A Research on the Aberration Constant and the Variation of Latitude by Means of a Floating Zenith Telescope. By Bryan Cookson, M.A., formerly Mackinnon Student of the Royal Society and Late Assistant in Astrophysics, Cambridge Observatory. Edited after his death by two Colleagues. (Plates 1–3.)

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Preface.

The greater part of this work was carried out by its author during his tenure of a Mackinnon Studentship of the Royal Society. All the photographs had been measured and reduced and a preliminary discussion of the whole material had been made by the author, when illness prevented him carrying the work to its completion. After his lamented death the papers relating to the investigation were entrusted to two of his colleagues on the Cambridge Observatory staff. In presenting this memoir for publication they are deeply conscious of their inability to do it full justice.

The preliminary discussion had shown its author that the results were abnormal, and during the last weeks of his life he was engaged in a critical examination of the whole work; he left, however, nothing in the shape of an account prepared for press. The principal task of the Editors has been to renew the search for systematic errors and to prepare for press an account of the investigation. They have been unable to improve in any sensible degree upon the author's results; and though they have shown explicitly, as far as possible, any serious modification which they have been led to attempt, they have not attempted to discriminate in detail between modifications suggested by the author's notes and other modifications arising in the course of the final discussion. It was the less necessary to do so, inasmuch as the author's preliminary solution stands essentially unchanged. The Editors have to admit that the final result cannot be considered entirely satisfactory. Although some of the difficulties which faced them are still outstanding, the work will nevertheless, they believe, rank as valuable pioneering in a new method.

One of the Editors (F. J. M. S.) is responsible for the whole of the later discussion and the preparation for press; the share of the other (A. R. H.) has been limited to discussion with his colleague of difficulties as they arose.

Most of the photographs were taken by Mr. A. D. Campbell, and they were all measured and reduced by him under the direction of the author. For the care and accuracy of his work, and for his willing co-operation in the revision, after he had left the Observatory, the thanks of all concerned are due to Mr. Campbell.

A. R. Hinks.
F. J. M. Stratton.

CONTENTS.

Part I.

§ 1. *Aberration and Latitude Variation.*—A short account of Professor Küstner's method * of determining the aberration constant independently of variation of latitude will form a fitting introduction to this paper. The earlier method of determining the constant of aberration, by observations throughout the year of the meridian zenith distance of a small number of stars, was rendered doubtful by the discovery of the variation of latitude. The fact that the displacement of a star's zenith distance contains a second periodic term with a period not far removed from a year was bound to spoil the accuracy of the aberration result, and some method had to be devised for disentangling the two factors. The device adopted by Professor Küstner to meet this difficulty was very simple. If two stars are observed transiting on the same night, then their apparent declinations will be affected equally by the variation of latitude, but differently by aberration which varies in its effect markedly from hour to hour. The difference of the observed declinations of the two stars will be independent of the variation of latitude. In fact, if

Δ_{12} = observed difference of declination given by the star observations, corrected for refraction, and reduced to the same epoch,

x_{12} = tabular difference of declination of the stars,

y = desired correction to the aberration constant used in reducing the star observations,

b_{12} = difference in the aberration factors for the two stars used in the reduction (see § 22),

then we have as an equation of condition

$$\Delta_{12} = x_{12} + b_{12}y \qquad (1)$$

Now in general x_{12} is affected by errors uncertain in amount, but possibly sufficiently great to rob equation (1) of any value as a determination of y. But if we adopt a list

* For a complete discussion of the method see *A.N.*, vol. cxxvi., No. 3015.

of stars 1, 2, . . . p and observe them cyclically in evening and morning pairs during the course of a year, we get a set of equations of the form

$$\left.\begin{array}{l}\Delta_{12}=x_{12}+b_{12}y\\ \Delta_{23}=x_{23}+b_{23}y\\ \cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\\ \Delta_{p1}=x_{p1}+b_{p1}y\end{array}\right\} \qquad (2)$$

Now, when these equations are added together $\Sigma x_{r(r+1)}$ must vanish, and the effect of the errors of any single term will be eliminated. We are left with the final equation,

$$\Sigma\Delta=\Sigma b, y \qquad (3)$$

where $\Sigma\Delta$ is observed and Σb is known accurately from theory. The correction, y, to the aberration constant is thus obtained at once independently of the variation of latitude and of errors in the catalogue places of the stars utilised.

§ 2. *Choice of Star Groups.*—KÜSTNER'S investigation includes an examination of the conditions governing the number and arrangement of the stars chosen in order that the coefficient of aberration may be obtained with the smallest possible error. The two simplest conditions laid down are that the successive stars should be equally separated in right ascension and that each pair should be observed when they culminate symmetrically about midnight. Also the number of groups utilised should be as small as possible. Difficulties at once arise in applying these conditions for observatories in high latitudes owing to the limitations imposed by the short summer nights. For Berlin, KÜSTNER showed that four stars with $\alpha=6^h$, 14^h, 18^h, 22^h would give the best results.

KÜSTNER'S programme was devised for visual work. For photographic work, where observations near dusk and dawn are less possible, the scheme had to be slightly modified, and for Cambridge, which is nearly in the same latitude as Berlin, five groups of stars were chosen. Naturally the results can be improved in many ways by using a group of stars instead of a single one. For instance, by taking stars on opposite sides of the zenith and equidistant from it, the advantages of the Talcott method may be combined with KÜSTNER'S method. Moreover, by taking a group of stars instead of one star, the accuracy of the mean derived latitude is increased. Details as to the actual star groups used are given below (§ 10).

§ 3. *Aberration Factors.*—Without going into KÜSTNER'S mathematical discussion of the alteration of the aberration factor at different times of the year, it may be of interest to show the way in which the difference of this factor for the evening and morning groups changes in amount at different seasons of the year. The following table gives the mean correction for aberration from apparent to real latitude for certain groups of plates taken in the evening and morning at different times in the year. The values have been derived from the Day Numbers in the Nautical Almanac.

TABLE I.—*Aberration Factors.*

Date.	Evening.		Morning.		$F_1 - F_2$.
	Group.	Factor = F_1.	Group.	Factor = F_2.	
1905 Sept. 18	V.	+ 17·80	I.	− 2·48	+ 20·28
1905 Dec. 10	I.	+ 13·29	II.	− 12·58	+ 25·87
1906 Mar. 14	II.	+ 2·96	III.	− 15·80	+ 18·76
1906 Mar. 24	III.	+ 3·21	IV.	− 6·04	+ 9·25
1906 June 26	IV.	+ 4·33	V.	− 5·05	+ 9·38

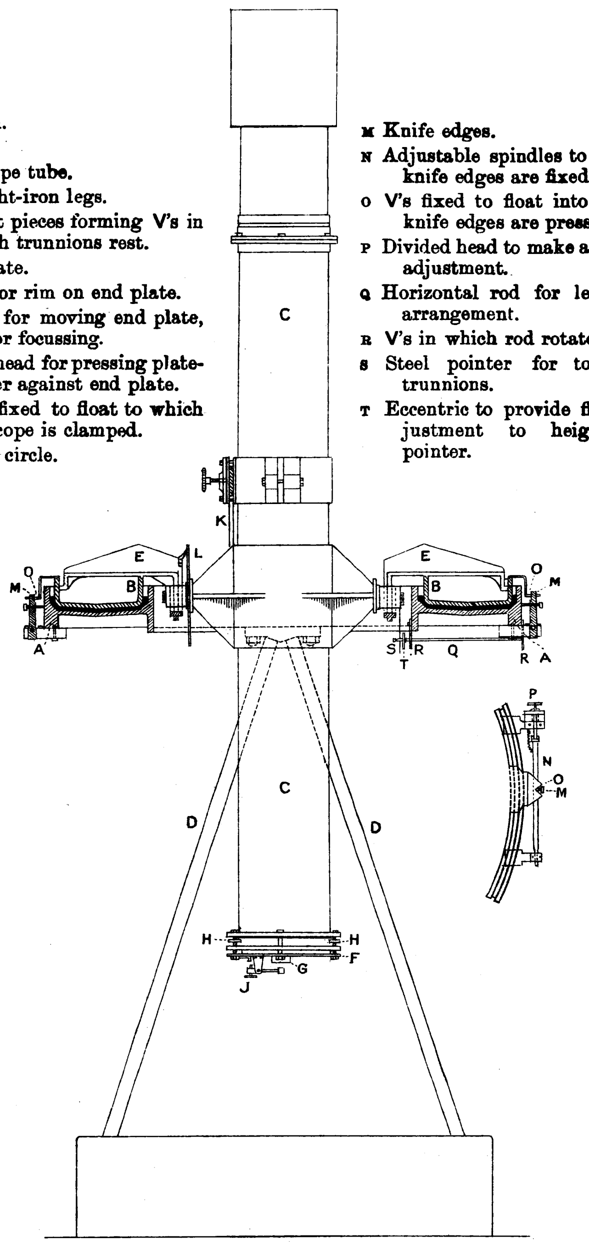
It will be noticed that the difference of the two factors is always positive. This is the case so long as the mean of the right ascensions of the two stars (or of the means of the two star groups) differs from that of the sun by a value between 6^h and 18^h. It will be noticed also how the aberration factor increases in the winter and decreases in the summer, in consequence of the changes in the length of the night with the accompanying limitations on the hours of observation.

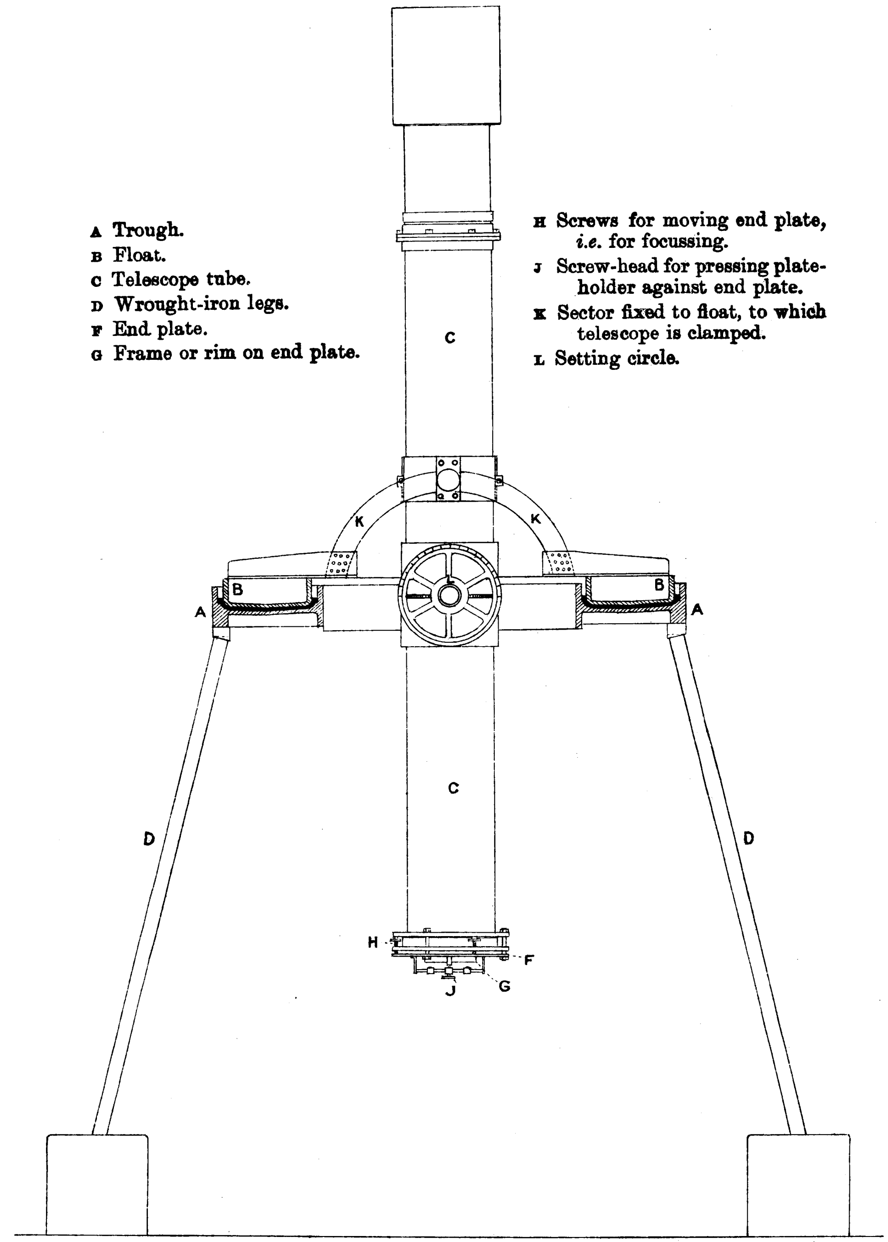
§ 4. *Variation of Latitude.*—KÜSTNER has pointed out how a series of observations made in accordance with his method to determine the aberration constant can be used also to examine changes in the latitude. During the intervals between the aberration observations, which can only be taken while two groups are visible in the night, one group is changing its hour of transit from morning to evening through midnight. This group can be observed during that interval and a continuous series of observations obtained, from which the movements of the pole in the meridian of the telescope can be derived.

PART II.

§ 5. *The Telescope.*—The instrument used in the following investigation has been already fully described in a paper published by its designer ("Description of a Floating Photographic Zenith Telescope," BRYAN COOKSON, *M.N.*, vol. lxi. p. 315). Part of the description will be reproduced here to facilitate the ready understanding of the work. A fixed trough in the form of a shallow annular basin contains mercury. An iron float concentric with the trough, and also annular in shape, fits inside, with half an inch clearance all round. The float carries two V's, on which rest the trunnions of the telescope. The telescope passes through the centre of the annulus (see Plate 1). The float is free to be rotated in azimuth. During observation it is held lightly by two opposite knife edges carried on the trough in the prime vertical; the knife edges are pressed by springs into two V's carried on the float; this arrangement leaves the float unconstrained in the meridian, yet permits of rotation through exactly 180°. It is assumed that the axis of rotation is vertical, and therefore that the line of inter-

MEM. ROY. ASTRON. SOC., VOL. LX., PLATE 1.





Design of the Instrument.

West, Newman photo-lith.

section of the plane of the meridian with the plane of a photographic plate carried by the telescope is the same line on the plate before and after a rotation of 180°. To prevent unnecessary jarring of the float or trough during the rotations a circumscribing polygon of wire is attached to the trough and stretched round the float to act as a spring buffer. This wire clears the float at every point when the float is in position. The telescope tube is kept in a fixed position relative to the float by being clamped to a vertical circular sector which is firmly fixed to the float. It may be set at various zenith distances by means of a clamp and a slow motion screw. The setting circle is divided to half a degree, which gives sufficient accuracy for setting the instrument. The object glass is a Cooke lens, Series I*c* (Taylor's patent), with $6\frac{1}{2}$ inches clear aperture and 65·4 inches focal length. The lens has a flat field of 14° diameter, and the maximum angular distance covered in the plates, $3^{\circ}\cdot 2$, is less than half of the field illuminated with full aperture. The star trails on the photographs are sharp and distinct. The tube of the telescope is of brass, $\frac{1}{8}$ inch thick and $7\frac{1}{4}$ inches internal diameter. At the lower end is a circular plate with a rectangular aperture slightly smaller than the sensitive plate. The aperture is surrounded by a raised rim carrying three points, against which the plate is pressed during exposure. The focussing is effected by three screws which move the end plate relatively to the telescope tube and which regulate the tilt of the plate to the optical axis of the lens.* When the focus has been found and the tilt adjustment made, these screws are clamped. Change of temperature does not affect definition sufficiently to require the readjustment of the focus from time to time.

§ 6. *Adjustments.*—The remaining adjustments are for level, azimuth, and collimation. The level error, b, had only for the purpose of these experiments to be kept within $\pm 1^{s}$. This means that in the distance between the trunnions (20 inches) the change in height should not be greater than 0·03 mm. The diameters of the trunnions do not differ by more than 0·01 mm. By bringing the trunnions successively over a scriber fixed on the trough a difference in their height of 0·01 mm. could be detected. A sliding weight attached to the float was moved until the touching point passed both trunnions with equal ease. This method of adjusting for level error was checked by observations of stars at zenith distances varying from 36° N. to 52° S., using a chronometer of known error. The resulting error, when the instrument had been finally adjusted for these experiments, was shown to be $b = +0^{s}\cdot 32$, circle west,† which lies well within the limit assigned. The azimuth error, a, could be adjusted by moving relative to the trough two knife edges, which fitted into V's attached to the float. These knife edges and V's ensured the rotation of the float through 180°, and the adjustment of the knife edges could be made to secure that the axis of the telescope should move in the meridian. The knife edges were held in position by screws with

* See below, § 17.

