·87	1	1
5. 32	68·9	+ 0·18	1	1
8. 27	69·2	+ 0·17	2	2
10. 14	69·7	+ 0·07	1	1
10. 14	69·7	− 0·48	1	1
14. 22	70·4	− 0·95	1	1
8. 17	71·4	− 0·75	2	2
8. 39	71·5	− 0·58	3	3
8. 26	71·6	− 1·09	1	1
9. 13	71·9	− 0·17	1	1
8. 6	72·1	− 1·25	3	3
13. 42	72·1	− 1·29	1	1
7. 12	73·3	− 0·26	1	1
4. 30	73·7	− 2·26	1	1
7. 7	73·7	− 1·28	3	3
11. 50	73·8	− 1·01	1	1
7. 2	73·9	+ 0·35	1	1
8. 23	75·5	+ 0·27	1	1
9. 38	75·5	+ 0·07	2	2
6. 40	77·0	− 0·26	1	1
9. 53	77·1	− 1·16	1	1
10. 3	77·6	− 0·61	3	3
8. 53	77·8	+ 0·12	3	3
9. 2	79·0	− 0·02	1	1
10. 44	79·0	+ 0·30	1	1
9. 36	79·6	− 0·39	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1906, *with those of Newcomb's Fundamental Catalogue*—continued.

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 180°, d.	Mar., Apr.—*contd.*			
h m	°	″		
10. 27	80·2	− 0·68	3	3
8. 11	80·5	− 0·66	1	1
12. 0	80·7	− 0·01	1	1
19. 46	81·4	+ 0·44	1	1
7. 22	81·5	+ 0·06	1	1
9. 55	81·5	− 0·69	2	2
11. 0	82·2	− 0·39	1	1
6. 27	82·6	− 0·42	3	3
9. 32	82·7	− 0·38	2	2
11. 41	82·9	− 1·02	2	2
11. 56	82·9	− 1·08	1	1
8. 41	83·2	− 2·07	1	1
11. 16	83·5	− 0·86	1	1
8. 50	83·7	− 0·66	2	2
8. 32	84·0	+ 0·51	1	1
9. 1	84·5	− 2·33	1	1
9. 33	84·9	− 1·18	1	1
17. 38	85·4	− 0·33	1	1
10. 55	85·9	+ 0·55	1	1
12. 43	85·9	− 3·02	1	1
12. 50	86·1	+ 0·48	1	1
19. 20	87·1	− 0·14	1	1
9. 9	87·3	− 1·01	1	1
11. 45	87·7	− 1·04	2	2
5. 19	88·2	− 0·58	1	1
5. 27	90·4	+ 0·23	1	1
12. 36	90·9	− 0·25	1	1
12. 36	90·9	− 0·56	1	1
5. 36	92·0	+ 0·31	1	1
11. 11	93·1	− 0·15	1	1
8. 20	93·6	− 1·83	1	1
13. 5	95·0	+ 0·99	1	1
9. 29	95·5	− 1·20	1	1
5. 13	97·0	− 0·60	1	1
5. 10	98·3	− 1·68	1	1
9. 22	98·3	− 0·58	1	1
7. 36	99·3	+ 1·27	1	1
5. 43	99·7	− 1·40	2	2
13. 20	100·7	− 0·85	1	1
14. 31	101·9	− 2·83	1	1
10. 0	102·6	+ 2·05	1	1
5. 52	104·2	− 1·64	1	1
6. 59	105·5	+ 0·02	1	1

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 180°, d.	Mar., Apr.—*contd.*			
h m	°	″		
8. 9	105·5	− 1·65	1	1
10. 44	105·7	− 0·53	1	1
10. 21	106·4	− 1·69	1	1
5. 47	110·9	− 2·03	1	1
7. 45	114·6	− 0·83	2	2
Position 0°, d.	May, June.			
3. 2	− 49·4	(+ 11·90)	1	1
3. 38	− 47·7	(+ 4·58)	1	1
3. 36	− 42·5	(+ 4·59)	1	1
4. 1	− 42·5	+ 1·28	1	1
3. 17	− 40·5	+ 1·95	2	2
1. 56	− 26·1	+ 0·15	1	1
2. 7	− 23·9	+ 0·08	1	1
2. 21	− 23·0	+ 0·32	1	1
0. 39	− 15·5	+ 2·04	1	1
23. 27	− 3·2	− 0·23	1	1
1. 24	− 1·2	+ 1·29	1	1
12. 14	1·8	+ 1·07	1	1
15. 6	2·4	+ 0·47	2	2
18. 3	3·4	+ 2·13	1	1
16. 55	7·8	+ 2·25	1	1
18. 7	10·0	+ 2·28	1	1
12. 7	11·9	+ 1·65	1	1
15. 47	11·9	+ 1·28	1	1
16. 34	12·4	+ 2·59	2	2
14. 27	13·9	+ 0·80	1	1
14. 1	25·2	+ 0·73	1	1
17. 8	24·2	+ 1·75	1	1
15. 22	30·7	+ 0·70	1	1
12. 25	31·1	+ 1·65	1	1
16. 43	33·0	− 0·94	1	1
17. 51	33·1	+ 2·09	1	1
17. 30	34·8	+ 2·56	1	1
17. 30	34·8	+ 2·98	1	1
17. 28	37·6	+ 1·35	1	1
14. 21	37·7	+ 0·65	1	1

