RESULTS

OBSERVATIONS OF THE FIXED STARS

MADE WITH THE

MERIDIAN CIRCLE

AT THE

GOVERNMENT OBSERVATORY, MADRAS,

IN THE YEARS

1862, 1863 AND 1864,

UNDER THE DIRECTION OF

NORMAN ROBERT POGSON,

C.I.E., F.R.A.S., & F.M.U.

GOVERNMENT ASTRONOMER AT MADRAS.

PUBLISHED BY ORDER OF THE GOVERNMENT OF MADRAS.

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To

THE RIGHT HON'BLE SIR MOUNTSTUART ELPHINSTONE GRANT DUFF,

LATE GOVERNOR OF MADRAS, C.C.S.I, C.I.E., F.R.S., M.A., &C., &C.

HONORABLE SIR,

The present volume, the first of a new series of Madras Observations, was intended to have been issued long before your retirement from the high and distinguished office of Governor of Madras, and was by your kind permission to be specially dedicated to you, whose discerning, enlightened and liberal views in regard to the encouragement of science, alone enabled me to commence publication, by the removal of certain arbitrary and suppressive restrictions which have prevented me and my predecessors from attempting anything of the kind for considerably more than thirty years past.

Without prompt publication of results, scientific researches in general, and above all astronomical observations, are comparatively useless. I came to India deeply impressed with this view, and with the full intention of bringing out an annual volume, and now that you Sir have rendered this possible, and I have every reason to feel assured that your successors in office will continue the valued privilege which you first saw fit to concede to the Madras Astronomer, *viz.*, the right of distribution of his publications, enjoyed by every other astronomer in the world but so long disallowed at Madras; the one Observatory of India will, I hope, speedily recover its prestige and remain an enduring evidence of one of the many benefits conferred upon Southern India, during your regime as Her Majesty's representative at Madras.

With grateful recollections of past kindness and best wishes for your health, happiness and future well earned distinctions,

I remain, Honorable Sir,

Your most obedient Servant,

N. R. POGSON.

INTRODUCTION.

Meridional observations were commenced at the Madras Observatory on January 9th, 1793, with a little twenty-inch transit instrument, by Stancliff, and a twelve-inch altitude and azimuth instrument, by Troughton; neither of them bearing an object glass of so much as an inch and a half in aperture. With these diminutive appliances the work of the Observatory was carried on until the year 1829. The records of the first nineteen years were simply copied out and transmitted to the Honorable Board of Directors of the East India Company. Those from 1812 to 1825 were published in two bulky folio volumes, but consisted only of unreduced observations of the Sun, Moon, old planets and brighter fixed stars. These two volumes were published by the Honorable Company's Astronomer, Mr. J. D. Goldingham, as Volumes 3rd and 4th, with a view to the previous records being subsequently printed, an arrangement which however was never carried out.

An important step in the history of the Observatory was made in the year 1830, when a five-foot Transit Instrument and a four-foot Mural Circle, both by Dollond, with object glasses of nearly four inches aperture, were erected under the superintendence of Mr. T. G. Taylor, one of the most able and energetic astronomers of his day. With these instruments, the celebrated "*Madras Catalogue*," containing positions of 11,015 stars reduced to the Epoch 1835, was accomplished between the years 1831 and 1843, and in spite of its weakest points, large instrumental errors of an unexpected nature in the Mural Circle, which Mr. Taylor did his best to eliminate before printing his final catalogue, its value at the present date may be inferred from the circumstance of a new edition being now called for by European astronomers. It is scarcely necessary to mention that I shall respond to this call with great pleasure as soon as the results of my own labors have been laid before the world, and time permits of the investigation of the remaining errors, both casual and systematic, which still require correcting in the former catalogue. The addition of the mean dates of observation in each co-ordinate, which will of course entail reference to every individual observation upon which the final star positions are based, is also a matter of such importance that there could be no excuse for its omission in case of a second edition of the Catalogue.

The Transit Instrument and Mural Circle were next employed, between 1849 and 1852, in the revision of 1440 stars of the British Association Catalogue, under the direction of Captain W. S. Jacob, Bombay Engineers; the results being published in Vol. VIII of the second series of Madras Observations.

A considerable number of star observations, made with the same instruments between 1853 and 1858, under the superintendence of Captain Jacob and of Major W. K. Worster, Madras Artillery, but only partially reduced to apparent places, will, when completed, form another catalogue of about 2,200 stars, for the epoch 1855. A selection of 317 of these stars, suspected of large proper motion, was printed in the "*Memoirs of the Royal Astronomical Society*", Vol. XXVIII.

There are also 1,331 observations of the Sun, 345 of the Moon, 1,680 of the principal planets and 333 of various minor planets, made with the old instruments during the same years, in continuation of those given in Volume 7 of the "*Madras Astronomical Observations*" awaiting publication.

It is now about forty years since the Astronomer Royal (then Prof. G. B. Airy) introduced a most important change in regard to meridian instruments, by suggesting a Transit Circle for the Royal Observatory in place of the two separate instruments hitherto employed for determining the absolute Right Ascensions and Polar Distances of celestial objects at Greenwich. The advantages of having both co-ordinates observed at the same time and by the same person, are so obvious, that it is surprising the old practice was so long endured by astronomers. The Royal Observatory was supplied with a magnificent Transit Circle in 1850, which was brought into use the following year, the object glass of its telescope being eight inches and its divided circle six feet in diameter. A fac-simile of the Greenwich instrument, subsequently supplied to the Cape Observatory, was first used there in 1855. Meanwhile however, in 1852, Mr. R. C. Carrington of Redhill, had a Transit Circle constructed for him by Messrs. Troughton and Simms, similar in all essential points to the new one at Greenwich, and divided by the same exquisite machinery, but with a five-inch object glass and a forty-two inch circle instead of the much larger and more costly size adopted at the Royal Observatory. When no longer required at the Redhill Observatory this fine instrument was removed to the Radcliffe Observatory, at Oxford, in 1861, and has been used there ever since.

In the year 1855, by the liberality of the Board of Directors of the Honorable East India Company, a new Transit Circle, similar to Mr. Carrington's, was ordered of Messrs. Troughton and Simms, upon the recommendation of Captain Jacob. The general superintendence of its construction was kindly undertaken by Mr. Carrington, who, in consultation with its able makers, advised such alterations in its various details as the experience of his own instrument had led him to consider advisable. The Transit Circle reached Madras in March, 1858, only a month before Captain Jacob's departure, and although orders were immediately issued for its erection, unforeseen difficulties and above all frequent changes in the direction of the Observatory, prevented it from being ready for use until four years after its arrival.

Similar instruments have since been supplied by the same eminent firm to Melbourne, Sidney and many other observatories, both public and private, at home and abroad. The description already given of any one of these instruments is so nearly applicable to all the others that the following brief details of the Madras Transit Circle may seem to many supererogatory, especially as the instrument has now been in constant use for nearly a quarter of a century.