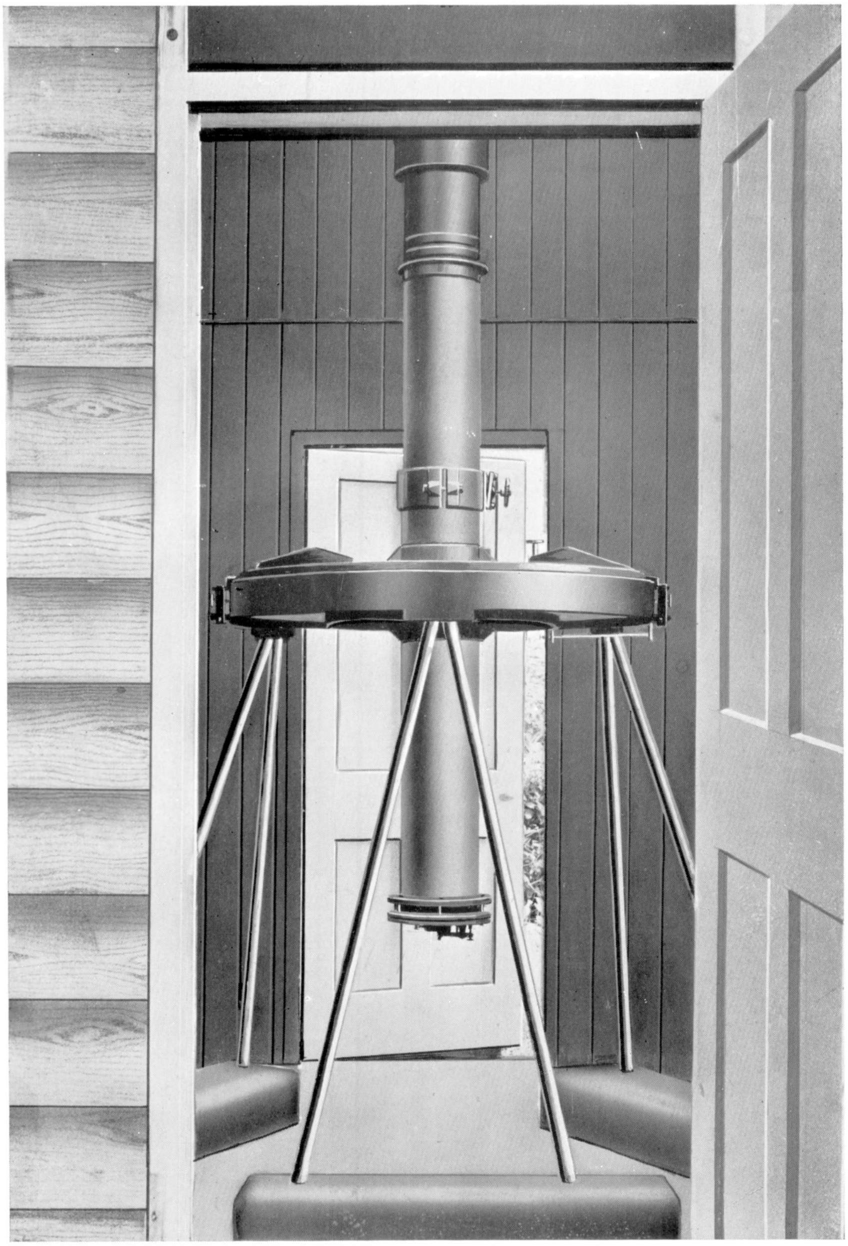
† The terms circle west and circle east indicate the position of the setting circle of the telescope for any particular observation or result.

divided heads and fastened by lock nuts. The final value of the azimuth error found before the commencement of these experiments was $a = -0^s{\cdot}23$, the upper limit allowable being $\pm 1^s$. No adjustment for either level or azimuth error was found necessary during the two years covered by the observations. The collimation error, c, was determined by a series of independent plates taken during the course of the investigation (see below, § 8). For this purpose the instrument is practically used as a photographic transit circle. Breaks in the trails of stars are made at noted times by sliding a shutter over the object glass. The distances of these breaks from the shadows of thin copper wires attached to the rim on the plate end of the telescope is measured by the micrometer and the collimation error at the ends of each wire ascertained. Only the errors of the central wire are required in the investigation. To correct for collimation error the frame carrying the wires can be moved by loosening the screws which attach it to the frame on the end plate. No such readjustment had to be made during the course of the experiments. As was pointed out in the earlier paper, errors up to $\pm 1^s$ in a, b, c would not affect the latitude as determined by a pair of Talcott stars by so much as $0''{\cdot}01$. The level and azimuth errors were well within the assigned limit. The collimation error of the central wire remained throughout greater than 1^s in amount. But this error was allowed for in the reductions.

§ 7. *New House and New Wire System.*—Mention must now be made of the several points in which the instrument and its surroundings during these observations differed from those described in the earlier paper. In the first place the telescope was no longer housed in the dome at the top of the main building of the Cambridge Observatory. To avoid some of the effects of temperature changes and of wind a special house was built in the autumn of 1904 in the Observatory grounds and near to the dome of the Northumberland telescope (see Plate 2).

Special attention was paid in the design of the building to the matter of ventilation. The walls are double, and arrangements have been made to encourage the circulation of air in the space between them. Much care has been taken to mimimise air currents through the opening in the roof used for observing the zenith. There are six shutters in the roof, three on each side of the central ridge; there are also an internal set of three shutters, the central one of which is immediately over the telescope and has a large aperture in it. A sliding screen, which is easily pulled by a cord across the aperture, serves as a cap to break the observations when required, *e.g.*, for adjustment plates. The building has no windows, but two doors, at the north and south end. These doors were invariably closed for two minutes or more before any observation was made.

The other chief point in which the instrument differs from the earlier description of it lies in the wire system. The old wire system was replaced in the summer of 1905 by a new system consisting of twelve fine copper wires. The distances of these wires from the central wire are given in the following table. The unit is a reseau interval (R = 5 mm.), and the measurements were made from direct measures of the shadows on a plate, corrected on the assumption that the wires are straight.



THE ZENITH TELESCOPE IN ITS HOUSE.

TABLE II.—*Distances from Central Wire.*

Wire Number.	Distances of Wire from Central Wire. At Reseau Line 3	13	23
1	3·2232	3·2162	3·2092
2	2·5889	2·6073	2·6255
3	2·3933	2·4023	2·4113
4	2·2172	2·2169	2·2166
5	1·6202	1·6185	1·6168
6	0·0000	0·0000	0·0000
7	1·5993	1·5951	1·5909
8	1·8057	1·8004	1·7951
9	2·2028	2·2046	2·2064
10	2·6076	2·5946	2·5815
11	3·0007	2·9860	2·9713
12	3·1950	3·1778	3·1606

The distance of the wires at any intermediate point is easily derived from the above table, also the inclinations of the wires to the central wire.

§ 8. *Collimation Plates.*—From time to time during the investigation, plates were taken in the manner described in the earlier paper to test the collimation error of the central wire. Three stars crossing at the top, the centre and the bottom of the wire were allowed to trail over the plate, breaks being made in the trails at noted times. As each star came to the meridian the instrument was reversed, and moved in zenith distance so that the second part of the trail for each star came close to the first, instead of as usual on the other side of the zenith point. From the positions of the breaks in each half of the trail a separate determination of the time of transit over the central wire was extrapolated. The difference in the deduced times gave twice the collimation error at the corresponding point.

The collimation error of the central wire at three points on the plate was thus determined. The collimation of the wire remained practically constant throughout the course of the investigation, as the figures of the following table testify. θ is the angle of inclination of the central wire to the meridian, expressed in circular measure.

[TABLE.

Table III.—*Collimation of Central Wire.*

Date.	At Top R=4.	At Centre R=13.	At Bottom R=22.	θ.
	s	s	s	
1905 July 19	−0·84	−1·26	−1·58	0·00104
1905 Dec. 19	−0·86	−1·22	−1·60	101
1906 Apr. 6	−0·60	−1·03	−1·35	106
1906 June 19	−0·58	−1·04	−1·36	111
1906 Aug. 22	−0·78	−1·10	−1·40	094
1907 Mar. 21	−0·75	−1·13	−1·54	113
1907 July 31	−0·67	−1·05	−1·46	104

Two other collimation plates were taken during the investigation: one, on 1906 December 7, was rejected because of uncertainty as to the times at which the trails were broken, and the other, on 1907 April 22, as being a bad plate. This second plate was measured and reduced, but it gave values markedly discordant with the remainder, and, being a bad plate photographically, it was discarded in interpolating for the collimation errors of the plates concerned in this investigation. The values it gave were :—

Top.	Centre.	Bottom.
$-1^{s}{\cdot}11$	$-1^{s}{\cdot}43$	$-1^{s}{\cdot}78$

This plate may be of importance, however, as suggesting the possibility of instrumental errors occurring from time to time and spoiling the results of occasional plates, while remaining undetected.

§ 9. *The Observations.*—The method of observation employed has been described in the earlier paper (*M.N.*, vol. lxi. p. 329). We may add here a few notes as to the precautions observed in the actual work of this investigation. The shutters were opened up some time well in advance of the exposure of the plate, and the doors were opened or not according to the wind. At least two minutes before the first exposure both doors were shut, and the observer took up his position in a corner of the building from which he could control the sliding cap over the telescope. On the first star of the group coming within three minutes of the meridian the cap was drawn aside and the star allowed to register a trail for a minute on one side of the plate. Then the cap was drawn over the object-glass and the telescope was rotated through 180°. After an interval of at least three minutes to allow the mercury and the telescope to get steady again, the cap was drawn aside and the star registered a second trail on the plate. This trail appeared naturally on the same side of the plate as the first trail, but at the opposite end (see below, § 12), and from the distance between the two trails the zenith distance of the star could be determined. The rotation of the telescope was always made in the same direction, from east to south; it was made steadily without jerks, in an average period of fifteen seconds. All the stars of a group registered two trails on the same plate. Variations in the observation programme were made to allow for bright moonlight, when the exposures had to be shortened to avoid fogging of the plate; the changes were so made as to secure the two trails of each star being equidistant from the meridian.

§ 10. *The Observed Stars.*—The groups of stars chosen for the investigation were decided upon according to the requirements of Professor KÜSTNER's adaptation of the Talcott method.* A certain number of groups of stars—in this case five—is chosen in such a way that one group may be observed in the evening, while the following group may be observed in the morning. Evening and morning plates are taken during the same night, so that the difference of the aberration corrections between evening and morning is freed from the effect of change of latitude. The further difficulty arising from uncertainty as to the exact values of the declinations of the stars in each group is removed by the cyclical manner in which during a year each group of stars figures first as a morning group and then as an evening group. Here it is important to note that uncertainty in the exact value of a star's declination is not very important. What is important is that any changes in the star's declination during the course of the observations should be accurately known. The stars employed are found in a variety of catalogues, but for proper motions the three chief sources utilised were the Groombridge proper motions, the proper motions of the Harvard zone, and Dr COHN's Breitendienst Catalogue.†

There remained ten stars which were not found in any of these lists. For these stars modern places were obtained by Mr W. E. HARTLEY with the Cambridge meridian circle, and proper motions were deduced by comparison with the older positions. These proper motions were quite small in every case. The subsequent appearance of Professor LEWIS BOSS's new catalogue ‡ has enabled the editors to apply a check on the proper motions adopted for the investigation. The result, viz., that in no case would the latitude derived from any plate be altered by as much as $0''\cdot01$, if Professor BOSS's values are adopted for the proper motions, is quite satisfactory. It shows that no appreciable gain will follow by modifying the values used in the computations. The following tables give the particulars of the groups of stars used. Some of the adopted positions could be modified by the use of catalogues which have recently appeared, and which are later than those from which the positions have been derived. No useful purpose in finding either the aberration constant or the variation of latitude would be served by this, so the values originally adopted have been retained (but see below, § 20). The missing numbers in the first column refer to stars originally selected for the working list, but ultimately discarded as too faint to appear on many of the plates, or else

* "Zur Bestimmung der Aberrations-Constante aus Meridian-Zenithdistanzen unabhängig von den Schwankungen der Polhöhe," *A.N.*, Bd. 126. See also Part I. of this paper.

† *New Reduction of Groombridge's Catalogue of Circumpolar Stars*, DYSON and THACKERAY; *Harvard College Observatory Annals*, vol. xxv., W. A. ROGERS; *Ableitung der Declinationen und Eigenbewegungen der Sterne für den Internationalen Breitendienst*, FRITZ COHN.

‡ *Preliminary General Catalogue of* 6188 *Stars, prepared at the Dudley Observatory, Albany*, LEWIS BOSS.

as being unsuitable for other reasons. It may be here mentioned that there was six months' preliminary work actually done along the lines of this investigation before the first plates discussed in this paper were taken. The second column of the table refers to the catalogue or other authority responsible for the adopted place. The magnitudes are from the Draper Catalogue.

Table IV.—*Star Places.*

Star No.	Catalogue.	α 1906·0.	δ 1906·0.	Precession in δ.	P.M. in δ.	Mag.
		Group I.				
		h m s	° ′ ″	″	″	
5	G.T.Y. 2	1 29 29	52 51 51·62	+18·544	−0·005	6·24
6	Hinks	1 37 40	52 24 43·92	+18·260	+0·003	6·36
9	G.T.Y. 2	1 44 55	51 28 12·65	+17·989	−0·112	6·20
11	G.T.Y. 2	1 50 29	52 50 38·98	+17·769	−0·013	6·27
12	A.G.C. 962	1 58 3	51 30 58·92	+17·453	0·000	6·38
		Group II.				
1	A.G.C. 3247	8 48 7	53 9 7·09	−13·421	0·000	6·22
2	A.G.C. 3253	8 50 31	51 6 11·81	−13·576	...	6·05
3	Cohn	8 58 43	51 11 55·76	−14·094	−0·074	5·85
4	G.T.Y. 1	9 2 16	51 59 3·60	−14·314	−0·035	4·81
6	Cohn	9 13 53	52 50 50·97	−15·007	+0·004	6·09
8	G.T.Y. 2	9 18 25	51 58 38·58	−15·268	−0·005	6·43
9	Newcomb	9 26 38	52 6 22·21	−15·718	−0·544	4·14
11	G.T.Y. 1	9 28 26	52 28 10·58	−15·819	−0·038	4·73
14	A.G.C. 3560	9 59 1	52 49 38·75	−17·320	+0·040	6·11
		Group III.				
1	G.T.Y. 1	14 10 7	52 13 46·16	−16·908	0·000	4·69
3	A.G.C. 4492	14 15 14	52 27 57·69	−16·663	−0·030	6·47
4	Newcomb	14 22 1	52 17 6·04	−16·322	−0·405	4·79
6	G.T.Y. 2	14 46 29	51 45 48·24	−14·992	+0·010	6·49
7	G.T.Y. 2	15 17 19	52 17 47·97	−13·069	0·000	5 38
8	G.T.Y. 2	15 35 49	50 43 46·24	−11·801	−0·035	6·32
9	A.G.C. 4821	15 40 18	52 39 26·06	−11·482	+0·045	5·34
10	G.T.Y. 2	15 48 42	53 11 17·49	−10·872	−0·010	6·54

TABLE IV.—*continued.*

Star No.	Catalogue.	α 1906·0.	δ 1906·0.	Precession in δ.	P.M. in δ.	Mag.
			GROUP IV.			
		h m s	° ′ ″	″	″	
1	G.T.Y. 1	16 34 0	53 5 18·98	−7·354	+0·035	4·37
2	G.T.Y. 1	16 34 1	53 6 46·89	−7·351	+0·026	4·37
3	A.G.C. 5133	16 59 5	52 44 20·16	−5·269	0·000	6·77
4	A.G.C. 5185	17 8 22	52 31 24·41	−4·482	−0·025	6·24
5	A.G.C. 5189	17 9 4	51 52 1·55	−4·421	0·000	6·86
8	Newcomb	17 28 18	52 22 14·64	−2·764	+0·009	4·19
9	Sayre Obs.	17 39 13	51 51 48·10	−1·836	−0·017	6·31
11	G.T.Y. 1	17 46 50	50 48 10·05	−1·154	+0·207	5·18
12	Newcomb	17 54 25	51 29 58·87	−0·489	−0·024	4·45
			GROUP V.			
1	Newcomb	19 14 56	53 11 41·24	+6·436	+0·121	4·94
2	G.T.Y. 2	19 19 20	52 11 42·75	+6·800	+0·009	6·91
3	Cohn	19 25 8	52 7 42·74	+7·276	−0·034	5·64
4	Newcomb	19 27 20	51 31 45·37	+7·454	+0·128	4·22
5	G.T.Y. 1	19 31 55	51 2 4·10	+7·824	−0·208	5·98
7	A.G.C. 6216	19 46 47	53 31 47·05	+9·006	0·000	6·18
9	Newcomb	19 53 12	52 11 20·82	+9·502	−0·034	5·18
10	G.T.Y. 1	19 56 46	51 47 52·18	+9·779	+0·006	5·69

The authorities mentioned in the above lists are :—

Astronomische Gesellschaft Catalogue, Harvard Zone.

Greenwich First and Second Ten-Year Catalogues.

Newcomb's Catalogue of Fundamental Stars.

Catalog für den Breitendienst, F. COHN.

Observations with the Zenith Telescope of the Sayre Astronomical Observatory, J. H. OGBURN.

Eros Reference Stars, A. R. HINKS.

§ 11. *Dates of Observations.*—The dates on which plates used in this investigation were obtained are given in the following table. Other plates were taken, but were rejected for a variety of causes: clouding up prevented all the stars of the group from being photographed; a hazy sky concealed the faintest stars of the group; bad weather conditions made the star trails so wavy that they could not be set upon for measuring with any confidence; or the reseau lines on the plate were too faint to be measurable. In all, 259 plates were taken during the interval covered by this work. Of these, 27 were adjustment or scale-value plates, 158 plates were retained, and 74 had to be rejected.

By inspecting Table V. we may see at once the dates and numbers of the plates retained, the groups to which they belong, the mean temperature of the telescope during the exposure and the position of the circle E. or W. when the first star of the plate approached the meridian.