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 0°, d.	May, June—*contd.*			
h m	°	″		
17. 47	41·6	+ 2·43	1	1
17. 24	41·7	+ 1·18	1	1
16. 5	44·8	− 0·06	1	1
20. 38	45·1	− 0·32	1	1
14. 35	45·2	+ 2·08	2	2
16. 31	47·4	+ 1·69	1	1
12. 29	48·1	+ 2·44	1	1
12. 34	48·6	+ 1·10	2	2
15. 27	48·8	+ 1·44	1	1
15. 28	48·8	− 0·29	1	1
13. 13	48·9	+ 2·28	1	1
13. 16	49·4	+ 1·16	1	1
17. 4	49·4	+ 1·88	1	1
17. 49	50·0	− 0·29	1	1
12. 21	50·5	+ 0·87	1	1
17. 53	52·7	+ 2·13	1	1
17. 11	53·1	+ 1·23	1	1
13. 1	53·7	+ 0·91	1	1
15. 11	56·3	+ 1·50	1	1
16. 58	56·3	+ 2·31	1	1
17. 13	56·8	+ 0·89	1	1
17. 17	57·4	+ 2·17	1	1
16. 37	58·2	+ 1·11	2	2
15. 19	59·4	+ 2·04	1	1
14. 30	59·8	+ 1·15	1	1
13. 7	61·6	+ 0·34	1	1
13. 56	62·2	+ 2·31	1	1
17. 42	62·2	+ 1·84	1	1
19. 26	62·2	+ 0·96	1	1
15. 53	62·8	+ 1·15	1	1
15. 30	63·0	+ 2·31	1	1
17. 26	63·8	+ 1·59	1	1
14. 6	64·5	+ 2·18	1	1
15. 3	64·8	+ 1·61	1	1
16. 26	68·3	+ 0·44	1	1
15. 37	70·0	+ 1·35	1	1
15. 37	70·0	+ 1·35	1	1
14. 11	70·3	+ 2·12	1	1
14. 47	70·5	+ 1·09	1	1
16. 17	70·6	+ 0·81	1	1
13. 50	71·1	+ 1·05	1	1
15. 41	71·6	+ 0·43	1	1
13. 42	72·1	+ 1·69	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1906, *with those of Newcomb's Fundamental Catalogue*—continued.

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
Position 0°, d. May, June.—*contd.*				
h m	°	″		
11. 50	73·8	+ 2·41	1	1
15. 41	74·3	+ 1·08	2	2
11. 44	74·9	+ 1·57	1	1
16. 47	74·9	+ 1·89	1	1
14. 51	75·2	+ 1·37	2	2
14. 36	75·9	+ 1·39	1	1
17. 1	77·1	+ 2·26	1	1
10. 3	77·6	+ 0·86	1	1
11. 9	79·0	+ 1·58	1	1
19. 41	79·6	+ 1·59	1	1
16. 53	80·5	+ 1·02	2	2
12. 0	80·7	+ 1·69	1	1
19. 46	81·4	+ 2·07	1	1
11. 0	82·2	+ 1·38	1	1
16. 45	82·6	+ 0·72	2	2
11. 41	82·9	+ 1·60	1	1
17. 38	85·4	+ 1·21	2	2
11. 55	85·8	+ 1·92	1	1
12. 43	85·9	+ 0·68	1	1
17. 55	87·1	+ 1·70	1	1
17. 43	87·3	+ 3·37	1	1
13. 56	88·0	+ 1·38	2	2
13. 29	90·1	+ 0·70	1	1
15. 44	93·1	+ 1·43	2	2
16. 9	93·5	+ 0·64	2	2
12. 31	95·3	+ 1·52	1	1
14. 55	98·1	+ 1·21	1	1
17. 57	98·2	+ 3·50	1	1
15. 11	99·0	+ 0·93	1	1
13. 20	100·7	+ 0·54	1	1
14. 51	101·0	+ 0·39	1	1
14. 49	101·5	+ 0·85	2	2
17. 36	102·8	+ 1·92	1	1
14. 44	103·8	+ 1·99	1	1
15. 30	104·5	− 0·67	2	2
14. 45	105·6	+ 1·33	1	1
17. 4	105·6	+ 1·42	1	1
15. 55	106·3	+ 0·35	1	1
15. 22	106·4	+ 0·89	1	1
12. 10	107·0	+ 2·46	1	1
16. 36	107·6	+ 1·12	1	1
15. 36	109·4	− 0·98	1	1
Position 0°, d. May, June—*contd.*				
h m	°	″		
18. 8	111·1	− 0·12	1	1
15. 54	112·4	+ 1·83	1	1
17. 16	114·9	+ 2·25	1	1
16. 23	116·2	+ 1·51	1	1
16. 30	118·0	+ 2·20	1	1
Position 0°, r. July, August.				
4. 55	− 46·3	− 1·73	1	1
5. 9	− 44·1	+ 1·49	1	1
8. 57	− 42·5	+ 1·11	1	1
4. 24	− 36·3	− 1·71	1	1
6. 29	− 28·4	− 0·97	2	2
6. 43	− 21·0	− 1·98	2	2
6. 30	− 10·3	+ 1·57	2	2
5. 31	− 4·8	− 0·05	1	1
6. 54	− 2·8	− 0·40	2	2
8. 6	− 1·1	− 0·67	1	1
19. 16	1·0	− 0·35	1	1
1. 24	1·2	− 0·15	1	1
18. 3	3·4	− 1·27	2	2
21. 18	3·4	+ 0·01	1	1
15. 47	11·9	− 0·98	1	1
15. 34	12·3	(+ 5·29)	1	1
16. 20	14·0	− 2·02	1	1
14. 50	15·5	+ 0·22	2	2
18. 22	17·3	− 0·70	1	1
21. 57	17·3	+ 0·91	1	1
20. 28	27·3	− 0·92	1	1
15. 22	30·7	+ 0·49	1	1
20. 10	43·5	− 0·13	1	1
17. 36	43·9	+ 0·93	1	1
16. 5	44·8	− 2·60	1	1
21. 30	44·8	− 0·21	1	1
19. 42	45·1	− 0·20	2	2
18. 12	47·9	− 1·39	1	1
17. 4	49·4	− 0·27	1	1
20. 18	50·0	− 0·98	1	1
Position 0°, r. July, August—*contd.*				
h m	°	″		
18. 41	50·4	+ 0·26	1	1
18. 21	50·5	− 0·47	1	1
16. 39	50·9	+ 0·08	2	2
21. 13	51·0	− 0·99	1	1
14. 28	51·3	− 1·37	1	1
20. 24	51·9	− 2·00	1	1
19. 22	53·9	− 0·60	1	1
20. 43	53·9	− 1·82	1	1
1. 4	54·9	− 0·27	1	1
16. 11	55·9	− 1·75	1	1
18. 46	56·7	− 1·36	1	1
19. 8	58·9	+ 0·40	1	1
0. 34	59·7	− 0·36	1	1
21. 8	60·2	− 0·07	2	2
15. 23	60·6	− 0·88	1	1
17. 42	62·2	+ 0·29	3	3
20. 50	62·3	+ 1·36	1	1
14. 40	62·5	− 0·43	1	1
19. 57	62·5	− 1·42	1	1
17. 51	63·9	+ 0·23	1	1
19. 39	64·5	− 0·02	1	1
19. 24	65·5	− 1·23	1	1
2. 1	67·0	− 0·96	1	1
16. 17	70·6	− 0·39	1	1
19. 54	70·8	− 0·38	1	1
23. 47	71·4	+ 1·91	1	1
14. 36	73·2	− 1·72	1	1
15. 52	74·0	− 0·01	2	2
15. 41	74·3	− 0·31	1	1
20. 35	74·4	− 1·38	1	1
16. 47	74·9	− 0·25	2	2
20. 30	75·7	− 1·50	1	1
17. 30	77·4	+ 0·88	4	3
19. 20	78·3	− 0·25	1	1
19. 13	78·6	− 0·58	1	1
20. 28	79·0	+ 1·25	1	1
19. 41	79·6	− 1·56	1	1
16. 49	79·7	− 0·78	1	1
18. 2	80·4	− 0·69	2	2
16. 53	80·5	+ 0·43	2	2
19. 46	81·4	− 1·21	1	1
15. 39	83·3	− 0·66	1	1
19. 50	83·8	+ 0·01	1	1
23. 35	84·9	+ 0·64	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1906, *with those of Newcomb's Fundamental Catalogue*—continued.

