APPENDIX NO. 1—1892.

ON THE VARIATION OF LATITUDE AT ROCKVILLE, MD., AS DETERMINED FROM OBSERVATIONS MADE IN 1891 AND 1892 IN COÖPERATION WITH THE INTERNATIONAL GEODETIC ASSOCIATION.

Submitted for publication October 14, 1892.

PREFATORY NOTE.

The Coast and Geodetic Survey having undertaken to coöperate with the International Geodetic Association in the observations for variation of latitude at Waikiki, near Honolulu, it seemed important to have determinations of latitude at points intermediate between that point and Berlin.

Washington, being nearly six hours west of Berlin in longitude, and in latitude nearly midway between Berlin and Waikiki, was geographically well placed for observations which would check those regularly made at these two stations. Still further light would be thrown upon the suspected progressive change in the position of the axis of rotation of the earth by a series of observations at San Francisco, nearly midway between Washington and Waikiki. The verification of the movement by these observations would remove all doubt as to its reality, and it was accordingly determined to do the best that could be done under the circumstances in the way of making observations for latitude as frequently as possible throughout a year at both of these points.

Other demands of the service forbade the detailing of one or more assistants to this duty alone. It was necessary to do it, if it was to be done at all, in addition to other regular work, and it therefore became, in a large degree, a voluntary service. Assistant George Davidson, in charge of the Sub-office at San Francisco, in carrying on the work there was much interrupted by necessary attention to office and field duties. In Washington the task was voluntarily assumed by Assistant Edwin Smith in addition to his regular duties as chief of the Instrument Division. The latter required his presence in the office during the day and necessitated a journey of 16 miles in the morning and again in the evening, to his home in Rockville, where the temporary observatory was located.

In considering the results herewith submitted, the above facts must not be lost sight of, and it must be remembered that the work at the

stations in the United States was undertaken primarily as a check upon the more careful and systematic investigation in progress at Berlin, and by Assistant Preston and Dr. Marcuse at Waikiki.

This paper contains the observations made at Rockville, and the reduction and computation of the results. An abstract of it was published in November, 1892, as Bulletin No. 25.

The instrumental methods and scheme of observing have been described by Mr. Smith, and the description of the method of reduction and the discussion of the results was prepared by Mr. Charles A. Schott, Assistant in charge of the Computing Division of the office, under whose direction the computations were made.

Mr. Preston's report of his observations and results at Waikiki is published as Appendix No. 2, 1892.

T. C. MENDENHALL,
Superintendent.

I.—DESCRIPTION OF THE STATION, INSTRUMENTS AND METHODS OF OBSERVING BY EDWIN SMITH, ASSISTANT U. S. COAST AND GEODETIC SURVEY, AND OBSERVER AT ROCKVILLE.

In conformity with the instructions of the Superintendent, dated March 25, 1891, the scheme adopted for the Rockville station was as follows: Eighty-eight pairs of stars were selected from the Coast and Geodetic Survey Catalogue of Stars for Observations of Latitude, Appendix No. 7, Report for 1876, extending over the twenty-four hours of right ascension and arranged in fifteen groups, which were observed as follows:

Group.	Nos. of pairs.	Dates of observations.
1	1 to 16	June 13, 15, 1891, and June 2, 6, 11, 12, 13, 15, 16, 17, 20, 23, 25, 26, 29, 1892.
2	5 to 19	June 23, 24, 25, 27, July 5, 6, 1891, and June 11, 12, 20, 23, 29. July 7, 8, 9, 1892.
3	9 to 24	July 9, 10, 12, 21, 22, 27, 29, 1891.
4	14 to 28	July 31, August 7, 9, 10, 11, 14, 15, 22, 1891.
5	20 to 35	August 15, 17, September 1, 3, 7, 9, 10, 12, 13, 14, 15, 17, 1891.
6	26 to 40	September 10, 12, 14, 17, 18, 19, 21, 23, 24, 25, 26, 28, 30, October 3, 5, 9, 14, 15, 16, 17, 1891.
7	34 to 48	October 22, 23, 24, 28, 29, 30, November 1, 2, 6, 7, 9, 1891.
8	41 to 55	November 17, 18, 20, 23, 24, 29, 30, December 1, 4, 5, 1891.
9	47 to 61	December 8, 9, 10, 13, 18, 28, 31, 1891.
10	54 to 65	January 7, 8, 16, 20, 21, 24, 25, 28, 1892.
11	59 to 70	January 31, February 10, 13, 15, 17, 1892.
12	66 to 77	March 10, 12, 14, 16, 19, 20, 21, 23, 24, 1892.
13	71 to 82	March 28, 29, April 4, 9, 11, 12, 13, 1892.
14	77 to 88 and 1	April 16, 19, 23, 26, 27, 29, 30, May 1, 3, 4, 5, 7, 8, 9, 1892.
15	83 to 88 and 1 to 8	May 16, 17, 19, 23, 24, 25, 28, 30, June 1, 1892.

On the variation of latitude at Rockville, Md.

The large number of groups is considered the weakest point in this series of observations. The conditions under which the work was done will readily explain why it would have been impossible to have limited the number of groups. It is to be regretted that the hours of observation were so limited, but to have extended them to two or three o'clock in the morning would have been fatal to the performance of the observer's duties at the office. The groups could have been limited to a small number only by so extending the hours of observation.

The observer has had little assistance in this work. With the aid of Mr. Frank A. Cook, the clerk of the Instrument Division, the stars were selected and the groups arranged only a few days before the observations were actually begun. Mr. Cook kindly volunteered to assist even after office hours, and with his help an effort was made to keep up the computations as the observations progressed; but this was soon found impracticable and the effort was abandoned. This part of the work was then referred by the Superintendent to the Computing Division of the Coast and Geodetic Survey Office, where the computations have been personally made by the chief of that Division, assisted by Messrs. Alexander Bonnot and Legh W. Reid, who were specially employed for the purpose.

DESCRIPTION OF STATION.

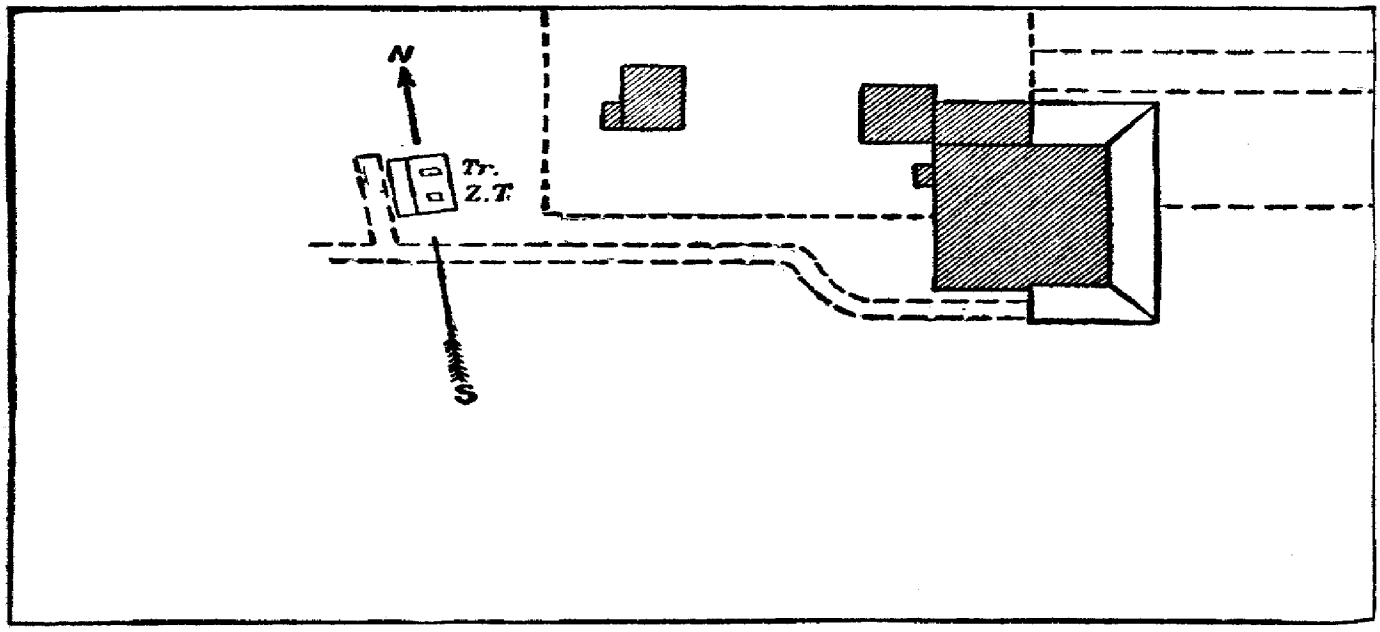
The town of Rockville is located on the Metropolitan Branch of the Baltimore & Ohio Railroad, about 16½ miles from Washington, D. C., in Montgomery County, Maryland.

The latitude station is located in the garden of the observer's residence on Forest avenue about 1 mile by the direct road from the railroad depot, but somewhat less than half a mile from the nearest point of the railroad. The station is about 500 feet above tide water, on one of the highest points within a radius of about 2 miles. The immediate vicinity is free from trees and other disturbing atmospheric influences, and altogether can be considered a very favorable location for such observations. The sketch shows the location of the observatory in the garden.

The pier upon which the zenith telescope is mounted is built of rough sandstone and cement, and its foundation is solid quartz rock. A ledge of this rock runs through the garden in a direction SW. to NE., and comes above the surface of the ground at several places. At the point where the pier is built the rock is about 2 feet below the surface. The pier has proved a very steady one. Throughout the thirteen months of observation the instrument required no adjustment in azimuth except when intentionally disturbed. The changes of level were slight and due more to temperature than to any other cause. The pier is 0·61 metre square, and the top 0·99 metre above the ground. At a distance of 1·98 metres north of this pier is another pier of the same

material, only one-half of which rests upon the solid rock. Upon this pier is mounted the transit instrument. As might be expected this pier is not as stable as the other, but serves its purpose very well.

Over the piers is built a wooden observatory 3·66 metres by 4·26 metres, divided into two rooms 4·26 metres by 2·44 metres and 4·26 metres by 1·22 metres, respectively, the smaller room being used as a recording and waiting room and the larger the observing room. By a system of ventilation under the eaves and at the peaks of the gables of the roof, an excessive rise of temperature is avoided. The width of the slit in the roof is 38 centimetres. The exterior of the building is painted a very light color, almost white. The zenith telescope pier is covered



Sketch of Garden, showing location of Observatory.

by a wooden case resting upon the floor of the observatory free from any contact with the pier.

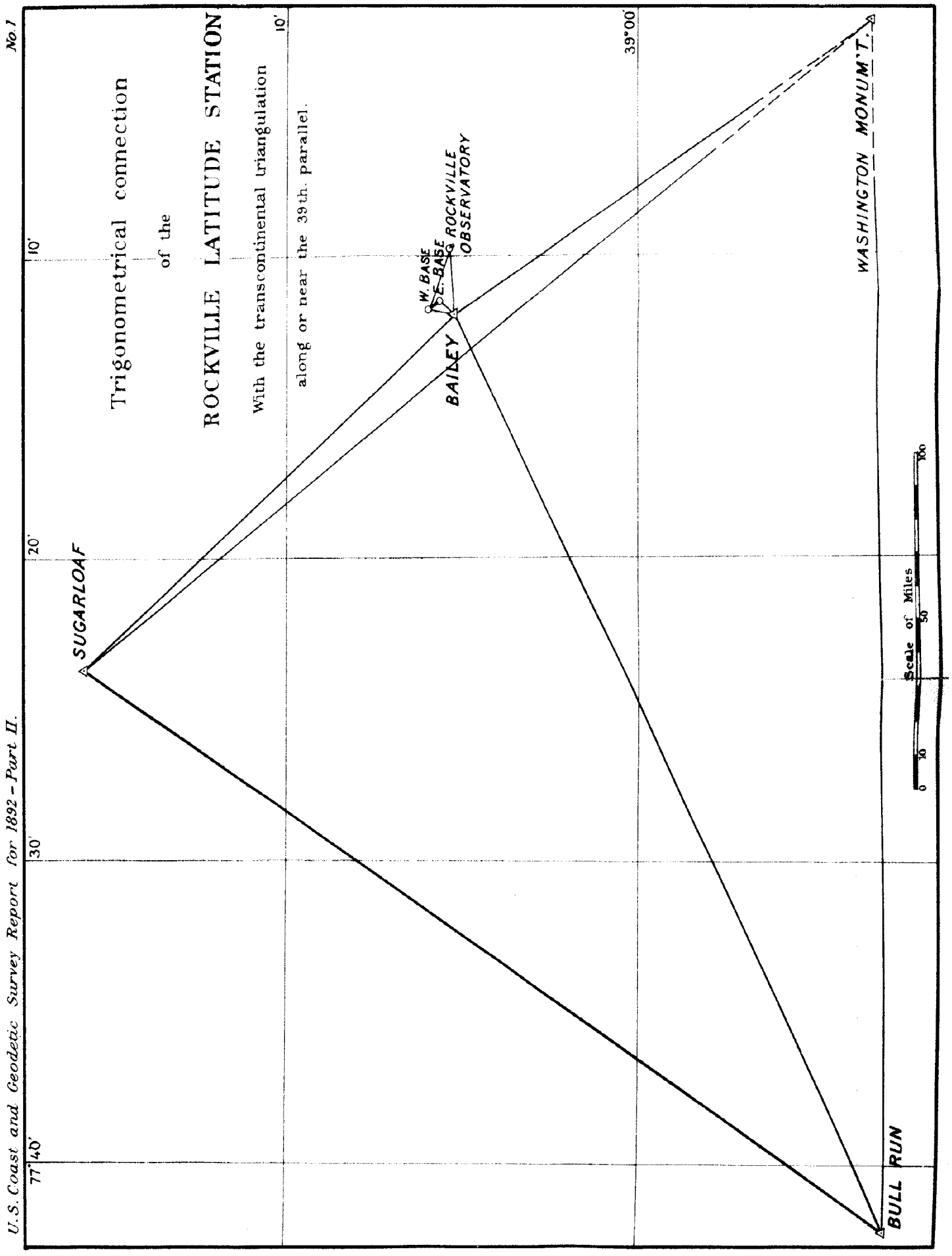
In the spring of 1892 this station was connected with the main triangulation of the Coast and Geodetic Survey, as shown in illustration No. 1 and the geodetic position of the zenith telescope pier was found to be as follows:

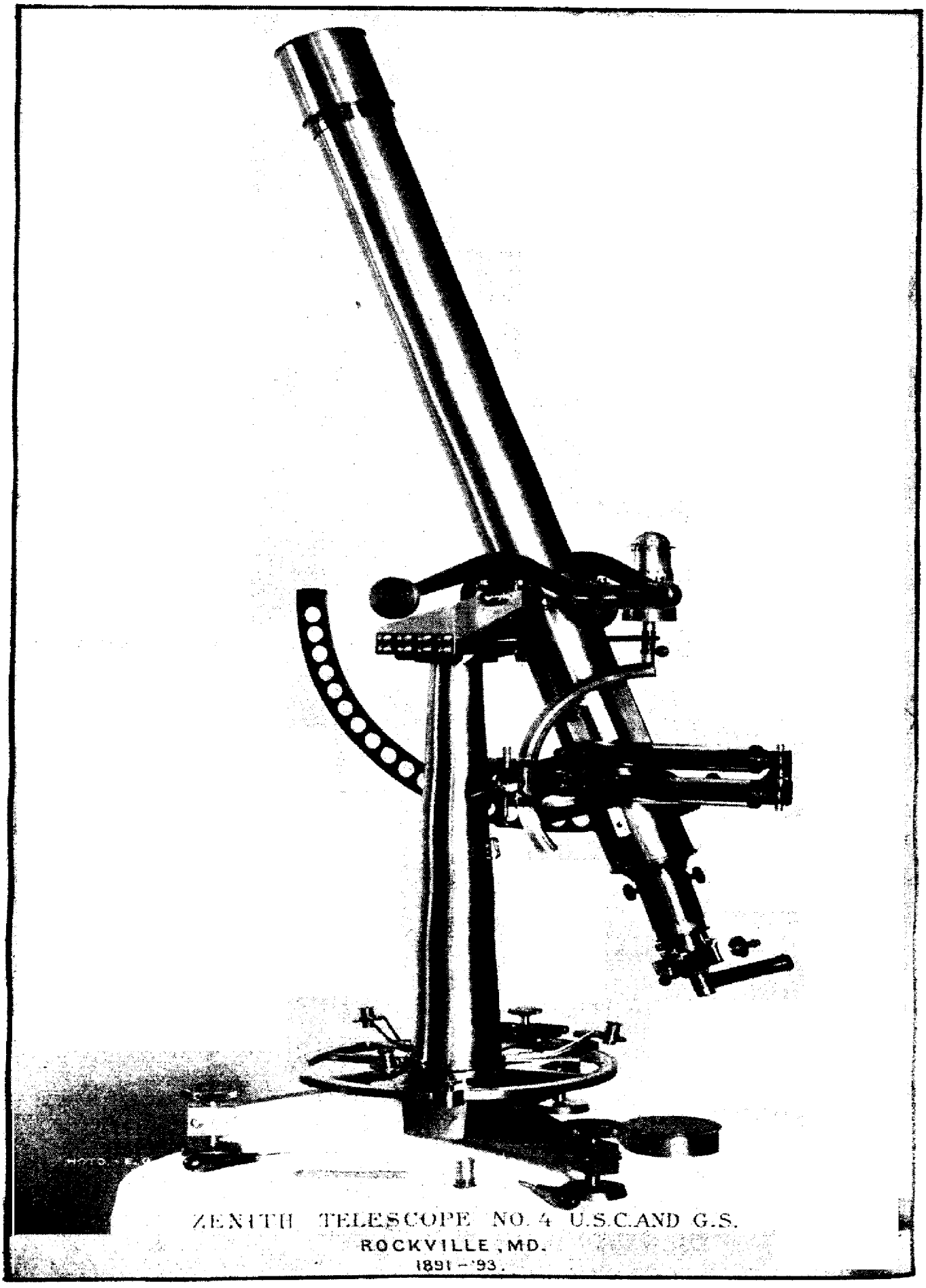
Latitude =39° 05′ 11″·21
Longitude =77° 09′ 36″·65

INSTRUMENTS.