Table V.—*Dates and Temperatures of Observations.*

Date.	Plate Number.	T.	Circle.	Date.	Plate Number.	T.	Circle.
			Group I.				
1905 Sept. 7	1	13°·0 C.	E	1906 Jan. 10	23	6°·4 C.	W
12	2	10·2	W	Aug. 28	27	12·8	W
17	3	10·1	W	30	29	17·3	E
20	4	9·0	E	Aug. 31	30	19·7	E
Sept. 22	5	11·3	E	Sept. 1	31	18·8	W
Oct. 4	6	7·2	E	Sept. 11	31*a*	12·3	E
5	7	6·6	W	Nov. 17	36	7·6	E
16	8	3·7	E	Nov. 28	37	9·9	W
19	9	4·1	W	Dec. 1	38	4·3	E
20	10	4·6	E	7	40	3·3	E
Oct. 21	11	3·4	W	10	41	0·9	W
Nov. 23	13	6·5	E	14	42	2·7	E
24	14	4·1	W	21	43	2·7	E
Nov. 29	15	5·8	E	1906 Dec. 26	44	−1·3	E
Dec. 8	16	6·9	E	1907 Jan. 2	46	4·2	E
9	17	5·5	W	18	48	5·7	W
25	20	6·2	W	1907 Jan. 19	49	3·5	E
1905 Dec 30	21	3·4	W				

TABLE V.—*continued.*

Date.	Plate Number.	T.	Circle.	Date.	Plate Number.	T.	Circle.
			GROUP II.				
1905 Nov. 23	12	4°·4 C.	E	1906 Apr. 3	42	9°·0 C.	E
24	13	3·0	W	4	43	9·2	W
Nov. 29	14	3·7	E	Apr. 6	44	10·0	E
Dec. 8	16	3·9	E	Nov. 30	45	5·6	W
9	17	3·9	E	1906 Dec. 12	47	3·4	E
1905 Dec. 19	18	3·1	E	1907 Jan. 3	48	2·7	E
1906 Jan. 10	19	4·0	E	6	49	4·4	W
13	20	6·5	W	Jan. 17	51	4·2	W
26	23	7·2	E	Feb. 9	53	2·6	E
Jan. 30	25	5·6	W	20	54	4·6	E
Feb. 12	26	2·0	E	21	55	3·2	W
14	27	3·0	W	22	56	0·0	W
20	28	3·9	W	23	57	0·9	E
Feb. 25	32	4·0	W	Feb. 28	59	5·1	E
Mar. 4	33	7·7	E	Mar. 1	60	5·4	W
5	34	9·3	E	4	61	3·6	W
7	36	11·3	E	5	62	5·6	E
12	37	0·8	E	18	63	8·0	E
17	39	12·7	W	1907 Mar. 25	64	10·3	W
1906 Mar. 29	41	4·0	W				
			GROUP III.				
1906 Feb. 20	19	3°·4 C.	E	1907 Feb. 20	37	3°·5 C.	W
Feb. 27	20	3·5	W	27	40	2·5	W
Mar. 3	21	4·1	W	Feb. 28	41	3·0	E
6	22	8·6	E	Mar. 5	42	3·1	E
17	24	8·7	E	Mar. 18	43	5·8	E
Mar. 29	25	1·3	W	May 2	46	8·3	W
Apr. 3	26	5·3	E	7	49	10·2	W
Apr. 6	27	4·6	E	9	51	12·6	W
May 17	30	7·4	E	12	54	17·5	W
19	32	10·2	W	24	58	14·3	W
May 29	33	15·1	W	1907 May 29	60	10·3	W
1906 June 2	35	12·5	E				

Table V.—*continued.*

Date.	Plate Number.	T.	Circle.	Date.	Plate Number.	T.	Circle.
			Group IV.				
1906 May 17	26	5°·5 C.	E	1907 May 8	43	10°·1 C.	W
19	27	9·1	W	10	45	15·2	E
May 29	29	12·8	W	17	47	7·1	E
June 2	30	11·4	E	May 24	48	12·4	E
6	31	10·4	E	June 10	50	14·4	E
17	32	14·1	E	16	51	11·8	E
June 19	33	15·8	W	17	52	13·3	W
July 3	36	16·4	E	19	53	13·7	E
1906 July 4	37	18·6	W	22	54	12·7	W
1907 Apr. 27	39	3·9	E	28	55	14·9	W
May 2	40	7·7	W	29	56	12·3	E
3	41	10·2	E	June 30	57	12·4	W
1907 May 7	42	9·5	E	1907 July 4	58	14·3	E
			Group V.				
1905 July 24	10	19°·5 C.	W	1906 July 27	30	18°·0 C.	W
July 29	11	20·1	W	Aug. 14	31	18·8	E
Sept. 7	12	14·0	W	16	32	15·6	W
12	13	15·5	E	20	33	21·3	W
17	15	14·7	W	27	35	17·3	E
21	17	13·3	W	28	36	18·0	W
22	18	13·6	W	29	37	17·6	E
23	19	11·9	E	30	38	21·6	W
1905 Sept. 28	20	14·3	W	Aug. 31	39	25·0	E
1906 June 17	21	11·5	W	Sept. 1	40	24·0	W
19	22	13·6	E	7	42	22·2	W
June 22	23	18·2	E	1906 Sept. 11	43	17·3	E
July 3	24	14·1	E	1907 June 16	45	10·7	E
4	25	15·3	W	19	47	12·4	E
5	26	16·4	E	28	49	12·6	W
11	27	12·7	E	June 29	50	9·7	E
25	28	15·3	W	1907 July 4	52	11·9	E
1906 July 26	29	17·3	E				

§ 12. *Appearance of Plates.*—Fig. 1 has been drawn to show the arrangement of the trails in Group IV., as they look when the plate is film up. It is drawn for the position Circle East, and the N., E., and W. edges are marked as in this position. When the instrument is turned Circle West the diagram should be rotated 180°.

GROUP IV.

Circle East.

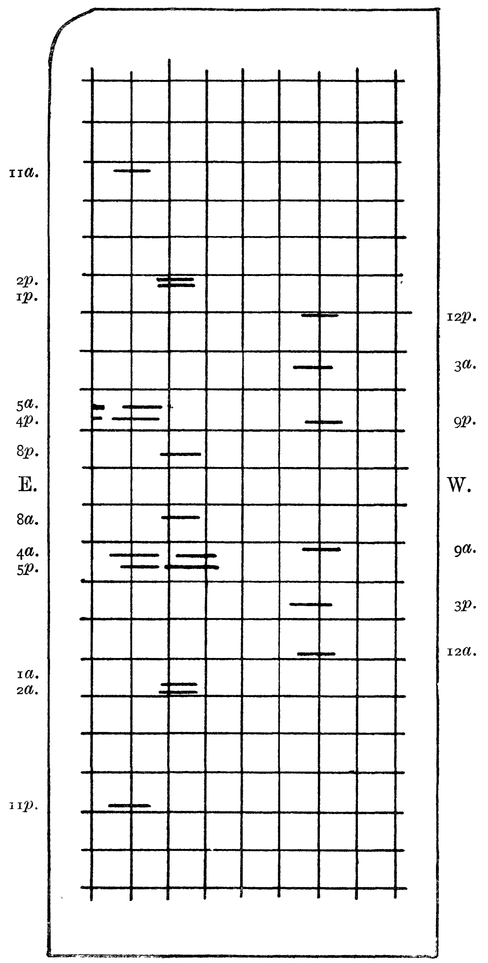


FIG. 1.

The trails are numbered to correspond with the star list, and are lettered *a* and *p* to denote the ante-meridian and post-meridian trail.

The programme of observation for this group may be represented thus:—

Start Circle E.
Expose for $1a$ and $2a$ together.
Turn Circle W.
Expose for $1p$ and $2p$ together.
,, $3a$.
Turn Circle E.
Expose for $3p$.
,, $4a$.
,, $5a$.
Turn Circle W.
Expose for $4p$.
,, $5p$.
Turn Circle E (to avoid trail 9 coming subsequently on top of 4).

Expose for $8a$.
Turn Circle W.
Expose for $8p$.
,, $9a$.
Turn Circle E.
Expose for $9p$.
,, $11a$.
Turn Circle W.
Expose for $11p$.
,, $12a$.
Turn Circle E.
Expose for $12p$.

Thus it will be seen that

For Stars begun Circle East:
A Star N. of Zenith has a trail below, p trail above
,, S. ,, a ,, above, p ,, below
For Stars begun Circle West:
A Star N. of Zenith has a ,, ,, p ,, ,,
,, S. ,, a ,, below, p ,, above

when the plate is viewed as in the diagram.

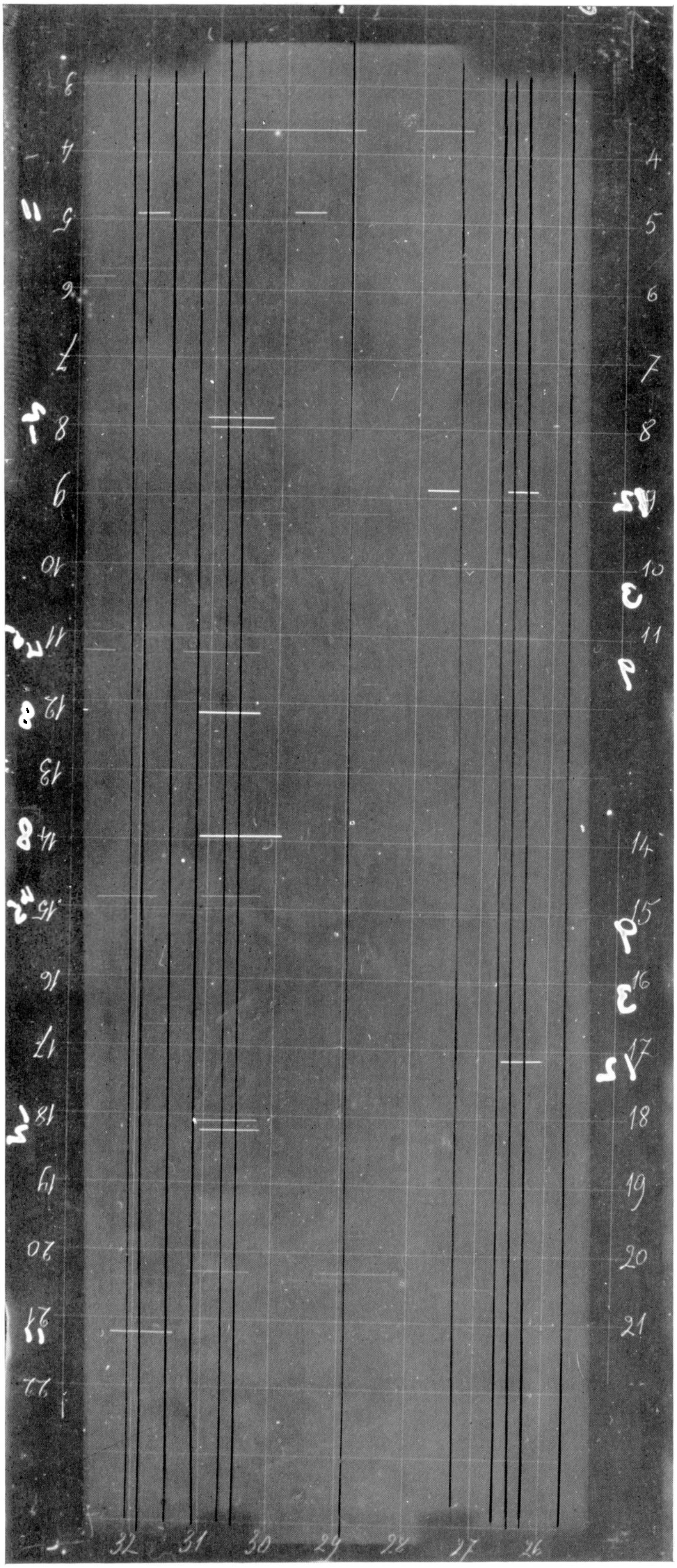
With this scheme it was easy to identify the trails and mark them with ink on the plate, as a preliminary to measurement.

The presence of the double trail for stars 4 and 5 is due to the fact that they are at such an interval in right ascension that two separate exposures had to be made on both sides of the meridian in order to secure for each star two trails at points equidistant from the central meridian; each star figures in both exposures.

Plate 3 gives a reproduction of one of the photographs used in the work (IV. 40). It will be noticed that there are some extra star trails present corresponding to stars not included in this investigation. The shadows of the wires are distinctly seen, though some of the star trails indicated in fig. 1 are not very distinct in the reproduced plate.

PART III.

§ 13. *Measurements.*—The photographs were all taken on Ilford Monarch Plates 2 inches by 5, on patent plate glass. The developer used throughout was Metol. The reseau was photographed upon the plate, before the star exposure, by passing parallel light through a Gautier silver on glass reseau ruled to the ordinary 5 mm. squares on to the plate, which was held up against the reseau by springs pressing on it



A LATITUDE PLATE (2-FOLD ENLARGEMENT).

at three points in the ordinary way. The measurements were made with the Cambridge Measuring Machine,* a special plate-holder having been constructed to hold the small plates used on the zenith telescope; the plates were held under the reading microscope with the trails horizontal and parallel to the x axis of the rectangular co-ordinates. A point on the trail of each star was selected such that, whenever possible, a point with the same value of x could be set on satisfactorily in the other trail of the star. The y of the trail was measured at the selected point and at points on either side at a distance of 0·35 mm. and 0·7 mm. The mean of these five readings was taken as giving the y of the selected or central point. For the two trails of each star on the plate a measured x and y are thus obtained in terms of reseau intervals. The mean of the two y's for each star gives an approximate value of the y of the zenith point on each plate. An approximate value k for the y of the zenith is now assumed, and a least square solution from all the stars on the plate is obtained for dk, a correction to the zenith point, and for θ, the inclination of the central reseau line to the meridian. The formula used in this solution was

$$dk + x_r\theta = z_r - k \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

z_r being the zenith point determined by the r^{th} star. In this equation there is omitted a small term which arises from the fact that the central reseau line does not necessarily cut the meridian in the zenith point. The effect of this small term upon the reductions is in practice negligible (see below, § 29).

Taking now as the origin of co-ordinates a definite point on the plate—the centre of the plate and not the zenith point—a correction had to be made to the measured x, y of each star to allow for the inclination of the reseau lines to the meridian. The co-ordinates were then (ξ, η) referred to axes parallel and perpendicular to the meridian through the centre of the plate.

§ 14. *Reduction to the Meridian.*—The collimation error of the centre wire at the date of observation and at the centre point is now obtained from the adjustment plates mentioned above (§ 12). The distance of the central wire from the central reseau line is measured on the plate for the centre, and the sum of these two distances is applied to the co-ordinate ξ as a correction. The star co-ordinates X, η are then referred to axes, the meridian and a line perpendicular to the meridian through the centre of the plate. There remains a further correction to the η co-ordinate to allow for the curvature of the trail. JACOBY † gives a formula for the necessary corrections as far as the terms of the fifth order. We are here only concerned with three terms, all the rest being negligible over a region so near the zenith as that dealt with. The formula adopted is

$$\Delta\delta = \eta + D_1(x \sec \delta)^2 + D_3\eta^3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where

$$D_1 = -\tfrac{1}{4}\sin 2\delta \,.\, (15)^2 \sin 1'',$$
$$D_3 = -\tfrac{1}{3}\sin^2 1''.$$

* *M.N.R.A.S.*, vol. lxi. p. 444.

† *Bulletin du Comité de la Carte du Ciel*, t. iii. 1er fasc., p. 3.

Adapting this formula to our notation and scale, it becomes

$$Y - \eta = \tfrac{1}{2}\, 623 \sin 1'' \tan \delta \,.\, X^2 - \tfrac{1}{3}\, 623^2 \sin^2 1'' \,.\, \eta^3 \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

The co-ordinates X, Y are the final adopted co-ordinates of the star trail.

§ 15. *Further Corrections and Derivation of Latitude.*—The difference of the two values of Y for the two trails of a star gives twice the zenith distance of the star. The daily corrections of the star in declination have now to be calculated and added with proper sign to the star's Z.D.; the correction for refraction has also to be applied. The daily corrections were calculated in duplicate from the *Nautical Almanac*, and from Finlay's Star Tables used in conjunction with the Cape Independent Day Numbers. In the *Nautical Almanac* reductions log A, log B, log C, log D were taken from the tables for midnight. The constant corrections due to each star were applied, and the daily corrections for each star were obtained for midnight. This was checked by the corresponding daily correction from the Cape Tables, and further corrections were subsequently applied for the difference of hour of the star's transit from midnight, and also for the lunar terms $C'c' + D'd'$. This double calculation checked here and there, where the resulting star positions were poor, by a complete recalculation of the daily corrections from the formulæ, has ensured, it is hoped, freedom from error in the daily corrections. The correction for refraction was calculated for each star from Albrecht's Tables.* This correction, as well as the daily correction, was converted into reseau intervals and applied to the zenith distances. This gave the final zenith distance of the star derived from the measurement of the plate in the direct position. The plate was now reversed through 180° and measured, and the whole of the above reductions were repeated. The mean value of the zenith distances of the star derived from the direct and the reversed measures was taken as the observed zenith distance of the star. A correction for proper motion was also applied to reduce all the observations to the epoch 1906·0, and for the observations during the years 1905, 1907, a further correction for precession had to be made to reduce to 1906·0. The values of the zenith distances thus obtained were added to the declinations of the respective stars, and finally a value of the latitude of the zenith telescope was derived from each pair of star trails.

§ 16. *Scale Value.*—A constant scale value was used in the reductions: 1 reseau-interval = 5 mm. = 623″·05. This scale value was obtained (see the earlier paper, p. 322) from measurements of Pleiades plates. Subsequent Pleiades photographs taken during the course of this investigation confirmed this scale value, and it was adopted. Unfortunately the range of temperature of the telescope tube over which Pleiades plates could be obtained was small, less than 6° C., and accidental errors masked a change of scale value accompanying a change in temperature. A detailed examination of the separate plates of each group of latitude stars, where a range of temperature of 16° C. for a single

* *Formeln und Hülfstafeln für geographischen Ortsbestimmungen*, TH. ALBRECHT.

group and 26° C. in all is to be found, showed unmistakable evidence of a change of scale value on the plate. By examining the distance of a star from the mean of the plate it was found to increase with a rise in temperature, and an empirical formula was obtained for a temperature correction to the scale value. This correction was found in various ways and with various systems of weighting, individual plates or individual stars being given equal weight, but the results were appreciably the same. The two corrections finally carried right through into the observations were made under the following assumptions :—

(*a*) The mean temperature (5°·5 C.) of the Pleiades plates from which the scale value R = 623″·05 was derived was taken as standard. The correction for each plate obtained was a numerical decrease of the measured Y co-ordinate by 0·0000118(T − 5·5)Y, where T was the temperature (in degrees Centigrade) of the telescope tube when the plate was taken. This is 0·6 times the amount suggested by the lengthening of the tube alone as computed in the earlier paper (p. 318). The difference, if real, is presumably to be attributed to temperature effects on the object glass or the plate.