Position 0°, r. July, August—*contd.*

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
17. 21	85·8	− 1·57	1	1
18. 51	85·9	+ 0·26	2	2
2. 57	86·3	+ 0·18	1	1
17. 55	87·1	− 0·49	1	1
19. 20	87·1	+ 1·63	1	1
0. 21	90·6	+ 0·52	1	1
18. 24	92·0	− 0·92	1	1
19. 31	97·2	− 1·31	1	1
15. 11	99·0	− 0·51	1	1
18. 37	99·1	− 0·23	1	1
20. 47	99·3	− 0·50	1	1
23. 10	99·6	− 1·20	1	1
20. 42	99·8	− 0·08	1	1
16. 32	100·4	− 0·82	2	2
22. 25	101·2	− 0·68	2	2
17. 4	105·6	+ 0·97	1	1
15. 55	106·3	− 0·31	1	1
19. 37	106·3	− 1·57	1	1
19. 35	106·5	− 0·43	2	2
21. 34	107·1	− 0·01	2	2
21. 17	107·2	− 0·44	3	3
16. 36	107·6	+ 0·50	2	2
21. 0	107·6	+ 0·57	3	3
18. 8	111·1	+ 2·08	1	1
21. 23	112·2	+ 0·57	1	1
19. 30	115·1	− 3·26	1	1
19. 9	115·4	− 2·78	1	1
20. 40	115·6	− 1·74	1	1
16. 30	118·0	− 0·76	1	1
18. 14	119·9	− 0·90	1	1

Position 180°, r. September, October.

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
8. 1	− 38·2	− 0·98	1	1
10. 29	− 32·4	+ 1·75	1	1
10. 25	− 31·1	− 0·09	2	2
9. 44	− 30·5	+ 0·18	1	1
10. 17	− 24·0	+ 1·84	1	1
11. 37	− 22·7	− 0·53	2	2
9. 2	− 22·5	− 0·70	1	1

Position 180°, r. Sept., Oct.—*contd.*

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
9. 49	− 16·7	− 1·74	1	1
7. 48	− 15·8	+ 0·54	1	1
16. 20	− 14·0	+ 0·90	1	1
14. 27	− 13·9	+ 0·39	1	1
12. 7	− 11·9	+ 0·10	2	2
9. 23	− 8·3	− 0·40	1	1
16. 55	− 7·8	+ 0·77	1	1
10. 19	− 7·0	+ 0·13	1	1
12. 48	− 6·1	− 0·45	1	1
10. 16	− 5·3	+ 0·84	1	1
18. 3	− 3·4	+ 1·60	1	1
12. 14	− 1·8	− 0·19	1	1
8. 6	− 1·1	− 0·14	1	1
19. 16	1·0	− 0·10	2	2
23. 27	3·2	+ 0·37	1	1
21. 18	3·4	− 0·26	3	3
21. 7	12·3	+ 1·44	1	1
23. 35	12·9	+ 0·50	1	1
0. 39	15·5	+ 0·50	2	2
19. 17	16·8	+ 1·03	1	1
20. 30	17·8	− 0·27	2	2
21. 40	19·1	+ 0·28	1	1
21. 27	19·9	+ 0·92	1	1
22. 35	26·9	+ 0·50	1	1
20. 28	27·3	+ 0·81	1	1
22. 2	27·7	+ 1·08	1	1
21. 16	27·8	+ 0·90	1	1
6. 29	28·4	+ 0·49	1	1
20. 43	28·5	− 0·03	2	2
0. 35	34·0	− 0·24	2	2
21. 49	34·2	− 0·05	2	2
4. 24	36·3	− 0·32	1	1
22. 19	38·2	+ 0·60	1	1
21. 43	41·1	+ 1·32	1	1
21. 25	43·9	+ 0·01	2	2
21. 1	46·4	+ 0·27	1	1
22. 57	48·2	− 0·10	1	1
22. 9	50·8	+ 1·86	1	1
21. 13	51·0	− 0·13	1	1
21. 11	52·4	+ 0·21	1	1