BUILDINGS.

These consist of two blocks;—one comprising the old Observatory with its more recent additions; a long, low, narrow structure, extending 196 feet from East to West, by 25 from North to South; the other, the residence of the Astronomer, facing south-east, about 120 yards south-west of the former, and covering a space of 75 by 50 feet. The original Observatory, built in 1792, consisted of a single room, 40 feet long by 20 broad and 15 high inside, with massive walls, over two feet in thickness. The floor rests on beams supported entirely by the walls and detached from the instrumental basement, which consists of a solid pyramidal mass of masonry, 37 feet long by 6 feet wide at its upper surface, 6 feet in depth, and 45 feet long by 12 feet broad below; probably little less firm or massive than a solid rock of similar dimensions. A conical granite pier rests on the centre of this mass, 4 feet in diameter at its base, tapering up to 2 feet at its total height of 18 feet, and weighing certainly over ten tons. This was the pier originally provided for the little 12-inch alt-azimuth by Troughton; while the small Transit by Stancliffe and the Transit-clock, both rested on granite supports each weighing about $2\frac{1}{2}$ tons. When Mr. Taylor replaced the small instruments by the Dollond Transit and the Mural Circle, in 1830, they were fixed on stone piers, the former as far east and the latter as far to the west as the basement would allow, on opposite sides of the great central conical frustum, which was retained in position as a huge counterpoise, though no longer used as a support for any instrument.

The present Meridian Circle occupies the same position as Mr. Taylor's Transit-instrument, looking through the same slits in the roof and walls, which have however been made 22 inches wide instead of only 15 as formerly. Two brick piers were first erected for its reception, but these were condemned by Major Worster, in January 1859, and were replaced by excellent granite ones, under Major Tennant's superintendence, in 1860. Each of these piers measures $4\frac{1}{2}$ feet by 2 and rises 4 feet above the floor of the room. Four composition blocks, each $4\frac{1}{4}$ feet long by 2 wide and 2 feet 2 inches high, were sent out with the new instrument from England, and on two of these, surmounting the granite base piers, rests the Meridian Circle, with its pivot centres 6 feet 2 inches from the floor. The other two composition blocks or cap stones support the counterpoise arrangements and raise the piers to a total height of 8 feet 4 inches. The clear space between the piers for the observer is 39 inches.

Want of proper instructions, or possibly the loss of such if sent, in regard to the cap stones, caused much difficulty and delay in the erection of the instrument, as if placed in position as they were sent out, the pivots would have been built into two 12-inch square holes, inaccessible even for cleaning and oiling; while the instrument could never have been lifted so much as six inches out of its bearings, whatever alterations or repairs might at any time become necessary. Two slices of $9\frac{1}{2}$ inches thickness were accordingly cut out of the middle of each cap stone and these were afterwards found very useful in overcoming another difficulty of construction which will be described further on.

About the year 1845, when the Magnetical Establishment was removed to the Observatory, the old transit room received considerable extensions, rendered necessary for the accommodation of the additional instruments and assistants transferred to the care of the Government Astronomer. Eastward was added; first, a covered passage, 20 feet long by 8 broad, leading to the Dip-circle room, which measured 16 feet by 26 feet; next a magnetic room, 45 feet by 15 feet, in which the Bifilar, Vertical Force and Declination Magnetometers were placed and read hourly up to March 1861; and third, a small Transit-theodolite room, 16 feet by 12 feet, used in connection with the Declination Magnetometer and as a computing room for the head magnetical Assistant. About 30 feet more eastward stands a small detached room, 22½ feet by 15 feet, used only for periodical determinations of the absolute Horizontal Force, by means of the usual deflexion apparatus supplied to all the magnetical observatories started upon the recommendation of the Royal Society in the year 1841.

Westward of the old transit room were added two small rooms, each 20 feet by 15 feet, the first being used as a computing and manuscript room and the other as a store room for instruments and other property not in actual use.

In the year 1872 three additional rooms for celestial photography were hurriedly run up on the roof over the Transit Circle room, just in time to secure photographs of the annular eclipse of the Sun on June 6th of that year. The fine silver glass nine-inch reflector by John Browning, used by Colonel J. F. Tennant, at Guntoor, on the occasion of the total solar eclipse on August 18th, 1868, having been altered, repaired and sent to Madras by the advice of the Astronomer Royal in 1871, for use at Avenashi in the Coimbatore District, during the next total eclipse which India was privileged to witness on December 12th, 1871; was afterwards brought to Madras and mounted upon the large granite conical pier before mentioned; a room, 21 feet by 15 feet, being built to enclose it. A flat sliding shutter was provided, which when rolled off westward, left a square opening of 10 feet, giving the reflector a fair command of the sky except near the horizon where it was never likely to be used for photographic purposes. Two small rooms adjoining; one dark for developing and the other for printing and other purposes, were also prepared in time for the annular eclipse in 1872. Very complete and convenient arrangements for securing celestial photographs were made, ostensibly with a view to the approaching Transit of Venus, on December 8th, 1874, and the Browning reflector was in readiness for that important event, but unfortunately cloudy weather prevented any photographs from being taken and the telescope was dismounted and sent to Calcutta, in compliance with orders from the Government of India, in February 1875.

A small portable equatorial, with a 3½-inch object glass by Dollond, has since been placed in the reflector-room and is occasionally used for casual phenomena, such as eclipses or occultations, but all photographic operations were of course stopped by the removal of the reflector. The recent wonderful advances in celestial photography may render the renovation and equipment of this part of the observatory a very important step in regard to observations in the near future.

The house, originally provided for the Astronomer's use only, is a still older and more substantial building than the Observatory proper already described, and much of it is now given up for purely official purposes. It contains in all eighteen rooms; eight on the ground floor; seven on the first floor and three on the roof. The ever increasing and already valuable and extensive Library occupies two rooms on the ground floor, and in these also are placed the electrical clock and telegraphic appliances used for giving true time to the local shipping and generally to all parts of India. A granite step of the north-east door of the Library is a bench-mark of the G. T. Survey of India and is 22 feet above mean sea level. The private office of the Astronomer is immediately over the Library, and on the roof are, a small Anemograph room, 10½ feet square; a 16-foot circular room with an excellent revolving dome, containing a fine eight-inch Equatorial by Messrs. Troughton and Simms, and another, slightly smaller but similar room, for the six-inch Equatorial by Messrs. Lerebours and Secretan, formerly used to such good purpose by Captain Jacob in measurements of double stars and of Saturn's satellites.

Photographs or drawings of the buildings and of the chief instruments were intended to have been given in this volume, but are unavoidably deferred for the present.

THE MERIDIAN CIRCLE.

This fine instrument, as already stated, was made by Messrs. Troughton and Simms, in consultation with the late Mr. R. C. Carrington, and its general excellence has proved most satisfactory. The clear aperture of the object glass is 5½ inches and its focal length about 50 inches; the magnifying powers of the eye-pieces being very nearly as engraved on each, *viz.*, 105, 147 and 230. The middle power has been used throughout. A Bohnenberger's eye-piece, power 106, was also supplied for determinations of the nadir point and level error.