(*b*) An alternative temperature correction was made as follows. The term in η^3 in the reduction of the plate (see § 14) had not been allowed for in the first attempt to determine the scale value and its changes. With this term included the scale value should be decreased, and therefore the adopted scale value would correspond to a higher temperature than 5°·5 C. The coefficient for the change of scale value can be determined as before by considering the alterations in the distance between the trails of two stars corresponding to a change of temperature. This coefficient comes out − 0·0000109 for 1° C., a value closely accordant with the previous determination. To determine the standard temperature for the adopted scale value is not so easy. The question is complicated by the fact that the scale value of the two sides of the plate are not the same owing to a tilt of the plate (see below, § 17). The side of the plate on the same side as the circle is further away from the object glass and therefore has a larger scale value. It has been assumed that the size of the X co-ordinates for all the stars is the same, so that one scale value may be used for all the stars on one side of the plate. For the determination of the standard temperatures for the two sides from the latitude plates a further assumption has been necessary, namely, that the declinations of all the stars on one plate are comparable in accuracy, *i.e.* that accidental errors in the star places are not so large as to ruin an attempt to derive a scale value from each plate (or from a group of plates of nearly the same temperature). With this assumption we may obtain a number of equations of the form

$$\text{Lat. given by star} - \text{mean of plate} = 0''{\cdot}0000109(T - \theta)Z$$

where

T = temperature of tube for plate.

Z = zenith distance of star expressed in seconds, positive when South of Zenith.

θ = standard temperature for adopted scale value (R = 623″·05).

Four solutions were made, two for each side of the plate, with different schemes for weighting individual results. The solutions obtained were as follows :—

For the same side of the plate as the circle $\theta = 12^\circ{\cdot}2$ C., $\theta = 12^\circ{\cdot}2$ C.
For the opposite side of the plate to the circle $\theta = 19^\circ{\cdot}1$ C., $\theta = 18^\circ{\cdot}1$ C.

The temperature corrections to the two sides were therefore taken as $-0.0000109(T-12{\cdot}2)Z$ and $-0{\cdot}0000109(T-18{\cdot}6)Z$ respectively.

The above method (*b*) of correcting for scale value may seem rather rough, but its results were closely in accord with method (*a*) when the latter had been corrected for the difference between the two sides of the plate. As a matter of fact the effect of the temperature correction or of any error of scale value is very slight, as the stars in the various groups have been chosen carefully, so that the sum of their zenith distances shall be very small. The effect of any factor such as a temperature factor upon the resulting mean latitude of the plate is very small.

§ 17. *Tilt.*—In the preceding paragraph mention was made of a tilt of the photographic plate to the optical axis of the lens, the tilt being about the axis of y. Further reference to that is made here, and not in the chapter on systematic errors, as a correction for the difference between the two sides of the plate has formed an integral part in each reduction of the observations and has not been applied to the results as a subsequent systematic correction. The systematic difference between the two sides of the plate, known as the C – R difference (circle—reverse), was known before these observations were made. It was not at first traced to its true source, and various empirical corrections for it were made. A plotting of the mean difference of latitude given for a single star by plates of the same epoch, according as the star trails were on the same side of the plate as the circle or the reverse, showed clearly that the difference depended on the co-ordinate Z of the star. Various solutions were made for a constant correction to be applied to each star, and the one adopted as giving the least value for $[vv]$, the sum of the squares of the residuals, was

$$C - R = kZ + h \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where

$$k = -0{\cdot}00543, \text{ and } h = +0''{\cdot}09.$$

The correction $-(kZ+h)$ was made to all observations on the circle side of the plate, as the reverse side gave on the whole more closely concordant results. Another reduction was made with

$$k = -0{\cdot}0045 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This was the best value for a linear solution after individual star positions had been modified by temperature.

After tilt had been recognised as the probable cause of this discordance, a least square solution for a correction of the form $AXY + BY^2$ was obtained. The difference from the previous solution was only slight, and the sum of the squares of the residuals was slightly increased. An alternative discussion on the basis of different scale values for the two sides of the plate has been already mentioned. This again showed no improvement on the first empirical solution in the matter of the sums of squares of the residuals. All these various solutions were followed right through to the end to see if any change was effected in the resulting value of the aberration constant or in the determination of the variation of latitude. No difference of any importance was obtained. The results of the various aberration determinations are given below (§ 23).

The amount of the tilt of the plate has been measured by the difference of the scale value on the two opposite sides of the plate. The range across the plate between the mean x's of the two sides is 25 mm. The difference in scale value across this range is 0·00006 of itself. Since v, the distance of the object glass, is 65·4 inches, this means that across the plate v is increased by 0·004 inch or 0·1 mm. This means a tilt of 1 in 250, or of 13′ of arc in the plate. Attempts have been made to measure the tilt at present observable. The plates silvered for this determination (plates similar to those used in the research) were found not to be very good plane surfaces, and a tilt varying from plate to plate was found. Any uncertainty whether the focussing screws might have been altered since the observations were finished, or at any rate since the subsequent discovery of the tilt, would rob any negative evidence on this point of much of its value, and further practical determination of tilt was therefore not attempted.*

Part IV.

§ 18. *Measured Zenith Distances.*—Below, in Table VI., there will be found the mean value of the direct and reverse measurements of the zenith distance of each star. These values do not include the daily corrections and the refraction correction, but represent merely half the distance between the pair of star trails after the corrections of §§ 13, 14 to reduce to the meridian have been made. This table gives the author's zenith distances uncorrected for any of the adjustments discussed in §§ 15–17. It was decided to insert these figures in case subsequent investigation should throw light on the discrepancies occurring in the results given by the instrument, when it would be useful to be able to refer to the original figures untouched by systematic corrections. The observer's remarks on the poor plates are appended to each table. The unit is a reseau interval, $R = 623''{\cdot}05$.

* Note added 1911, April 25. Mr Campbell is clear that no readjustment of the focussing screws was made.

[Table.

Table VI.—*Measured Zenith Distances.*

Group I.

Plate.	Star. 5	6	9	11	12
1	−3·73057	−1·11820	+4·32416	−3·61330	+4·05778
2	268	1990	228	575	649
3	497	2289	2047	724	420
4	598	376	1923	1901	332
5	3687	2483	849	2031	5247
6	4285	3081	256	618	4739
7	321	134	1199	508	638
8	761	579	0764	2933	199
9	926	670	603	3077	4070
10	4948	747	578	123	3979
11	5045	3791	30519	3305	3974
13	6265	5033	29377	4400	2743
14	260	041	237	471	703
15	311	201	9125	708	561
16	610	348	8924	4885	435
17	814	550	854	5016	2168
20	833	680	560	245	1870
21	6971	724	502	291	850
23	7012	5873	28454	5372	1758
27	5471	4275	30090	3686	3483
29	565	349	062	846	451
30	675	344	30000	860	410
31	5631	367	29945	3897	392
31*a*	6030	4737	9576	4245	3027
36	8957	7681	6744	7056	4·00203
37	9297	8059	366	430	3·99845
38	441	091	296	533	754
40	417	268	097	686	596
41	589	287	6021	764	463
42	610	422	5934	854	413
43	754	547	776	998	231
44	783	574	738	7970	171
46	887	680	666	8125	9072
48	866	668	632	127	8960
49	−3·79861	−1·18653	+4·25625	−3·68224	+3·99112

Remarks on Discordant Measures in Group I.

Star.	Plate.	
5	17	One trail; remeasured with no better result.
	20	Reversed and direct measures agree.
	30	Reversed and direct agree, but trail is wavy; remeasured with no better result.
6	16	Wavy trail.
9	20	Wavy; reversed measures are worse than direct.
12	16	Reversed and direct agree; remeasured with no better result.

TABLE VI.—*continued.*

GROUP II.

Plate.	Star. 1	2	3	4	6	8	9	11	14
12	− 5·39297	+ 6·44078	+ 5·88427	+ 1·34711	− 3·63785	+ 1·38643	+ 0·64325	− 1·45705	− 3·52184
13	330	017	440	691	777	599	317	718	140
14	217	065	516	772	718	727	457	593	2057
16	206	242	507	829	702	815	497	603	1915
17	304	125	594	786	685	793	383	601	886
18	393	4023	592	754	707	783	529	570	888
19	696	3722	287	534	3918	619	310	719	923
20	39805	693	8155	409	4045	473	4221	5800	1968
23	40165	364	7943	4129	342	176	3962	6109	2191
25	297	3226	749	3977	4478	8014	802	269	425
26	636	2936	425	600	5000	7694	516	643	726
27	789	864	216	514	4913	625	401	707	2826
28	0980	584	7089	302	5185	382	3155	6884	3017
32	1173	414	6876	3109	357	207	2956	7122	156
33	286	263	790	2956	595	7010	738	328	401
34	410	227	764	871	657	6996	733	402	539
36	448	2198	665	785	702	892	638	471	611
37	588	1875	365	584	5822	665	461	600	734
39	1816	842	6359	453	6066	536	2273	7761	3890
41	2066	619	5903	2137	317	206	1916	8084	4256
42	210	454	884	1918	567	034	763	323	514
43	257	438	855	990	514	6070	807	316	526
44	42319	1418	85837	1999	6653	35950	1740	8420	54534
45	37646	5900	90360	6607	1820	40710	6515	3610	49758
47	568	827	434	691	777	790	637	464	587
48	895	613	145	437	899	578	554	580	531
49	7832	660	90060	412	1908	547	520	612	542
51	8208	5298	89849	6179	2157	40308	6285	3830	49633
53	8810	4743	9363	5613	2738	39856	5751	4475	50177
54	9217	357	8937	162	3230	393	319	847	585
55	267	318	925	167	367	282	338	791	668
56	272	246	799	125	227	311	340	832	641
57	321	176	796	5065	284	282	238	4897	698
59	492	079	730	4859	544	170	132	5029	905
60	554	4186	660	931	543	9121	5065	4961	0928
61	692	3984	442	799	542	8976	4955	5273	1085
62	39690	939	572	750	3619	910	930	233	084
63	40103	541	8162	323	4099	553	476	674	588
64	− 5·40381	+ 6·43513	+ 5·87962	+ 1·34191	− 3·64119	+ 1·38461	+ 0·64330	− 1·45907	− 3·51873

Remarks on Discordant Measures in Group II.

Star.	Plate.	
1	49	One trail extremely faint; remeasured in reverse position; direct position gives good result.
	64	Reversed and direct measures agree.
2	37	Reversed and direct agree.
	64	Reversed measure gives bad result.
4	42	Reversed and direct agree; measured twice in direct position.
6	55	One trail extremely faint and broken by cloud.
	64	Reversed and direct agree; wavy.
8	64	Reversed and direct agree.
9	64	Reversed and direct agree.
11	60	Top trail alone gives a result 0″·10 better in both reverse and direct measures.

Plate 64 was taken on a bright night.

Table VI.—*continued.*

Group III.

Plate.	Star. 1	3	4	6	7	8	9	10
19	−0·06786	−1·43506	−0·38925	+2·62410	−0·45743	+8·59621	−2·53922	−5·60776
20	905	643	9017	314	808	705	898	709
21	6943	683	032	326	780	667	967	631
22	7020	3765	123	306	5830	663	3997	738
24	338	4063	418	2030	6034	676	4149	0879
25	769	470	39866	1567	385	144	500	1188
26	7959	650	40021	455	521	9022	616	357
27	8142	4775	0049	61372	6615	8889	4621	1401
30	9866	6642	1977	59502	8464	7128	6517	3249
32	09910	6679	1963	506	8521	7213	6615	383
33	10415	7143	2478	9061	9003	6713	7157	3878
35	10573	7323	42643	8861	9160	56433	7314	64036
37	04135	0867	36246	64835	3531	61719	1979	58829
40	155	859	313	911	630	712	948	874
41	237	0932	334	846	552	765	1967	913
42	285	1036	401	763	598	665	2009	801
43	4614	1386	6705	4516	3767	1591	2151	58952
46	6503	3226	8570	2729	5522	60054	3770	60655
49	634	460	733	559	683	59879	3971	822
51	780	555	8829	448	810	772	4091	0901
54	6894	3661	9081	2362	5867	699	227	1122
58	7371	4151	473	1923	6511	9014	4916	818
60	−0·07640	−1·44350	−0·39624	+2·61550	−0·46770	+8·58843	−2·55013	−5·61769

Remarks on Discordant Measures in Group III.

Star.	Plate.	
1	27	Wavy; slightly better when means of three measures are taken.
4	60	Wavy; reverse and direct agree.
6	25	Wavy; reverse and direct agree.
	58	Wavy; reverse and direct agree.
9	58	Wavy; reverse and direct agree.
10	58	Wavy; measured twice in reverse position with practically same result.

Table VI.—*continued.*

Group IV.

Plate.	Star. 1	2	3	4	5	8	9	11	12
26	−5·05392	−5·19379	−3·03270	−1·78568	+2·00515	−0·90140	+2·03043	+8·15534	+4·13124
27	509	19501	397	8693	560	318	2917	597	3060
29	5969	20007	3915	9181	2·00048	801	454	5193	2575
30	6197	187	4081	384	1·99805	0926	2264	4842	370
31	406	409	335	79640	549	1227	1913	655	2078
32	6933	0951	925	80114	9087	757	515	194	1620
33	7109	1093	4937	232	8957	1816	1422	4131	1548
36	685	684	5688	0952	320	2707	0701	3294	0905
37	7885	21843	5668	81005	1·98161	92730	0618	3264	0680
39	2930	16923	1233	76576	2·02551	88477	4585	7024	4484
40	3222	7201	358	780	373	717	342	6936	284
41	252	257	558	6853	330	758	348	846	241
42	407	395	608	7047	139	940	197	626	237
43	435	442	587	6945	182	829	290	757	154
45	550	554	1805	7104	2113	8936	4130	662	4075
47	3876	7896	2148	489	1655	9362	3725	6174	3701
48	4291	8265	2417	7851	1304	89664	3425	5946	3394
50	5164	9130	3290	8705	0596	90551	2593	5063	2577
51	320	284	676	968	189	898	251	4775	192
52	387	359	562	8943	211	0800	205	842	133
53	459	453	667	9077	005	1041	2156	615	127
54	5712	19665	3841	163	2·00045	074	1980	608	2016
55	6026	20034	4216	565	1·99594	466	584	119	1573
56	5999	038	116	606	593	534	587	052	566
57	6082	042	304	691	512	544	655	4132	387
58	−5·06108	−5·20078	−3·04418	−1·79766	+1·99406	−0·91623	+2·01406	+8·13955	+4·11418

Remarks on Discordant Measures in Group IV.

Star.	Plate.	
1	37	Wavy; reverse and direct agree; bright moon.
	55	Both trails wavy; reverse and direct agree.
2	37	Wavy; reverse and direct agree; bright moon.
	55	Both trails wavy; reversed measures give better result.
5	36	One trail; wavy; bright moon.
	54	Bottom trail broken by cloud; reversed measures give better result; bright moon.
8	36	Wavy; reverse and direct agree; bright moon.
	37	Wavy; reverse and direct agree; bright moon.
9	31	Top trail wavy; reverse and direct agree; bright moon.
	43	Wavy; reverse and direct agree; moon.
11	26	Top trail wavy; reverse and direct agree; measured four times.
12	31	Reverse and direct agree; bright moon.
	37	Wavy; reversed measures give better result; bright moon.
	54	Both trails broken by cloud; direct measures give better result; bright moon.
	57	One trail; wavy and broken by cloud; direct measures poor.
	58	Wavy; reverse and direct agree; bright moon.

Table VI.—*continued.*

Group V.

Plate.	Star. 1	2	3	4	5	7	9	10
10	−5·68236	+0·09055	+0·47872	+3·94158	+6·80064	−7·61251	+0·13540	+2·39600
11	68520	8783	7603	3972	79794	1464	3332	9397
12	70010	7223	5988	2380	8139	3232	1506	7590
13	198	100	980	261	8149	427	375	455
15	352	7035	803	2133	7950	544	285	315
17	358	6871	609	1975	774	614	114	194
18	398	901	639	992	800	625	100	199
19	391	856	638	952	784	652	098	113
20	70447	06793	5598	1906	77655	3771	1020	37075
21	66876	10295	9063	5310	81130	0230	4381	40418
22	6967	220	8998	283	1177	281	374	385
23	7155	10112	824	5214	0907	0554	4134	40333
24	852	09372	146	4449	327	1120	3560	39544
25	855	296	127	362	221	219	461	543
26	7839	9312	8084	367	80205	170	396	486
27	8223	8990	7724	4003	79905	1578	3002	9228
28	9010	369	154	3369	270	2401	2413	8446
29	055	332	7040	351	249	373	385	463
30	133	8247	6941	3225	9135	2499	2346	8375
31	69922	7328	6157	2353	8325	3374	1394	7390
32	70030	231	5960	300	137	464	297	361
33	171	7107	886	2197	8060	674	1135	7167
35	438	6858	599	1877	7822	3812	0877	6919
36	484	817	575	896	782	4011	829	874
37	526	716	616	806	806	3980	826	888
38	469	820	538	867	703	3980	833	849
39	525	752	451	776	686	4086	712	778
40	608	695	468	776	650	092	681	717
42	779	536	274	629	349	366	471	538
43	70860	6453	5211	1485	77400	4331	0335	6360
45	67332	9799	8499	4798	80476	0983	3514	9504
47	7632	561	8326	603	80477	1245	3341	9352
49	8008	256	7927	184	79835	656	2832	8772
50	158	9070	742	4005	819	1803	812	740
52	−5·68355	+0·08843	+0·47544	+3·93796	+6·79582	−7·62005	+0·12532	+2·38498

Remarks on Discordant Measures in Group V.

Star.	Plate.	
1	12	Top trail wavy; reversed measures give worse result than direct.
2	24	Wavy, with small amplitude.
	25	Wavy; reverse and direct agree.
	37	Bottom trail has a jump in it.
	49	Faint and wavy.
3	24	Wavy, with small amplitude; reverse and direct agree.
	27	Wavy; reversed measures worse than direct.
	32	Broken by cloud; bottom trail hardly visible; reverse and direct agree.
	49	Wavy; reverse and direct agree.
4	25	Wavy; reverse and direct agree.
5	25	Bottom trail wavy; same in both positions.
7	36	Slightly wavy.
	49	Wavy; reverse and direct agree.
	52	Top trail wavy; reverse and direct agree.
9	25	Wavy; reverse and direct agree.
	26	Moon; bottom trail broken up by clouds; only one trail measured.
	39	Wavy; reverse and direct agree.
10	24	Wavy, with small amplitude; reverse and direct agree.