Position 180°, r. Sept., Oct.—*contd.*

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. − Observed N.P.D.	No. of Obs.	Weight.
h m	°	″		
0. 16	52·6	+ 0·44	1	1
0. 13	53·7	+ 0·30	1	1
21. 21	53·7	+ 0·67	1	1
21. 14	55·5	+ 0·74	2	2
22. 5	57·3	+ 1·30	1	1
22. 5	57·3	+ 0·58	1	1
20. 25	59·9	+ 1·02	1	1
21. 45	60·3	+ 0·01	2	2
0. 3	61·4	− 0·64	1	1
20. 50	62·3	+ 0·04	1	1
1. 14	63·2	+ 0·06	1	1
21. 40	64·8	+ 0·41	1	1
22. 2	65·1	+ 0·90	2	2
2. 1	67·0	+ 0·69	1	1
23. 20	67·1	+ 0·50	2	2
3. 59	68·2	+ 0·31	1	1
2. 53	69·0	+ 0·65	1	1
22. 6	69·5	− 0·09	1	1
6. 23	69·7	+ 1·20	1	1
19. 54	70·8	− 0·63	1	1
4. 23	71·0	+ 1·28	1	1
4. 45	71·3	+ 0·07	1	1
6. 32	73·5	+ 0·94	1	1
4. 30	73·7	− 0·38	1	1
19. 33	73·7	+ 0·76	1	1
20. 35	74·4	+ 0·50	1	1
1. 26	75·1	+ 0·75	1	1
23. 24	77·8	+ 0·20	1	1
20. 28	79·0	+ 1·03	2	2
19. 41	79·6	+ 0·95	2	2
21. 39	80·6	− 0·04	1	1
2. 8	81·6	− 0·04	1	1
0. 15	82·3	− 0·05	1	1
1. 8	82·9	+ 0·97	1	1
19. 59	83·0	+ 0·12	2	2
23. 54	83·7	− 1·40	1	1
19. 50	83·8	+ 0·97	2	2
23. 35	84·9	+ 0·75	1	1
19. 20	87·1	+ 0·18	1	1
23. 12	87·2	− 0·13	2	2
23. 22	89·3	+ 0·56	1	1
21. 56	89·8	− 0·65	1	1

Comparison of North Polar Distances observed with the Altazimuth in four different positions, in the Year 1906, *with those of Newcomb's Fundamental Catalogue*—continued.

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. – Observed N.P.D.	No. of Obs.	Weight.
Position 180°, r.		**Sept., Oct.—*contd.***		
h m	°	″		
22. 23	90·5	+ 1·46	2	2
0. 21	90·6	− 0·19	1	1
20. 6	91·1	+ 0·48	2	2
21. 58	92·6	+ 0·70	2	2
22. 32	94·7	+ 0·43	1	1
0. 0	96·2	+ 1·55	2	2
23. 9	96·6	− 0·26	1	1
5. 10	98·3	+ 0·50	1	1
21. 32	98·3	+ 0·17	2	2
22. 15	98·3	+ 0·50	1	1
23. 10	99·6	− 0·38	1	1
20. 42	99·8	+ 0·52	1	1
21. 41	101·8	+ 0·01	1	1
21. 48	104·0	+ 1·21	3	3
22. 44	104·1	− 1·26	1	1
22. 1	104·3	+ 0·79	3	3
19. 52	105·7	− 1·19	1	1
19. 35	106·5	− 0·64	1	1
21. 17	107·2	− 0·44	3	3
21. 0	107·6	+ 1·60	1	1
20. 21	108·5	+ 0·05	2	2
21. 37	109·3	+ 0·51	1	1
19. 40	110·0	− 0·26	1	1
23. 18	110·6	− 0·11	1	1
23. 28	111·4	+ 0·53	1	1
19. 30	115·1	+ 0·69	1	1
23. 44	118·7	+ 1·26	1	1
21. 55	118·9	+ 1·80	1	1
Position 180°, d.		**Nov., Dec.**		
8. 32	− 37·0	+ 1·27	1	1
10. 25	− 31·1	− 0·01	1	1
15. 22	− 30·7	− 0·39	1	1
14. 1	− 25·2	− 0·33	1	1
17. 8	− 24·2	− 0·53	1	1
12. 51	− 24·1	+ 0·12	1	1
16. 28	− 21·0	− 1·17	1	1
14. 50	− 15·5	− 0·78	1	1
14. 27	− 13·9	− 0·11	1	1
10. 27	− 13·8	+ 0·30	1	1

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. – Observed N.P.D.	No. of Obs.	Weight.
Position 180°, d.		**Nov., Dec.—*contd.***		
h m	°	″		
15. 34	− 12·3	+ 0·53	2	2
15. 47	− 11·9	+ 0·76	1	1
16. 55	− 7·8	+ 0·76	1	1
1. 24	− 1·2	− 0·02	1	1
23. 27	3·2	+ 0·34	1	1
23. 35	12·9	− 0·23	1	1
0. 39	15·5	+ 0·83	1	1
23. 14	22·4	+ 0·65	1	1
2. 21	23·0	+ 0·54	1	1
2. 7	23·9	+ 0·08	1	1
1. 56	26·1	− 0·39	1	1
0. 45	26·3	+ 0·12	1	1
23. 20	28·2	− 0·63	1	1
23. 49	33·0	− 0·75	1	1
2. 57	36·9	− 0·96	1	1
3. 17	40·5	− 0·49	1	1
23. 3	41·2	+ 0·87	1	1
23. 32	44·1	− 0·23	2	2
22. 57	48·2	+ 1·98	1	1
3. 38	58·0	+ 0·35	1	1
3. 48	58·4	− 1·48	1	1
2. 42	61·1	− 0·05	1	1
0. 3	61·4	− 0·37	1	1
22. 59	62·4	− 0·46	1	1
2. 44	63·1	− 0·37	1	1
3. 35	65·0	− 0·29	1	1
22. 45	65·9	− 0·23	1	1
3. 43	66·2	− 0·51	1	1
6. 17	67·4	− 1·77	1	1
2. 33	68·4	− 0·73	1	1
2. 53	69·0	− 1·40	1	1
3. 15	69·2	− 0·74	1	1
6. 58	69·3	− 0·26	1	1
2. 5	70·9	− 0·17	1	1
9. 13	71·9	− 0·77	1	1
2. 25	72·7	− 0·10	1	1