Zenith telescope No. 4; transit No. 5; sidereal break circuit chronometers Negus No. 1589, Hutton No. 220, and Hutton No. 202; cylinder chronograph; electric lamps, batteries, etc.; Centigrade thermometers Nos. 6287, 6288, and 6289; mercurial barometer No. 1735.

Zenith telescope No. 4 (see illustrations Nos. 2 and 3) was originally made by Troughton & Simms of London in 1849. The Coast and Geodetic Survey possesses four of these instruments, known as Nos. 1, 2, 3,


No. 1
Trigonometrical connection
of the
ROCKVILLE LATITUDE STATION
With the transcontinental triangulation
along or near the 39th. parallel.
U.S. Coast and Geodetic Survey Report for 1892 – Part II.
77°40'
30'
20'
10'
39°00'
10'
SUGARLOAF
BAILEY
W. BASE
E. BASE
ROCKVILLE OBSERVATORY
WASHINGTON MONUM'T.
BULL RUN
Scale of Miles
0
10
50
100



ZENITH TELESCOPE NO. 4 U.S.C.AND G.S.
ROCKVILLE, MD.
1891 – '93.

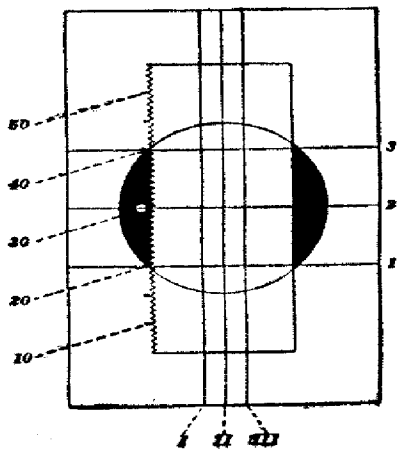
and 4, all made at about the same time. In their original form they had many defects and gave unsatisfactory results, and for some years past had been unused. When it was proposed that the Coast and Geodetic Survey should take part in these researches on the variations of latitude, in coöperation with the International Geodetic Association, no other instruments were available, and it was decided to have two of these remodeled at the Survey Office, one for the party going to the Hawaiian Islands and the other for the party to be located near Washington, D. C. No. 2 was selected for the former and No. 4 for the latter.

The remodeling of these instruments was done in the shops of the Instrument Division of the Coast and Geodetic Survey Office, and every precaution was taken to make them as perfect as possible under the circumstances. The new features are as follows for each instrument:

New base and leveling screws; new vertical axis; new wyes for horizontal axis of telescope, with adjustment for level; new and larger horizontal axis for telescope; new micrometer screw and reconstruction of micrometer box and slide; new and improved clamp to telescope; two new fine levels attached to telescope; new stride level for telescope axis; the whole instrument repolished, bronzed, etc.; electric lamps, batteries, etc., for illumination of telescope field, the reading of levels, etc.

Owing to want of time, No. 2 did not have the new base and vertical axis. This is very much to be regretted, as the old form is too weak. In every other respect the instruments are equal. Though these instruments are by no means such as would have been selected had there been time to purchase or construct new ones, it was believed they would answer the purpose.

The optical parts are those originally furnished with the instrument. The objective has a clear aperture of 7·6 centimetres and a focal length of 116·6 centimetres. The glass has a slight green color, but the images of the stars observed were bright and well defined. The diagonal eye-piece gives a power of 100. It gives good definition only very near the middle of the field, and having no parallactic motion in right ascension, only three good pointings could be made on a southern star while crossing the field. The micrometer is of the usual form. The diagram shows the field when the screw and eye-piece are set centrally. The three vertical lines are fixed spider webs about eight and a half equatorial seconds apart. The three horizontal lines are spider webs fixed to the slide moved by the micrometer screw at distances of ten revolutions of the screws. The micrometer is so arranged that if taken



apart the head and rack can be replaced so as to have the same relation to each other. Increasing readings of the screw indicate increasing zenith distances.

The two levels attached to the telescope were selected from a lot purchased from the Keuffel & Esser Company of New York in 1889. They were made by Adolph Pessler, mechanician, of Freiburg, in Saxony. These levels have proved very satisfactory, and it is doubtful if superior levels can be obtained. The glass tubes are 150 millimetres long and 18 millimetres in diameter. They have a chamber at one end, by which the length of the bubble can be controlled. The length of a division is 2 millimetres. As viewed upon the instrument, the graduations are from left to right, the upper level scale being numbered from 0 to 50 and the lower end from 60 to 110.

Each glass tube is mounted in a brass tube, in which it rests upon two points near each end, and is held in place by a light spring above these points at each end. Each brass tube is covered by a glass tube. The two levels thus mounted are attached to a brass arm by ball and socket joints at one end and opposing screws at the other end, by which the two levels may be made parallel to each other. The levels are mounted upon the left-hand side of the telescope and when pointing north the scales read from north to south.

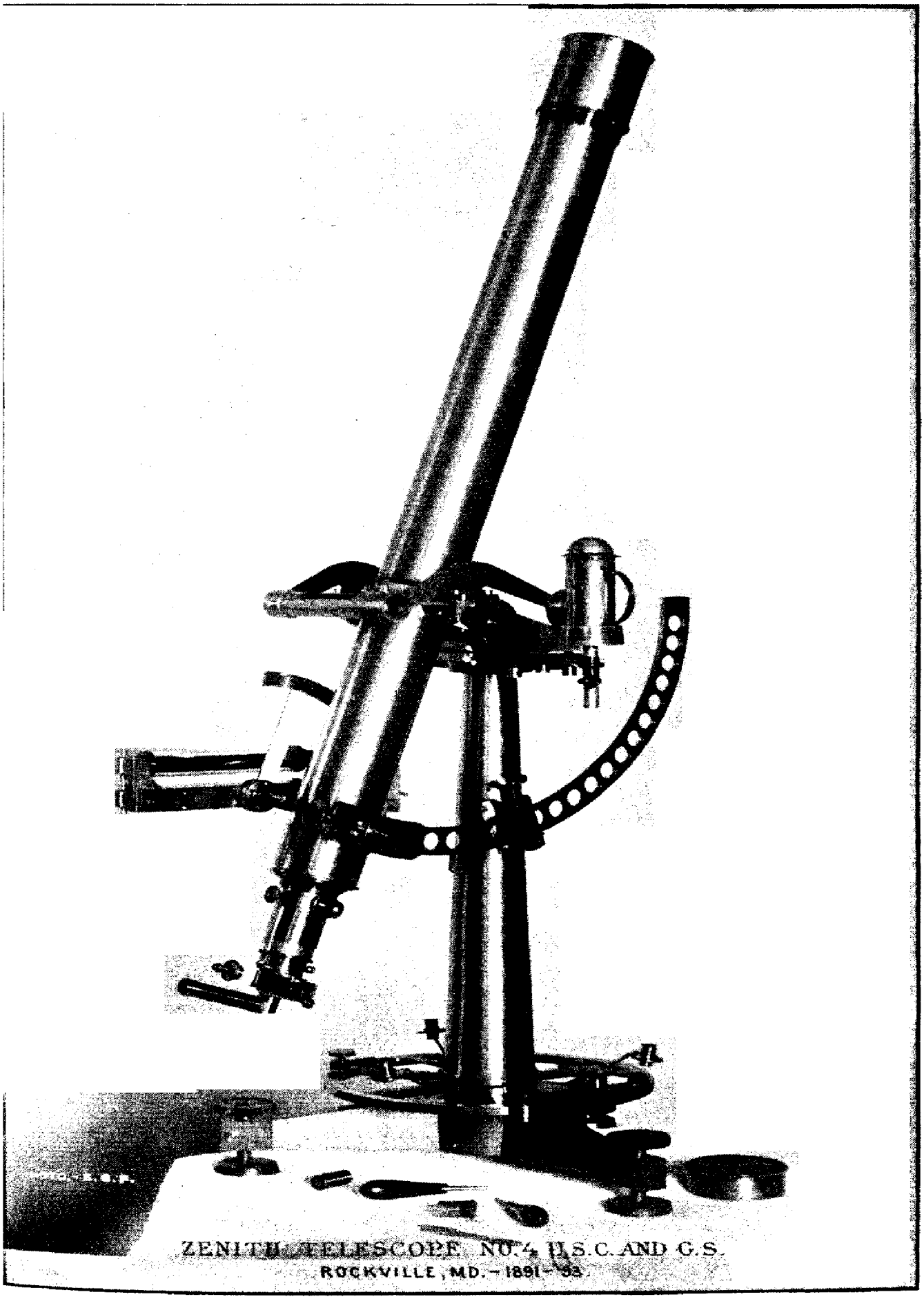
The illumination of the field is by a small mirror, mounted centrally in the horizontal axis, which reflects light received from a small electric lamp through one end of the axis.

Transit No. 5 is also an instrument made by Troughton & Simms in 1849, and remodeled at the Coast and Geodetic Survey Office in 1890. The dimensions and power of the telescope are about the same as those of zenith telescope No. 4. The pivots are so nearly equal that there is no appreciable correction. The value of one division of the stride level is 0·96 second. A similar instrument is illustrated in the Coast and Geodetic Survey Report for 1880, Appendix 14. This instrument was used for the determination of the corrections to the chronometers and also as a collimator for the adjustments of zenith telescope No. 4.

CONSTANTS OF ZENITH TELESCOPE NO. 4.

Levels.—The are values and errors of the level scales were determined and investigated at the Coast and Geodetic Survey Office by Mr. E. G. Fischer, the chief instrument maker of the Coast and Geodetic Survey instrument shop, in May, 1891, and again in January, 1892, at high and low temperatures. The details will appear with the report of the chief of the Computing Division on the computations and results. There was found to be no appreciable difference of value for change of temperature, and the errors of different parts of the scales are so small that mean values are used. These are as follows:

Upper level, 1 div. =1·600 seconds.
Lower level, 1 div. =1·364 seconds.



ZENITH TELESCOPE NO. 4 U.S.C. AND G.S.
ROCKVILLE, MD. - 1891 - '93.

On the variation of latitude at Rockville, Md.

Micrometer.—The true distances between the threads of the micrometer were determined by pointings made with the three threads upon a small speck on the glass diaphragm of the transit. The distances were found to be as follows:

Previous to June 13, 1892,

1 to 2 = 9·9418 revolutions;
1 to 3 = 19·9763 revolutions;
2 to 3 = 10·0345 revolutions;

After June 13, 1892,

1 to 2 = 9·8900 revolutions.

The arc value of the screw was determined and its errors investigated by observing transits of α Ursæ Minoris and λ Ursæ Minoris at eastern and western elongations, only that part of the screw between 20 and 40 revolutions being used. The head of the screw was set successively at 0, 25, 50, and 75 divisions in each of the 20 revolutions. The observations were recorded on the chronograph, three breaks being made at each transit, the mean of which was taken. Thirteen such sets of transits were observed as follows:

June 8, 9, and 10, 1891, on λ Ursæ Minoris at eastern elongation. September 18, 19, 21, 23, and 24, 1891, on α Ursæ Minoris at eastern elongation. January 27, February 22 and 23, and March 3 and 9, 1892, on α Ursæ Minoris at western elongation.

These observations show no appreciable periodic errors in a revolution, but there is an appreciable difference in whole revolutions and also an appreciable correction for temperature. The detailed results will appear in the report of the chief of the Computing Division on the computations and results. The mean arc value of one revolution is $44''·6606 - 0·001159\ t$, t being degrees centigrade.

The equatorial intervals between the vertical threads were determined August 6, by observations of transits of ω Draconis, φ Draconis, η^2 Draconis, and γ Draconis at upper culmination to be

I to II = 8·56 seconds;
II to III = 8·84 seconds.

METHOD OF OBSERVATION.

The collimation of the zenith telescope was frequently examined by pointings on the middle thread of the transit, the zenith telescope being reversed in its wyes. No re-adjustment of the collimation was required up to November 18, 1891. On this date the micrometer box had to be removed and was replaced the same day, and no re-adjustment has been required since.

The azimuth of the zenith telescope when pointing north was frequently examined by pointings upon the micrometer thread of the transit set in the meridian, and when pointing south by transits of

standard stars, the correction to the chronometer being accurately known. The stops required no re-adjustment throughout the whole series except when intentionally removed for observing for value of micrometer. The error of collimation and the deviation of the line of collimation from the meridian have not exceeded one second of time throughout the series.

It was intended to use only that part of the micrometer screw between 20 and 40 revolutions, 30 revolutions being the middle of the field. All pointings between 20 and 40 revolutions were to be made with thread 2, all below 20 revolutions with thread 1, and all above 40 revolutions with thread 3, the extreme limits being 10 to 50 revolutions, so the screw would have been moved only over those revolutions between 20 and 40. This scheme was carried out till November 18, when thread 3 was found to be slack. It was on this date that the micrometer box was removed with the intention of putting in a new thread. On examination at the office a new thread was thought unnecessary, and the micrometer box was replaced as it was. Observations the same night proved thread 3 to be useless and it was abandoned, thread 2 being used in its place.

In the beginning, the method of observation and record usually adopted in the Survey was followed—that is, a single pointing was made on the star when on the meridian, and a single reading of the levels was made after pointing on the star. Beginning on July 27, 1891, the method used at Berlin 1889–'90 was followed as nearly as practicable—that is, the levels were read, three pointings were made on the star near the three vertical threads, and the levels were again read.

Specimen of record.

[Rockville, Md., June 13, 1891. Observer, Edwin Smith.]

No. of pair.	Star No. U.S.C. and G.S. Catalogue.	N. or S.	Micrometer.		Level.		Microm. thread.	Time of culm. by chro. Hutton 202.	Remarks.
			Revs.	Divs.	North.	South.			
								h. m. s.	
1	1148	S.	40	49·0	*39·3	11·7	3	14 05 55	Thermometers :
	1188	N.	19	36·6	11·6	40·3	1	10 06	6287 outside 20°·0 C.
					†98·2	70·0			6288 north 21°·8.
					71·1	99·3			6289 south 22°·0.
2	1198	N.	26	61·8	11·1	40·0	2	15 48	
	1206	S.	33	87·0	39·8	10·7	2	28 11	
					70·9	99·1			
					98·9	70·2			
3	1215	S.	12	57·5	40·8	11·6	1	36 05	
	1220	N.	48	11·7	12·2	41·5	3	39 49	
					99·8	71·1			
					72·1	100·8			

* Upper level. † Lower level.