§ 19. *Latitude derived from each Star.*—When the zenith distances above were corrected for refraction, the daily correction, precession, and proper motion (see § 15), a value of the latitude of the telescope was derived from each pair of star trails. The following table gives these values of the latitude and also the mean latitude obtained from each plate. Seconds only are given in the table, and as the latitude is nearly 52° 12′ 50″, the figure 5 must be understood before 0, 1, 2 or 3 in the unit place, and the figure 4 before 7, 8 or 9 in the unit place.

Table VII.—*Latitude given by each Star.*

Group I.

Plate.	Star. 5	6	9	11	12	Mean.
	″	″	″	″	″	″
1	50·15	50·09	50·45	49·28	49·95	49·98
2	0·24	0·46	0·69	9·13	0·60	0·22
3	0·13	9·87	0·81	9·45	0·28	0·11
4	0·32	0·14	0·82	9·12	0·50	0·18
5	0·41	0·09	0·94	8·91	0·53	0·18
6	0·11	9·81	0·57	8·65	0·59	9·95
7	0·25	9·77	0·55	9·62	0·29	0·10
8	0·52	9·94	0·74	9·90	0·42	0·30
9	0·33	0·21	0·55	9·82	0·45	0·27
10	0·50	0·06	0·69	9·85	0·24	0·27
11	0·17	0·07	0·60	9·02	0·42	0·06
13	0·35	0·08	1·11	9·84	0·45	0·37
14	0·52	0·19	0·43	9·82	0·38	0·27
15	1·21	0·20	0·71	9·39	0·45	0·39
16	0·60	0·82	0·83	9·69	1·22	0·63
17	9·45	9·48	0·50	9·01	9·63	9·61
20	1·05	0·39	0·10	9·52	9·70	0·15
21	0·49	0·39	0·50	9·67	0·09	0·23
23	0·36	9·79	0·56	9·55	9·89	0·03
27	9·87	9·49	0·48	9·03	9·99	9·77
29	9·94	9·65	0·84	8·64	0·32	9·88
30	9·38	0·05	0·73	8·83	0·35	9·87
31	0·11	0·10	0·67	8·88	0·49	0·05
31*a*	0·27	0·28	0·93	9·19	0·67	0·27
36	0·15	9·95	0·77	9·53	0·38	0·16
37	0·19	9·81	0·65	9·47	0·42	0·11
38	9·77	0·08	0·71	9·33	0·39	0·06
40	0·97	0·08	0·58	9·63	0·57	0·37
41	0·23	0·31	0·45	9·46	0·12	0·11
42	0·56	9·92	0·34	9·41	0·29	0·10
43	0·56	0·07	0·30	9·47	0·17	0·11
44	0·56	0·13	0·35	9·98	0·13	0·23
46	0·41	0·00	0·41	9·66	0·12	0·12
48	0·38	0·08	0·36	9·89	9·81	0·10
49	0·33	0·11	0·26	9·25	0·74	0·14

Table VII.—*continued.*

Group II.

Plate.	Star. 1	2	3	4	6	8	9	11	14	Mean.
	″	″	″	″	″	″	″	″	″	″
12	2·01	2·47	9·75	9·70	0·40	9·63	0·33	9·66	2·00	0·66
13	1·75	2·03	9·71	9·53	0·34	9·26	0·18	9·47	2·11	0·49
14	2·10	1·96	9·79	9·59	0·21	9·52	0·48	9·66	1·84	0·57
16	2·28	3·10	9·68	9·88	0·14	9·83	0·36	9·25	2·05	0·73
17	1·67	2·37	0·21	9·60	0·23	9·66	9·62	9·22	2·17	0·53
18	1·58	2·03	0·40	9·60	0·20	9·61	0·43	9·33	1·70	0·55
19	1·79	1·98	0·17	9·94	0·43	9·97	0·25	9·61	2·02	0·68
20	1·62	2·24	9·80	9·60	0·09	9·47	0·09	9·51	2·05	0·50
23	1·52	2·21	0·43	9·85	0·22	9·49	0·28	9·42	2·24	0·63
25	1·55	2·17	0·03	9·72	0·17	9·28	0·07	9·20	1·50	0·41
26	2·06	2·85	0·49	9·93	9·49	9·79	0·73	9·36	2·01	0·75
27	1·54	2·88	9·61	9·81	0·44	9·77	0·12	9·37	1·81	0·60
28	1·44	2·13	9·88	9·56	9·86	9·35	9·97	9·37	1·72	0·36
32	1·46	2·19	9·69	9·52	0·01	9·45	9·94	9·11	2·08	0·38
33	2·17	2·60	0·51	9·97	9·98	9·65	0·03	9·27	2·03	0·69
34	1·52	2·52	0·53	9·59	9·77	9·75	0·18	9·00	1·42	0·48
36	1·72	2·72	0·31	9·63	9·94	9·51	0·01	9·01	1·40	0·47
37	1·91	1·82	9·57	9·35	0·33	9·28	0·16	9·41	1·89	0·41
39	1·30	2·33	0·27	9·34	9·71	9·33	9·79	9·32	1·94	0·38
41	1·79	3·02	9·57	9·56	0·41	9·59	0·13	9·70	2·30	0·67
42	1·48	2·58	0·08	8·83	9·56	9·20	9·72	8·98	1·62	0·23
43	1·39	2·61	0·04	9·44	0·08	9·65	0·20	9·23	1·71	0·48
44	1·31	2·82	0·28	9·86	9·57	9·26	0·09	8·93	2·10	0·47
45	1·33	2·64	9·89	9·47	9·75	9·34	9·72	8·86	1·42	0·27
47	1·97	2·19	0·27	9·88	9·85	9·51	0·04	9·39	1·61	0·52
48	1·48	2·14	9·59	9·45	9·98	8·92	0·02	9·12	1·74	0·27
49	2·32	2·32	9·49	9·71	0·36	9·14	0·19	9·29	1·95	0·53
51	1·63	2·22	9·65	9·73	0·20	8·96	9·97	9·11	2·31	0·42
53	2·01	2·53	0·40	0·08	0·47	9·95	0·28	8·87	2·35	0·77
54	1·89	2·37	9·99	9·59	9·82	9·33	9·90	9·02	2·14	0·46
55	1·75	2·35	0·13	9·81	9·12	8·84	0·20	9·45	1·82	0·39
56	1·86	2·10	9·53	9·73	0·17	9·22	0·41	9·38	2·16	0·51
57	1·74	1·85	9·70	9·56	0·02	9·23	9·98	9·07	1·99	0·35
59	1·83	2·30	0·42	9·43	9·57	9·69	0·47	9·53	1·93	0·57
60	1·69	3·23	0·21	0·10	9·83	9·63	0·30	0·20	2·02	0·80
61	1·46	2·31	9·49	9·93	0·50	9·39	0·29	8·93	1·75	0·45
62	1·68	2·46	0·45	9·79	0·22	9·16	0·33	9·39	1·98	0·61
63	1·56	2·34	0·33	9·65	9·89	9·56	0·15	9·36	1·72	0·51
64	0·94	3·28	0·23	9·98	0·98	0·22	0·50	9·20	1·34	0·74

Table VII.—*continued.*

Group III.

Plate.	Star. 1	3	4	6	7	8	9	10	Mean.
	″	″	″	″	″	″	″	″	″
19	0·57	9·94	0·00	0·25	9·48	0·53	0·24	9·29	0·04
20	0·45	9·70	9·97	9·98	9·17	0·94	0·29	9·54	0·00
21	0·70	9·90	0·30	0·42	9·57	0·90	0·00	9·49	0·16
22	0·56	9·72	0·04	0·52	9·41	0·92	9·90	9·51	0·07
24	0·39	9·63	9·90	0·28	9·33	1·95	9·91	9·52	0·11
25	0·36	9·73	9·66	9·73	9·21	0·50	9·57	9·34	9·76
26	0·30	9·71	9·80	0·09	9·35	0·66	9·74	9·21	9·86
27	9·97	9·67	0·36	0·23	9·38	0·42	0·29	9·42	9·97
30	0·49	9·45	9·71	0·03	9·59	0·54	9·81	9·22	9·85
32	0·77	9·82	0·42	0·65	9·58	1·77	9·85	9·06	0·24
33	0·16	9·46	9·77	0·60	9·47	1·54	9·48	9·03	9·94
35	0·16	9·35	9·74	0·43	9·62	0·93	9·66	9·21	9·89
37	0·24	9·73	9·88	0·00	9·43	0·76	9·91	9·43	9·92
40	0·50	0·08	9·76	0·61	8·70	0·54	9·78	8·75	9·84
41	0·08	9·73	9·74	0·24	9·21	0·84	9·65	9·28	9·85
42	0·53	9·82	9·98	0·29	9·32	0·49	9·70	9·45	9·95
43	0·53	9·65	0·01	0·37	9·57	0·97	9·75	9·44	0·04
46	0·18	9·59	9·63	0·17	9·10	1·26	9·73	8·68	9·79
49	0·64	9·47	9·96	0·48	9·45	1·52	9·81	8·95	0·04
51	0·38	9·51	9·98	0·38	9·30	1·48	9·72	9·13	9·99
54	0·58	9·74	9·33	0·80	9·90	1·98	9·87	8·74	0·12
58	0·75	9·88	0·11	1·43	9·39	1·24	9·14	8·00	9·99
60	0·30	9·86	0·43	0·45	9·24	1·76	0·06	9·85	9·24

TABLE VII.—*continued.*

GROUP IV.

Plate.	Star. 1	2	3	4	5	8	9	11	12	Mean.
26	9″·18	9″·90	8″·79	9″·75	9″·43	0″·12	0″·26	9″·23	9″·58	9″·58
27	9·10	9·80	8·63	9·61	0·35	9·64	0·07	0·17	9·77	9·68
29	9·40	9·81	8·58	9·74	0·28	9·77	0·30	0·74	9·84	9·83
30	9·20	9·89	8·77	9·69	9·99	0·22	0·31	9·78	9·79	9·74
31	9·23	9·86	8·57	9·49	9·82	9·75	9·59	9·99	9·49	9·53
32	9·23	9·76	8·27	9·93	0·29	9·90	0·54	0·59	9·99	9·83
33	8·77	9·51	8·85	9·87	0·16	0·22	0·66	0·88	0·24	9·91
36	9·00	9·69	8·23	9·52	0·17	8·95	0·53	0·09	0·70	9·66
37	8·00	8·89	8·62	9·46	9·61	9·08	0·22	0·15	9·58	9·29
39	9·52	0·19	8·46	9·91	9·96	0·03	0·32	9·88	9·95	9·80
40	9·14	9·91	9·09	0·03	0·20	9·83	0·40	0·24	9·89	9·86
41	9·22	9·81	8·70	9·79	0·16	9·79	0·36	0·19	9·84	9·76
42	9·29	9·97	8·73	9·54	9·94	9·58	0·32	9·75	0·67	9·75
43	9·41	9·99	9·15	0·47	0·49	0·53	1·16	0·81	0·44	0·27
45	9·34	9·96	8·45	0·11	0·66	0·47	0·74	0·75	0·50	0·11
47	9·45	9·96	8·42	9·83	9·95	9·90	0·30	9·83	0·23	9·76
48	9·00	9·80	8·86	9·66	9·84	0·06	0·44	0·36	0·26	9·81
50	8·90	9·75	8·83	9·75	0·85	0·01	0·71	0·30	0·62	9·97
51	9·56	0·41	8·14	9·87	0·03	9·66	0·39	0·31	0·05	9·82
52	9·44	0·26	9·17	0·32	0·48	0·56	0·41	1·03	0·60	0·25
53	9·57	0·24	9·09	0·09	0·09	9·67	0·70	0·21	0·56	0·02
54	8·94	9·87	9·00	0·58	1·06	0·48	0·66	1·21	0·89	0·30
55	8·55	9·14	8·35	9·79	9·97	9·85	0·01	0·04	0·04	9·53
56	8·96	9·35	9·24	9·78	0·22	9·71	0·31	9·92	0·29	9·75
57	8·76	9·64	8·38	9·57	0·02	9·93	1·02	0·69	9·45	9·72
58	9·52	0·33	8·69	0·13	0·39	0·55	0·61	0·72	0·80	0·19

Table VII.—*continued.*

Group V.

Plate.	Star. 1	2	3	4	5	7	9	10	Mean.
10	9·40″	8·23″	0·19″	9·86″	9·97″	8·24″	9·87″	9·61″	9·42″
11	9·33	8·23	0·22	0·39	0·01	8·62	0·35	0·10	9·66
12	9·83	8·38	0·25	0·60	9·91	8·53	9·96	9·94	9·68
13	9·40	8·33	0·96	0·61	0·77	8·15	0·07	0·02	9·79
15	9·05	8·62	0·55	0·54	0·26	8·25	0·35	0·03	9·71
17	9·55	8·15	9·95	0·20	0·80	8·52	0·01	0·03	9·65
18	9·44	8·51	0·28	0·42	0·10	8·63	0·10	0·22	9·71
19	9·53	8·27	0·35	0·27	0·08	8·60	0·24	9·84	9·65
20	9·47	8·19	0·44	0·32	9·64	8·36	0·28	0·14	9·60
21	9·64	8·02	0·02	9·81	9·48	8·46	9·54	9·48	9·31
22	9·76	8·37	0·35	0·33	0·44	8·85	0·17	9·94	9·78
23	9·70	8·61	0·32	0·93	9·78	8·18	9·72	0·65	9·74
24	8·98	7·66	9·75	9·83	9·63	8·29	9·79	9·37	9·16
25	9·34	7·54	9·99	9·63	9·28	8·05	9·52	9·70	9·12
26	9·80	7·99	0·06	0·02	9·77	8·74	9·48	9·71	9·45
27	9·24	7·86	9·71	9·64	9·77	8·07	9·56	0·02	9·23
28	8·90	8·52	0·70	0·24	0·36	7·66	9·94	9·83	9·52
29	8·94	8·58	0·30	0·59	0·60	8·14	0·09	0·26	9·69
30	8·76	8·35	9·98	9·95	0·13	7·71	0·16	0·00	9·38
31	9·14	7·97	0·48	9·91	0·48	7·95	9·92	9·60	9·43
32	8·99	7·90	9·82	0·14	9·89	7·98	9·93	0·02	9·33
33	9·02	8·01	0·26	0·41	0·34	7·68	9·95	9·85	9·44
35	8·99	8·16	0·23	0·17	0·63	8·65	0·24	0·24	9·66
36	9·19	8·14	0·32	0·54	0·63	7·63	0·22	0·24	9·61
37	8·91	7·72	0·81	0·21	1·02	8·16	0·46	0·58	9·73
38	9·48	8·58	0·60	0·77	0·56	8·41	0·74	0·57	9·95
39	9·32	8·34	0·13	0·41	0·64	8·00	0·22	0·36	9·68
40	8·96	8·10	0·43	0·59	0·60	8·13	0·19	0·16	9·65
42	8·95	8·20	0·30	0·77	9·82	7·66	0·16	0·31	9·52
43	9·15	8·44	0·72	0·65	0·98	8·72	0·20	0·10	9·87
45	0·06	8·47	0·54	0·92	9·74	9·47	0·36	0·34	9·99
47	9·15	7·88	0·35	0·60	0·62	8·58	0·16	0·24	9·70
49	9·59	9·07	0·96	1·07	9·70	9·29	0·06	9·69	9·92
50	9·28	8·23	0·11	0·27	9·98	9·72	0·20	9·77	9·70
52	9·70	8·43	0·49	0·60	0·01	9·07	0·11	9·88	9·79

§ 20. *Use of the München Catalogue.*—It will be noticed on an inspection of the above table that errors of the catalogue star places very badly affected the latitudes derived from the stars. Thus a difference of over 3″ may be found between the mean latitude given by two stars in the same group, photographed on the same set of plates. This difference is immaterial in the investigation of the aberration constant or the variation of latitude, where we are in the end only concerned with changes in the latitude from one plate to another of the same group. But the editors felt that these errors in the star places might materially affect any determination of scale value or temperature error. The recent catalogue of zenith stars made by Professors Bauschinger and Oertel at Munich * appeared most opportunely to test this point. Nearly all the stars of Groups II., III., IV., V., were found there well observed. Only two stars of Group I. were found, but this gap was filled by the Astrographic Catalogue of Catania.† Thus the star places of each group were obtained from a homogeneous source. By use of these places the differences between individual stars of the same group was reduced to 1″·70, or about a half of the previous difference. Subsequent corrections for temperature and tilt reduced the largest outstanding residual between the mean latitude of two stars of the same group to 1″·20. The places for the Catania and München stars used in the discussions of temperature and scale value are given below. Stars not found in either source were discarded.

TABLE VIII.—*Catania and München Star Places.*

Star No.	Catania No.	δ, 1906·0.	Originally Adopted δ.
	GROUP I.		
5	Lastra 2153, 450	52° 51′ 52″·50	51″·62
6	,, 2290, 242	52 24 43·93	43·92
9	,, 2155, 173	51 28 11·86	12·65
11	,, 2155, 512	52 50 40·61	38·98
12	,, 2151, 247	51 30 59·38	58·92

* *Neue Annalen der K. Sternwarte in München*, Bd. iv. [This catalogue was published after the author's death.]
† *Catalogo Astrofotographico, zona di Catania*, vol. vi., parte 1*a*.