Approximate R.A.	Approximate N.P.D.	Newcomb N.P.D. – Observed N.P.D.	No. of Obs.	Weight.
Position 180°, d.		**Nov., Dec.—*contd.***		
h m	°	″		
4. 17	72·7	+ 0·40	1	1
4. 14	74·6	+ 1·60	1	1
2. 46	75·3	− 0·48	1	1
1. 0	75·6	− 0·36	1	1
3. 25	77·4	+ 0·29	1	1
23. 24	77·8	− 0·50	1	1
9. 2	79·0	− 0·20	1	1
12. 37	79·2	− 0·15	1	1
22. 36	79·7	+ 0·52	1	1
2. 19	79·8	+ 1·53	1	1
3. 22	80·6	− 0·96	1	1
2. 8	81·6	+ 0·59	1	1
23. 6	81·8	+ 0·08	1	1
2. 23	82·0	− 0·64	1	1
5. 50	82·6	− 0·66	1	1
23. 54	83·7	− 0·69	1	1
3. 58	84·3	− 0·63	1	1
4. 46	84·6	− 0·31	1	1
2. 30	84·8	− 0·86	1	1
12. 43	85·9	− 0·39	1	1
2. 57	86·3	− 0·36	1	1
2. 38	87·2	− 0·93	1	1
1. 57	87·7	− 0·78	1	1
0. 20	88·6	+ 0·52	1	1
2. 34	90·1	− 0·14	1	1
22. 30	90·6	+ 0·08	1	1
20. 6	91·1	+ 0·25	1	1
2. 14	93·4	+ 0·03	1	1
5. 3	95·2	− 1·66	1	1
4. 10	97·8	− 0·54	1	1
2. 51	99·3	− 3·15	1	1
20. 47	99·3	− 0·73	1	1
23. 10	99·6	− 0·73	1	1
3. 28	99·8	− 1·37	1	1
3. 38	100·1	− 0·65	1	1
1. 46	100·8	− 1·67	1	1
22. 25	101·2	− 1·31	1	1
3. 53	103·8	− 0·18	1	1
12. 24	106·0	+ 0·57	1	1
23. 18	110·6	− 0·21	1	1
12. 29	112·9	− 0·89	1	1
22. 52	120·1	+ 1·69	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:—

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 1906, *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 180°, r. Jan., Feb.			Position 0°, d. May, June.			Position 180°, r. Sept., Oct.		
°	″		°	″		°	″	
− 34·1	+ 1·49	3	− 41·2	+ 1·73	3	− 32·7	+ 0·15	5
− 22·8	+ 0·74	5	− 24·3	+ 0·18	3	− 23·0	+ 0·02	4
− 15·5	+ 0·77	17	− 15·5	+ 2·04	1	− 14·0	+ 0·05	6
− 3·8	+ 0·95	9	− 2·2	+ 0·53	2	− 5·1	+ 0·28	8
3·8	+ 0·47	8	4·6	+ 1·44	6	2·6	− 0·10	6
10·9	+ 1·99	1	12·5	+ 1·78	5	16·4	+ 0·51	9
28·7	+ 0·71	3	24·7	+ 1·24	2	27·9	+ 0·53	7
31·5	+ 0·48	7	34·1	+ 1·38	8	35·2	− 0·05	6
44·2	+ 0·49	9	46·8	+ 1·34	15	44·7	+ 0·30	5
53·8	+ 0·55	15	55·6	+ 1·32	13	54·5	+ 0·70	11
65·9	+ 0·60	28	63·2	+ 1·46	11	65·3	+ 0·36	15
74·5	+ 0·66	29	74·1	+ 1·42	19	75·3	+ 0·57	13
83·2	+ 0·60	19	84·1	+ 1·44	16	84·7	+ 0·15	15
94·9	+ 0·09	20	94·9	+ 1·33	9	95·0	+ 0·58	17
105·5	+ 0·58	18	104·5	+ 0·79	15	106·5	+ 0·23	21
112·9	+ 0·35	10	114·5	+ 1·53	5	114·9	+ 0·83	5
120·0	− 0·32	1						
Position 180°, d. March, April.			Position 0°, r. July, August.			Position 180°, d. Nov., Dec.		
− 34·4	− 0·19	6	− 44·3	+ 0·29	3	− 32·9	+ 0·29	3
− 26·8	− 0·22	5	− 36·3	− 1·71	1	− 24·8	− 0·48	4
− 17·0	− 1·05	11	− 24·7	− 1·48	4	− 13·3	+ 0·21	6
− 2·9	− 0·15	11	− 10·3	+ 1·57	1	− 4·5	+ 0·37	2
2·7	− 0·90	12	− 3·8	− 0·38	4	3·2	+ 0·34	1
15·5	− 0·23	5	2·5	− 0·61	5	14·2	+ 0·30	2
21·5	− 0·11	3	15·3	− 0·39	6	25·0	+ 0·07	6
33·8	− 0·05	7	27·3	− 0·92	1	35·0	− 0·86	2
47·3	− 0·79	5	30·7	+ 0·49	1	43·6	+ 0·22	5
55·5	− 0·68	10	46·1	− 0·56	9	58·2	− 0·57	2
66·0	− 0·53	21	53·6	− 0·73	14	65·7	− 0·60	12
74·5	− 0·64	33	62·8	− 0·20	13	75·9	+ 0·12	13
83·5	− 0·66	34	75·7	− 0·08	20	84·4	− 0·43	14
95·3	− 0·49	14	83·8	− 0·11	14	95·6	− 0·80	10
104·1	− 0·89	8	97·1	− 0·52	8	102·4	− 0·65	5
113·4	− 1·23	3	105·7	− 0·18	19	111·8	− 0·55	2
			115·3	− 0·97	7	120·1	(+ 1·69)	(1)

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

$$a+b \sin \text{Z.D.},$$

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

Newcomb – Altazimuth.

Position of Altazimuth.		
180°, r (Jan., Feb.).	+0″·64	−0″·21 sin Z.
180°, d (Mar., Apr.).	−0·55	−0·14 sin Z.
0°, d (May, June).	+1·32	−0·02 sin Z.
0°, r (July, Aug.).	−0·41	+0·11 sin Z.
180°, r (Sept., Oct.).	+0·31	+0·18 sin Z.
180°, d (Nov., Dec.).	−0·17	−0·33 sin Z.

Assuming the formula for the four positions as

$+ a + b$ sin Z.D. for the positions 0° d and 180° r,

and

$- a + b$ sin Z.D. „ „ 0° r and 180° d,

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

$$\pm 0''{\cdot}46 - 0''{\cdot}06 \sin \text{Z.D.}$$

excluding the period May – June, for which the value of a is abnormally large.