The horizontal axis consists of a central 12-inch cube and two cones, each ten inches in diameter at the cube and in one casting of gun-metal therewith; bearing at their extremities the pivots, also of gun-metal, which are 3 inches in diameter and rest in brass Y's, adjustable vertically only by screw-motion; any change in azimuth requiring the forcible bodily movement of the east pivot support by means of double wedges, but such adjustment has only been once needed since the instrument was finally mounted in 1862. The pivots and Y's are so well boxed in with close fitting brass covers that dust and moisture are effectually excluded.

The two ends of the telescope are each screwed to the cube by twelve stout bolts. There are two nearly similar gun-metal 42-inch circles, each firmly secured by means of eight screws to truly faced flanges, attached to the conical axes on opposite sides of the cube. The clear space between the two circles is just 30 inches. The eastern circle is coarsely divided, to 10′ only, for setting, and is also intended as a handle for turning the instrument round. It is clipped by two clamps, with slow motions and tangent rods, which have generally been used for making bisections in preference to the micrometer of the eyepiece, ever a fruitful source of error in polar distance determinations. The western circle carries a rim of gold, inclined at a level of about 12° to the plane of the circle to facilitate reading and illumination, and is divided with Messrs. Troughton and Simm's well known precision into 5′ spaces. The divisions are read off by six microscopes of very considerable magnifying power, so placed as to bring their micrometer eyepieces within a circle of 30 inches diameter and for the lower microscope to read zenith-distances. Each microscope micrometer screw moves a pair of close parallel wires, the nearest division of the limb being brought midway between them instead of being bisected by cross wires. The divided circle is enclosed in a light open work box to shield it from accidental injury by the observer.

The greatest source of delay and difficulty in mounting the instrument was in regard to the fixing of the six microscopes. It was obviously intended that they should be placed as they now are, for the lower one to read zenith distances, and the hole for it to look through was drilled in the lower part of the western pier in readiness. This however caused the upper microscope, in the cap-stone above, to come immediately above the flame of an argand lamp, provided for lighting up the field of view, or the wires in a dark field, and for the general illumination of the limb opposite to each microscope. It was soon found that the much smaller flame of a thin flat wick gave ample illumination for the limb and also for the wires in a bright field, though not sufficient for the satisfactory use of bright wires in a dark field. With one of the slices cut out of the cap-stones, as mentioned on page vi, a conical frustum, of 24 inches base and 19 at its face, was attached to the western pier, projecting 6 inches from it, and with a continuation of the 12-inch square space left for the pivot supports, through its centre. By placing a small lamp therein, with a bent chimney to carry off all smoke and as much heat as possible, the difficulty was at last overcome; certainly not as arranged by Messrs. Troughton and Simms but quite effectual for the purpose. The conical projection lies between the micrometers, serving as a protection to them against possible injury, but is neither in the way nor in the least unsightly, and no one seeing the instrument for the first time would imagine for a moment that it was any addition to or departure from the original design. The light of the small lamp is guided and condensed by a frame of seven lenses; a large central one for illuminating the field, and six smaller ones for distributing it where required upon the divided limb under each microscope.

Two pairs of brass arcs had been provided for the support of the other four microscopes; one pair for the eyepieces and micrometers on the outside western face of the pier, and a larger pair, to bear the objectives on its eastern or inner side; apertures being also left in the composition stones for the long tubes connecting the eyepieces and their objectives; but in order to fix the upper microscope after cutting out a $9\frac{1}{2}$ inch slice just where it had to come, two more similar metal arcs had to be cast and made up here. Considering the difficulty of getting anything of the kind done in Madras in those times, it would have been much better for Messrs. Troughton and Simms to have sent out a skilled mechanic to assist in the erection of the instrument, but it fortunately happened, that in September, 1861, a German Mathematical Instrument maker, the late Mr. F. Doderet, was sent out by the Right Honorable, the Secretary of State for India, to start workshops for the repair of levels, theodolites, &c., for the Public Works Department, and as no place, plant or assistants were prepared for him, I was readily granted the benefit of his services for six months. Major Tennant, when in charge of the Observatory had purchased for Government an excellent lathe, by Holtzaffel, and with it and a supply of other tools from the Arsenal, we set vigorously to work and got the Transit usable for time determinations by the end of the year, and all the modifications required in the microscope arrangements finished in May 1862, when complete observations were first steadily commenced.

Heavy counterpoises, with their fulcra resting on inch thick iron plates, crossing the cap stones, relieve the Y's of most of the weight of the instrument, by means of two pair of 5-inch friction rollers, applied to grooves on the axis between the circles and pivots; small additional weights sufficing to lift it out of its bearing for cleaning and oiling. The residual pressure of the pivots upon each Y is about 10 or 12 lbs.

A finder, 15 inches in length and $1\frac{1}{2}$ in aperture was added to the telescope, presumably for estimating the magnitudes of the brighter stars but its utility for that or any other purpose is very questionable.

The telescope eyepiece was provided with a system of seven vertical and one horizontal spider lines, moveable each way by micrometer screws of practically the same thread. The single horizontal line was replaced by a close pair, about 12″ apart, and bisections have throughout been made by bringing stars exactly midway between the two when crossing the centre vertical wire. For observations of Mars especially, the estimated equality of the segments above and below, was unquestionably better than tangential contacts of a single line with either north or south limb.

For collimating, two 35-inch telescopes with $2\frac{3}{4}$-inch object glasses, are mounted on piers, level with the centre of the Transit-circle, inside the room, and at a distance of 57 inches from the object glass of the instrument when turned to either the north or south horizon. The central cube is pierced by two 4-inch circular apertures, so that the wires in each collimator can be seen through the other when the circle reads 180.° The south collimator micrometer moves horizontally, for fixing an approximate meridian line, and the north one vertically, so as to give a nearly horizontal line for flexure determinations. Having only native assistants for observers and considering therefore that extreme simplicity would ensure the safest results, I did not adopt the Greenwich pattern of wires, but preferred simple crosses; that in the north collimator being arranged as in the sign × and that in the south collimator as a +, which I thought better suited to those who had to use them.

Upon my arrival at Madras I found the collimators placed outside the Observatory in small square detached rooms, twenty feet further from the Transit-circle than they now are. This was far more convenient as regarded space inside, and would have permitted of reflexion observations being taken much lower, had such been possible and urgently desirable; but I soon found upon trial, that the passage of the visual rays through three strata of air of very unequal temperatures, caused the wires to appear so faint and tremulous that I gladly removed the collimators inside the Observatory, as Mr. Carrington's were placed at Redhill, and the result was all that could be expected or desired.