Table VIII.—*continued.*

Star No.	München No.	δ, 1906·0.	Originally Adopted δ.
		Group II.	
3	578	51° 11′ 56″·01	55″·76
4	582	51 59 3·94	3·60
6	594	52 50 51·35	50·97
8	599	51 58 38·90	38·58
9	606	52 6 22·32	22·21
11	610	52 28 11·51	10·58
14	632	52 49 37·43	38·75
		Group III.	
1	797	52 13 45·92	46·16
3	806	52 27 58·01	57·69
4	810	52 17 6·32	6·04
6	828	51 45 48·63	48·24
7	852	52 17 48·75	47·97
8	873	50 43 46·90	46·24
9	875	52 39 27·12	26·06
10	880	53 11 18·50	17·49
		Group IV.	
1	912	53 5 19·93	18·98
2	913	53 6 47·69	46·89
4	935	52 31 24·63	24·41
8	949	52 22 14·84	14·64
9	957	51 51 47·99	48·10
11	962	50 48 11·06	10·05
12	970	51 29 59·06	58·87
		Group V.	
1	1054	53 11 41·50	41·24
3	1069	52 7 43·39	42·74
4	1071	51 31 45·42	45·37
5	1080	51 2 4·93	4·10
9	1106	52 11 21·62	20·82
10	1109	51 47 52·65	52·18

§ 21. *Latitudes derived from Means of Plates.*—In the following table are given five sets of latitudes derived from different reductions. Only the means of the plates and not the individual star results are given. First, there are given (i) the latitudes derived from the values of § 19 by use of the München and Catania star places of § 20.

In (ii) are given these values when the individual star places are modified by the adoption of a correction for temperature. This correction is the one given above, § 16 (*a*). It may be mentioned that it is only in Group V. that this temperature correction makes a serious difference. This is because in that group the rejection of the stars not in the Munich catalogue leaves the sum of the zenith distances of the stars no longer a small quantity, and temperature has therefore a decided effect on the deduced mean latitude. The reduction to (ii) corrects for this temperature effect.

In (iii) is given the author's original set of latitude results modified only by a constant correction applied to each group. This correction, which does not affect either the resulting value of the aberration constant or the variation of latitude, has been made to facilitate comparison with the results of the four other reductions. It shows what kind of difference has been obtained by all the temperature and tilt corrections which the editors have applied to the results left by the author. The actual constant corrections applied in the five groups have been $+0''\cdot42$, $-0''\cdot32$, $+0''\cdot52$, $+0''\cdot55$, $+0''\cdot74$. In this reduction more stars are used than in the others, and the München and Catania star places have not been used, but the places of Table IV. The empirical correction for tilt given in equation (7) has been applied.

In (iv) are given the values of (ii) modified by the empirical tilt correction given by equation (8), after allowance for temperature.

In (v) are given the latitudes derived by reduction (*b*) of § 16, in which tilt and temperature were combined. The reason of the results of all these reductions being given is to show what can be done to improve the results of the investigation by these temperature and tilt corrections. The discordances which spoil the deduced values of the aberration constant and the latitude variation resist all attempts to eliminate them by these methods. In connection with the above two sentences it should be steadily borne in mind that an absolute difference affecting all the plates of the group is not of any importance. All that really is of importance is the difference from plate to plate of the same group. The same convention holds for the meaning of the figures as for Table VII.

[TABLE

Table IX.—*Mean Latitude derived from each Plate.*

Plate Number.	Reduction. i	ii	iii	iv	v
	Group I.				
1	50″·41	50″·42	50″·34	50″·38	50″·33
2	0·66	0·66	0·69	0·70	0·69
3	0·55	0·55	0·59	0·59	0·59
4	0·61	0·62	0·53	0·58	0·53
5	0·61	0·62	0·54	0·58	0·54
6	0·38	0·39	0·31	0·35	0·31
7	0·54	0·54	0·58	0·58	0·58
8	0·74	0·74	0·66	0·70	0·66
9	0·71	0·70	0·74	0·74	0·75
10	0·71	0·71	0·63	0·67	0·63
11	0·49	0·49	0·53	0·53	0·54
13	0·80	0·81	0·72	0·77	0·72
14	0·71	0·71	0·75	0·75	0·75
15	0·83	0·82	0·64	0·78	0·75
16	1·07	1·07	0·98	1·03	0·99
17	0·05	0·04	0·12	0·08	0·09
20	0·59	0·59	0·63	0·63	0·63
21	0·67	0·66	0·70	0·70	0·71
23	0·47	0·47	0·50	0·51	0·51
27	0·22	0·22	0·25	0·26	0·26
29	0·32	0·33	0·24	0·29	0·24
30	0·30	0·31	0·22	0·27	0·22
31	0·49	0·49	0·52	0·53	0·53
31*a*	0·71	0·72	0·63	0·68	0·63
36	0·59	0·60	0·51	0·56	0·52
37	0·55	0·55	0·58	0·59	0·59
38	0·49	0·50	0·41	0·46	0·42
40	0·80	0·80	0·72	0·76	0·72
41	0·55	0·55	0·58	0·59	0·59
42	0·54	0·54	0·46	0·50	0·46
43	0·55	0·55	0·47	0·51	0·47
44	0·67	0·67	0·59	0·63	0·59
46	0·55	0·55	0·47	0·51	0·47
48	0·54	0·53	0·58	0·57	0·58
49	0·58	0·56	0·50	0·52	0·50

TABLE IX.—*continued.*

Plate Number.	Reduction.				
	i	ii	iii	iv	v
GROUP II.					
	"	"	"	"	"
12	50·35	50·36	50·33	50·35	50·32
13	0·23	0·23	0·18	0·23	0·21
14	0·30	0·30	0·24	0·29	0·27
16	0·32	0·33	0·41	0·32	0·29
17	0·39	0·39	0·20	0·38	0·36
18	0·33	0·33	0·22	0·32	0·31
19	0·48	0·48	0·34	0·47	0·45
20	0·23	0·23	0·19	0·23	0·21
23	0·42	0·42	0·30	0·41	0·39
25	0·14	0·15	0·10	0·15	0·12
26	0·40	0·41	0·42	0·40	0·37
27	0·30	0·29	0·29	0·29	0·27
28	0·09	0·10	0·04	0·10	0·08
32	0·11	0·11	0·07	0·11	0·10
33	0·35	0·35	0·36	0·34	0·32
34	0·18	0·18	0·15	0·17	0·15
36	0·12	0·11	0·14	0·10	0·08
37	0·14	0·15	0·08	0·14	0·12
39	0·11	0·11	0·07	0·11	0·10
41	0·31	0·31	0·36	0·31	0·30
42	9·86	9·86	9·90	9·85	9·83
43	0·20	0·19	0·17	0·19	0·18
44	0·16	0·16	0·16	0·15	0·13
45	9·92	9·92	9·95	9·92	9·90
47	0·22	0·22	0·19	0·21	0·19
48	9·97	9·98	9·94	9·97	9·95
49	0·15	0·16	0·21	0·16	0·14
51	9·99	9·99	0·11	9·99	9·97
53	0·47	0·49	0·44	0·48	0·45
54	0·12	0·12	0·12	0·11	0·08
55	0·06	0·06	0·08	0·06	0·04
56	0·23	0·24	0·20	0·24	0·22
57	0·08	0·08	0·02	0·07	0·05
59	0·28	0·28	0·24	0·27	0·25
60	0·47	0·47	0·49	0·47	0·45
61	0·18	0·18	0·12	0·18	0·17
62	0·33	0·33	0·28	0·32	0·30
63	0·24	0·23	0·17	0·23	0·21
64	0·50	0·49	0·43	0·49	0·48

Table IX.—*continued.*

Plate Number.	Reduction. i	ii	iii	iv	v
Group III.					
19	50·57"	50·57"	50·59"	50·59"	50·50"
20	0·54	0·55	0·52	0·53	0·42
21	0·69	0·70	0·67	0·68	0·58
22	0·60	0·60	0·62	0·62	0·53
24	0·64	0·63	0·66	0·65	0·57
25	0·29	0·29	0·27	0·27	0·17
26	0·39	0·39	0·42	0·41	0·32
27	0·50	0·50	0·52	0·52	0·42
30	0·38	0·38	0·40	0·40	0·30
32	0·77	0·78	0·75	0·76	0·65
33	0·47	0·47	0·45	0·45	0·34
35	0·41	0·41	0·43	0·43	0·34
37	0·45	0·46	0·43	0·44	0·33
40	0·37	0·36	0·35	0·34	0·25
41	0·37	0·38	0·39	0·40	0·30
42	0·48	0·48	0·50	0·50	0·41
43	0·57	0·57	0·59	0·59	0·50
46	0·33	0·32	0·30	0·30	0·20
49	0·57	0·57	0·55	0·55	0·45
51	0·51	0·51	0·49	0·49	0·40
54	0·65	0·65	0·63	0·63	0·52
58	0·53	0·55	0·50	0·53	0·41
60	0·77	0·77	0·75	0·75	0·64

TABLE IX.—*continued.*

Plate Number.	Reduction. i	ii	iii	iv	v
GROUP IV.					
26	50''·18	50''·18	50''·13	50''·16	50''·06
27	0·20	0·19	0·23	0·21	0·15
29	0·41	0·40	0·39	0·42	0·36
30	0·31	0·28	0·29	0·26	0·18
31	0·08	0·07	0·08	0·05	9·96
32	0·46	0·46	0·38	0·44	0·33
33	0·49	0·47	0·46	0·49	0 43
36	0·25	0·24	0·21	0·22	0·12
37	9·81	9·79	9·84	9·81	9·74
39	0·43	0·43	0·35	0·41	0·32
40	0·38	0·38	0·42	0·40	0·34
41	0·32	0·31	0·31	0·29	0·20
42	0·34	0·33	0·30	0·31	0·21
43	9·87	9·86	9·82	9 88	9·82
45	0·73	0·72	0·66	0·70	0·61
47	0·39	0·36	0·31	0 34	0·27
48	0·41	0·40	0·36	0·38	0·29
50	0·47	0·46	0·53	0·44	0·35
51	0·50	0·49	0·38	0·47	0·37
52	0·84	0·83	0·82	0·85	0·80
53	0·62	0·60	0·57	0·58	0·50
54	0·85	0·84	0·85	0·86	0·79
55	0·09	0·08	0·08	0·10	0·03
56	0·22	0·21	0·30	0·19	0·10
57	0·33	0·32	0·27	0·34	0·28
58	0·84	0·82	0·74	0·80	0·72

Table IX.—*continued.*

Plate Number.	Reduction. i	ii	iii	iv	v
	Group V.				
10	50″·31	50″·19	50″·20	50″·18	50″·24
11	0·58	0·43	0·44	0·42	0·49
12	0·59	0·51	0·46	0·50	0·56
13	0·82	0·72	0·50	0·69	0·73
15	0·64	0·55	0·49	0·54	0·60
17	0·44	0·34	0·44	0·33	0·41
18	0·60	0·52	0·49	0·51	0·57
19	0·57	0·51	0·36	0·48	0·51
20	0·55	0·47	0·40	0·46	0·51
21	0·17	0·12	0·09	0·11	0·16
22	0·68	0·60	0·48	0·57	0·61
23	0·70	0·57	0·44	0·54	0·58
24	0·06	9·98	9·86	9·95	9·99
25	0·08	0·01	9·91	0·00	0·03
26	0·32	0·21	0·15	0·18	0·22
27	0·16	0·09	9·93	0·06	0·10
28	0·34	0·24	0·30	0·23	0·29
29	0·64	0·52	0·39	0·49	0·53
30	0·34	0·21	0·17	0·20	0·27
31	0·43	0·29	0·14	0·26	0·31
32	0·31	0·23	0·12	0·22	0·26
33	0·31	0·12	0·22	0·11	0·21
35	0·65	0·54	0·36	0·51	0·54
36	0·70	0·57	0·40	0·56	0·63
37	0·84	0·72	0·44	0·69	0·74
38	0·96	0·80	0·75	0·79	0·86
39	0·69	0·51	0·38	0·48	0·51
40	0·67	0·48	0·43	0·47	0·54
42	0·56	0·39	0·30	0·38	0·45
43	0·81	0·70	0·58	0·67	0·70
45	0·84	0·79	0·70	0·76	0·80
47	0·70	0·63	0·40	0·60	0·64
49	0·68	0·61	0·71	0·60	0·66
50	0·45	0·44	0·40	0·41	0·41
52	0·64	0·58	0·49	0·55	0·59

§ 22. *Theory of Aberration Determination.*—In the correction to a star place arising from aberration, the *Nautical Almanac* notation gives two terms, $Aa' + Bb'$, where A, B contain the factor $K = 20{\cdot}47$, the adopted value of the constant of aberration. If we write $Aa' + Bb' = 20{\cdot}47L$, or $L = (Aa' + Bb')/20{\cdot}47$, then for an alteration δK in the constant of aberration we should have in the daily correction an alteration $\delta K \,.\, L$ or $\delta K \,.\, (Aa' + Bb')/20{\cdot}47$. Hence the aberration factor b_{12} mentioned in § 1 is the difference between $(Aa' + Bb')/20{\cdot}47$ for the two stars 1, 2. Now the sign of this difference in the sense (evening − morning) is always positive, for aberration displaces a star towards a point 90° in front of the sun, and this is always more towards the north in the hours before midnight than in the hours after midnight. The northward shift of a star in the evening gives too low a value for the latitude in the evening. This is corrected by the tabular aberration. If the resulting evening latitude remains too low when compared with the morning latitude, the correction for aberration has not been made large enough and the aberration constant, K, must be increased. If the evening latitude is too high, the aberration has been over-corrected and the constant K must be decreased. The sign of δK, the correction to K, is therefore opposite to that of (evening latitude − morning latitude) and its magnitude is the difference of latitude multiplied by the factor $20''{\cdot}47 \left(\frac{1}{(Aa' + Bb')\ \text{evening} - (Aa' + Bb')\ \text{morning}}\right)$ or $1/b_{12}$. No reliance can be placed upon the result of a pair of stars or even of a pair of plates, as errors in the star places are there effective. But when a set of stars—or plates—have been grouped together cyclically in the manner explained in § 1, these errors are automatically eliminated and the resulting value of the aberration constant should be reliable.

§ 23. *Corrections to the Constant of Aberration.*—In the following table are given the particulars for one of the set of latitudes (column iv) given in Table IX. The table gives the dates and numbers of the actual plates used in the determination of the correction to the aberration constant. These were selected so as to be equal in number and as far as possible coincident in date for each pair of star groups. Weather conditions are mainly responsible for occasionally reducing the number of pairs of plates used in the different combinations. The mean latitude derived from each plate and the mean value of the aberration correction $Aa' + Bb'$ for the stars of that plate are next given in the table. At the end of each set of plates is given in Clarendon type the mean date of the set, the mean latitude, and the mean value of the aberration correction. It is upon the differences of these mean latitudes and mean aberration corrections that the calculation of the constant of aberration depends.

Table X.—*Aberration Plates.*

Date.	Plate.	Mean Latitude.	Aberration Factor.	Plate.	Mean Latitude.	Aberration Factor.
1905 Sep. 7	V. 12	52° 12′ 50″·50	+16″·16	I. 1	52° 12′ 50″·38	− 5″·30
12	V. 13	·69	+17·04	I. 2	·70	− 4·12
17	V. 15	·54	+17·81	I. 3	·59	− 2·92
20	...	...	...	I. 4	·58	− 2·18
21	V. 17	·33	+18·33	...	...	...
22	V. 18	·51	+18·45	I. 5	·58	− 1·69
Sep. 28	V. 20	·46	+19·04	...	...	...
Oct. 4	...	...	...	I. 6	·35	+ 1·30
Sep. 18	...	**50·50**	**+17·80**	...	**50·53**	**− 2·48**
Nov. 23	I. 13	52 12 50·77	+11·98	II. 12	52 12 50·35	−13·01
24	I. 14	·75	+12·12	II. 13	·23	−13·04
Nov. 29	I. 15	0·78	+12·80	II. 14	·29	−13·15
Dec. 8	I. 16	1·03	+13·55	II. 16	·32	−13·10
9	I. 17	0·08	+13·84	II. 17	·38	−13·07
19	...	...	...	II. 18	·32	−12·58
1905 Dec. 25	I. 20	·63	+14·59	...	...	...
1906 Jan. 10	I. 23	·51	+14·17	II. 19	·47	−10·14
1905 Dec. 10	...	**50·65**	**+13·29**	...	**50·34**	**−12·58**
1906 Feb. 20	II. 28	52 12 50·10	− 2·00	III. 19	52 12 50·59	−18·85
25	II. 32	·11	− 0·85	...	...	...
Feb. 27	...	...	...	III. 20	·53	−18·39
Mar. 3	...	...	...	III. 21	·68	−18·00
4	II. 33	·34	+ 0·77	...	...	...
5	II. 34	·17	+ 1·48	...	...	...
6	...	...	...	III. 22	·62	−17·65
17	II. 39	·11	+ 3·10	III. 24	·65	−15·98
Mar. 29	II. 41	50·31	+ 6·22	III. 25	·27	−13·50
Apr. 3	II. 42	49·85	+ 7·20	III. 26	·41	−12·29
Apr. 6	II. 44	50·15	+ 7·76	III. 27	·52	−11·54
Mar. 14	...	**50·14**	**+ 2·96**	...	**50·53**	**−15·80**
May 17	III. 30	52 12 50·40	+ 0·85	IV. 26	52 12 50·16	− 8·38
19	III. 32	·76	+ 1·49	IV. 27	·21	− 7·78
May 29	III. 33	·45	+ 4·64	IV. 29	·42	− 4·65
June 2	III. 35	·43	+ 5·86	IV. 30	·26	− 3·37
May 24	...	**50·51**	**+ 3·21**	...	**50·26**	**− 6·04**
June 17	IV. 32	52 12 50·44	+ 1·53	V. 21	52 12 50·11	− 7·79
June 19	IV. 33	·49	+ 2·19	V. 22	50·57	− 7·19
1906 July 3	IV. 36	50·22	+ 6·64	V. 24	49·95	− 2·78