Taking the coefficient of sin Z.D. from the results of the reflexion observations as −0″·24, the values found for the a term in the different positions are given below.

Position of Instrument.	Difference of N.P.D. Newcomb – Altazimuth. Value of a.	Weight.
180°, r (Jan., Feb.).	+0″·65	201
180°, d (Mar., Apr.).	−0·53	188
0°, d (May, June).	+1·32	133
0°, r (July, Aug.).	−0·28	130
180°, r (Sept., Oct.).	+0·41	153
180°, d (Nov., Dec.).	−0·20	89

The weighted mean is ±0″·56 −0″·24 sin Z.D.; or excluding the result for May–June, it becomes ±0″·46 −0″·24 sin Z.D.

The quantity employed in the reductions was ±0″·30 −0″·24 sin Z.D., derived from the reflexion observations.

In these formulæ the upper sign refers to positions 0° d and 180° r, the lower to to 0° r and 180° d.

Adopted Corrections to North Polar Distances of the Altazimuth, 1906.

N.P.D.	Corrections to Results of Direct Observations.		Corrections to Results of Reflexion Observations.	
	0° d. 180° r.	0° r. 180° d.	0° d. 180° r.	0° r. 180° d.
°	"	"	"	"
− 45	+ 0·54	− 0·06	− 0·65	− 0·05
− 40	+ 0·54	− 0·06	− 0·65	− 0·05
− 30	+ 0·52	− 0·08	− 0·63	− 0·03
− 20	+ 0·50	− 0·10	− 0·61	− 0·01
− 10	+ 0·48	− 0·12	− 0·57	+ 0·03
0	+ 0·45	− 0·15	− 0·52	+ 0·08
+ 10	+ 0·41	− 0·19	− 0·47	+ 0·13
20	+ 0·38	− 0·22	− 0·41	+ 0·19
30	+ 0·34	− 0·26	− 0·35	+ 0·25
40	+ 0·30	− 0·30	− 0·30	+ 0·30
50	+ 0·25	− 0·35	− 0·23	+ 0·37
60	+ 0·21	− 0·39	− 0·17	+ 0·43
70	+ 0·17	− 0·43	− 0·11	+ 0·49
80	+ 0·14	− 0·46	− 0·06	+ 0·54
90	+ 0·11	− 0·49	− 0·02	+ 0·58
100	+ 0·09	− 0·51	+ 0·02	+ 0·62
110	+ 0·08	− 0·53	+ 0·04	+ 0·64
120	+ 0·06	− 0·54	+ 0·06	+ 0·66
125	+ 0·06	− 0·54	+ 0·06	+ 0·66

Altazimuth Colatitude Investigation.

Correction to Assumed Colatitude 38°. 31′. 23″·42 from observations in the Year 1906.

(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. {28} 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 Above Pole.	No. of Observations Below Pole.	Weight.	Star's Name.	Approximate R.A.	Approximate N.P.D.	Excess of N.P.D. above Pole.	No. of Observations Above Pole.	No. of Observations Below Pole.	Weight.
	h m	° ′	″					h m	° ′	″			
λ Ursæ Minoris	19. 15	1. 0	+ 0·35	4	3	9	τ Draconis	19. 17	16. 49	−0·10	1	1	3
Groomb. 1119	8. 6	1. 5	+ 0·95	6	2	8	16 Cephei	21. 57	17. 16	+0·29	2	3	6
Polaris	1. 25	1. 11	+ 0·86	5	3	10	χ Draconis	18. 22	17. 18	−0·41	2	2	5
Bradley 1672	12. 14	1. 46	+ 0·02	1	1	3	Groomb. 3241	20. 30	17. 47	+2·61	2	2	5
Groomb. 2283	15. 6	2. 24	− 0·63	4	1	5	O.A.(N.)20021-2	20. 1	18. 21	+0·50	2	2	5
Cephei 51	6. 54	2. 48	+ 0·05	5	3	10	11 Cephei	21. 40	19. 7	+0·49	1	1	3
Bradley 3147	23. 27	3. 12	+ 0·53	2	2	6	β² Cephei	21. 27	19. 51	−0·69	1	1	3
Groomb. 3548	21. 18	3. 21	+ 0·47	4	5	11	3 Draconis	11. 37	22. 44	+0·94	1	2	4
δ Ursæ Minoris	18. 3	3. 23	− 0·21	5	11	18	ι Cassiopeiæ	2. 21	23. 1	−0·67	1	4	5
Piazzi X. 22	10. 19	6. 57	+ 0·08	2	1	4	55 Cassiopeiæ	2. 7	23. 54	−0·52	1	2	4
ε Ursæ Minoris	16. 55	7. 48	− 2·28	1	6	5	ζ Draconis	17. 8	24. 10	−1·05	2	5	7
Piazzi IX. 37	9. 23	8. 15	+ 1·35	2	1	4	α Draconis	14. 1	25. 10	−0·13	1	1	2
Groomb. 2066	13. 50	10. 32	+ 0·78	2	1	3	53 Cassiopeiæ	1. 56	26. 3	+0·51	1	1	2
Bradley 1634	12. 7	11. 51	− 0·86	1	2	4	θ Cephei	20. 28	27. 19	+1·57	2	2	4
ζ Ursæ Minoris	15. 47	11. 54	− 0·51	3	3	7	α Cephei	21. 16	27. 48	−0·76	1	2	3
Bradley 2777	21. 7	12. 15	+ 0·20	2	2	5	8 Lyncis	6. 29	28. 26	+0·70	3	2	5
θ Ursæ Minoris	15. 34	12. 20	− 0·03	4	1	4	η Cephei	20. 43	28. 31	−0·65	2	1	3
γ Cephei	23. 35	12. 53	− 0·40	2	1	3	υ Ursæ Majoris	9. 44	30. 31	−0·75	3	1	2
Lalande 40304-5	20. 40	13. 30	+ 0·75	3	2	6	ι Draconis	15. 22	30. 42	−0·25	2	1	2
5 Ursæ Minoris	14. 27	13. 53	− 1·28	1	4	5	74 Ursæ Majoris	12. 25	31. 4	−0·94	1	3	4
η Ursæ Minoris	16. 20	14. 1	+ 0·77	2	3	6	Bradley 2868	21. 49	34. 13	+2·38	2	1	2
Lalande 39736	20. 24	14. 15	+ 0·58	4	2	6	1 Camelopardi	4. 24	36. 17	+2·27	1	1	2
β Ursæ Minoris	14. 50	15. 27	− 0·50	3	5	9	Piazzi VIII. 105	8. 32	36. 57	−1·92	1	1	2
21 Cassiopeiæ	0. 39	15. 31	− 1·96	3	1	4	27 Lyncis	8. 1	38. 13	+2·46	2	1	2
Groomb. 1374	7. 48	15. 49	+ 0·61	1	2	4	α Persei	3. 17	40. 28	−1·22	1	2	2
Piazzi IX. 187	9. 49	16. 40	+ 1·82	3	1	4	Capella	5. 9	44. 5	−0·90	1	2	(2)