A convenient transit observing seat runs on six rollers, between the circle piers, from one collimator pier to the other; and on the instrumental basement, a foot below the boarded floor, in which are five hinged trap doors, is a railway for two moveable reflexion troughs, besides a fixed circular one, vertically below the centre of the Transit-circle, for use with the Bohnenberger eyepiece, for nadir point and level error determinations.

CLOCKS AND CHRONOGRAPH.

One of those rare and matchless old clocks, by Shelton, with a gridiron pendulum the compensation of which as nearly approaches perfection as possible, was found in India when the Observatory was first started in 1792, and is to this day by far the steadiest timekeeper in the place. It was used as the transit-clock till 1859, when it was replaced by a new one by Dent, with a mercurial pendulum, of the best modern construction, but certainly no improvement upon the old one except in its far louder and more convenient beat. Some of the mercury was accidentally spilt in setting up the new clock and though more was added to replace the missing quantity, its compensation has never yet been so satisfactory as that of the old Shelton, which has since been used with the principal Equatoreal. The performance of the Dent transit-clock has, however, been good throughout and no better could be desired as a standard sidereal regulator.

A curious old clock, by Haswall, used by Mr. Goldingham in his pendulum experiments in 1821, with a mainspring instead of a weight and a very peculiar double escapement, was formerly used with the old mural-circle and was most capricious in its daily rate. The escapement being simplified and the spring exchanged for a barrel and weight, it has been used with the smaller equatoreal since 1866, and has worked better, though never comparable to the two first named.

An excellent mean time electrical clock by Shepherd & Son, was supplied to the Observatory in 1872, and though severely criticized when under trial at the India Store Department for instruments, at Lambeth, it has worked well enough at Madras. It transmits hourly currents, by which a time gun at Fort St. George, about three miles distant, is fired at noon and 8 p.m., and a semaphore at the Marine Office, a mile further, is dropped at 8 a.m. and 2 p.m., with as few failures as are usually made in time signals elsewhere. It also passes alternately positive and negative currents, second by second, for the control of sympathetic clocks, one of which has been going at the Marine Office since 1879, as fairly as could be expected considering its very indifferent treatment ever since it was set up. When first received at Madras, the Shepherd clock had a magnetic contrivance for the daily rectification of its small error, as necessary in all electrical motor clocks, and this was undoubtedly the source of dissatisfaction when on its trial in London, as until it was discarded nothing could be done with the clock here. As soon however as a simple gravitation adjustment was substituted, consisting of a small brass weight of 159 grains, which when placed upon a shelf about 18 inches below the point of suspension of the pendulum makes the clock gain a hundreth of a second per minute, or lose at the same rate when placed on another shelf below the pendulum jar, all irregularities ceased and no further difficulty was experienced.

Application was made for a chronograph in 1863, chiefly with a view to carrying out telegraphic longitude operations, and for observations of Mars in opposition for investigation of the constant of solar parallax. A barrel chronograph was specified as being the only kind desired, the time marks being read off with so much more certainty, speed and convenience when in parallel rows on a single sheet than from many yards of a thin paper tape or fillet. My application received no reply at the time, but several years later a French fillet recorder was sent out; too late for the special purposes for which it was wanted and quite unsuitable, even if it had been supplied when asked for.

OBJECTS SELECTED FOR OBSERVATION WITH THE TRANSIT CIRCLE.

The objects selected for observation with the new Meridian-circle were; the brighter stars inclusive, down to the 5th magnitude; the moon and moon-culminating stars given in the Nautical Almanac; Mars and the stars observed with him at successive oppositions, on the meridian, as well as those used east and west, with the Equatoreal, for parallax investigations; minor planets in opposition, if not under the 10th magnitude; comparison stars used for differential observations of comets and planets from 1861; all known variable stars; zero stars for maps of those objects (in) hand, and as many others, not below the 9th magnitude, as time would permit, between 130° and 150° Polar Distance, as determining stars for the zones of the Southern Survey, in extension of the late Prof. Argelander's great Northern Survey, which, with that distinguished astronomer's warm approval and advice I had intended to make my chief personal labor at Madras. The very extraordinary opposition met with to this work, from a quarter whence such was least expected, partitioning out in portions to other observatories the work I had undertaken as a whole, compelled me to abandon any participation in its accomplishment at the end of 1863, after it had been fairly commenced in that year.

The refusal of European assistance, after I had been authorized to apply to Prof. Argelander and Mr. Hind to suggest for appointment any well qualified young astronomer either of them might know of as available, was a death blow to the too ambitious programme I had undertaken and an unforeseen justification for my renunciation of the Southern Survey. The local Government and its distinguished chief, Sir W. Denison R. E., had warmly supported my plea for a German or English assistant, and were so well assured of its being granted, that the plan and estimate for separate quarters in the Observatory grounds, for the accommodation of a Deputy Astronomer, were sanctioned and the foundations actually laid out, before the refusal of the promised help was received from the India Office in London. My intention was to have only a small catalogue of stars observed by the native assistants with the Meridian Circle, pending completion of the first few maps of the Southern Survey, and as soon as the approximate catalogues, similar to those of the Bonn "*Durchmusterung*" were available, to have all the stars they contained observed in zones with the new instrument, just as the "*Durchmusterung*" itself has been since dealt with by the northern observatories.

Finding that the Meridian-circle must be used by native observers only, who though good for the slow methodical processes of ordinary meridian observations, could never be entrusted with the more arduous work of zoning; the best course was to increase the former observing list by the addition of as many anonymous stars of more than 120° Polar Distance as could be found, not less than the 8th magnitude. No star was to be observed on less than five nights and all objects of more than ordinary interest on at least ten nights, and this has been adhered to throughout, wherever possible.

OBSERVATIONS.

Observations with the Meridian Circle, the results only of which are given in this volume, were almost entirely made by three native assistants, who were as fair observers as could probably be found of their class. The first Assistant, C. Sashoo Iyengar, was scrupulously careful and accurate and was warmly commended by every Astronomer, from 1837 up to the time of his death, in March, 1863. He was succeeded by C. Ragoonatha Chary, whose better mathematical attainments and general aptitude for science, justified me and my friend, Mr. E. B. Powell, then Director of Public Instruction, and one of the greatest authorities upon the subject of Double Stars, in recommending him for the honor of election as a Fellow of the Royal Astronomical Society. The other native assistant who took part in the meridian observations was T. Moottoosawmy Pillay; also a very trusty, painstaking man. All three had used the old meridian instruments, but it was not until after more than a year's practice with the new Transit-circle that I dare trust them to determine all their own instrumental corrections in the ordinary course of the night observations; though decidedly convinced that it is far better to do so than to make special determinations and interpolate for the required dates, however steady the corrections may be. There were such evident personalities between them, that from the first I made each assistant find his own corrections; nearly always being present, until I became assured that it would be safe to entrust them with such manipulations alone. The corrections for index and run of the microscopes micrometers were, from the first, found at night, but those for inclination and collimation in the day time, until September 1863. Due allowance being made for diurnal aberration, the right ascension micrometer was set to the corrected reading for no collimation; and until April 1863, when the use of the polar distance micrometer was first considered prudent, bisections were made with the tangent rods and slow motions of the clamps. Even then it proved a very questionable step and was a fruitful source of error long after its introduction.