On the variation of latitude at Rockville, Md.

Specimen of record.

[Rockville, Md., July 27, 1891. Observer, Edwin Smith.]

No. of pair	Star No. U. S. C. and G. S. Catalogue.	N. or S.	Micrometer. Revs.	Micrometer. Divs.	Level. Left.	Level. Right.	Microm. thread.	Time of culm. by chro. Hutton 220.	Remarks.
								h. m. s.	
				86·5					
9	1336	N.	34	86·5	*11·6	42·6			Thermometers:
				84·8	†11·6	42·6	2	15 59 54	6287 outside 16°.6 C.
									6288 north 19°.1.
				0·0	*10·1	41·4			6289 south 19°.5.
	1354	S.	26	1.0	†10·1	41·6	2	16 17 11	
				0·0					Barometers:
					*71·5	101·8			29·645 in. At. Th. 66° F.
					†71·5	101·8			
					*70·0	100·7			
					†70·0	100·7			
				28·5					
10	1360	N.	32	27·5					
				29·5	12·5	44·0	2	20 46	
				54·0	11·1	42·6			
	1367	S.	27	54·8	11·2	42·8	2	25 29	
				54·1					
					72·7	103·4			
					71·0	101·8			
					71·1	101·9			
				62·5					
11	1382	N	31	61·0	10·2	41·9			
				61·0	10·2	41·9	2	33 44	
				5·0	9·3	40·9			
	1386	S.	28	5·8	9·2	40.9	2	36 33	
				6·2					
					70·2	101·1			
					70·2	101.2			
					69·1	100·0			
					69·1	100.0			

* Before bisecting star. † After bisecting star.

Thermometer No. 6288 was hung in the north end and No. 6289 in the south end of the observatory, and No. 6287 in the open air on the east side of the observatory. The barometer was hung in the observatory near the transit. The temperature and pressure of atmosphere, as indicated by these instruments, were noted at the beginning, the middle, and the end of each night's work.

Record of temperature and pressure of atmosphere at Rockville, Md., during observations for latitude.

Date.		Time.		Thermometers.			Barom. reduced to 0° C.
				Outside.	Inside N.	Inside S.	
1891.		*h.*	*m.*	*C.*	*C.*	*C.*	*mm.*
June	13	14	00	+20·2	+21.8	+22·0	
	13	17	32	18·0	18·8	19·0	
	15	14	00	25·5	25·0	26·5	
	15	17	32	23·1	24·1	24·0	
	23	14	58	21·0	22·5	23·5	
	23	18	20	19·5	21·5	21·5	
	24	14	58	19·7	23·0	22·6	
	24	18	00	19·6	20·5	21·0	
	25	15	56	20·5	23·5	23·2	
	25	18	00	19·0	21·5	21·3	
	27	14	58	17·8	19·2	19·5	
	27	18	20	15·5	16·4	16·5	
July	5	14	58	16·8	19·0	19·0	
	5	18	20	13·7	16·0	16·0	
	6	14	58	19·5	23·1	23·0	
	6	18	15	17·5	19·5	19·5	
	9	15	55	16·7	18·4	18·5	
	10	15	55	17·5	20·0	20·0	
	10	18	25	16·4	17·5	17·6	
	10	19	56	15·6	17·0	17·0	
	12	15	55	19·6	22·3	22·3	
	12	19	56	16·8	18·6	18·6	
	21	15	55	21·3	23·8	24.0	
	21	19	55	19·5	21·0	21·0	
	22	15	55	21·5	22·8	23·0	
	22	19	20	20·5	21·0	21·3	
	27	15	55	16·6	19·1	19·5	750.0
	27	18	00	16·6	17·7	18·0	750·5
	27	19	55	16·5	17·5	17·5	750·6
	29	15	55	21·0	23·3	23·4	746·2
	29	18	00	19·5	21·0	21·2	746·4
	29	19	55	18·5	19·8	20·0	746·3
Aug.	7	17	00	23 0	24·8	24·8	750·8
	7	20	35	20·0	21·6	21·8	751·2
	9	17	40	25·5	26·6	26·6	749·2
	9	20	49	22·5	24·5	24·5	749·0
	10	17	00	26·2	27·8	27·6	750·0
	10	20	49	24·5	25·5	25·5	750·2
	11	17	00	24·5	26·5	26·5	748·6
	14	17	28	21·2	22·3	22·5	749·5
	15	17	28	20·0	22·5	22·5	749·5
	15	21	05	16·1	18·5	18·5	750·7
	15	22	33	15·5	17·6	18·0	750·9
	17	18	37	20·0	21·0	21·0	750·3
	22	18	00	23·0	24·5	24·7	745·7
	22	20	12	22.4	23·1	23·2	745·7
Sept.	1	18	37	18·3	19·6	20·0	752.3
	1	21	05	17·5	18·5	19·0	752·5
	1	22	33	16·0	17·5	17·5	752·8
	3	18	37	20·1	21·3	21·5	750·8
	3	21	05	18·4	19·4	19·6	750·8
	3	22	33	17·8	18·5	19·0	750·9
	7	19	00	16·6	18·0	18·0	749·5
	7	21	05	14·5	16·6	17·0	749·9
	9	18	37	13·5	15·5	15·9	757·3
	9	20	35	11·5	13·1	13·5	757·9

Record of temperature and pressure of atmosphere at Rockville, Md., during observations for latitude.

Date.	Time.	Thermometers.			Barom. reduced to 0° C.
		Outside.	Inside N.	Inside S.	
1891.	*h.* *m.*	*C.*	*C.*	*C.*	*mm.*
Sept. 9	22 19	+9·5	+12·8	+12·6	758·0
10	19 00	15·2	16·5	17·0	758·4
10	20 35	13·7	15·2	15·5	758·6
10	23 19	12·0	14·0	14·0	758·4
12	18 37	18·6	19·9	20·2	752·1
12	20 33	16·4	18·0	18·1	752·0
12	23 19	14·4	16·0	16·3	751·5
13	18 37	19·5	21·0	21·4	749·0
14	18 37	15·1	17·0	17·0	750·1
14	20 48	12·8	15·2	15·5	750·5
14	23 27	10·4	13·0	13·0	751·1
15	18 37	19·0	20·6	20·9	749·6
15	21 05	18·0	19·4	19·5	750·7
15	22 33	17·2	18·4	18·5	750·8
17	18 37	22·5	24·0	24.0	756·4
17	20 48	20·2	21·5	21·6	756·6
17	23 36	19·0	20·0	20·1	756·7
18	20 35	20·5	23·5	23·5	752·3
18	22 00	20·0	22·5	22·5	752·0
18	23 36	19·0	21·4	21·5	752·1
19	20 12	19·5	21·6	21·8	752·2
19	22 00	18·5	20·4	20·5	752·7
19	23 20	17·0	19·5	19·5	753·1
21	20 12	20·1	22·0	22·1	751·8
21	22 00	19.1	20·6	20·6	751·9
21	23 20	17·8	20·0	20·0	751·8
23	20 12	22·4	23·8	24·0	751·3
23	22 00	21·0	23·0	23·0	751·5
23	23 20	19·8	21·6	21·7	751·8
24	20 35	19·1	21·0	21·3	754·7
24	22 00	19·0	20·0	20·1	755·1
24	23 20	18·0	19·0	19·5	755·1
25	20 12	20·6	21·6	22·0	752·8
25	22 19	19·5	20·5	20·6	753·0
25	23 20	18·6	20·0	20·3	753·0
26	20 12	22·0	23·5	23·7	752·6
26	22 20	20·6	22·0	22·2	753·0
26	33 20	20·0	21·4	21·5	753·1
28	20 12	19·6	20·5	20·8	753·9
28	22 20	19·3	20·1	20·3	753·8
28	23 20	19·4	20·0	20·0	753·2
30	20 13	11·9	14·1	14·5	757·6
30	22 20	11·3	12·5	13·0	758·1
30	23 20	10·7	12·0	12·3	757·9
Oct. 3	20 13	20·5	22·5	22·6	749·8
3	22 02	18·1	20·5	20·6	749·6
3	23 20	16·5	19·5	19·5	749·0
5	20 13	13·8	15·3	15·5	748·3
5	22 20	13·5	14·6	14·7	749·3
5	23 20	11·9	13·2	13·5	749·7
9	20 13	9·5	10·6	11·0	751·4
9	22 10	8·4	9·5	9·8	751·4
9	23 20	8·4	9·0	9·2	751·4
14	20 13	11·1	12·3	12·5	757·5
14	22 20	9·6	11·0	11·0	747·8
14	23 20	9·6	10·5	10·7	747·7

Record of temperature and pressure of atmosphere at Rockville, Md., during observations for latitude.

Date.	Time.	Thermometers.			Barom. reduced to 0° C.
		Outside.	Inside N.	Inside S.	
1891.	*h.* *m.*	*C.*	*C.*	*C.*	*mm.*
Oct. 14	00 05	+10·6	+10·5	+10·5	747·7
15	20 13	9·0	11·0	11·0	749·2
15	22 10	8·0	9·5	9·5	750·0
15	23 20	6·6	8·5	8·6	750·8
16	20 13	8·1	9·4	9·6	755·6
16	22 20	6·5	7·6	8·0	756·8
16	23 20	6·1	7·1	7·5	756·9
17	20 13	7·5	9·0	9·5	756·4
17	22 10	6·3	7·8	8·0	756·5
17	23 20	5·5	7·0	7·0	756·6
22	22 02	+ 4·6	+ 5·4	+ 5·5	747·0
22	23 20	5·0	5·2	5·4	747·0
23	22 02	5·1	7·0	7·0	748·3
23	23 50	6·0	6·6	6·8	748·4
23	1 30	5·0	5·7	5·8	748·4
24	22 02	7·2	9·0	9·0	746·9
24	23 50	6·5	8·4	8·6	747·7
24	1 40	7·2	8·9	9·0	747·8
28	22 02	4·0	4·5	5·1	757·7
28	23 50	1·1	2·5	3·0	758·4
28	1 30	— 1·1	1·1	1·0	758·9
29	22 02	+ 8·0	8·5	8·3	759·7
29	23 50	6·6	7·4	7·3	759·7
29	1 30	6·0	6·5	6·5	759·6
30	22 02	11·6	12·7	12·5	756·4
30	23 50	11·2	12·0	11·9	756·1
30	1 40	10·1	10·8	10·7	755·6
31	22 02	15.7	16·5	16·2	747·6
Nov. 1	22 02	7·1	7·9	8·0	753·2
1	23 50	5·1	6·1	6·3	754·6
1	1 40	3·3	4·7	5·0	755·3
2	22 02	2·5	3·5	4·0	757·6
2	23 50	— 0·6	1·6	1·6	758·3
2	1 40	0·5	1·1	1·2	758·8
6	22 02	+ 1·0	2·6	2·7	752·5
6	23 50	— 0·2	1·6	1·8	752·4
6	1 40	+ 0·3	1·2	1·5	752·1
7	22 02	4·5	6·1	6·4	750·2
7	23 50	3·1	5·7	5·6	750·1
7	1 40	1·7	4·1	4·3	749·9
9	22 02	9·4	10·1	10·3	752·6
9	23 50	7·5	8·3	8·5	753·1
9	1 30	5·9	6·9	7·0	752·8
17	23 36	— 2·2	— 1·5	— 1·5	752·5
17	1 10	3·1	2·5	2·4	754·3
18	23 36	5·1	4·1	3·9	766·1
18	1 30	6·5	5·3	5·0	766·6
18	3 20	8·1	6·4	6·2	766·9
20	23 36	+ 3·2	+ 4·2	+ 4·5	773·5
20	1 30	3·0	3·9	4·0	768·5
20	3 20	1·9	2·8	3·0	767·3
23	23 36	6·3	7·2	7·2	735·1
23	1 30	5·0	6·0	6·0	736·5
23	3 20	3·6	5·0	5·0	737·2
24	23 36	3·9	4·9	5·0	746·0
24	1 30	2·4	3·6	3·5	747·0

Record of temperature and pressure of atmosphere at Rockville, Md., during observations for latitude.

Date.	Time.	Thermometers.			Barom. reduced to 0° C.
		Outside.	Inside N.	Inside S.	
1891.	*h.* *m.*	*C.*	*C.*	*C.*	*mm.*
Nov. 24	3 20	+1·9	+3·0	+3·4	747·8
29	23 36	— 6.5	— 6·2	— 5·9	756·8
29	1 40	7·5	7·1	6·7	757·1
29	3 20	8·0	7·5	7·4	757·0
30	23 36	4·1	3·0	2·6	758·5
Dec. 1	23 36	+ 0·5	+ 1·2	+ 1·1	757·7
1	1 40	— 1·4	— 0·4	— 0·4	757·6
1	3 20	1·5	0·9	0·6	757·2
4	23 36	+ 6·4	+ 6·9	+ 6·7	746·1
4	1 30	6·3	6·5	6·6	747·8
5	23 36	8·0	8·5	8·2	752·0
5	1 30	6·5	7·3	7·1	751·8
5	3 20	6·0	6·8	6·5	751·8
8	1 21	— 0·1	0·5	0·4	758·9
8	3 25	0·7	0·1	0·0	758·7
8	4 40	1·0	— 0·1	— 0·2	758·4
9	1 21	+ 4·6	+ 6·0	+ 6·0	756·5
9	3 25	3·0	5·1	5·0	756·4
9	4 40	1·8	3·9	4·0	756·4
10	1 21	3·5	6.5	6·5	755·2
10	3 25	3·2	6·5	6·5	755·1
10	4 40	2·4	4·8	5·1	755·1
13	1 21	4·9	6·5	6·2	755·3
13	3 25	2·2	5·0	5·0	755·1
13	4 40	2·5	4·3	4·5	754·6
18	1 21	— 6·9	— 5·5	— 5·3	762·8
18	3 25	5·9	5·5	4·9	762·2
18	4 40	8·0	6·4	6·0	759·5
28	1 21	0·5	+ 0·2	+ 0·1	756·2
28	3 25	1·5	— 0·8	— 0·6	755·9
28	4 40	0·9	0·5	0·5	755·8
30	1 21	+ 1·1	+ 3·0	+ 2·7	757·8
30	3 25	0·4	1·7	1·8	758·8
30	4 40	— 0·2	1·1	1·4	759·2
1892.					
Jan. 7	2 58	7·2	— 6·2	— 6·0	747·8
7	4 40	9·2	7·8	7·4	748·3
7	5 45	11·5	9·0	8·9	748·6
8	2 58	3·2	2·5	2·7	750·7
8	4 40	4·5	3·1	3·0	751·1
16	2 58	8·8	7·4	7·4	762·7
16	4 40	10·5	8·7	8·5	763·0
16	5 45	9·0	8·5	8·3	762·9
20	3 05	10·9	10·2	9·9	756·5
20	4 38	11·7	11·0	10·7	756·3
20	5 45	13·4	12·2	12·0	756·5
21	3 05	2·0	1·0	1·0	756·8
21	4 38	4·5	2·6	2·5	757·1
21	5 45	4·9	3·4	3·4	757·6
24	3 05	+ 0·5	+ 1·8	+ 2·0	743·9
24	4 38	— 0·4	1·0	0·8	743·4
24	5 45	1·0	0·0	0·0	743·3
25	3 05	+ 5·6	7·5	7·8	736·6
25	4 38	5·0	6·0	6·5	736·8
25	5 45	4·0	5·4	5·5	737·0
28	3 05	1·0	3·5	3·5	747·3

Record of temperature and pressure of atmosphere at Rockville., Md. during observations for latitude.