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

The assumed colatitude 38°. 31′. 23″·42 was found by applying to the adopted colatitude of the Transit-Circle, with Pulkowa Refractions 38°. 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°. 31′. 23″·42 from these results is − 0″·056. The colatitude determined from the observations of 1906 is, therefore, 38°. 31′. 23″·36.

Altazimuth Extra-Meridian Tables.

The following are the factors which multiply the motion in N.P.D. in 10 Solar minutes in order to obtain the effect of this motion (B) on the Azimuthal motion in one second, (B′) on the Z.D. motion in 1 second. The second is a Lunar second for the Moon, a Sidereal second for the Sun and Planets.

N.P.D.	Azimuth 90°.			Azimuth 80°.			Azimuth 70°.			N.P.D.
	B. Moon.	B. Sun, Planets.	B′.	B. Moon.	B. Sun, Planets.	B′.	B. Moon.	B. Sun, Planets.	B′.	
60°	1241	1199	115	1222	1181	117	1166	1126	122	60°
61	1228	1187	117	1210	1169	119	1154	1116	123	61
62	1217	1176	118	1198	1158	120	1143	1105	124	62
63	1206	1166	119	1188	1148	121	1133	1095	125	63
64	1195	1155	120	1177	1138	122	1123	1086	126	64
65	1185	1146	121	1167	1129	123	1114	1077	127	65
66	1176	1137	122	1158	1120	123	1105	1068	128	66
67	1168	1128	122	1149	1111	124	1096	1059	128	67
68	1159	1120	123	1141	1102	125	1088	1051	129	68
69	1151	1112	123	1133	1095	126	1081	1044	129	69
70	1144	1105	124	1126	1088	126	1074	1037	130	70
71	1137	1098	125	1119	1082	127	1067	1031	130	71
72	1130	1092	125	1113	1076	127	1061	1025	131	72
73	1123	1086	126	1107	1070	128	1056	1020	131	73
74	1117	1080	126	1101	1064	128	1050	1015	131	74
75	1112	1075	127	1096	1059	129	1045	1010	132	75
76	1107	1070	127	1091	1054	129	1040	1005	132	76
77	1102	1066	128	1086	1050	129	1036	1001	132	77
78	1098	1062	128	1082	1046	130	1032	997	133	78
79	1095	1058	128	1078	1042	130	1028	993	133	79
80	1091	1054	128	1075	1039	130	1025	990	133	80
81	1087	1051	129	1072	1036	130	1022	987	133	81
82	1085	1048	129	1069	1033	130	1019	985	134	82
83	1083	1046	129	1066	1030	131	1017	983	134	83
84	1081	1044	130	1064	1028	131	1015	981	134	84
85	...	...	...	1063	1027	131	1013	979	134	85
86	...	...	...	1061	1026	131	1012	978	134	86
87	...	...	...	1060	1025	131	1011	977	134	87
88	...	...	...	1059	1024	131	1010	976	135	88
89	...	...	...	1058	1023	131	1010	976	135	89, 90

B is expressed in units of the Sixth Decimal Place. B′ is expressed in units of the Fifth Decimal Place.

Altazimuth Extra-Meridian Tables.—continued.

N.P.D.	Azimuth 60°.			Azimuth 45°.			Azimuth 30°.			N.P.D.
	B. Moon.	B. Sun, Planets.	B′.	B. Moon.	B. Sun, Planets.	B′.	B. Moon.	B. Sun, Planets.	B′.	
60°	1075	1039	130	877	848	143	...	...	...	60°
61	1064	1028	131	869	840	143	...	...	...	61
62	1054	1019	132	860	832	144	608	587	156	62
63	1045	1009	132	853	824	144	603	582	156	63
64	1036	1001	133	845	817	145	598	577	156	64
65	1027	992	133	838	810	145	593	572	156	65
66	1019	984	133	831	803	146	588	568	156	66
67	1012	977	133	824	797	146	584	564	156	67
68	1005	970	134	818	791	146	580	560	156	68
69	998	963	135	812	785	146	576	556	157	69
70	991	956	135	807	780	147	572	552	157	70
71	985	950	136	802	775	147	568	549	157	71
72	979	944	136	798	771	147	564	546	157	72
73	973	939	137	794	767	147	561	543	157	73
74	968	934	137	790	763	148	558	540	157	74
75	963	929	138	786	759	148	555	537	157	75
76	959	925	138	782	756	148	553	535	158	76
77	955	922	138	779	753	148	551	533	158	77
78	952	919	139	776	750	148	549	531	158	78
79	949	916	139	773	747	148	547	529	158	79
80	946	913	139	771	745	149	545	527	158	80
81	943	910	139	769	743	149	544	526	158	81
82	940	907	140	767	741	149	543	525	158	82
83	938	905	140	766	740	149	542	524	158	83
84	936	903	140	765	739	149	541	523	158	84
85	934	902	140	764	738	149	540	522	158	85
86	933	901	140	763	737	149	539	521	158	86
87	932	900	140	762	736	149	538	520	158	87
88	931	899	140	761	735	149	537	519	158	88
89	931	899	140	760	734	149	537	519	158	89, 90

Table of Curvature Corrections in Azimuth in time for outer 10 Wires, i.e., 2 to 6 and 22 to 26.