Observations were entered, in pencil, in convenient recording books as they were made. The standard barometer, by Newman, supplied by the Royal Society in 1841, and one of two thermometers, verified at Kew, were recorded for refraction reductions; the one used being at either a north or south window, according to the direction of the wind at the time of observation.

REDUCTION OF THE OBSERVATIONS.

These were carried out in folio day books. The originals were bound for preservation in the Observatory, but as in the tropics it seems impossible to ensure that for long, copies were made for safer deposit in England, where they may be readily available for reference whenever desirable.

The arrangement of the day books is as follows:—

Left side.—Polar Distance : 12 columns.

1.—Reference Number.
2.—Date and Observer.
3.—Barometer.
4.—Thermometer.
5.—Name of Object.
6.—Deduced Circle Reading:—*i. e.*—zenith distance counted round through south nadir and north, up to 360°; the means of the six microscopes, corrected for index, run of micrometers, and curvature if not observed at the centre of the field.
7.—Refractions, computed by "*Bessel's Tables*" as modified and expanded in an appendix to the Greenwich Observations for 1853.
8.—Apparent Polar Distance, assuming the latitude as given in the Nautical Almanac; *viz.*, 13° 4′ 8″·1 north.
9.—Reductions to January 1st; using the "Day Numbers" of the Nautical Almanac, and constants calculated for every star not in the N. A. list for the year.
10.—Mean Polar Distances of Stars.
11.—Apparent Polar Distance by Ephemeris.
12. Correction to Ephemeris.

Right side.—Right Ascension : 17 columns.

1.—Reference Number.
2.—Name of Object.
3.—Number of Wires.
4.—Estimated Magnitudes.
5.—Mean of Wires:—the clock time of transit over the mean of the seven wires being meant in all cases, and every object observed over a less number being reduced thereto by the adopted intervals of the wires noted.
6.—Inclination correction.
7.—Collimation correction.
8.—Meridian correction.
9.—Personal equation of Observer.
10.—Sum of columns 6, 7, 8 and 9.
11.—Corrected clock time of transit.
12.—Clock correction applied.
13.—Apparent Right Ascension.
14.—Reduction to January 1st, calculated as in column 9 of the Polar Distance page.
15.—Mean Right Ascensions of Stars.
16.—Apparent Right Ascension by Ephemeris.
17.—Correction to Clock or Ephemeris.

The contents of the Observing or Recording books and of the Reduction or Day books are now rarely published except at national Observatories; colonial and private Observatories seldom having either the staff or the funds required for printing such voluminous details, of questionable interest or utility to those who only desire results.

The horizontal wires were most carefully adjusted, so that a star brought exactly between them upon entering the field of view was satisfactorily so when quitting it at the opposite side and no correction was therefore required for the very few cases in which a star was not bisected close to the middle transit wire.

The value of one revolution of the Polar Distance micrometer, found by bisecting the cross of the north collimator with the close horizontal wires at different settings of the micrometer and reading off the Circle, was $26''\cdot33$. Measured by means of coincidences between the wires and their reflected image, it was $26''\cdot37$. The mean value, $26''\cdot35$ was adopted.

The value of one revolution of the Right Ascension micrometer, found in a similar manner, after turning the eyepiece end through 90°, until the close horizontal wires were in a vertical line and then reading off the Circle when the centre wire was made to bisect the cross of the north collimator at various readings, was $26''\cdot66 = 1\cdot771$ seconds of time.

The intervals of the seven wires from their mean, determined by twelve complete transits of polar stars in 1862, were as follows:—

$+36^{s}\cdot979$ $+24^{s}\cdot705$ $+12^{s}\cdot351$ $+0^{s}\cdot109$ $-12^{s}\cdot348$ $-24^{s}\cdot697$ $-37^{s}\cdot098$

The Madras factors for inclination and meridian corrections were found by the following formulæ; the Polar Distance being considered negative for below pole factors.

Inclination factor = $+0\cdot974+(9\cdot35435)$ cotan. Polar Distance.

Meridian factor = $+0\cdot226-(9\cdot98861)$ cotan. Polar Distance.

The correction for diurnal ~~observation~~ aberr ation at Madras being $0^{s}\cdot020$, for the centre wire $+ 0^{s}\cdot109$, and the zero of collimation having been found by taking the mean of the R. A. micrometer readings of the centre wire, when bisecting the crosses in the north and south collimators, after they had been adjusted upon each other; we have for any other reading of the R. A. micrometer:

Collimation correction = $1^{s}\cdot771$ (zero of coll. − adopted reading − $0\cdot073$).

The reading of coincidence of the centre wire with its reflected image in mercury being taken, we have also;

Inclination correction = $1^{s}\cdot771$ (zero of coll. − coincidence reading).

The small altitude of the pole at Madras renders the observation of stars often impossible at their lower transit. Weather permitting, the Meridian-correction was found by a pair of polar stars, but frequently of necessity from one only, combined with a south star, when of course no other use was made of the observation, beyond that of furnishing the correction for the night. The correction was interpolated when not otherwise determinable.

Personal equations were merely used for the convenience of avoiding changes in the local time, for the public signals, as different observers came on duty. The watches usually extended over half a month and the clock errors were never mixed. Upon several occasions, when the instrument was in use only as a Transit, before the Circle arrangements were completed, I observed a number of clock stars intermediate between those of the native assistants, and from comparisons thus obtained, it appeared that they all required negative corrections to their recorded times relatively to my own. The numbers adopted were; for Sashoo $-0^{s}{\cdot}75$, for Ragoonatha $-0^{s}{\cdot}35$, and for Moottoosawmy $-0^{s}{\cdot}23$. I afterwards found that similar differences in the habits of bisection existed between the native observers and myself; rendering it equally necessary for each one to determine his own corrections for Index and Run, and causing apparent changes in the corrections certainly not due to the instrument, as may be readily seen in the following tables of adopted "*Instrumental Corrections*", where the numbers enclosed in brackets are the determinations of different observers on the same night.

The Nautical Almanac positions of Standard stars were used entirely for finding the clock corrections, a few being rejected for the purpose, especially Sirius and 61 Cygni. Whatever corrections are due to the Nautical Almanac stars will therefore affect the Madras Right Ascension throughout.

For the determination of the Meridian corrections, as well as with a view to securing data for correction of the assumed latitude, the positions of a number of the brighter stars in the "*Catalogue of* 164 *Stars within* 6° *of the North Pole*", given in Vol. XVI of the "*Radcliffe Observations*" were employed. I preferred using the positions given therein to those of the "*Radcliffe Catalogue of Stars for* 1845", as they were entirely my own bringing up, under the supervision of my esteemed chief Mr. Johnson, then Radcliffe

Observer, who was ever anxiously watchful for the results as the work was in progress.