Date.	Time.	Thermometers.			Barom. reduced to 0° C.
		Outside.	Inside N.	Inside S.	
1892.	*h.* *m.*	*C.*	*C.*	*C.*	*mm.*
Jan. 28	4 00	+ 4·7	+ 4·8	+ 4·5	747·3
31	4 17	— 1·8	— 0·5	— 0·5	752·9
31	6 07	1·7	0·8	0·5	753·2
31	8 20	2·0	1·0	1·0	753·1
Feb. 10	4 17	0·6	0·0	0·0	743·5
10	5 17	0·5	0·0	0·0	742·7
13	4 17	3·6	2·7	2·5	746·6
13	6 05	1·6	0·4	0·2	758·0
13	8 17	3·9	1·8	1·6	758·4
17	4 17	5·8	3·8	3·5	763·4
17	7 05	6·7	5·8	5·7	762·7
17	8 17	7·2	5·7	5·7	762·1
Mar. 10	7 05	3·0	2·5	2·0	742·6
10	8 12	3·3	3·0	3·3	742·2
12	7 05	+ 8·3	+ 9·0	+ 9·5	745·4
12	8 35	7·0	8·0	8·3	746·4
14	7 05	— 3·5	— 3·0	— 2·8	755·6
14	8 45	4·5	4·0	3·7	756·5
14	10 28	6·0	5·0	4·9	756·8
16	7 05	7·5	3·8	3·6	756·0
16	8 46	7·8	5·2	5·9	756·2
16	9 25	7·4	5·5	5·4	757.6
19	7 05	0·5	+ 1·0	+ 1·0	745·7
19	8 40	1·3	0·0	0·2	746·8
19	10 25	2·6	— 0·8	— 0·8	746·9
20	7 05	1·4	0·4	0·3	755·4
20	8 40	3·5	2·0	2·0	756·4
20	10 30	3·3	2·5	2·2	756·9
21	7 05	4·8	1·7	1·5	760·7
21	8 53	5·1	3·6	3·5	761·1
21	10 30	6·0	4·5	4·5	760·9
23	7 05	+ 9·0	+10·0	+10·5	747·9
23	8 25	7·2	8·0	8·6	746·9
24	7 05	4·0	5·6	6·0	752·1
24	8 40	3·1	4·5	4·8	752·3
24	9 30	3·0	4·0	4·0	752·1
28	8 25	3·7	4·7	5·0	751·8
28	10 20	3·1	4·0	4·0	752·6
28	12 00	2·0	3·1	3·5	753·3
29	8 25	6·7	7·2	7·6	755·1
29	10 12	5·7	6·1	6·6	755·3
Apr. 4	8 25	20·7	21·6	21·5	748·1
4	10 20	19·0	19·6	19·6	748·1
4	12 12	17·0	18·0	17·8	747·8
9	8 25	0·0	0·6	0·6	745·2
9	10 20	— 0·9	— 0·3	— 0·2	746·3
11	8 25	+ 3·0	+ 4·3	+ 4·5	752·3
11	10 20	1·5	2·5	2·6	752·7
11	12 00	0·0	1·1	1·5	753·0
12	8 25	5·0	6·0	6·1	753·5
12	10 20	2·5	4·0	4·0	754·5
12	12 00	1·6	3·0	3·0	754·6
13	8 25	8·8	11·0	11·0	752·8
13	10 20	7·8	9·9	10·2	752·4
13	10 47	7·5	9·0	9·0	752·3
16	10 17	5·1	6·5	6·9	748·8

Record of temperature and pressure of atmosphere at Rockville, Md., during observations for latitude.

Date.	Time.	Thermometers.			Barom. reduced to 0° C.
		Outside.	Inside N.	Inside S.	
1892.	*h.* *m.*	*C.*	*C.*	*C.*	*mm.*
April 16	12 22	+ 4·4	+ 5·1	+ 5·6	748·8
19	10 17	6·8	8·3	8·5	757·3
19	11 00	7·2	8·1	8·3	757·7
23	10 17	10·6	12·0	11·7	749·9
23	12 22	8·9	10·2	10·1	750·7
23	14 00	7·4	8·6	8·6	751·3
26	10 17	10·0	11·3	11·4	758·7
26	12 17	7·1	9·0	9·5	759·2
26	14 00	5·4	7·8	8·1	759·4
27	10 17	10·6	11·8	12·0	757·5
27	12 22	10·5	10·9	11·0	757·0
29	10 17	9·5	10·9	11·0	752·3
30	10 17	13·9	15·1	15·0	756·9
30	12 22	10·7	11·8	12·0	757·3
30	14 00	10·1	10·9	10·6	757·1
May 1	10 17	20·5	21·0	21·0	748·6
3	12 22	21·6	22·5	22·4	747·5
3	13 53	21·0	21·8	21·6	747·0
4	10 40	23·2	25·4	25·2	751·2
4	12 22	21·0	23·1	23·0	752·1
4	13 40	21·1	22·5	22·4	752·2
5	10 17	17·7	17·8	18·0	751·3
5	12 22	15·1	15·6	15·9	750·9
5	14 12	13·8	14·3	14·4	750·1
7	10 17	13·5	14·5	14·6	748·3
7	12 22	11·0	11·9	12·0	749·8
7	14 12	9·1	10·0	10·3	750·4
8	10 17	12·1	13·9	13·6	754·6
8	14 00	9·9	10·3	10·7	755·9
9	10 17	15·5	18·9	18·5	753·5
9	12 22	14·8	16·4	16·5	753·9
9	14 12	12·5	14·0	14·0	753·8
16	12 10	17·5	18·5	19·0	752·4
16	14 00	16·4	17·2	17·5	753·3
16	15 50	13·6	15·1	15·5	753·9
17	12 10	17·1	18·0	18·1	752·5
17	13 55	15·0	15·9	16·0	752·3
17	15 25	14·1	15·0	15·0	752·0
19	12 10	13·1	14·6	14·8	740·2
23	12 10	8·1	10·0	10·0	742·5
23	13 55	6·6	8·5	8·7	743·5
23	15 48	5·8	7·2	7·4	744·2
24	12 10	13·6	15·9	16·0	748·3
24	15 58	12·1	13·0	13·0	748·6
25	12 10	20·0	20·9	20·9	744·8
25	15 58	17·2	18·0	18·0	744·8
28	12 10	14·4	15·6	16·0	748·5
28	14 30	12·8	13·5	13·5	749·0
28	15 58	11·9	12·5	12·5	749·1
30	12 10	21·6	23·2	23·0	750·8
30	14 00	20·0	21·0	21·1	751·4
30	15 48	18·6	19·5	19·7	751·3
June 1	12 10	24·0	24·8	24·7	752·5
1	14 00	22·0	22·6	22·7	752·9
1	15 48	20·5	21·5	21·5	752·6
2	14 00	23·2	23·7	23·5	749·3

Record of temperature and pressure of atmosphere at Rockville, Md., during observations for latitude.

Date.	Time.	Thermometers.			Barom. reduced to 0° C.
		Outside.	Inside N.	Inside S.	
1892.	*h.* *m.*	*C.*	*C.*	*C.*	*mm.*
June 2	15 48	+21·5	+22·2	+22·3	749·3
2	17 30	21·0	21·8	21·9	749·4
6	14 00	21·0	23·0	23·0	749·6
6	15 48	19·8	21·5	21·5	749·5
6	17 30	18·8	20·6	20·8	749·2
11	14 00	17·3	19·1	19·4	750·2
11	15 48	15·4	17·1	17·3	750·5
11	18 08	14·0	16·0	16·0	750·5
12	14 00	21·2	23·1	23·0	750·4
12	16 02	20·5	22·0	22·0	750·8
12	18 18	19·5	20·8	20·9	750·3
13	14 00	25·1	26·2	26·1	750·2
13	16 02	22·8	23·9	23·9	750·1
13	17 30	21·6	22·5	22·5	749·7
15	14 00	23·0	24·4	24·5	750·0
15	16 02	21·1	22·4	22·5	750·8
15	17 12	20·3	21·5	20·7	750·9
16	14 00	24·6	25·2	25·2	751·3
17	14 00	21·8	23·0	23·0	751·4
17	16 20	20·3	21·6	21·8	751·8
20	14 00	23·5	24·5	24·7	744·7
20	16 02	22·3	23·5	23·6	745·0
20	18 18	21·4	22·5	22·5	744·9
21	14 00	25·5	27·1	27·0	744·1
23	14 00	25·6	27·8	27·5	744·2
23	16 20	24·2	25·5	25·5	743·9
23	18 18	24·0	25·0	25·0	744·9
25	14 00	21·1	23·5	23·5	748·2
25	17 02	17·6	20·0	20·1	749·7
25	17 30	17·8	19·1	19·4	749·8
26	14 00	22·1	23·5	23·6	747·9
26	15 24	21·0	22·0	22·2	748·1
29	14 30	23·1	23·9	23·9	747·8
29	16 02	22·0	22·6	22·6	748·3
29	18 17	21·2	22·0	22·1	748·5
July 7	14 58	18·0	20·6	20·6	759·4
7	16 48	16·6	18·3	18·5	759·8
7	18 00	16·1	17·0	17·2	759·9
8	14 58	20·1	22·1	22·1	755·1
8	16 48	18·1	19·8	19·9	754·9
8	18 00	17·0	18·6	18·7	744·8
9	14 58	21·1	22·6	22·7	752·7
9	16 48	19·7	20·7	20·6	753·2
9	18 00	18·6	20·0	20·0	753·1

No lights were used in the observing room other than the small electric lamps for illuminating the field of the telescope, and the small electric hand lamps used for reading the micrometer, levels, setting, etc. These lamps were arranged with spring contacts, by pressing which the lamps were illuminated only for the time actually necessary. A dim illumination of the observing room was obtained from a lamp in the recording room, showing through a small window in a partition

separating the two rooms. Every precaution was taken to avoid any sudden change of temperature in the zenith telescope.

The first observations for latitude were made June 13, 1891, and the last July 9, 1892. In the whole series 1808 observations were made on 146 nights. On many of these nights the observations were very much broken on account of clouds, there being only 89 nights upon which complete groups were observed. No serious difficulties were encountered during these observations up to April 30, on which date the level readings were very wild. On May 4 it was discovered that the observatory had settled to such an extent that the casing about the pier rested against it. This difficulty was immediately remedied. The twelve observations of April 30, the four of May 1, and the first three of May 4 have to be rejected.

On June 13, 1892, it was necessary to strengthen the springs of the micrometer, to do which the slide carrying the spider webs had to be removed. The computation of observations subsequent to that date developed a discrepancy in the results from pairs in which one star was observed with thread 1 and the other star with thread 2. An investigation of the distance between threads 1 and 2 on August 24 and 26 developed the fact that the relation of these threads must have been disturbed on June 13. The distances between these threads before and after June 13, 1892, have already been given.

II.—REDUCTION OF THE OBSERVATIONS AND DISCUSSION OF THE RESULTS BY CHARLES A. SCHOTT, ASSISTANT U. S. COAST AND GEODETIC SURVEY.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY,
September 28, 1892.

The results of the astronomical observations, specially made for the last three years, at several places in the northern hemisphere, for the purpose of inquiring into the supposed variation of the geographical latitude, and for investigating its laws of change, leave no further doubt of the fact that the latitude of a place is slightly variable. The phenomenon, as deduced from observations in Europe, in North America, and the Hawaiian Islands, indicates a periodic variation such as would be produced by the revolution of the axis of rotation about that of the earth's figure.

The length of the period, which was found to disagree with the Eulerian period of about 306 days, was first worked out by Dr. Chandler,* who made it variable, and at present increasing, and assigned to it 427 days, nearly, for the epoch 1875; on the other hand Prof. Newcomb's researches† point to a uniform rotation with a constant length of 430 days, nearly, as deduced from observations between 1865 and

* Gould's Astronomical Journal No. 267.
† Astronomische Nachrichten No. 3097.

1891. Further, according to the former investigator, the half range of the variation is 0″·22, whereas the latter suspects the radius of the circle described by the instantaneous pole of rotation to be on the increase, the Berlin observations for 1890 indicating 0″·30.

The direction of motion is necessarily from west to east, and the lengthening out of the period from 306 to 430 days is ascribed to the earth's elastic yielding, the Eulerian period demanding an absolutely rigid body.

The assistance afforded by the Survey for the elucidation of the phenomenon consists in the occupation of three stations at which latitude observations were to be made by means of the zenith telescope (Talcott's method) on every favorable or desirable night, and continued over a space of at least one year. These stations are Rockville, Md. (near Washington, D. C.), San Francisco, Cal., and Waikiki (near Honolulu), Hawaiian Islands. The observations at Rockville, which are here discussed, cover the period between June, 1891, and July, 1892.

The position of the latitude station at Rockville was connected, in the summer of 1892, by Mr. J. B. Boutelle, by triangulation with the transcontinental arc of the parallel, and its geodetic coördinates are as follows: Latitude 39° 05′ 11″·21; longitude 77° 09′ 36″·65 W. from Greenwich; hence it is about 15½ statute miles or about 25 kilometres N. 29° W. (true) from Washington, D. C. We have longitude of Rockville $5^h\ 08^m\ 38^s$ W., and longitude of Berlin $0^h\ 53^m\ 35^s$ E.; hence Rockville west of Berlin $6^h\ 02^m\ 13^s$. The astronomical latitude is 39° 05′ 10″·47, nearly, indicating a local deflection in the meridian of $A. - G. = -0''.74$.

The Rockville station was placed in charge of Edwin Smith, Assistant Coast and Geodetic Survey, by whom all observations were made. Between June 13, 1891, and July 9, 1892, nearly 1800 individual measures for latitude were secured on 146 nights. Early in January, 1892, these records were placed in my hands for reduction and report, and the temporary services of two computers, Mr. A. Bonnot and Mr. L. W. Reid, were specially provided for the computation of the apparent places of the 88 pairs of stars involved. Their mean places are due to Mr. H. Farquhar of the Computing Division.

The mean north polar distances of the stars depend on the places assigned to them in the principal and other available catalogues, corrected for their known systematic errors, following Boss's system, and are specially discussed with respect to the value of the catalogue itself as well as to the number of observations involved. The mean places are thus closely connected with Boss's system; the proper motions were independently discussed by the method of least squares after each star's N. P. D., found in the several catalogues, had been referred to the epoch 1891·0; the proper motions depend on special investigation, except in the case of Bradley-Auwers stars, of which the given

proper motion was adopted unless found capable of improvement. Respecting weights Mr. Farquhar makes the following statement:*

"Combination weights used for adopted polar distances in Rockville latitude list: Twenty catalogues used in computing latitudes on this Survey were tested and their probable errors reported in June, 1890. These results were made the basis of the following series of weights; the unit of weight corresponding to a probable error of $\pm \sqrt{0.1}''$ and the ratio of observation error to systematic error being taken (for all catalogues alike) $= \sqrt{5}$, so that if w_∞ be the weight of an infinite number of observations and w_1 of one, $w = \frac{n}{n+5} w_\infty = \frac{6n}{n+5} w_1$.

"The weight of no polar distance therefore can exceed six times that of a single observation, given in the table below:

Catalogue.	w_1
Lalande δ, Weisse-Bessel ε,	0·015
d'Agelet α, Piazzi β,	·02
Rümker ε,	·025
Taylor β,	·04
Groombridge β,	·06
Armagh '75,	·07
Armagh '40, Jacob β, Smyth β,	·08
Auwers-Bradley α, Paris '45, Main β, Glasgow, Cape '40 ε,	·09
Radcliffe '60,	·10
Radcliffe '45,	·12
Pond β, Cambridge '30 β, Greenwich 6 y.	·14
Washington,	·16
Cape '50 ε, Bonn β, Paris '60, Rome,	·18
Paris '75,	·20
Henderson, Greenwich 7y1, Melb. β, Cape '80 ε, Ann Arb. ε,	·25
Struve Pos. M. β Greenwich 12y (1 + 2), Brussels, Becker ε,	·3
Pulkowa Merid. Circle, Greenwich 7y2, Cordoba γ,	·35
Abo β, Harv. '85 ε,	·4
Greenwich 9y., Harv. '75,	·5
Leiden β,	·6
Romberg α,	·7
Pulkowa Vert. Circle β, Greenwich 10y,	·8

"In this table weights were deduced for catalogues marked:

"α..... from probable errors of observation given in the prefaces to the catalogues.