TABLE X.—*continued.*

Date.	Plate.	Mean Latitude.	Aberration Factor.	Plate.	Mean Latitude.	Aberration Factor.
1906 July 4	IV. 37	52° 12′ 49″·81	+ 6″·95	V. 25	52° 12′ 50″·00	− 2″·45
June 26	...	**50·24**	**+ 4·33**	...	**50·16**	**− 5·05**
Aug. 28	V. 36	52 12 50·56	+ 14·00	I. 27	52 12 50·26	− 7·56
30	V. 38	·79	+ 14·46	I. 29	·29	− 7·14
Aug. 31	V. 39	·48	+ 14·74	I. 30	·27	− 6·92
Sep. 1	V. 40	·47	+ 14·90	I. 31	·53	− 6·70
11	V. 43	·67	+ 16·83	I. 31a	·68	− 4·42
Sep. 2	...	**50·59**	**+ 14·99**	...	**50·41**	**− 6·55**
Nov. 30	...	...	...	II. 45	52 12 49·92	− 13·17
Dec. 1	I. 38	52 12 50·46	+ 13·01	...	...	...
10	I. 41	·59	+ 13·90	...	...	...
1906 Dec. 12	...	...	...	II. 47	50·21	− 12·93
1907 Jan. 2	I. 46	·51	+ 14·54	...	...	...
3	...	...	...	II. 48	49·97	− 11·14
17	...	...	...	II. 51	49·99	− 9·06
1907 Jan. 18	I. 48	·57	+ 13·56	...	...	...
1906 Dec. 23	...	**50·53**	**+ 13·75**	...	**50·02**	**− 11·57**
1907 Feb. 20	II. 54	52 12 50·11	− 2·06	III. 37	52 12 50·44	− 18·86
Feb. 28	II. 59	·27	+ 0·21	III. 41	·40	− 18·33
Mar. 5	II. 62	·32	+ 0·93	III. 42	·50	− 17·80
18	II. 63	·23	+ 3·86	III. 43	·59	− 17·09
Mar. 7	...	**50·23**	**+ 0·73**	...	**50·48**	**− 18·15**
May 2	III. 46	52 12 50·30	− 4·01	IV. 40	52 12 50·40	− 12·63
7	III. 49	·55	− 2·42	IV. 42	50·31	− 11·31
8	...	...	...	IV. 43	49·88	− 11·02
9	III. 51	·49	− 1·78	...	...	...
10	...	...	...	IV. 45	50·70	− 10·48
12	III. 54	·63	− 0·82	...	...	...
17	...	...	...	IV. 47	·34	− 8·45
24	III. 58	·53	+ 3·00	IV. 48	·38	− 6·31
29	III. 60	·75	+ 4·56	...	...	...
May 14	...	**50·54**	**− 0·24**	...	**50·34**	**− 10·03**
June 16	IV. 51	52 12 50·47	+ 1·13	V. 45	52 12 50·76	− 8·16
19	IV. 53	·58	+ 2·11	V. 47	·60	− 7·26
28	IV. 55	·10	+ 5·00	V. 49	·60	− 4·46
June 29	IV. 56	·19	+ 5·32	V. 50	·41	− 4·14
July 4	IV. 58	·80	+ 6·87	V. 52	·55	− 2·53
1907 **June 25**	...	**50·43**	**+ 4·09**	...	**50·58**	**− 5·31**

The resulting equations for the correction δK to the constant of aberration are—

$$\left.\begin{aligned}
+0{\cdot}03 &= x_{51} + 20{\cdot}28\ \delta K/20{\cdot}47 \\
-0{\cdot}31 &= x_{12} + 25{\cdot}87\ \delta K/20{\cdot}47 \\
+0{\cdot}39 &= x_{23} + 18{\cdot}76\ \delta K/20{\cdot}47 \\
-0{\cdot}25 &= x_{34} + 9{\cdot}25\ \delta K/20{\cdot}47 \\
-0{\cdot}08 &= x_{45} + 9{\cdot}38\ \delta K/20{\cdot}47 \\
\\
-0{\cdot}18 &= x_{51} + 21{\cdot}54\ \delta K/20{\cdot}47 \\
-0{\cdot}51 &= x_{12} + 25{\cdot}32\ \delta K/20{\cdot}47 \\
+0{\cdot}25 &= x_{23} + 18{\cdot}88\ \delta K/20{\cdot}47 \\
-0{\cdot}20 &= x_{34} + 10{\cdot}27\ \delta K/20{\cdot}47 \\
+0{\cdot}15 &= x_{45} + 9{\cdot}40\ \delta K/20{\cdot}47
\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (9)$$

For the first year we have on adding

$$-0{\cdot}22 = 83{\cdot}54\ \delta K/20{\cdot}47 \quad \text{or} \quad \delta K = -0{\cdot}054\,;$$

for the second year

$$-0{\cdot}49 = 85{\cdot}41\ \delta K/20{\cdot}47 \quad \text{or} \quad \delta K = -0{\cdot}117\,;$$

and for the whole series

$$-0{\cdot}71 = 168{\cdot}95\ \delta K/20{\cdot}47 \quad \text{or} \quad \delta K = -0{\cdot}086.$$

This gives the unexpected value for K, $20''{\cdot}384$. A large negative correction to K is also found from reductions (iii) and (v) of § 21. For these reductions Table X. need not be repeated in detail, but below are given the figures corresponding to the left-hand side of equations (9).

Table XI.—*Numerical Terms of Equations* (9) *for Reductions* (*iii*), (*iv*), *and* (*v*).

iii	iv	v
$+0''{\cdot}04$	$+0''{\cdot}03$	$-0''{\cdot}06$
$-0{\cdot}36$	$-0{\cdot}31$	$-0{\cdot}31$
$+0{\cdot}35$	$+0{\cdot}39$	$+0{\cdot}31$
$-0{\cdot}25$	$-0{\cdot}25$	$-0{\cdot}22$
$-0{\cdot}13$	$-0{\cdot}08$	$+0{\cdot}05$
$-0{\cdot}14$	$-0{\cdot}18$	$-0{\cdot}25$
$-0{\cdot}46$	$-0{\cdot}51$	$-0{\cdot}51$
$+0{\cdot}18$	$+0{\cdot}25$	$+0{\cdot}17$
$-0{\cdot}06$	$-0{\cdot}20$	$-0{\cdot}02$
$+0{\cdot}13$	$+0{\cdot}15$	$+0{\cdot}28$

The coefficients of δK are slightly different for reduction (iii), which involves all the stars, and not merely those of the München and Catania Catalogues. Reduction (iii) is in fact the author's solution, (iv) and (v) representing different methods of revising his results. It will be easily noticed how slight an alteration in the final result has been thus obtained.

TABLE XII.—*Corrections to* $K = 20''.47$.

Reduction.	iii	iv	v
First year . .	$-0''.075$	$-0''.054$	$-0''.056$
Second year . .	-0.074	-0.117	-0.079
The whole . .	-0.075	-0.086	-0.068

Other reductions and solutions for δK under slightly varying assumptions as to the proper correction for tilt and other errors, also without any such corrections at all, have been made. But the general result of a large negative correction to K remains in all the solutions. The evening plates continue to show too high a value for the latitude compared with the morning plates.

§ 24. *Derivation of Latitude Variation.*—When the aberration correction has been obtained it is possible so to combine the observations of the different star-groups as to make them comparable *inter se* for a determination of the variation of latitude. To illustrate the method we shall take solution (v), and we shall adopt the correction $\delta K = -0''.068$. The correction to the latitudes of any plate will be $-0''.068 \times \dfrac{(A\alpha' + Bb')}{20.47}$. The application of this correction to the plates used in § 23 will act as a check on the value of δK. The sum for the two years of the differences of the corrected latitudes of corresponding pairs should vanish. The left-hand side of the corrected equations (9) for solution (v) are now $+0.01, -0.22, +0.37, -0.19, +0.08, -0.17, -0.43, +0.23, +0.01, +0.31$, and these numbers add up to zero, showing that no further correction to the aberration constant is required. However, there still remains a difference between the separate groups which must be taken into account in determining the variation of latitude. Thus when plates of groups V. and I. of the same date are compared, the mean latitude β_V given by the plates in V. is greater than that derived from I. by $-0''.01$ in the first year, and $+0''.17$ in the second year. On the average for the two years we get

$$\beta_V - \beta_I = +0''.08;$$

similarly

$$\begin{aligned} \beta_I - \beta_{II} &= +0.32 \\ \beta_{II} - \beta_{III} &= -0.30 \\ \beta_{III} - \beta_{IV} &= +0.09 \\ \beta_{IV} - \beta_V &= -0.19. \end{aligned}$$

The third group is the central group in value. We may take it as our standard and apply a further correction to all the other groups.

$$\left.\begin{array}{l}\text{Correction to I.} = \beta_{\rm III} - \beta_{\rm I} = -0''\!\cdot\!02 \\ \text{Correction to II.} = \beta_{\rm III} - \beta_{\rm II} = +0\cdot30 \\ \text{Correction to III.} = \beta_{\rm III} - \beta_{\rm III} = 0 \\ \text{Correction to IV.} = \beta_{\rm III} - \beta_{\rm IV} = +0\cdot09 \\ \text{Correction to V.} = \beta_{\rm III} - \beta_{\rm V} = -0\cdot10\end{array}\right\} \quad . \quad . \quad . \quad . \quad (10)$$

§ 25. *Resulting Variation of Latitude.*—The following table gives a complete list in order of dates of the latitudes derived from reduction (v) after applying the corrections stated in § 24. The plates are divided into groups, each covering a short interval of time. The mean latitude of the group is given on the right. The notation of Table VII. has been preserved.

TABLE XIII.—*Latitudes corrected for Aberration and reduced to Group III. as Standard. (Reduction v.)*

Date.	Group I.	II.	III.	IV.	V.	Mean.
1905 July 24	...	...	...	...	0·13	0·25
July 29	...	...	...	...	0·37	
Sep. 7	0·33	...	...	...	0·41	
12	0·68	...	...	...	0·57	0·50
17	0·58	...	...	...	0·44	
20	0·52	...	...	...	...	
21	...	...	...	...	0·25	
22	0·53	...	...	...	0·41	0·40
23	...	...	...	...	0·35	
Sep. 28	...	...	...	...	0·35	
Oct. 4	0·29	...	...	...	...	0·42
5	0·56	...	...	...	...	
16	0·63	...	...	...	...	
19	0·71	...	...	...	...	0·61
20	0·59	...	...	...	...	
Oct. 21	0·50	...	...	...	...	
Nov. 23	0·66	0·66	...	...	...	
24	0·69	0·55	...	...	...	0·64
Nov. 29	0·69	0·61	...	...	...	
Dec. 8	0·92	0·63	...	...	...	0·57
1905 Dec. 9	0·02	0·70	...	...	...	

TABLE XIII.—*continued.*

Date.	Group I.	II.	III.	IV.	V.	Mean.
1905 Dec. 19	...	0·65	...	...	...	
25	0·56	...	...	...	...	0·62
1905 Dec. 30	0·64	...	...	...	...	
1906 Jan. 10	0·44	0·78	...	...	...	0·59
13	...	0·54	...	...	...	
26	...	0·71	...	...	...	0·57
Jan. 30	...	0·44	...	...	...	
Feb. 12	...	0·68	...	...	...	
14	...	0·58	...	...	...	0·55
20	...	0·39	0·56	...	...	
25	...	0·40	...	...	...	0·44
Feb. 27	...	...	0·48	...	...	
Mar. 3	...	...	0·64	...	...	
4	...	0·62	...	...	...	
5	...	0·45	...	...	...	0·51
6	...	...	0·59	...	...	
7	...	0·37	...	...	...	
12	...	0·41	...	...	...	
17	...	0·39	0·62	...	...	0·45
Mar. 29	...	0·58	0·21	...	...	
Apr. 3	...	0·11	0·36	...	...	
4	...	0·45	...	...	...	0·36
Apr. 6	...	0·40	0·46	...	...	
May 17	...	...	0·30	0·18	...	0·35
19	...	...	0·65	0·27	...	
May 29	...	...	0·32	0·47	...	
June 2	...	...	0·32	0·28	...	0·29
6	...	...	...	0·06	...	
17	...	...	...	0·42	0·09	
19	...	...	...	0·51	0·53	0·41
1906 June 22	...	...	...	...	0·50	

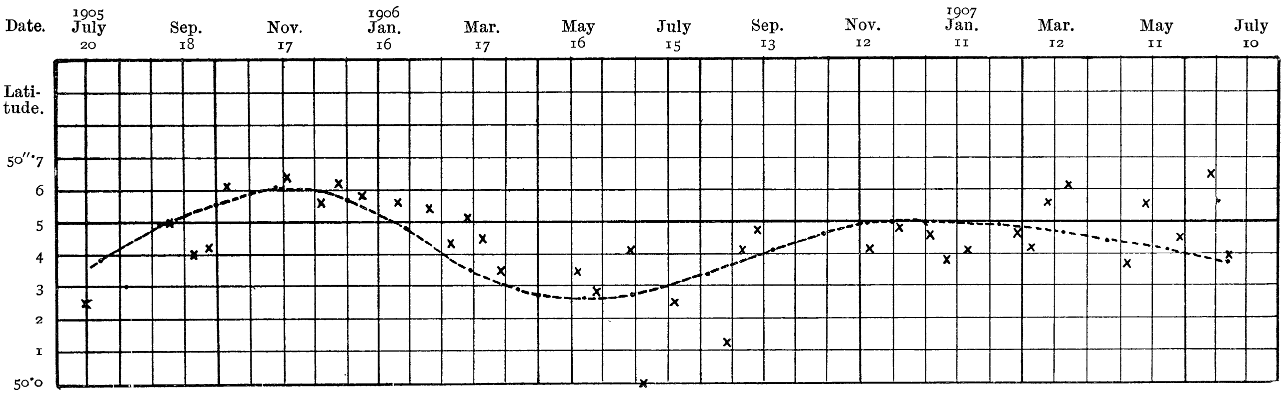
Table XIII.—*continued.*

Date.	Group I.	II.	III.	IV.	V.	Mean.
1906 July 3	...	...	...	0·19	9·90	
4	...	...	...	9·81	9·94	0·00
5	...	...	...	...	0·13	
11	...	...	...	...	0·00	
25	...	...	...	...	0·18	
26	...	...	...	...	0·41	0·25
July 27	...	...	...	...	0·15	
Aug. 14	...	...	...	...	0·18	
16	...	...	...	...	0·12	0·12
20	...	...	...	...	0·07	
27	...	...	...	...	0·39	
28	0·27	...	...	...	0·48	
29	...	...	...	...	0·59	0·41
30	0·24	...	...	...	0·71	
Aug. 31	0·22	...	...	...	0·36	
Sep. 1	0·53	...	...	...	0·39	
7	...	...	...	...	0·30	0·48
Sep. 11	0·62	...	...	...	0·54	
Nov. 17	0·46	...	...	...	...	
28	0·53	...	...	...	...	0·41
Nov. 30	...	0·24	...	...	...	
Dec. 1	0·36	...	...	...	...	
7	0·65	...	...	...	...	
10	0·52	...	...	...	...	0·49
12	...	0·53	...	...	...	
14	0·39	...	...	...	...	
21	0·40	...	...	...	...	0·46
1906 Dec. 26	0·52	...	...	...	...	
1907 Jan. 2	0·40	...	...	...	...	
3	...	0·29	...	...	...	0·39
6	...	0·47	...	...	...	
17	...	0·28	...	...	...	
18	0·52	...	...	...	...	0·41
1907 Jan. 19	0·44	...	...	...	...	

TABLE XIII.—*continued.*

Date.	Group I.	II.	III.	IV.	V.	Mean.
1907 Feb. 9	...	0·76	...	...	...	
20	...	0·39	0·39	...	...	0·47
21	...	0·34	...	...	...	
22	...	0·52	...	...	...	
23	...	0·35	...	...	...	0·42
27	...	...	0·31	...	...	
Feb. 28	...	0·55	0·36	...	...	
Mar. 1	...	0·75	...	...	...	
4	...	0·47	...	...	...	0·57
5	...	0·60	0·47	...	...	
18	...	0·50	0·56	...	...	0·61
Mar. 25	...	0·76	...	...	...	
Apr. 27	...	...	...	0·46	...	
May 2	...	...	0·21	0·47	...	0·37
3	...	...	...	0·33	...	
7	...	...	0·46	0·34	...	
8	...	...	...	0·95	...	
9	...	...	0·41	...	...	0·57
10	...	...	...	0·73	...	
12	...	...	0·52	...	...	
17	...	...	...	0·39	...	
24	...	...	0·40	0·40	...	0·45
May 29	...	...	0·62	...	...	
June 10	...	...	...	0·44	...	
16	...	...	...	0·46	0·73	
17	...	...	...	0·88	...	0·65
19	...	...	...	0·58	0·56	
22	...	...	...	0·87	...	
28	...	...	...	0·10	0·57	
29	...	...	...	0·17	0·32	0·40
June 30	...	...	...	0·35	...	
1907 July 4	...	...	...	0·79	0·50	

The following figure represents graphically the variation of latitude which results from Table XIII. The dotted curve represents the curve of variation for the latitude of Cambridge derived from Dr. Albrecht's figures.* The crosses give the mean latitudes of the groups of Table XIII.



The Latitude Datum to which Albrecht's Latitude Variation curve ------ has been adjusted is 50″·43.

Scale—1 Horizontal division = 20 days.
1 Vertical division = 0″·1.

Fig. 2.

The different reductions give slight variants on the above figure. But all the reductions agree in two outstanding discrepancies. The two groups of plates in the summer of 1906 gave low latitudes, and the last plates of the series show a tendency for the latitude to increase instead of decreasing. There is a fair agreement with Albrecht in the early plates. The outstanding differences are discussed in the next part.

Part V.

§ 26. *Probable Errors.*—In determining the probable errors of the result it must be noted that in no case are we concerned with the absolute value of the declination of the star. We are concerned solely with the fluctuations in the star's zenith distance through such causes as may affect the zenith point on the plate and the measures of the star relative to the other stars on the plate. It is impossible to disentangle the real fluctuations of latitude so as to allow completely for the former of these two disturbing factors. We are therefore driven back upon internal discordances as our sole measure of the reliability of our results, but we note that unknown instrumental causes affecting the position of the zenith on the plates may nullify the value of the probable errors determined solely from discordances. We take the latitudes given by the individual stars of each plate smoothed for temperature and tilt. The mean difference between each individual star and the mean of the plate is next determined and by a constant correction is eliminated. This removes uncertainty as to the star's

* *Resultate des Internationalen Breitendienstes*, Bd. iii. p. 224 ; *A.N.*, Bd. clxxv., S. 179 ; *A.N.*, Bd. clxxviii., S. 75.

catalogue place. The residuals between the star and the mean of the plate may then be taken as the measure of the accuracy of the star's measured position. This differs naturally from star to star, the average value being $0''{\cdot}23$; the resultant mean square error, or m.s.e., for the latitude of a plate as judged by internal discordances does not differ much from group to group, the values being given in Table XIV.