A flexure correction of 1″·72 × sin Zenith Distance, was applied provisionally to the Polar Distances in this volume and I regret not having awaited a final value before using such a correction at all.

Any investigation of the correction to the assumed latitude before the flexure correction is finally settled would be premature; nor do I think it will be worth while to trifle with partial year to year enquiries now that all the observations for the Catalogue are completed. There is good reason to believe that the latitude requires to be increased (Mr. Taylor used 9″·2 instead of 8″·1 for his "*General Catalogue for* 1835") and it will be far better to combine all observations taken of each star, above and below pole, when reduced to the epoch 1875, a work which I hope to proceed with as early as other duties will permit, while the next volume is in hand.

Instrumental Corrections adopted in 1862.

Date.	Index.	Run in 5′	Clock Rate	Inclina-tion.	Meridian.	Determining Stars.
1862.	″	″	s	s	s	
May 31	− 3·5	+ 0·7	− 0·36	0·00	+ 0·39	
June 2	− 5·0	+ 0·8	− 0·32	0·00	+ 0·53	ρ Bootis and Polaris
3	− 4·5	+ 0·8	− 0·44	0·00	+ 0·45	ρ Bootis and 34 R. P. L.
4	− 4·1	+ 0·8	− 0·46	0·00	+ 0·49	108 R. P. L. and β Corvi.
5	− 3·8	+ 0·8	− 0·34	0·00	+ 0·50	108, 111, 115 R. P.L., and ε, β Corvi, Spica.
7	− 4·8	+ 0·5	− 0·34	+ 0·13	+ 1·16	111 R. P. L. and α Libræ.
9	− 3·5	+ 0·5	− 0·32	− 0·08	+ 0·09	
10	− 4·0	+ 0·7	− 0·36	− 0·06	+ 0·09	ε Urs. Min. and Antares.
12	− 5·2	+ 0·5	− 0·42	− 0·02	+ 0·13	111 R. P. L. and Antares.

The Inclination correction was adjusted on each of the first five nights on which the instrument was used. It was afterwards determined, about noon, on June 7, 9, 12.
The Right Ascension micrometer was set to the corrected reading for no collimation, except on June 7, when it was left by mistake so as to require a correction of − 0·14 second.

Instrumental Corrections adopted in 1862.

Date	Index.	Run in 5′	Clock Rate.	Inclination.	Meridian.	Determining Stars.
1862.	″	″	s	s	s	
June 13	− 4·6	+ 0·5	− 0·40	− 0·05	+ 0·11	
16	− 4·1	+ 0·3	− 0·38	− 0·06	+ 0·03	
19	− 3·6	+ 0·2	− 0·41	− 0·05	− 0·05	111 R. P. L., β Urs. Min. and β¹ Scorpii.
21	− 4·5	+ 1·0	− 0·36	− 0·06	+ 0·19	3 Urs. Min. and β Libræ.
24	....	....	− 0·23	− 0·05	+ 0·21	111 R. P. L and α Serpentis.
27	....	....	− 0·25	− 0·05	+ 0·18	
30	....	....	− 0·38	− 0·05	+ 0·13	
July 3	+ 0·3	0·0	− 0·35	+ 0·02	+ 0·11	ε Urs. Min. and θ Ophiuchi.
4	+ 0·3	− 0·2	− 0·34	+ 0·02	+ 0·13	δ Urs. Min. and β¹ Scorpii.
8	+ 0·1	0·0	− 0·39	+ 0·02	+ 0·07	
12	− 1·1	+ 0·2	− 0·35	− 0·05	+ 0·01	δ Urs. Min. and ρ Capricorni.
15	+ 3·5	+ 0·1	− 0·33	− 0·03	+ 0·04	ε Urs. Min. and β¹ Scorpii.
16	+ 3·9	+ 0·1	− 0·36	− 0·03	+ 0·05	
18	+ 4·1	0·0	− 0·40	− 0·02	+ 0·04	
19	+ 3·8	0·0	− 0·39	− 0·02	+ 0·03	
22	+ 2·6	0·0	− 0·33	− 0·02	0·00	
23	+ 2·7	+ 0·5	− 0·22	− 0·03	− 0·02	ε Urs. Min and β¹ Scorpii.
24	+ 2·7	+ 0·5	− 0·18	− 0·01	+ 0·04	
25	+ 3·0	+ 0·3	− 0·20	− 0·01	+ 0·09	ε Urs. Min. and β¹ Scorpii.
26	+ 2·4	− 0·1	− 0·28	− 0·01	+ 0·06	ε Urs. Min. and β¹ Scorpii.
28	+ 2·4	− 0·1	− 0·56	− 0·07	+ 0·08	δ Urs. Min. and β¹ Scorpii.
July 29	+ 2·5	− 0·3	− 0·58	− 0·07	+ 0·12	131 R. P. L. and δ Aquilæ.
30	+ 2·7	+ 0·2	− 0·63	− 0·07	+ 0·12	
31	+ 2·4	0·0	− 0·63	− 0·07	+ 0·12	
Aug. 1	+ 2·2	0·0	− 0·12	− 0·07	+ 0·05	δ Urs. Min. and α² Capricorni.
2	+ 2·4	− 0·1	− 0·10	− 0·07	+ 0·03	δ Urs. Min. and α Ophiuchi.

The microscopes were removed on June 23, for a few days, during the fastening of a conical stone ring to the western pier, between them and the lamp.
The microscopes were re-adjusted throughout on July 3 and 15.
The Clock rate was diminished 0·5 second after the observations on July 31.
The Inclination correction was determined, usually about noon, on June 14, 17, 20, July 3, 10, 15, 21, 28 and August 4.
The Right Ascension micrometer was set to the corrected reading for no collimation, except on June 19, when by a careless mistake it was left seven revolutions wrong and a correction of − 12·40 seconds had to be used.

Instrumental Corrections adopted in 1862.