"β..... from Boss's investigations, $\frac{2}{3}$ of his weights being taken—*i. e.*, his unit being supposed to correspond to a probable error of $\pm \sqrt{0.15}''$.

"γ..... from a determination of systematic error by myself, using Boss's method.

"δ..... from determination of observation error by myself and formula above as in (α).

"ε..... from simple estimate, the places being too few for better methods.

* Under date of September 12, 1892.

"Others from the results obtained in 1890.

"Piazzi, Taylor, Jacob, Main, and a few others used by Safford, I have to take at second hand, being without the originals. For stars of the Berliner Jahrbuch, Dr. Auwers's combination of the authorities used by him was usually accepted, $\frac{5}{6}$ of his total weights being allowed them (*i. e.*, his probable error taken $= \pm \sqrt{0.16}''$ for $w = 1$) and the weights of this table used for the remaining authorities."

The resulting mean N. P. D.'s of the stars composing the 88 pairs observed for latitude of Rockville are given below. The first column gives the star's number in the Coast Survey Field Catalogue (Appendix No. 7, Report for 1876), the second column its number in the British Association Catalogue (London, 1845); column 4 contains the square of the probable error (e^2), and the last column the proper motion (μ'):

No. in—		Mean N. P. D. for 1891·0.				e^2	μ'
C. and G. S. Catalogue.	B. A. Catalogue.	°	′	″			″
1184	4706	64	23	30·66		·02	+0·076
1188	4726	37	42	0·85		·02	+0·016
1198	4758	50	42	18·25		·07	+0·030
1206	4812	51	12	53·21		·01	—0·149
1215	4847	73	6	50·99		·01	—0·005
1220	4874	28	16	24·45		·02	+0·036
1231	4906	52	16	50·06		·04	—0·090
1241	4958	49	10	45·54		·01	+0·043
1247	4980	41	25	39·94		·03	—0·023
1254	5031	60	25	51·42		·04	—0·019
1262	5071	37	38	55·92		·08	+0·004
1275	------	64	31	7·10		·06	+0·021
1278	5122	48	47	42·79		·01	+0·014
1280	5130	48	43	50·00		·02	+0·014
1294	5178	53	0	{32·81}{36·06}	35·08	·02	—0·007
1316	------	30	5	49·84		·05	+0·032
1330	5315	71	52	48·38		·04	—0·146
1336	5348	31	8	36·71		·02	—0·345
1354	5466	70	35	26·17		·02	—0·036
1360	5511	13	59	37·42		·02	—0·258
1367	5520	87	46	37·98		·01	+0·093
1381	5574	36	52	50·85		·03	—0·024
1382	5575	36	51	{22·88}{24·44}	23·30	·04	—0·024
1386	5597	64	55	50·59		·07	+0·003
1392	5628	25	12	15·39		·03	+0·012
1397	5647	76	32	52·10		·05	—0·001
1407	5740	24	41	55·28		·03	—0·047
1418	5765	77	6	32·80		·02	+0·018
1424	------	49	5	10·64		·05	—0·007
1432	5834	53	4	4·40		·02	+0·009

Results of observations for the variation of latitude at Rockville, Md.

No. in—		Mean N. P. D. for 1891·0.				ϵ^2	μ'
C. and G. S. Catalogue.	B. A. Catalogue.	°	′	″			″
1442	5860	65	23	30·05		·03	+0·004
1448	------	36	28	32·50		·12	—0·02
1456	5918	31	15	24·79		·07	—0·021
1462	------	70	39	50·59		·06	+0·096
1473	5978	28	2	30·80		·03	+0·500
1476	5991	73	59	48·64		·05	—0·099
1502	6079	33	6	36·59		·01	—0·070
1514	6106	68	24	14·01 13·09	13·55	·04	—0·015
1539	6203	47	52	39·70		·03	+0·008
1547	6235	53	59	4·06		·05	—0·020
1589	6404	48	40	31·69		·04	+0·025
------	6456	53	9	51·90		·03	+0·010
1608	6466	53	14	22·67		·04	—0·006
1628	6520	43	13	10·60		·04	+0·092
1641	6571	58	53	53·65		·03	+0·009
1648	6582	68	57	29·31		·09	—0·005
1666	6640	32	33	39·71		·05	0·000
1676	6667	53	54	1·94		·03	—0·007
1690	6718	47	49	34·00		·04	+0·035
1718	6794	71	7	51·56		·04	—0·021
1741	6852	30	34	46·23		·04	—0·045
1756	6895	40	11	54·87		·02	+0·005
1779	6957	61	38	7·21		·04	+0·045
1801	7022	50	5	31·34		·01	+0·003
1809	7061	51	55	2·74		·04	+0·052
1819	----	38	3	40·80		·04	—0·067
1825	7126	63	55	2·22		·03	+0·024
1852	7211	23	44	20·15		·03	—0·023
1859	7223	77	51	43·69		·04	—0·086
1885	7301	42	54	16·44		·03	+0·014
1896	----	59	15	8·85		·08	—0·02
1917	----	57	51	0·80		·05	0·00
1926	7455	43	45	27·45		·12	—0·049
1948	7542	28	24	35·33		·02	+0·016
1959	7567	73	8	59·42		·04	+0·017
1968	7598	41	11	41·19		·01	+0·016
1971	7607	60	19	59·67		·04	+0·039
1974	7627	64	35	15·46		·02	+0·014
1984	7676	37	38	35·92		·05	+0·007
2004	7749	32	20	9·75		·03	+0·007
2020	7807	69	42	9·09		·03	+0·031
2026	----	50	44	43·80		·05	+0·018
----	7879	50	56	9·58		·10	+0·026
2043	7880	50	55	47·40		·08	+0·026
2047	7901	51	31	1·27		·02	+0·012

No. in—		Mean N. P. D. for 1891·0.				ϵ^2		μ'
C. and G. S. Catalogue.	B. A. Catalogue.	°	′	″				″
2055	7915	50	20	37·77		·04		+0·008
2059	7932	48	45	10·10		·03		—0·002
2063	----	53	9	23·88		·40		+0·053
2070	7972	47	16	1·36		·03		—0·009
2078	----	54	13	48·04		·06		—0·008
2093	8039	23	22	42·09		·02		—0·010
2121	8149	78	17	1·32		·03		+0·032
2131	----	61	56	5·34		·14		+0·020
2142	8231	40	7	54·98		·03		+0·012
2154	----	33	9	14·73		·14		+0·05
2159	8296	68	56	6·77		·08		+0·030
2178	8366	29	17	34·57		·07		—0·003
4	8	72	23	38·40		·04		+0·035
10	28	49	33	59·11		·04		+0·142
22	67	52	38	6·84		·02		+0·038
27	102	74	9	27·84		·07		+0·023
32	126	27	40	11·72		·01		+0·009
45	166	59	44	8·13		·01		+0·093
55	198	42	18	44·41		·01		+0·014
66	227	49	30	53·36		·03		+0·021
77	259	52	5	31·38		·01		—0·020
93	314	35	36	52·88		·02		+1·561
111	365	65	59	37·17		·05		+0·030
134	456	31	19	39·54		·03		+0·026
150	523	70	15	41·89		·03		+0·678
176	614	36	2	23·22		·03		+0·010
196	693	65	27	45·30		·09		+0·097
202	710	61	51	39·23		·03		+0·018
208	735	40	12	54·52		·02		+0·025
220	786	55	47	17·27		·03		+0·051
232	829	46	10	0·47		·04		+0·017
242	870	72	59	21·78		·04		+0·012
250	----	28	55	27·56		·05		—0·04
259	918	38	4	56·43		·03		+0·033
263	941	63	58	10·56		·04		+0·017
					[For 1892·0]			
275	974	61	20	23·65	9·70	·03		+0·038
287	1007	40	10	39·86	26·40	·04		+0·031
292	1025	61	20	50·62	37·36	·05		+0·039
297	1043	40	31	38·65	25·57	·02		+0·037
306	1062	31	29	59·40	46·59	·04	·05	—0·007
331	1135	70	38	57·43	45·67	·03		+0·019
370	1253	66	11	40·98	30·81	·05		+0·022
378	----	35	27	37·24	27·40	·14	·16	+0·13
392	1286	28	25	29·14	19·69	·03		+0·013
417	1350	73	28	39·99	31·35	·07		+0·036
430	----	59	52	52·47	44·20	·08		+0·04
456	----	41	54	42·94	35·58	·05		+0·043

Results of observations for the variation of latitude at Rockville, Md.

No. in—		Mean N. P. D. for 1891–1892.				ϵ^2		μ
C. and G. S. Catalogue.	B. A. Catalogue.	°	′	″	″			″
463	1449	67	15	0·96	2·77	·02		+0·021
479	1494	34	55	18·22	11·88	·05		+0·011
483	1504	36	25	23·44	17·28	·03		—0·009
491	1528	65	7	6·91	1·07	·03		+0·061
512	1591	74	32		27·84		·05	+0·005
520	----	27	27		45·89		·12	-------
531	----	49	4		39·24		1·20	—0·015
533	1663	52	42		58·36		·04	+0·012
562	1751	24	21		43·20		·05	+0·039
577	1846	77	23		0·56		·09	+0·024
606	----	60	28		47·07		·12	0·000
611	1963	41	16		4·66		·07	+0·068
700	2381	48	55		32·27		·01	+0·001
705	2416	53	2		12·80		·04	+0·023
718	2464	58	0		4·50		·02	—0·180
729	2488	43	34		56·49		·07	+6·040
745	2558	71	13		36·87		·04	+0·056
757	----	30	39		36·86		·03	—0·012
769	2707	21	12		31·62		·03	—0·003
776	2778	80	28		55·31		·02	+0·055
781	2792	36	25		58·91		·09	+0·103
792	2850	65	33		18·70		·03	+0·071
796	2876	24	36		23·38		·05	—0·097
804	2942	76	55		56·04		·04	+0·004
813	2982	27	38		3·45		·01	—0·017
825	3047	74	15		48·68		·04	—0·020
835	3087	22	41		37·39		·03	+0·043
842	3111	78	53		50·88		·03	+0·005
849	3140	35	31		57·07		·04	—0·066
865	3246	66	33		21·79		·02	+0·040
873	3273	58	21		16·88		·20	+0·05
888	3341	43	28		34·31		·02	+0·098
911	3505	46	32		47·68		·01	+0·047
921	3542	55	32		48·82		·09	+0·020
926	3572	52	44		22·43		·01	+0.104
932	3607	49	1		8·42		·05	+0·016
936	3639	35	46		5·50		·10	+0·082
945	3671	66	14		47·00		·03	—0·014
952	----	36	51 55		39·76 19·29		·04	+0·034 +0·064
958	3742	64	40		27·70		·02	+0·015
966	2767	33	2		19·71		·01	—0·030
976	3834	68	53		4·78		·01	+0·137
1003	3964	68	2		50·83		·04	+0·061
1010	3985	33	46		15·23		·04	+0·025
1022	4052	82	47		0·54		·03	+0·031
1035	4122	19	11		55·77		·04	+0·022

No. in—		Mean N. P. D. for 1892·0.	e^2	μ'
C. and G. S. Catalogue.	B. A. Catalogue.			
		° ′ ″		″
1044	4148	40 24 58·75	.07	—0·004
1057	4195	61 7 52·42	.01	+0·085
1063	4216	31 0 0·27	·02	—0·087
1070	{4241 / 4242}	71 1 {41·42 / 42·08}	·03	—0·019
1094	4335	33 27 14·38	·01	+0·016
1109	4387	68 16 1·65	·03	+0·056
1118	4433	49 16 30·69	·03	—0·008
1128	4479	52 24 7·21	·05	—0·001
1137	4526	65 5 31·95	·30	+0·19
1149	4564	36 31 57·68	·07	—0·059
1162	4607	40 8 51·39	·02	+0·018
1175	4656	61 58 41·65	·02	+0·057

For star [1819] C. and G. S. Catalogue, the catalogues contained no late determinations, but observations of it were found at six Coast Survey stations, which furnished the means of deducing for it a satisfactory place.

To secure accuracy in the apparent places two independent computations were made, the computers using the independent star (or day) numbers contained in the American Ephemeris and Nautical Almanac.

The instrumental constants are as follows:

Equatorial interval of vertical threads of diaphragm, I to II = $8^s{\cdot}56$ and of II to III = $8^s{\cdot}84$, thread II representing the line of collimation. The value of $I = i \sec. \delta$, where $i = 8^s{\cdot}7$, was tabulated for different values of δ to be used in connection with the usual table for the reduction to meridian.

Level values, recapitulation of results from the several sets of observations.

Level No. 7, the upper level, as attached to the telescope is graduated from 0 to 50 divisions. Two sets of observations on each date were made with a level trier, the bubble being made to traverse with forward and backward motion. The results are:

	″	°
January 11, 1892	1 division = 1·632 at	— 0·4 C.
12, 1892	1·640	+ 9·6
May 22, 1891	1·547	+ 23·9
January 13, 1892	1·589	+ 37·9
Mean	1·600	+ 17·8
	± 14	

N. B.—Two sets made May 19, 1892, at 38°·0 C. gave 1 division = 1″·632, but the tube was thought not sufficiently protected.

Results of observations for the variation of latitude at Rockville, Md.

Similarly we have for level No. 13, the lower level, graduated from 60 to 110 divisions:

		1 division =	″		°
January	11, 1892		1·393	at —	0·4 C.
	12, 13, 1892		1·374	+	9·6
May	18, 1891		1·342	+	19·2
January	13, 1892		1·348	+	37·9
Mean			1·361	+	16·6
			± 8		

N. B.—A series of observations made on the same day as above (May 19) was rejected for like reason.

In the latitude reduction the average value or 1″·482 ± 0″·010 was used irrespective of the temperature, changes of which apparently do not sensibly affect the value. As each level was read twice before and after reversal of telescope, any error of reading could readily be detected.

The investigation of the value of the micrometer screw.—A large number of observations were made to determine the value and irregularities of the screw. This was the more demanded since the sums of the micrometer corrections to the latitude do not exactly balance in the several groups. Observations were made about the time of elongation of the star, and for that part of the screw contained between 20 and 40 turns, also for $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ turns. Corrections were applied for deviations from the mean state of level during a series of observations, also for curvature*, but not for rate of chronometer, which was too small to have any effect. The correction for differential refraction was applied.

Date.	Star.	Elongation.	Whole turns and fractions.	Temperature.	Value of one turn.	Probable error.	Relative weight p.	No. of set.
				°	″	″		
1891, June 8	λ Urs. Min.	E.	$\frac{1}{4}$ to $\frac{1}{4}$	+16·5 C.	44·641	±0·008	2	1
9	λ Urs. Min.	E.	$\frac{1}{4}$ to $\frac{1}{4}$	+20·5	·660	8	2	2
10	λ Urs. Min.	E.	$\frac{1}{4}$ to $\frac{1}{4}$	+21·0	·616	4	2	3
Sept. 18	α Urs. Min.	E.	$\frac{1}{2}$ to $\frac{1}{2}$	+24·5	·637	9	1	4
19	α Urs. Min.	E.	$\frac{1}{2}$ to $\frac{1}{2}$	+21·7	·632	9	1	5
21	α Urs. Min.	E.	$\frac{1}{4}$ to $\frac{1}{4}$	+23·3	·613	5	2	6
23	α Urs. Min.	E.	$\frac{1}{2}$ to $\frac{1}{2}$	+25·0	·660	11	1	7
24	α Urs. Min.	E.	$\frac{1}{2}$ to $\frac{1}{2}$	+22·0	·653	8	1	8
1892, Jan. 27	α Urs. Min.	W.	$\frac{1}{2}$ to $\frac{1}{2}$	— 7·0	·740	10	0	
Feb. 22	α Urs. Min.	W.	$\frac{1}{2}$ to $\frac{1}{2}$	+ 2·9	·683	10	1	9
23	α Urs. Min.	W.	$\frac{1}{4}$ to $\frac{1}{4}$	+ 0·4	·666	6	2	10
Mar. 3	α Urs. Min.	W.	$\frac{1}{4}$ to $\frac{1}{4}$	+ 1·9	·653	4	2	11
9	α Urs. Min.	W.	$\frac{1}{4}$ to $\frac{1}{4}$	+ 7·6	44·634	±0·005	2	12

* A table was used for the various values of $\frac{1}{6}(15 \sin 1'')^2 \tau^3$

When these values for one turn at the several temperatures were plotted they indicated a dependence on t and t^2. They were treated

accordingly, and the expression for value of one turn or revolution of the screw or $R = 44''{\cdot}6773 - 0{\cdot}00865\ t + 0{\cdot}000311\ t^2$ was found to represent the above tabular values, but when applied for the reduction of the latitude observations made at *low* temperature the formula failed to be satisfactory. It became evident that the micrometer observations made at the temperature $-7^{\circ}{\cdot}0$ C. had to be rejected, though not suspected at the time. The 12 conditional and 2 normal equations were then formed anew, whence the final value $R = 44''{\cdot}6606 - 0{\cdot}001150\ t$. It represents the observations as follows:

Set.	R observed.	R computed.	C.—O.
	//	//	//
1	44·641	44·642	+·001
2	·660	·637	—·023
3	·616	·636	+·020
4	·637	·632	—·005
5	·632	·636	+·004
6	·613	·634	+·021
7	·660	·632	—·028
8	·653	·635	—·018
9	·683	·657	—·026
10	·666	·660	—·006
11	·653	·658	+·005
12	·634	·652	+·018

The probable error of an observation of unit weight is

$$\cdot 675\sqrt{\frac{\cdot 005337}{12-1}} = \pm 0''{\cdot}015$$

and the probable error of resulting value of R,

$$\frac{0{\cdot}015}{\sqrt{19}} = \pm 0''{\cdot}0034.$$

It may be remarked that the screw has 100 threads to the inch, or to 2.540 cm.; hence one turn moves the thread $\frac{1}{4}$ mm. and one division corresponds to a linear move of 0·0025 mm.