TABLE XIV.

Group	I.	II.	III.	IV.	V.
m.s.e. of latitude from one plate.	$0''{\cdot}11$	$0''{\cdot}09$	$0''{\cdot}09$	$0''{\cdot}09$	$0''{\cdot}12$

We shall not be far wrong if we take $0''{\cdot}10$ as the m.s.e. of the latitude of a single plate determined by internal discordances. It is of interest to discover how this error arises. In part it may be traced to errors of measurement. If the reversed and direct measures are compared,* it is possible to derive a value of the m.s.e. of the resulting latitude for a plate. This has been done for Groups I. and II., and is found to be $0''{\cdot}06$ in both cases, so that it would seem that errors of measurement contribute about three-fifths of the internal discordances of the various plates. The remainder must be attributed to instrumental, photographic, or external accidental causes.

The m.s.e. of the mean of a group of plates for latitude variation—consisting of four on an average—will be $0''{\cdot}05$, giving a probable error of $0''{\cdot}03$. The probable error of the aberration constant will be †

$$\epsilon_\kappa = \frac{\sqrt{p}}{\Sigma b \sqrt{n}}\, \epsilon_\Delta \qquad \text{(11)}$$

where

ϵ_Δ = p.e. of difference of morning and evening latitudes
$= 0{\cdot}6745 \times \sqrt{2} \times$ m.s.e. of latitude from one plate
$= 0''{\cdot}09$
p = No. of groups of plates = 5
n = No. of plates taken in each group
b = Aberration factor.

This gives for each year the p.e. of the derived aberration constant $= 0''{\cdot}019$, and for the two years we have for the probable error of the result $= 0''{\cdot}014$. The large value of the correction found, $0''{\cdot}068$, is therefore probably not to be traced to accidental errors as shown by internal discordances. If it may not be regarded as a valid correction, in view of other determinations, and we do not think that it may be so regarded, it

* It should be noted that in the comparison of direct and reversed measures the usual personal error of measurement in any one direction does not enter. The quantities compared are the distances between a pair of parallel trails of like intensity, both of which, it is presumed, are equally affected by these errors.

† KÜSTNER, *A.N.*, cxxvi., S. 244.

remains to find some systematic errors affecting the latitudes given by various plates. The same remark applies to the discrepancies from the latitude variation curve. The groups that differ most markedly from ALBRECHT's curve are groups consisting of a more than average number of plates, and the discrepancies, amounting to as much as nine times the probable error in one case and exceeding five times the probable error in four or five cases, are too large to be ascribed to accidental causes of the size suggested by the probable error. Some cause or causes affecting the zenith on the plate or the axis around which the telescope turns must be found.

§ 27. *Odd Residuals.*—As a first step towards discovering these causes the large individual residuals between a star and the mean of a plate were examined to see what information they would yield. As was to be expected, the least consistent stars were further from the zenith than the markedly consistent stars, but there was nothing noticeable in the arrangement of the inconsistencies. There seemed on the whole a tendency for the bad plates to come grouped together in batches, but it was impossible to trace this to the existence of boxes of bad plates; and this mainly for two reasons: (*a*) between a third and a quarter of the plates had been rejected for various reasons, such as clouding over in the middle of the exposure; also other plates belonging to another series of observations were being taken during the course of the investigation. (*b*) There were six plate-holders in use, and it would be quite possible for more than one box of plates to be in use at one time.

The following is a list of the worst plates as shown by their giving large residuals between individual stars and the mean of the plate. Any remarks which have been made in the observer's note-book or by the measurer (see Table VI.) are here reproduced.

[TABLE.

TABLE XV.

Plate.	Date.	Observer's Remarks.	Measurer's Remarks.
I. 6	1905 Oct. 4	Wind 5.	...
I. 16	Dec. 8	Bright moonlight; clouded up later.	Wavy trail for star 6; R. and D. agree for 12.
I. 20	Dec. 25	Clouded up later.	Wavy for 9; R. and D. agree for 5.
I. 48	1907 Jan. 18	Mist low down.	...
II. 26	1906 Feb. 12	Fine night. Moon.	...
II. 55	1907 Feb. 21	...	One trail for 6 faint and broken.
III. 58	May 24	...	Wavy for 6, 9, 10; R. and D. agree.
IV. 54	June 22	Bright moon.	Trails of 5 and 12 broken by cloud.
V. 10	1905 July 24	...	...
V. 23	1906 June 22	Heavy dew; dense fog later.	...
V. 26	July 5	High small cirrus clouds.	Bottom trail of 9 broken by cloud and not measured.
V. 28	July 25	Grand sky.	...
V. 33	Aug. 20	Wind 3.	...
V. 37	Aug. 29	Moon.	Bottom trail has a jump in it.
V. 49	1907 June 28	...	Trails of 2, 3, 7 wavy; R. and D. agree.

An examination of the temperatures of these plates given in Table V. shows nothing systematic connecting the discordant plates with high or low temperatures; nor does the number of the plate-holder given in the observation records show any preference for some particular plate-holder. Nor does there seem any marked connection between these plates and the variation of latitude discrepancies or the unsatisfactory value of δK. Only five of them figure in the groups which are badly discordant with ALBRECHT, namely, I. 48, IV. 54, V. 23, 26, 33; and these plates are by no means responsible for the discordant values given by the groups of which they form part. Again, only six of the discordant plates figure in the aberration series at all. Of these I. 6 and I. 16 both increase the size of the negative correction to K, the other plates, I. 20, 48, III. 58, and V. 49, are insensible in their effects. If I. 6 and I. 16 were rejected, the negative value of δK would be reduced by 0·012, *i.e.*, it would be $-0''\cdot063, -0''\cdot074, -0''\cdot056$ for reductions (iii), (iv), and (v) respectively. The examination of internal discordances then has not helped materially towards the solution of the problem.

§ 28. *Reseau.*—A special series of plates were taken for the determination of errors in the reseau. The errors found were of the order of the errors of measurement. They were not adopted in this work at all. This was justifiable, because each star depended for its zenith distance practically on the same part of the reseau throughout, except for the difference between the two sides of the plate, and this difference was examined and allowed for in the reduction for tilt. Now, as only differences between one plate and another are of account, this neglect of the certainly small and almost constant reseau error is fair. It should be noted, however, that some indication of a slight tilt of the plate to the reseau was noted in the examination for reseau errors, the evidence suggesting that one end of the plate was nearer the reseau than the other. This fact is worth bearing in mind in the discussion of the points arising in the next section.

§ 29. *The Inclination of the Central Reseau Line to the Meridian.*—It has been pointed out in § 13 that in the determination of the inclination of the central reseau line to the meridian a slight error would enter owing to the fact that the central reseau line did not necessarily cut the meridian in the zenith. Signs of this error appear in a comparison of the values of this inclination θ when determined in two different ways. In the table below are given the mean values of θ in successive sets of plates. θ was determined (a) by the least square solution of § 13, and (b) by direct measurement of the inclination of the reseau line to the shadow of the central wire on the plate, combined with the known inclination of this wire to the meridian. (This latter inclination remained almost constant; see Table III.) The angles are given in circular measure.

Table XVI.

Interval.	θ_a	θ_b	$\theta_a - \theta_b$
1905 July 24–1905 Sep. 28	0·00128	0·00267	− 0·00139
Sep. 7–1906 Jan. 10	128	272	144
Nov. 23– Apr. 6	118	214	96
1906 Feb. 20– June 2	231	285	54
May 17– July 4	220	292	72
June 17– Sep. 11	426	471	45
Aug. 28–1907 Jan. 19	530	557	27
Nov. 30– Mar. 25	437	455	18
1907 Feb. 20– May 29	474	519	45
Apr. 27– July 4	634	641	7
June 16– July 4	622	622	0

These figures suggest a steady increase of θ and a decrease of $\theta_a - \theta_b$, with an increase of time. Some progressive change in the reseau-holder, the gradual shifting of a circular stop held down by a screw excentrically placed, would explain the gradual increase of θ. The same explanation would also account for the steady diminution of $(\theta_a - \theta_b)$, which would take place if the central reseau line on the plate steadily approached the meridian near the zenith. The difference between the two θ's is probably more than can be accounted for by the omission of the second order terms mentioned above, but the change may be partly due to a steady alteration in these terms. Any tilt of the plate to the reseau or to the axis of the telescope, such as has been traced, would also probably affect the least square solution for θ_a and help to account for the differences between the two θ's. There is no evidence that the uncertainty of θ_a has affected the results. No connection between large values of $\theta_a - \theta_b$ and discordant plates can be traced. Further, an examination of the reduction to the meridian using θ_b in place of θ_a shows even in the most unfavourable case no difference of the order of $0''\cdot01$ in the resulting zenith distance of a star.

§ 30. *Proper Motions.*—As changes in the star places are important rather than adopted standard values, the question must be considered whether possible errors in the adopted proper motions would affect the results. The comparison with Professor Boss's proper motions is decisive against any sensible error having crept in through wrong proper motions, so far as the stars in question are found in his catalogue. With regard to the stars not found there, any large proper motion should be shown by a steady change in the residual between the star and the mean of the plate. No evidence has been found of any such change as could cause a sensible effect.

§ 31. *Daily Corrections.*—As the aberration constant enters into the daily corrections, any error made in applying these corrections or in obtaining them would introduce an error into the determination of the constant. The duplicate calculation of the daily corrections by different methods was made in order to avoid such errors. Further checks have also been applied. For the groups of plates with poor results, as shown by comparison with ALBRECHT, the daily corrections have been recomputed from the American Ephemeris without any difference of more than $0''\cdot01$ being detected, and in several cases, chosen at random, the corrections have been recalculated direct from the formulæ. Though no error can be traced in the calculation of the daily corrections, yet it is possible that an error might have crept in through them. For they were transformed from seconds of arc into reseau intervals before being introduced, and, as we have seen above (§ 16), the scale value adopted for this has not been always above suspicion. However, it will be seen easily that this error cannot be sensible in its effect. The largest value of the daily correction is $20''$; the largest range in temperature from the standard is 20°C. The alteration in the daily correction, allowing for a temperature correction, is therefore at most $0\cdot00001 \times 400'' = 0''\cdot004$, which is negligible.

§ 32. *Determination of Aberration Constant by Different Groups of Stars.*—Possibly some light may be thrown on the sources of error by the following results. Each of the five groups of stars was divided into two parts, composed of the first and last half of the group in order of right ascension; the aberration was determined from each half separately. The resulting value of the correction δK derived from the second half was nearly four times in magnitude the correction derived from the first half: this was the same in both years. The figures suggest some factor steadily changing the latitude in the same direction in the evening and morning observations; but a more detailed analysis of the figures shows that this suggestion is illusory. If we form sets of stars by taking the first one from each group and then the second one, and so on, and if the aberration constant is determined from each group, there is no real evidence of a progressive change in the resulting value of δK. It would seem then that the above result must probably be ascribed to accidental causes, and the cause of the discrepancies is yet to seek.

§ 33. *Tilt of the Float.*—One further possible source of error has been examined. An unequal temperature across the mercury trough might, if maintained, lead to a tilt of the axis about which the telescope was rotated. Calculation shows that if a steady temperature gradient across the trough was maintained from N. to S., so that there was a difference of temperature of 1° C., then the telescope would be tilted through about $0''\cdot2$. If the temperature gradient remained unaltered in direction and amount after the rotation of the telescope, this would be equivalent to a change of the apparent zenith by $0''\cdot2$. Experiments have been tried by opening one or both doors of the telescope house, and varying the conditions to obtain different temperatures on the opposite side of the trough. The greatest difference obtained was $0^\circ\cdot25$ C. A difference of $0^\circ\cdot1$ C. was frequently obtained and maintained for a long interval by keeping the conditions constant, but no greater difference than $0^\circ\cdot1$ C. was obtained when temperature readings were taken under the actual conditions governing the observations discussed in this paper. It is conceivable that the aberration determination has been affected in this way. It is not, however, possible that this cause can have been operative in producing the large discrepancies noted in the latitude variation curve, especially since it has been found that reversal of the instrument carries at least the surface layers of the mercury through 90°, and prevents the establishment of a permanent temperature gradient.

§ 34. *Other Sources of Error.*—There remain for suggestion several other possible sources of error, which might be too irregular in their action to be determined by any systematic search. For instance, there might be differences in the capillary action of the mercury in different parts of the trough, or there might be some yielding or flexure in the instrument. The latter is not very likely in view of the construction and the method of use of the instrument. The editors would welcome suggestions of possible errors not yet traced; the removal of their effects would improve the usefulness of the instrument.

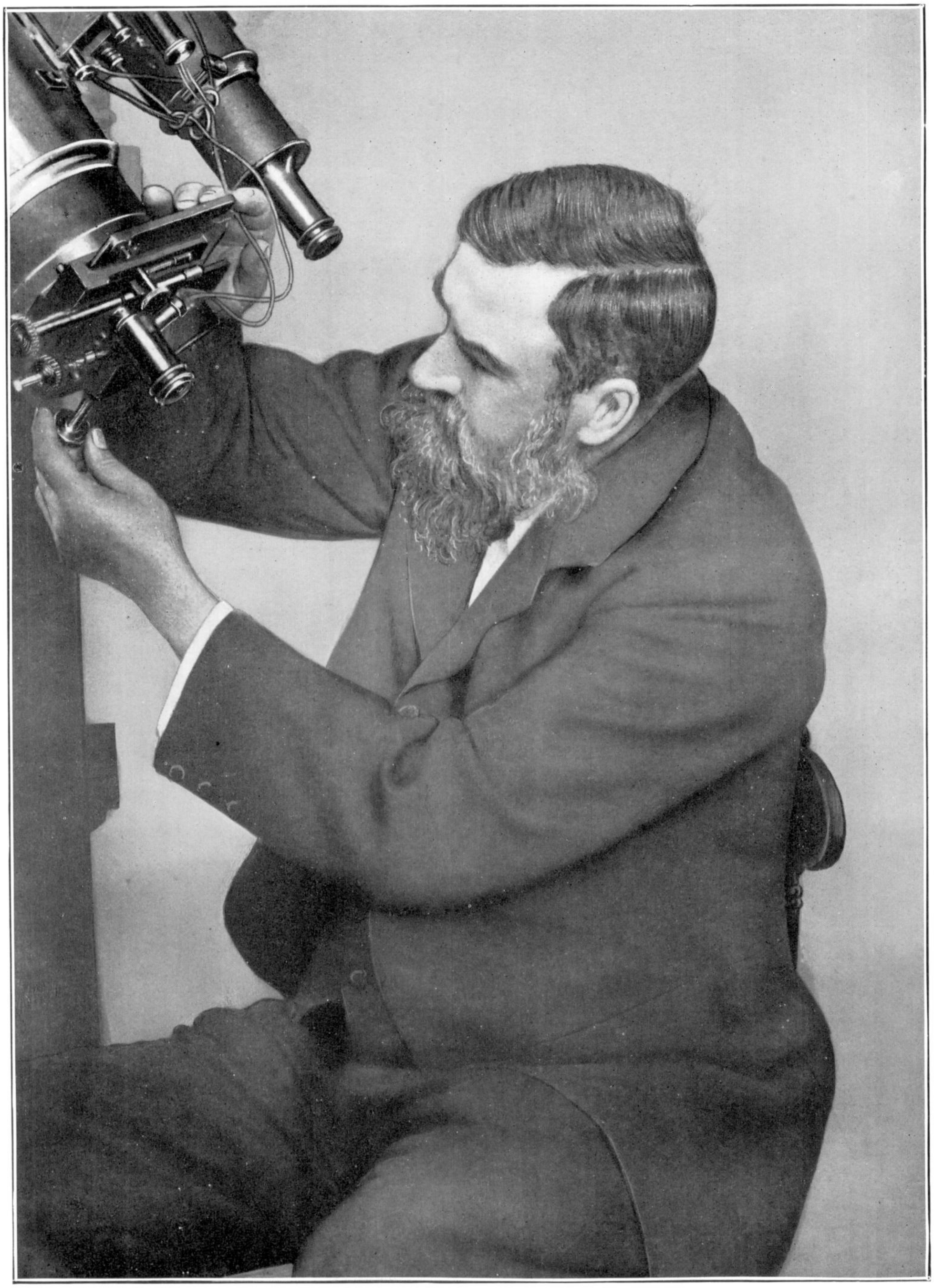
Part VI.

§ 35. *Final Conclusions.*—We may summarise as follows the results of the above discussion :—

The internal concordance of the results from individual plates is sufficiently close to suggest that a good determination of the aberration constant and of the variation of latitude could be derived from the observations. The results, however, are considerably divergent from the accepted values. The editors do not suggest that the results of this single pioneer investigation should be taken as definitive. Rather do they assume the action of some systematic error not yet discovered. It had been hoped that the principle of flotation employed in the telescope would give it superior freedom from systematic deviations from the vertical when compared with a visual telescope of the usual type and of the same size. So far these hopes have not been fulfilled. Future investigation may, however, reveal the errors remaining and lead to their elimination. In that case, even though there is no gain in the accuracy of measurement, the advantages of the photographic method, coupled with the simplicity of construction and use of the instrument, may win for it a place in some future scheme of latitude investigation, and thus justify the hopes of its designer.

Note added 1911 *May* 30.

It is pleasant to be able to add that further work with the instrument is to be undertaken immediately. The Zenith telescope, which had been presented to the Cambridge Observatory by Mrs. Bryan Cookson, has, at the request of the Astronomer Royal, been lent to the Royal Observatory, Greenwich, for a period of seven years.



JOHN FRANKLIN-ADAMS.