Date.	Index.	Run in 5′	Clock Rate.	Inclination.	Meridian.	Determining Stars.
1862.	″	″	s	s	s	
Aug. 5	+ 1·9	+ 0·2	− 0·07	− 0·05	+ 0·03	
9	+ 2·2	+ 0·1	− 0·15	− 0·05	+ 0·03	
12	+ 3·5	0·0	− 0·07	− 0·12	+ 0·03	
13	+ 3·7	− 0·3	− 0·02	− 0·12	+ 0·03	
14	+ 2·3	− 0·3	− 0·10	− 0·12	+ 0·09	λ Urs. Min. and h^2 Sagittarii.
16	+ 3·3	+ 0·1	− 0·26	+ 0·01	+ 0·09	
18	+ 3·2	0·0	− 0·33	+ 0·01	+ 0·09	
20	+ 4·2	0·0	− 0·52	+ 0·01	+ 0·09	δ Urs. Min. and Altair.
21	+ 3·2	− 0·2	− 0·42	+ 0·01	+ 0·08	δ Urs. Min. and β Aquilæ.
22	+ 3·1	− 0·5	− 0·28	+ 0·01	+ 0·17	131 R. P. L. and δ Aquilæ.
23	+ 3·2	− 0·5	− 0·28	+ 0·01	+ 0·16	150 R. P. L. and 3 Aquilæ.
25	+ 2·7	− 0·5	− 0·32	− 0·09	+ 0·13	
26	+ 2·7	− 0·1	− 0·39	− 0·09	+ 0·12	
27	+ 2·8	− 0·3	− 0·35	− 0·09	+ 0·10	
28	+ 0·5	+ 0·4	− 0·27	− 0·09	+ 0·09	
Sep. 1	− 0·9	0·0	− 0·33	− 0·22	+ 0·03	
3	+ 0·3	− 0·1	− 0·36	− 0·22	0·00	
5	{ + 0·6 / + 1·2 }	0·0	− 0·19	− 0·22	− 0·03	γ Aquilæ and 51 Cephei.
6	+ 0·7	+ 0·4	− 0·17	− 0·26	+ 0·02	150 and 72 R. P. L.
8	+ 1·5	+ 0·2	− 0·30	− 0·23	+ 0·02	
9	+ 1·8	+ 0·2	− 0·21	− 0·23	+ 0·02	
10	+ 1·1	+ 0·1	− 0·24	− 0·23	+ 0·01	12 and 89 R. P. L.
11	+ 0·7	+ 0·2	− 0·38	− 0·23	+ 0·01	
12	+ 0·2	+ 0·1	− 0·39	− 0·23	+ 0·01	
13	+ 0·9	+ 0·1	− 0·40	− 0·23	+ 0·01	
15	+ 0·9	+ 0·1	− 0·32	− 0·21	+ 0·01	
16	+ 0·4	0·0	− 0·35	− 0·22	+ 0·01	

The two brass arcs which support microscopes B and C were removed for necessary alterations and repair of a broken screw on August 28.

The Inclination correction was determined, usually about noon, on August 11, 16, 25, 29, September 1, 2, 4, 8, 16.

The Right Ascension micrometer was set to the corrected reading for no collimation except on September 1 when it was slightly misplaced, leaving a correction of + 0·02 second, and also on September 3 and 5, when the required correction was + 0·01 second.

F

Instrumental Corrections adopted in 1862.

Date.	Index.	Run in 5′	Clock Rate.	Inclination.	Meridian.	Determining Stars.
1862.	″	″	s	s	s	
Sep. 17	+0·6	+0·2	−0·23	−0·22	+0·02	
18	0·0	+0·2	−0·12	−0·22	+0·02	
20	0·0	+0·2	−0·32	−0·22	+0·02	
22	+1·8	+0·2	−0·01	−0·31	+0·02	151 R. P. L. and 12 Ceti
23	+1·7	0·0	+0·02	−0·22	+0·02	
24	+1·7	+0·3	−0·26	−0·22	+0·02	
26	+2·8	+0·1	−0·73	−0·26	+0·03	
27	+2·3	−0·3	−0·79	−0·26	+0·03	
29	+2·5	−0·3	−0·77	−0·26	+0·03	150 R. P L. and β Aquarii.
30	+2·9	+0·8	−0·81	−0·26	+0·02	150, 158 R. P. L., and ρ Capricorni
Oct. 1	+0·8	+0·2	−0·80	−0·31	+0·03	
2	+1·2	+0·3	−0·76	−0·31	+0·04	150 and 72 R. P. L.
3	+1·6	−0·2	−0·76	−0·31	+0·03	
4	+1·1	0·0	+0·27	−0·31	+0·03	
6	+0·8	+0·5	+0·14	−0·31	−0·01	150 R. P. L. and ι Piscium.
7	+0·8	−0·4	+0·22	−0·31	+0·03	150 and 70 R. P. L.
8	+0·8	0·0	+0·20	−0·27	+0·03	
9	+0·6	−0·2	+0·12	−0·27	+0·03	
10	+2·2	−0·2	+0·24	−0·27	+0·03	
11	+1.6	+0·1	+0·27	+0·11	−0·03	150 R. P. L. and ζ Pegasi.
13	+1·5	+0·1	+0·17	+0·11	−0·03	150 and 72 R. P. L.
14	+1·7	−0·1	+0 20	+0.11	−0·04	150 R. P. L. and α Aquarii.
15	+1·8	+0·1	+0·26	+0·11	+0·01	150 and 72 R. P. L.
16	+1·6	0·0	+0·17	+0·10	−0·05	150 and 72 R. P. L.
17	+2·0	+0·4	+0·12	+0·10	−0·06	
18	+1·2	+0·3	+0·13	+0·10	−0·07	
20	+1·7	+0·3	+0·17	+0·10	−0·08	
21	+1·2	0·0	+0·17	+0·10	−0·09	Polaris and δ Sculptoris.

The Clock rate was diminished by 1 second after the observations on October 3.

The Inclination correction was determined, usually about noon, on September 24, 26, October 8, 11, 16. It was adjusted on October 4.

The Right Ascension micrometer was set to the corrected reading for no collimation before beginning to observe.

Instrumental Corrections adopted in 1862.

Date.	Index.	Run in 5′	Clock Rate.	Inclination	Meridian.	Determining Stars.
1862.	″	″	s	s	s	
Oct. 23	+ 1·1	− 0·1	+ 0·11	+ 0·13	− 0·07	Polaris and δ Sculptoris.
24	+ 1·0	− 0·1	+ 0·11	+ 0·13	− 0·07	
25	+ 0·3	+ 0·1	− 0·01	+ 0·13	− 0·06	
27	+ 0·8	+ 0·2	− 0·35	+ 0·13	− 0·05	
28	− 0·5	+ 0·2	− 0·19	+ 0·13	− 0·05	158 and 79 R. P. L.
29	....	....	− 0·01	+ 0·13	− 0·02	
31	+ 2·1	+ 0·4	+ 0·01	+ 0·13	+ 0·04	26 R. P. L. and β Ceti.
Nov. 1	+ 3·1	+ 0·6	+ 0·05	+ 0·09	+ 0·09	ω Piscium and 72 R. P. L.
3	+ 3·3	+ 0·5	+ 0·06	+ 0.09	+ 0·11	153 and 72 R. P. L.
4	+ 3·2	+ 0·1	+ 0·08	+ 0·09	+ 0·14	153 and 93 R. P. L.
5	+ 3·0	+ 0·1	+ 0·02	+ 0·09	+ 0·12	153 and 72 R. P. L.
6	+ 3·1	+ 0·6	+ 0·07	+ 0·09	+ 0·17	153 and 72 R. P. L.
7	+ 2·4	− 0·2	+ 0·00	+ 0·09	+ 0·07	26 and 89 R. P. L.
8	+ 1·7	0·0	− 0·11	+ 0·09	+ 0·~~18~~ ·08	26 and 103 R. P. L
11	+ 0·6	+ 0·5	− 0·03	+ 0·09	+ 0·21	153 and 72 R. P. L.
12	+ 1·4	+ 0·5	+ 0·03	+ 0·09	+ 0·12	150 and γ Piscium.
13	+ 1·9	+ 0·4	+ 0·03	+ 0·06	+ 0·16	150 and 72 R. P. L.
14	+ 1·3	− 0·3	− 0·01	+ 0·06	+ 0·09	Polaris and θ Aquarii.
15	0·0	− 0·3	− 0·04	+ 0·06	− 0·01	26 and 92 R. P. L.
20	+ 1·3	− 0·3	− 0·28	+ 0·13	+ 0·09	Polaris and β Ceti.
22	+ 3·1	− 0·3	− 0.24	+ 0·13	+ 0·11	
24	+ 4·5	− 0·3	− 0·12	+ 0·13	+ 0·12	
25	+ 3·7	− 0·1	− 0·13	+ 0·13	+ 0·13	Polaris and γ Ceti.
26	+ 3·1	− 0·4	− 0·18	+ 0·13	+ 0·13	
28	+ 4·4	− 0·4	− 0·18	+ 0·14	+ 0·13	12 R. P. L. and θ Ceti.
29	+ 4·6	− 0·3	− 0·08	+ 0·14	+ 0·14	
Dec. 1	+ 2·1	− 0·3	− 0·10	+ 0·17	+ 0·18	33 and 89 R. P. L.
2	+ 2·2	− 0.2	− 0·17	+ 0·17	+ 0·10	33 and 114 R. P. L.