Investigation of the progressive and periodic inequalities of the screw.— The value of the screw for the successive intervals $40 - 30$, $39\frac{3}{4} - 29\frac{3}{4}$, $39\frac{1}{2} - 29\frac{1}{2}$, $39\frac{1}{4} - 29\frac{1}{4}$, $39 - 29$ turns, etc., gave the above average value of R for the whole screw from turn 20 to turn 40; hence, by comparing this value with the individual values at the different parts of the screw, reckoned from its middle, and taking means of corresponding values for all the sets available, we get the following corrections:

Results of observations for the variation of latitude at Rockville, Md.

Turns.	Divisions.	Adopted correction.	Turns.	Divisions.	Adopted correction.
		″			″
At 40	+0·2	+.09	At 30	+·05	+·13
39	+0·1	.00	29	+·01	+·18
38	—0·3	—.04	28	+0·7	+·18
37	—0·1	.00	27	+0·3	+·13
36	0·0	+·04	26	—0.2	+·13
35	+0·3	+·04	25	+0·4	+·09
34	0·0	·00	24	+0·1	+·04
33	—0·3	—·04	23	+0·0	—·04
32	—0·1	—·04	22	—0·8	—·13
31	—0·2	+·04	21	—0·6	—·22
--	-----	-----	20	—0·8	—·31

The adopted corrections are simply the smoothed out values of the preceding column converted to seconds of arc. Thus between 40 and 30 turns the screw is quite perfect, but less so towards the other end.

The micrometer reduction to the latitude includes this correction.

Periodic inequality of the screw.—A discussion of the measures of quarter, half, and three-quarter turns, indicated that any periodic inequality of the screw was too small to be detected with certainty from the material on hand; the mean correction from 13 determinations at any of the above fractional turns would not amount to 0″·02.

Intervals of the micrometer threads 1, 2, *and* 3.—The part of the screw utilized in the latitude work generally falls between turns 20 and 40, but for larger micrometric differences the fixed threads 1 or 3 were employed instead of 2, the middle thread. By means of a collimator a series of measures of the intervals was made with the following results:

September 21, 1891.	Turns and divisions.	″
Space between threads 1 and 2	9 94·18	Diff. from 10 whole turns 2·60
Space between threads 1 and 3	19 97·63	Diff. from 20 whole turns 1·06
Space between threads 2 and 3	10 03·45	Diff. from 10 whole turns 1·54

Thread 3 was found unsatisfactory, it being slack and dragging on the vertical threads, and was soon abandoned. About June 12, 1892, the spring holding the micrometer slide became weak; the slide was therefore removed. The space 1 to 2 was found to have changed in consequence, and was redetermined August 24 and 26, 1892. The weighted mean of six sets of measures gave the value 4″·91 for the difference from ten turns, which quantity was used after June 12, 1892.

The reduction of the observations for latitude was made in the usual way, checked, scrutinized, and results tabulated. A few obvious misreadings of the whole turns or other similar errors were corrected and a few observations with results too wide from the truth for a possible error of measure were rejected with the consent of the observer. In all, 1789 individual results for latitude were secured. These are given in the following table:

Results for latitude of

[39° 05′ + tab

Pair No ...		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
C. and G. / S. Cat.		1184 / 1188	1198 / 1206	1215 / 1220	1231 / 1241	1247 / 1254	1262 / 1275	1280 / 1294	1316 / 1330	1336 / 1354	1360 / 1367	1382 / 1386
1891.												
June	13	9·57	10·22	10·71	10·77	9·84	9·96	10·91	10·23	10·50	10·85	10·85
	15	9·46	10·50	10·36	10·65	-- --	10·32	11·13	10·28	10·64	10·85	10·76
	23					10·33	10·54	10·90	10·24	11·04	10·74	-- --
	24					9·83	10·32	11·50	10·78	11·30	10·95	10·94
	25					10·48	10·31	11·27	10·49	11·02	10·67	10·99
	27					11·13	11·30	11·36	10·66	10·93	10·88	10·87
July	5					10·56	11·13	11·17	10·46	10·60	10·51	10·44
	6					10·66	10·36	11·13	10·43	10·72	10·45	10·90
	10									10·51	10·52	10·79
	12									11·22	9·99	10·10
	21									11·19	10·47	10·32
	22									10·35	10·21	10·63
	27									9·69	10·61	10·21
	29									10·62	10·56	10·57
	31											
Aug.	7											
	9											
	10											
	11											
	14											
	15											
	17											
	22											
Sept.	1											
	3											
	7											
	9											
	10											
	12											
	13											
	14											
	15											
	17											

Rockville, Md., 1891–'92.

ular seconds.]

12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.
1392	1407	1424	1442	1456	1473	1502	1539	1589	1628	1648	1676	1718
1397	1418	1432	1448	1462	1476	1514	1547	1608	1641	1666	1690	1741
11·60	10·54	9·95	10·96	10·64								
11·97	11·25	9·45	11·11	11·42								
11·61	11·05	10·83	10·71	11·25	10·93	9·77	10·41					
11·81	10·99	11·46	10·95	11·14	11·46	9·61	10·55					
11·90	11·09	10·50	11·22	11·35	11·20	9·50	10·62					
12·06	10·97	10·96	11·66	11·81	11·57	9·72	10·78					
11·57	10·93	10·88	10·93	11·05	11·55	9·56	10·83					
11·79	10·64	9·87	11·07	-- --	11·45	9·95	-- --					
11·20	10·30	10·43	11·19	10·43	10·96	9·53	9·73	10·80	10·37	10·22	10·24	10·33
11·54	10·98	9.83	9·74	10·58	10·76	9·35	10·08	10·08	10·59	10·15	10·51	10·61
11·42	10·50	9·96	10·65	10·68	11·06	9·78	9·58	10·32	10·20	10·09	10·69	10·48
11·50	10·55	9·86	10·87	10·71	10·89	9·91	10·29	10·28	9·68	-- --	-- --	-- --
11·58	10·83	10·40	10·63	10·93	-- --	9·89	10·38	10·70	10·39	10·57	10·65	10·84
11·45	10·79	10·16	10·57	10·34	10·53	9·74	10·23	10·16	10·28	10·24	10·71	10·23
		10·40	10·87	10·64	11·27	9·85	10·29	-- --	-- --	-- --	-- --	-- --
		10·02	-- --	11·00	11·17	9·98	9·93	10·29	10·28	10·10	10·40	10·89
		9·74	10·63	11·13	11·11	9·82	10·17	10·09	-- --	10·39	10·61	10·42
		10·04	10·82	10·93	11·22	9·75	9·98	10·36	10·30	10·55	10·62	10·36
		9·56	10·18	10·90	10·70	-- --	-- --	-- --	-- --	-- --	-- --	-- --
					10·89	10·01	-- --	-- --	-- --	-- --	-- --	-- --
					11·11	10·02	10·17	10·31	10·58	9·97	10·25	10·16
					-- --	-- --	-- --	10·17	-- --	-- --	-- --	-- --
					11·10	9·48	10·08	10·12	10·34	9·87	10·55	10·59
								9·80	10·21	10·41	10·72	10·28
								10·13	10·20	10·33	10·68	10·09
								10·93	10·34	9·30	10·94	10·06
								10·45	10·58	10·07	10·39	10·19
								10·10	10·26	9·83	10·30	10·28
								9·55	9·84	9·89	10·34	10·50
								9·71	10·20	-- --	-- --	-- --
								10·18	10·61	10·20	10·23	10·56
								10·09	10·32	9·90	10·19	10·85
								10·08	10·00	9·87	10·61	10·54

Pair No.		25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.
C. & G. S. Cat.		1756 1779	1801 1809	1819 1825	1852 1859	1885 1896	1917 1926	1948 1959	1968 1971	1974 1984	2004 2020	2026 2043
Aug.	7	10·64	10·97	10·80	10·21							
	9	10·67	10·86	10·45	10·54							
	10	10·61	11·04	10·67	10·34							
	11	-- --	-- --	-- --	-- --							
	14	-- --	-- --	-- --	-- --							
	15	10·40	10·62	10·76	10·32	10·70	10·72	10·21	10·40	9·54	10·58	10·91
	17	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
	22	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
Sept.	1	10·26	10·88	10·25	10·07	9·89	-- --	10·74	10·68	10·60	10·72	10·71
	3	10·15	10·86	10·42	10·17	9·95	9·90	10·54	10·46	10·35	9·96	10·03
	7	10·39	10·86	10·20	10·14	-- --	-- --	-- --	-- --	-- --	-- --	-- --
	9	10·27	10·76	10·36	10·40	-- --	10·50	10·78	10·50	10·79	10·84	10·27
	10	10·75	10·97	10·65	10·38	9·95	10·38	10·63	10·62	10·30	10·87	10·10
	12	10·35	10·78	10·28	10·00	9·89	10·07	10·06	9·98	10·12	10·68	9·60
	13	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
	14	10·42	10·99	10·84	10·26	9·99	10·68	10·64	10·67	10·30	10·64	10·13
	15	10·20	10·78	10·92	-- --	9·99	10·27	10·72	10·44	10·48	10·36	10·13
	17	10·39	10·96	10·09	10·17	9·69	10·36	10·28	10·17	10·37	10·68	9·95
	18		11·27	10·57	9·82	10·21	10·64	10·45	10·08	10·57	10·68	9·71
	19		11·30	11·11	10·45	10·01	10·62	10·41	10·23	10·84	10·62	10·38
	21		10·66	10·39	10·46	9·97	10·34	10·07	10·32	10·44	10·78	10·26
	23		10·84	10·72	10·40	10·05	10·74	10·37	10·62	10·96	10·50	10·87
	24		10·66	10·43	9·95	9·53	9·41	9·93	10·11	10·28	10·35	9·87
	25		11·14	10·72	9·76	9·94	10·48	10·20	10·15	10·49	10·47	9·90
	26		11·14	10·77	10·38	9·93	9·94	10·15	10·37	10·15	10·40	9·99
	28		10·90	10·64	10·10	10·25	10·26	10·19	10·42	10·37	10·77	10·02
	30		10·96	10·66	10·50	-- --	9·91	10·03	10·34	10·45	10·33	9·78
Oct.	3		11·57	10·59	10·33	10·47	9·97	10·82	10·13	10·44	10·73	10·23
	5		10·86	10·33	10·48	9·85	10·08	10·22	9·92	10·59	10·75	10·07
	9		11·24	10·79	10·11	10·13	10·67	10·06	10·24	11·04	10·65	10·10
	14		10·85	10·57	10·38	10·05	10·29	10·07	10·39	10·38	10·59	10·30
	15		10·95	10·42	10·16	10·17	10·46	10·06	9·96	10·78	10·62	9·91
	16		11·04	10·81	10·24	10·18	10·12	10·17	10·10	10·06	10·22	9·88
	17		10·73	10·13	10·06	9·79	9·75	9·99	10·13	10·69	10·05	10·01
	22										10·33	9·93
	23										10·89	10·43
	24										10·88	10·10
	28										10·28	9·79
	29										10·76	9·77
	30										10·85	10·59
	31										10·28	-- --
Nov.	1										10·54	9·53
	2										10·35	9·52
	6										10·05	9·37
	7										10·52	9·58
	9										10·30	10·07
	17											
	18											
	20											
	23											
	24											
	29											
	30											
Dec.	1											
	4											
	5											

36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.
2047	2059	2070	2093	2131	2154	2178	10	27	45	66	93
2055	2063	2078	2121	2142	2159	4	22	32	55	77	111
10·56	10·59	9·83	10·13	-- --							
10·63	10·85	10·14	10·46	11·08							
-- --	-- --	-- --	-- --	-- --							
10·53	10·75	9·95	10·02	10·97							
-- --	-- --	-- --	-- --	-- --							
10·42	10·39	9·81	10·27	10·62							
10·88	10·82	10·33	10·01	10·52							
10·30	10·85	9·98	10·19	10·67							
10·45	10·76	10·36	10·60	10·90							
10·62	10·79	10·13	10·78	10·91							
10·49	10·56	9·59	10·07	-- --							
10·40	10·40	10·15	10·06	10·47							
10·23	10·35	9·82	10·27	10·73							
9·98	10·73	10·18	10·29	10·06							
10·36	10·87	9·80	10·59	10·61							
10·77	10·84	9·86	10·49	10·84							
10·50	10·58	9·45	10·13	10·71							
10·13	10·42	9·68	10·41	10·56							
10·45	11·01	10·04	9·94	10·28	10·30						
10·42	10·65	9·95	10·19	10·36	-- --						
10·33	10·13	9·61	10·24	10·30	-- --						
10·42	10·59	10·05	10·53	10·77	-- --						
9·88	10·25	9·72	-- --	-- --	-- --						
10·02	10·57	9·92	9·94	10·59	10·29	10·52	10·85	10·47	10·22	10·15	10·57
10·36	10·38	9·92	9·68	10·91	10·25	9·46	10·13	10·50	9·85	9·27	10·10
10·16	9·75	10·09	10·11	10·11	10·21	10·39	10·83	9·92	10·94	10·37	10·46
10·58	10·46	9·73	10·25	10·87	10·52	10·60	11·26	10·70	10·60	10·62	10·31
10·37	10·51	10·15	10·75	10·77	10·50	10·69	11·09	10·65	10·99	10·67	10·41
-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
10·58	10·30	9·67	10·06	10·48	10·13	10·57	11·30	10·96	10·92	10·79	10·56
10·03	10·67	9·54	9·88	10·41	10·81	10·40	10·60	10·11	10·45	10·19	10·38
10·36	10·42	9·38	9·93	10·80	9·98	10·19	10·83	10·37	10·56	10·02	10·09
9·86	10·28	9·59	9·97	10·63	10·38	10·49	11·09	10·42	10·89	10·42	10·17
10·23	10·41	9·95	10·19	10·75	10·45	10·20	10·63	9·91	10·38	9·90	10·65
					10·91	10·29	-- --	10·55	11·19	10·65	10·80
					10·78	10·21	10·33	10·43	10·75	11·37	9·70
					10·69	10·75	10·48	10·07	10·98	10·04	10·57
					10·34	10·64	10·26	10·14	10·91	10·08	10·30
					10·18	10·34	10·26	10·59	10·45	10·24	10·19
					10·25	10·25	10·30	10·34	10·73	10·00	10·11
					10 30	10·74	10·67	11·17	-- --	-- --	-- --
					10·50	10·37	10·51	10·66	10·68	10·30	10·14
					10·43	10·73	10·56	10·33	10·55	10·41	-- --
					10·74	-- --	10·58	10·67	10·76	10·48	10·44