N.P.D.	Azimuth.						N.P.D.
	90°	80°	70°	60°	45°	30°	
°		s	s	s	s	s	°
30	...	...	...	...	0·80	0·13	30
31	...	...	...	...	0·54	0·11	31
32	...	...	...	...	0·40	0·09	32
33	...	...	...	...	0·30	0·08	33
34	...	...	...	...	0·24	0·07	34
35	...	...	...	1·70	0·20	0·06	35
36	...	...	...	0·89	0·17	0·06	36
37	...	...	...	0·62	0·14	0·05	37
38	...	...	1·83	0·45	0·12	0·04	38
39	...	...	0·98	0·34	0·10	0·04	39
40	...	1·86	0·67	0·27	0·09	0·04	40
41	1·49	1·01	0·47	0·22	0·08	0·03	41
42	0·86	0·66	0·36	0·18	0·07	0·03	42
43	0·59	0·47	0·28	0·15	0·06	0·03	43
44	0·43	0·35	0·23	0·13	0·06	0·03	44
45	0·33	0·27	0·19	0·11	0·05	0·02	45
46	0·26	0·22	0·15	0·10	0·05	0·02	46
47	0·21	0·18	0·13	0·08	0·04	0·02	47
48	0·18	0·15	0·11	0·07	0·04	0·02	48
49	0·15	0·13	0·10	0·07	0·04	0·02	49
50	0·13	0·11	0·09	0·06	0·03	0·02	50
55	0·07	0·06	0·05	0·04	0·02	0·01	55
60	0·04	0·04	0·03	0·02	0·02	0·01	60
65	0·03	0·02	0·02	0·02	0·01	0·01	65
70	0·02	0·02	0·01	0·01	0·01	0·00	70
75	0·01	0·01	0·01	0·01	0·00	0·00	75
80	0·01	0·01	0·01	0·01	0·00	0·00	80
85	0·00	0·00	0·00	0·00	0·00	0·00	85
90	0·00	0·00	0·00	0·00	0·00	0·00	90

For mid 10 wires, *i.e.*, 7, 8, 9, 11, 13, 15, 17, 19, 20, 21, use $\frac{2}{17}$ of the correction for outer 10.

For mid 10 close wires, *i.e.*, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, use $\frac{1}{20}$ of the correction for outer 10.

Sign of curvature −E +W.

"Upper" Transits, or N.P.D. greater than 90° +E −W.

Table of Curvature Corrections in Zenith Distance in time for outer 10 Wires, i.e., I. to V. and XVII. to XXI.

For Azimuth 30° the correction is tabulated for the mid 10 wires, viz., VI. to X., XII. to XVI.

N.P.D.	Azimuth.						N.P.D.
	90°	80°	70°	60°	45°	30°	
	s	s	s	s	s	s	°
30	...	...	...	...	0·04	0·02	30
35	...	...	0·00	0·02	0·05	0·02	35
40	0·01	0·01	0·02	0·03	0·06	0·02	40
45	0·02	0·02	0·02	0·03	0·07	0·02	45
50	0·02	0·02	0·02	0·03	0·07	0·02	50
55	0·02	0·02	0·03	0·03	0·07	0·02	55
60	0·02	0·02	0·02	0·03	0·07	0·02	60
65	0·02	0·02	0·02	0·03	0·06	0·01	65
70	0·02	0·02	0·02	0·03	0·05	0·01	70
75	0·01	0·01	0·02	0·02	0·04	0·01	75
80	0·01	0·01	0·01	0·01	0·03	0·01	80
85	0·00	0·01	0·01	0·01	0·01	0·00	85
90	0·00	0·00	0·00	0·00	0·00	0·00	90

For mid 10 wires, *i.e.*, VI., VII., VIII., IX., X., XII., XIII., XIV., XV., XVI., use $\frac{1}{11}$ of correction for outer 10.

Insensible except in Azimuth 45° between N.P.D. 36° and 67°.

Sign of curvature + E (North of Equator).
+ W (Upper Transits).
+ W (South of Equator).
− E (South of Equator).
− E (Upper Transits).
− W (North of Equator).

Table of Diurnal Aberration in Zenith Distance.

Diurnal Aberration.	Azimuth. 90°	80°	70°	60°	45°	30°	Diurnal Aberration.
"	Z.D. ° °	Z.D. ° °	Z.D. ° °	Z.D. ° °	Z.D. ° °	Z.D. ° °	"
0·19	0–12	0 – 6	...	...	...	...	0·19
0·18	12–21	6 –21	0 –11	...	...	...	0·18
0·17	21–29	21 –28	11 –23	0 – 1	...	...	0·17
0·16	29–35	28 –33	23 –30	1 –21	...	...	0·16
0·15	35–40	33 –39	30 –36	21 –29	...	...	0·15
0·14	40–44	39 –43	36 –41	29 –35	...	...	0·14
0·13	44–49	43 –47	41 –45	35 –41	0 –21½	...	0·13
0·12	49–52	47 –52	45 –50	41 –46	21½–31	...	0·12
0·11	52–56	52 –55½	50 –54	46 –51	31 –38	...	0·11
0·10	56–60	55½–59½	54 –58	51 –54½	38 –44½	...	0·10
0·09	60–63	59½–62	58 –62	54½–59	44½–51	0–26	0·09
0·08	63–67	62 –66	62 –65	59 –63	51 –55½	26–37	0·08
0·07	67–70	66 –70	65 –69	63 –66½	55½–61	37–46	0·07
0·06	70–73	70 –72½	69 –71½	66½–70	61 –65½	46–54	0·06
0·05	73–76	72½–76	71½–75	70 –73½	65½–70	54–61	0·05
0·04	76–79	76 –79	75 –79	73½–77	70 –74½	61–68	0·04
0·03	79–83	79 –82½	79 –81½	77 –81	74½–79	68–74	0·03
0·02	83–85	82½–85½	81½–85	81 –84	79 –83½	74–81	0·02
0·01	...	...	...	...	...	81	0·01

The quantities given are the limiting Zenith Distances for each value of the Diurnal Aberration.

Diurnal Aberration shifts the apparent place towards the East Point of the Horizon. Hence for a Western object the True Zenith Distance is greater than the observed, for an Eastern object, less.