The Inclination correction was determined, usually about noon, on October 23, November 1, 14, 17, 29 and December 1.

The Right Ascension micrometer was set to the corrected reading for no collimation before beginning to observe.

Instrumental Corrections adopted in 1862.

Date.	Index.	Run in 5′	Clock Rate.	Inclination.	Meridian.	Determining Stars.
1862.	″	″	s	s	s	
Dec. 3	+1·8	+0·4	−0·17	+0·17	+0·11	Polaris and ν Piscium
4	+1·9	+0·3	−0·23	+0·17	+0·18	α Arietis and ε Urs Min.
5	+1·1	+0·3	−0·28	+0·17	+0·14	10 R. P. L. and β Ceti.
6	+0·8	+0·2	−0·33	+0·17	+0·16	
8	−0·1	+0·2	−0·39	+0·17	+0·20	40 R. P. L. and ε Urs. Min.
9	−0·1	+0·4	−0·34	+0·17	+0·21	43 R. P. L. and ε Urs. Min.
10	+0·2	+0·4	−0·24	+0·17	+0·15	26 R. P. L. and γ Ceti.
11	+0·6	+0·1	−0·25	+0·17	+0·18	Polaris and α Arietis.
20	....	....	−0·37	+0·12	+0·18	
25	....	....	−0·31	+0·12	+0·19	
29	....	....	−0·30	+0·12	+0·20	33 R. P. L. and 67 Ceti.
31	....	....	−0·37	+0·04	+0·22	33 R. P. L. and 67 Ceti.

Instrumental Corrections adopted in 1863.

Date.	Index.	Run in 5′	Clock Rate.	Inclination.	Meridian.	Determining Stars.
1863.	″	″	s	s	s	
Jan. 3	....	....	−0·32	+0·14	+0·18	
5	+2·5	0·0	−0·30	+0·14	+0·15	
6	+0·8	+0·2	−0·23	+0·14	+0·13	43 R. P. L. and γ¹ Eridani.
7	+0·4	+0·1	−0·27	+0·14	+0·08	Procyon and δ Urs. Min.
8	+1·1	+0·2	−0·35	+0·14	+0·16	33 R. P. L. and γ¹ Eridani.
9	+1·1	−0·4	−0·60	+0·14	+0·16	33 R. P. L. and δ Urs. Min.
10	+1·0	−0·4	−0·76	+0·14	+0·11	33 R. P. L. and δ Urs. Min.
12	....	....	−0·37	+0·14	+0·10	
14	−1·3	+0·3	−0·34	+0·16	+0·08	35 R. P. L. and δ Orionis.
15	−1·5	+0·3	−0·38	+0·16	+0·31	34 R. P. L. and ο¹ Eridani.

The Inclination correction was determined about noon on December 15, 16, 30 in 1862 and also on January 15, 1863.

The Right Ascension micrometer was set to the corrected reading for no collimation before beginning to observe.

Separate Results of Madras Meridian Circle Observations in 1862.

Number.	Star.	Date of Observation.	Observer.	Mean Right Ascension. 1862.			No. of Wires.	Mean Polar Distance. 1862.			Magnitude.
				h.	*m.*	*s.*		°	′	″	
110	43 Bootis ψ	June 2	P	14	58	31·97	6	62	30	46·1	...
	.. ..	„ 3	M		58	31·95	6		30	46·7	...
	... ...	„ 4	M		58	32·16	5		30	46·2	...
111	24 Libræ ι	June 9	R	15	4	21·54	6	109	16	1·9	...
	... ...	„ 10	R		4	21·50	...		16	1·3	...
112	111 R. P. L.	June 5	M	15	5	58·16	5	5	30	59·3	...
		„ 19	S		5	58·05	5		31	0·7	...
113	27 Libræ β	May 31	P	15	9	34·93	...	98	52	18·7	...
	... ...	June 16	S		9	34·81	...		52	16·1	...
	... ...	„ 21	S		9	34·90	...		52	16·4	...
114	32 Libræ ζ[1]	June 9	R	15	20	28·60	6	106	13	57·4	...
	... ...	„ 10	R		20	28·69	...		13	57·4	...
115	114 R.P.L. ... *s.p.*	Dec. 2	M	15	23	16 62	1	2	14	37·9	...
116	5 Coronæ Borealis α..	May 31	P	15	28	50·84	6	62	49	9·1	...
	... ...	June 4	M		28	50·72	...		49	10·0	...
	... ...	„ 12	R		28	50·70	...		49	7·2	...
	... ...	„ 16	S		28	50·88	...		49	7·4	...
	... ...	„ 21	S		28	50·84	...		49	8·7	...
	... ...	July 4	R		20	50·68	...		49	7·4	...
117	24 Serpentis α ...	May 31	P	15	37	28·38	6	83	8	17·6	...
	... ...	July 8	S		37	28·11	6		8	15·2	...
118	115 R. P. L	June 5	M	15	49	0·87	5	4	43	35·0	...
119	16 Ursæ Minoris ζ ...	July 22	M	15	49	4·15	...	11	46	58·0	...
120	7 Scorpii δ	July 8	S	15	52	10·41	...	112	13	32·7	...
121	8 Scorpii β[1]	June 4	M	15	57	24·94	...	109	25	29·6	...
	... ...	„ 9	R		57	25·00	...		25	28·6	...
	... ...	„ 10	R		57	25·01	..		25	29·1	...
	... ...	„ 19	S		57	24·94	6		25	29·8	...