Pair No.		48.	49.	50.	51.	52.	53.	54.	55.	56.	57.
C. & G. S. Cat.		134 150	176 196	202 208	220 232	242 250	259 263	275 287	292 297	306 331	370 378
1891.											
Oct.	23	10·66									
	24	10·58									
	28	10·73									
	29	11·00									
	30	10·40									
	31	-- --									
Nov.	1	10·53									
	2	10·54									
	6	10·08									
	7	10·41									
	9	10·64									
	17	-- --									
	18	9·98	11·17	-- --	11·14	10·34	10·24	9·09	9·05		
	20	10·62	10·09	9·91	11·42	10·77	10·77	10·13	9·90		
	23	10·60	9·75	10·48	10·80	10·74	10·43	10·10	9·63		
	24	10·34	9·79	10·31	11·10	10·52	10·32	9·47	9·76		
	29	9·99	9·80	10·30	10·77	10·57	10·60	9·63	9·71		
	30	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --		
Dec.	1	9·70	9·74	10·58	10·92	11·15	10·87	10·06	9·98		
	4	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --		
	5	10·73	10·38	10·45	11·34	10·83	10·70	10·30	10·05		
	8	10·58	10·03	10·50	11·16	10·76	10·54	10·23	9·91	10·75	9·77
	9	11·07	10·74	10·87	11·62	10·68	10·53	10·47	9·97	11·02	9·86
	10	11·07	9·96	10·17	11·33	11·05	10·49	9·72	10·21	10·67	9·77
	13	10·94	9·89	10·60	11·03	10·82	10·69	10·89	9·80	10·24	9·56
	18	10·13	9·92	10·43	10·72	10·44	9·90	9·57	9·79	10·28	9·53
	28	11·32	10·24	10·37	10·78	10·50	10·35	9·99	9·68	10·84	9·49
	30	10·41	9·76	10·01	10·99	10·46	10·07	9·82	9·37	10·89	8·94
1892.											
Jan.	7							9·46	9·51	10·53	9·23
	8							10·01	9·83	-- --	9·64
	16							9·75	10·47	10·44	8·28
	20							9·84	10·16	10·61	9·44
	21							10·26	9·48	10·78	8·46
	24							9·62	9·46	10·48	8·88
	25							9·92	9·46	10·92	9·49
	28							10·20	9·68	10·78	-- --
	31										
Feb.	10										
	13										
	15										
	17										
Mar.	10										
	12										
	14										
	16										
	19										
	20										
	21										
	23										
	24										

58.	59.	60.	61.	62.	63.	64.	65.	66.	67.
392	430	463	483	512	531	562	606	700	718
417	456	479	491	520	533	577	611	705	729
10·75	11·04	10·28	10·53						
10·84	11·03	10·89	10·58						
10·46	10·77	10·57	-- --						
10·25	11·02	10·98	10·55						
9·91	10·95	10·57	10·89						
10·43	10·78	11·05	9·29						
10·15	10·85	10·55	10·82						
10·78	10·63	11·50	10·51	10·61	11·02	10·48	9·87		
10·59	10·74	-- --	-- --	-- --	-- --	-- --	-- --		
10·10	10·83	10·17	10·60	10·08	10·37	9·59	9·61		
10·21	10·44	9·51	10·13	10·63	10·35	10·12	-- --		
10·25	10·21	10·84	10·68	10·81	10·48	10·38	9·76		
10·02	9·96	10·09	10·39	10·60	11·00	10·50	9·82		
10·74	10·14	9·85	10·77	10·54	10·80	10·21	9·69		
-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --		
	10·42	10·21	9·91	10·45	10·52	10·16	9·64	10·42	9·63
	10·34	10·29	9·62	10·85	-- --	-- --	-- --	-- --	-- --
	10·66	10·71	10·52	10·73	10·97	10·49	9·62	10·70	10·55
	10·04	10·29	10·34	10·42	10·73	10·37	10·17	10·10	9·87
	10·68	10·06	10·47	10·57	10·88	-- --	10·90	10·78	10·27
								10·68	10·12
								10·41	10·33
								10·61	9·50
								10·38	10·01
								10·16	9·86
								10·23	10·17
								10·46	9·53
								10·36	10·60
								10·36	10·08

Pair No.		68.	69.	70.	71.	72.	73.	74.	75.	76.	77.
C. & G. S. Cat.		745 757	769 776	781 792	796 804	813 825	835 842	849 865	873 888	911 921	926 932
1892.											
Jan.	31	9·90	9·76	9·95							
Feb.	10	-- --	-- --	-- --							
	13	10·76	10·37	10·42							
	15	10·20	10·30	10·09							
	17	10·27	10·43	10·25							
Mar.	10	10·69	10·32	-- --							
	12	10·97	10·66	10·38	-- --	10·56	10·11	-- --	-- --	-- --	-- --
	14	10·12	10·18	10·38	10·10	10·19	10·01	10·77	8·99	10·61	10·34
	16	10·46	9·81	10·01	10·08	10·41	10·20	-- --	-- --	-- --	-- --
	19	10·24	10·32	10·31	10·49	9·87	10·27	10·68	9·38	10·44	-- --
	20	10·21	10·15	9·91	10·40	10·26	9·81	10·48	9·45	10.39	10·04
	21	10·56	10·27	10·00	11·29	9·98	10·20	-- --	9·76	10·60	9·94
	23	10·39	10·39	10·40	-- --	-- --	-- --	-- --	-- --	-- --	-- --
	24	10·49	10·75	10·43	10·77	10·13	10·10	10·78	-- --	-- --	-- --
	28				10·39	10·33	10·28	10·46	9.75	9·64	10·09
	29				10·71	10·53	10·30	10·74	-- --	-- --	-- --
Apr.	4				10·82	10·57	10·32	11·05	10·22	10·58	10·55
	9				10·32	10·30	10·41	10·83	9·83	10·70	10·15
	11				10·67	10·66	10·32	11·08	9·61	10·43	10·33
	12				10·25	10·17	10·13	10·65	9·68	10·62	10·57
	13				11·05	10·99	10·63	11·01	10·16	10·12	10·26
	16										10·18
	19										10·38
	23										10·41
	26										10·31
	27										10·11
	29										11·10
	30										10·38
May	3										-- --
	4										10·22
	5										10·26
	7										10·39
	8										10·89
	9										9·83
	16										
	17										
	19										
	23										
	24										
	25										
	28										
	30										
June	1										

78.	79.	80.	81.	82.	83.	84.	85.	86.	87.
936	952	966	1003	1022	1044	1063	1094	1118	1137
945	958	976	1010	1035	1057	1070	1109	1128	1149

10·60	9·64	10·25	10·21	10·60					
-- --	-- --	-- --	-- --	-- --					
10·54	9·64	10·42	-- --	10·75					
10·78	-- --	-- --	-- --	-- --					
10·61	9·84	10·29	10·19	10·50					
10·61	10·01	10·26	10·45	10·67					
10·55	-- --	-- --	-- --	-- --					
10·66	10·33	10·15	10·47	10·72					
10·63	-- --	-- --	-- --	-- --					
11·10	10·09	10·64	10·67	10·77	11·21	10·91	10·01	10·77	10·96
10·79	10·23	10·55	10·78	10·63	10·86	10·73	10·11	10·41	10·24
10·88	10·16	10·50	10·98	10·82	-- --	-- --	-- --	-- --	-- --
10·88	10·49	10·37	-- --	-- --	-- --	-- --	-- --	-- --	-- --
10·95	10·24	10·40	11·05	10·64	10·86	10·37	10·29	10·71	11·05
-- --	-- --	-- --	10·40	10·67	10·96	10·48	10·18	10·61	10·73
10·77	-- --	10·77	10·86	11·30	11·02	10·87	10·44	-- --	10·86
10·37	10·20	10·24	10·85	10·70	10·67	10·50	9·87	10·48	10·61
10·87	10·34	10·58	10·89	10·75	10·83	10·55	10·31	10·48	10·44
11·17	10·38	10·59	10·65	10·73	10·46	10·74	10·34	10·20	10·68
10·33	9·72	10·72	10·77	10·74	11·10	10·16	10·55	10·40	10·88
					10·91	10·62	10·16	10·51	10·41
					10·78	10·49	9·90	10·39	10·39
					10·70	10·71	-- --	-- --	-- --
					11·17	10·92	10·34	10·39	10·82
					11·07	10·39	10·03	10·32	10·44
					10·86	10·39	10·17	10·61	10·59
					10·85	10·47	9·77	10·59	10·46
					10·53	10·24	10·16	10·38	10·49
					10·67	10·54	10·08	10·50	10·27

Pair No.		88.	1.	2.	3.	4.	5.	6.	7.	8.	9.
C. & G. S. Cat.		1162 1175	1184 1188	1198 1206	1215 1220	1231 1241	1247 1254	1262 1275	1280 1294	1316 1330	1336 1354
1892.											
Apr.	23	10·19	10·70								
	26	10·39	10·34								
	27	-- --	-- --								
	29	-- --	-- --								
	30	11·06	10·70								
May	3	10·14	10·33								
	4	-- --	-- --								
	5	10·20	9·97								
	7	10·20	9·92								
	8	10·39	9·83								
	9	10·58	10·88								
	16	10·00	10·14	10·08	10·22	10·52	10·17	10·72	10·45	09·97	
	17	10·04	9·86	9·77	10·21	9 80	-- --	-- --	-- --	-- --	
	19	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	
	23	10·37	10·17	9·84	10·49	10·22	10·55	10·78	11·02	10·67	
	24	10·19	10·01	9·93	10·09	10·45	10·32	-- --	-- --	-- --	
	25	10·59	10·09	10·06	10·45	10·84	10·14	10·45	10·99	10·04	
	28	10·38	9·92	10·05	10·51	10·09	10·55	10·44	10·70	10·16	
	30	10·15	9·96	9·81	10·36	10·57	10·35	10·41	10·65	10·04	
June	1	10·28	9·88	10·11	-- --	-- --	10·56	10·38	10·86	10·08	
	2		9·96	9·91	10·41	10·35	10·34	10·36	10·69	10·14	10·62
	6		10·07	10·07	10·71	10·20	10·46	-- --	11·21	-- --	-- --
	11		9·63	9·65	10·66	10·18	10·14	10·45	10·46	10·14	10·25
	12		9·72	9·21	10·23	10·52	-- --	10·23	10·50	10·01	10·46
	13		9·95	9·91	10·29	10·51	10·01	9·96	10·73	9·94	10·51
	15		9·96	10·11	10·16	9·97	9·89	10·71	10·37	9·99	10·25
	16		9·72	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
	17		9·71	9·82	10·31	10·83	-- --	10·80	10·63	-- --	10·73
	20		9·20	9·65	10·32	10·49	10·21	10·36	10·69	10·06	-- --
	21		9·34	9·64	10·85	10·63	-- --	-- --	-- --	-- --	-- --
	23		9·74	9·75	9·42	9·92	10·38	10·58	11·08	10·32	10·85
	25		9·52	10·01	10·26	11·19	-- --	9·89	10·12	10·89	10·62
	26		9·63	9·44	9·83	10·11	9·95	-- --	-- --	-- --	-- --
	29		9·92	10·11	10·38	10·59	10·44	10·38	10·68	10·16	10·48
July	7						10·36	10·38	10·68	10·26	10·45
	8						9·76	10·48	10·43	9·59	10·13
	9						9·90	10·41	10·65	10·02	10·39

10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
1360	1382	1392	1407	1424	1442	1456	1473	1502	1539
1367	1386	1397	1418	1432	1448	1462	1476	1514	1547
10·81	-- --	11·71	10·81	11·44	11·02	10·91	-- --	-- --	-- --
10·36	10·55	11·91	10·59	11·07	10·83	10·69	-- --	-- --	-- --
10·52	10·39	11·72	10·83	10·94	10·84	10·67	10·94	9·57	9·93
10·42	10·37	11·50	10·66	11·11	10·66	10·54	11·37	-- --	10·34
10·52	10·24	11·65	10·70	9·87	10·76	10·93	-- --	-- --	-- --
10·47	10·40	11·35	-- --	-- --	-- --	-- --	-- --	-- --	-- --
-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
10·49	10·49	11·61	10·81	10·05	10·74	10·73	11·23	9·46	10·35
-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
10·90	10·63	11·69	11·25	10·20	11·04	11·07	11·52	10·30	10·28
10·33	10·37	11·65	10·37	9·08	10·78	-- --	-- --	-- --	-- --
-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
10·47	10·59	11·55	10·93	10·36	10·88	11·10	11·54	9·87	10·15
-- --	10·33	11·63	10·85	9·42	-- --	11·03	11·50	10·14	10·24
10·54	10·27	11·32	10·24	9·90	10·75	10·55	10·83	9·59	10·15
10·46	10·42	11·61	10·98	9·89	10·73	10·91	11·23	9·65	10·07

COMBINATION OF RESULTS FOR VARIATION OF LATITUDE, AS OBSERVED AT ROCKVILLE, MD., IN 1891–'92.

In order to deduce any result for systematic variation from the individual results for latitude, as obtained directly from observations, it is essential that in the combination, the declinations of the stars, taken from various catalogues, should be referred to a uniform system, and at the same time that any change in latitude, whether periodic, progressive, irregular, or any absence of change, should not be interfered with. This was secured by the method of combination adopted in the reduction of the Berlin and other series of observations as carried out by Dr. Th. Albrecht* and is the same as followed for the Rockville series.

The first step of the reduction consists in dividing the whole series of results into groups, each of a sufficient number of pairs of stars to give a closely approximate value of the mean latitude and with the sums of the positive and negative micrometer corrections, as near as may be, balancing each other. The observer's arrangement respecting groups was altered with a view of strengthening the connections of the groups. At the close of a year's work the re-observation of the same pairs of a group would afford the means of improving the whole series by the introduction of the condition that the closing error of the sum of the corrections to the mean results of the groups at the end of the year be zero.

The second step is the reduction of the declinations of each pair of stars to the mean declination system of the group. Comparing the mean result for latitude of each pair in the group with the mean result by all the pairs—*i. e.*, with the mean latitude of the group—a correction was obtained to the result by each pair. In general, the smallness of these corrections (as given below) indicate that the tabular declinations were fairly accurate.

The pairs constituting each group, the number of days of observation for each, and the mean latitude for the same are tabulated below, together with the reduction of the result by each pair to the mean of its group.†

*Provisorische Resultate der Beobachtungen in Berlin, Potsdam und Prag, betreffend die Veränderlichkeit der Polhöhe, etc. Von Th. Albrecht. Berlin, 1890.

† From these observations it has been found that the mean error of reduction to the mean declination system of a group for a single determination is $\pm 0''\cdot23$. Since the number of determinations of the various groups ranges from eight to twenty-eight, the mean errors of the reductions to the mean declination system in the above table are within $\pm 0''\cdot04$ and $\pm 0''\cdot08$.—*Edwin Smith.*—[Added November 9, 1892.]

					°	′	″
Group	I	Pairs, 9, 10, 11, 12, 13	Days, 21	φ_i =	39	05	10·83
	II	14, 15, 16, 17, 18, 19	19	φ_{ii}			10·53
	III	20, 21, 22, 23, 24, 25	12	φ_{iii}			10·30
	IV	26, 27, 28, 29, 30, 31, 32, 33	21	φ_{iv}			10·38
	V	34, 35, 36, 37, 38, 39, 40	28	φ_v			10·32
	VI	41, 42, 43, 44, 45, 46, 47, 48	16	φ_{vi}			10·43
	VII	49, 50, 51, 52, 53, 54, 55	13	φ_{vii}			10·36
	VIII	56, 57, 58, 59, 60, 61	12	φ_{viii}			10·32
	IX	62, 63, 64, 65	8	φ_{ix}			10·33
	X	66, 67, 68, 69, 70	12	φ_x			10·26
	XI	71, 72, 73, 74, 75, 76	9	φ_{xi}			10·33
	XII	77, 78, 79, 80, 81, 82	12	φ_{xii}			10.49
	XIII	83, 84, 85, 86, 87, 88	16	φ_{xiii}			10·49
	XIV	1, 2, 3, 4, 5, 6, 7, 8	13	φ_{xiv}			10·26

			″	″	″	″	″	″	″	″
Group	I	Red'n	+·21	+ ·27	+·28	—·80	+·05			
	II		+·19	— ·30	—·38	—·62	+·83	+·29		
	III		+·11	·00	+·27	—·17	—·10	—·10		
	IV		—·60	— ·20	+·16	+·34	+·10	+·12	+·14	—·05
	V		—·24	+ ·33	—·05	—·23	+·42	+·10	—·31	
	VI		+·05	+ ·06	—·24	+·04	—·20	+·15	+·14	·00
	VII		+·35	— ·02	—·72	—·35	—·12	+·33	+·53	
	VIII		—·33	+1·03	—·05	—·34	—·20	—·16		
	IX		—·20	— ·41	+·06	+·56				
	X		—·15	+ ·23	—·12	—·02	+·05			
	XI		—·17	— ·05	+·09	—·46	+·66	—·07		
	XII		+·18	— ·26	+·39	+·06	—·17	—·20		
	XIII		—·37	— ·04	+·35	·00	—·10	+·17		
	XIV		+·40	+ ·33	—·08	—·13	+·03	—·17	—·46	+·12

The sum of the corrections for each group should be zero.

The preceding corrections were applied to the results of the respective pairs, forming a new table of results (marked A_1 B_1 C_1 D_1 E_1 F_1, in MS. and not reproduced here) preparatory to the next step, viz:

Comparison of the mean declination of the groups by means of the results obtained on the *same night* from pairs ranging over *two* or more groups. Such comparisons between results of the same date leave, of course, any changes in latitude absolutely untouched. This third step, then, consists in ascertaining the differences in the mean declination system of any two adjacent groups or overlapping groups. For this purpose all results of pairs belonging to the same group were made use of, and not only those results which form the full or complete set of all pairs for every night. For any date *common* to two or more groups, the mean latitude was taken for all pairs observed in each, and their number noted as the weight to the mean, and the same was done for the other groups. These comparisons being made for every day of observation, the final difference between any two groups will be that of their

weighted means. The following tables marked A_{II} B_{II} C_{II} contain these comparisons:

Comparison of mean values of groups.

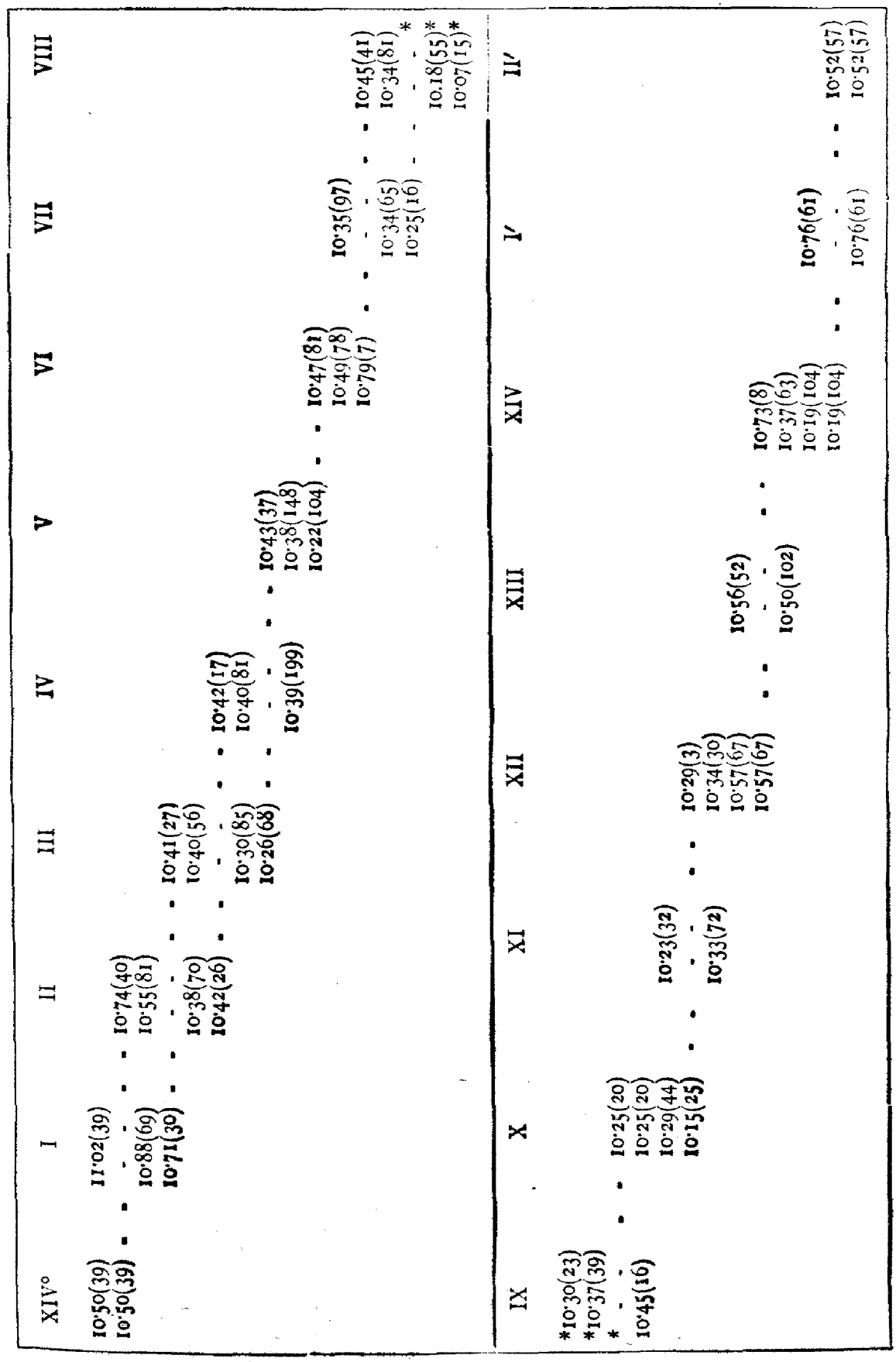
Date.	XIV.	I.	II.	III.	IV.	V.	VI.
1891.	"	"	"	"	"	"	"
June 13	10·28 8	10·87 5	10·35 3				
15	10·39 7	11·09 5	10·50 3				
23	10·38 4	11·04 4	10·65 6				
24	10·49 4	11·20 5	10·86 6				
25	10·52 4	11·13 5	10·73 6				
27	10·99 4	11·14 5	11·08 6				
July 5	10·71 4	10·81 5	10·80 6				
6	10·52 4	10·90 5	10·61 4				
10		10·66 5	10·38 6	10·41 5			
12		10·77 5	10·06 6	10·41 5			
21		10·78 5	10·28 6	10·38 5			
22		10·65 5	10·42 6	10·04 2			
27		10·58 5	10 57 5	10·65 5			
29		10·80 5	10·26 6	10·35 5			
31			10·55 6				
Aug. 7			10·48 5	10·43 6	10·45 3		
9			10·43 6	10·44 5	10·40 3		
10			10·46 6	10·47 6	10·47 3		
11			10·06 4				
14			10·56 2				
15			10·60 3	10·28 6	10·41 8	10·79 2	
17				10·28 1			
22			10·39 3	10·32 5			
Sept. 1				10·28 6	10·43 7	10·76 2	
3				10·26 6	10·33 8	10·04 2	
7				10·33 6	10·19 3		
9				10·33 6	10·54 7	10·60 2	
10				10·25 6	10·48 8	10·40 6	
12				10·08 6	10·15 8	10·50 7	
13				10·01 2			
14				10·37 6	10·55 8	10·43 7	
15				10·26 6	10·49 7	10·29 2	
17				10·25 6	10·26 8	10·31 7	
18					10·45 8	10·42 7	
19					10·62 8	10·43 7	
21					10·33 8	10·59 7	
23					10·60 8	10·66 7	
24					10·04 8	10·21 6	
25					10·36 8	10·27 7	
26					10·36 8	10·26 7	
28					10·39 8	10·29 7	
30					10·36 7	10·33 7	
Oct. 3					10·54 8	10·54 7	
5					10·29 8	10·31 7	
9					10·54 8	10·28 7	
14					10·37 8	10·37 7	10·35 1
15					10·37 8	10·30 7	
16					10·34 8	10·10 7	
17					10·16 8	10·35 7	

Comparison of mean values of groups.

Date.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
1891.	"	"	"	"	"	"	"	"
Oct. 22	10·01 5							
23	10·33 7	10·47 8						
24	10·32 7	10·02 8						
28	10·04 7	10·48 8						
29	10·35 7	10·70 8						
30	10·57 7	10·68 8						
31	10·04 1							
Nov. 1	10·17 7	10·72 8						
2	10·06 7	10·43 8						
6	10·04 7	10·26 8						
7	10·06 7	10·53 8						
9	10·27 7	10·35 8						
17		10·77 6						
18		10·44 8	10·18 6					
20		10·52 8	10·43 7					
23		10·41 8	10·28 7					
24		10·32 8	10·18 7					
29		10·25 8	10·20 7					
30		10·70 4						
Dec. 1		10·36 8	10·47 7					
4		10·48 6						
5		10·62 7	10·58 7					
8		10·58 1	10·45 7	10·52 6				
9		11·07 1	10·70 7	10·70 6				
10		11·07 1	10·42 7	10·48 5				
13		10·94 1	10·53 7	10·43 6				
18		10·13 1	10·11 7	10·36 6				
28		11·32 1	10·27 7	10·31 6				
30		10·41 1	10·07 7	10·37 6				
1892.								
Jan. 7			9·92 2	10·53 6	10·50 4			
8			10·35 2	10·55 3				
16			10·54 2	10·07 6	9·91 4			
20			10·43 2	10·06 6	10·18 3			
21			10·30 2	10·20 6	10·36 4			
24			9·97 2	9·97 6	10·48 4			
25			10·12 2	10·32 6	10·31 4			
28			10·37 2	10·45 1				
31				9·95 3	10·19 4	9·93 5		
Feb. 10				9·85 3	10·65 1			
13				10·40 3	10·45 4	10·56 5		
15				9·99 3	10·42 4	10·11 5		
17				10·17 3	10·77 3	10·40 5		
Mar. 10						10·44 4		
12						10·55 5	10·36 2	
14						10·16 5	10·11 6	10·52 1
16						10·13 5	10·19 3	
19						10·18 5	10·19 6	
20						10·13 5	10·13 6	10·22 1
21						10·16 5	10·46 5	10·12 1
23						10·43 5		
24						10·42 5	10·30 4	

Comparison of mean values of groups.

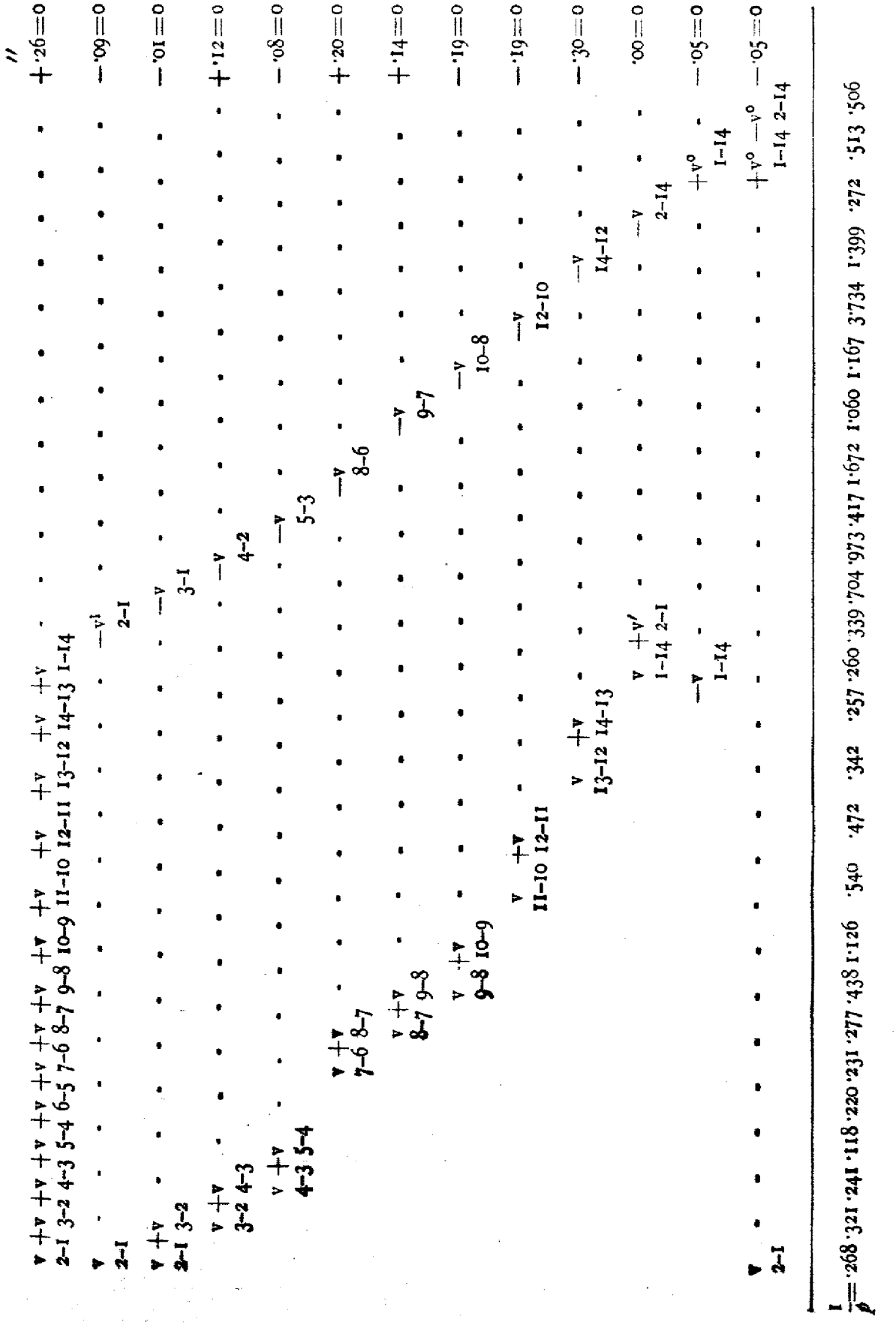
Date.	XI.	XII.	XIII.	XIV.	I.	II.
1892.	"	"	"	"	"	"
Mar. 28	10·14 6	10·23 6				
29	10·42 4					
April 4	10·59 6	10·41 5				
9	10·40 6	10·42 2				
11	10·46 6	10·29 6				
12	10·25 6	10·43 6				
13	10·66 6	10·36 2				
16		10·42 6				
19		10·46 2				
23		10·61 6	10·68 6	11·10 1		
26		10·55 6	10·46 6	10·74 1		
27		10·58 6				
29		10·80 4				
30		10·61 6	10·72 6	11·10 1		
May 3		10·35 2	10·52 6	10·73 1		
4		10·71 5	10·76 4			
5		10·44 6	10·39 6	10·37 1		
7		10·64 6	10·47 6	10·32 1		
8		10·73 6	10·47 6	10·23 1		
9		10·35 6	10·61 6	11·28 1		
16			10·44 6	10·28 8		
17			10·33 6	10·04 4		
19			10·50 2			
23			10·67 6	10·47 8		
24			10·41 6	10·27 5		
25			10·54 6	10·38 8		
28			10·42 6	10·30 8		
30			10·32 6	10·27 8		
June 1			10·39 6	10·35 6		
2				10·27 8	10·92 4	10·96 3
6				10·47 6	10 80 4	10·70 3
11				10·16 8	10·74 5	10·48 6
12				10·06 7	10·68 5	10·64 5
13				10·16 8	10·72 5	10·36 3
15				10·14 8	10·61 4	
16				10·12 1		
17				10·33 6	10·94 1	
20				10·12 8	10·80 4	10·43 6
21				10·24 4		
23				10·15 8	11·06 5	10·73 6
25				10·27 7	10·67 5	9·88 2
26				9·90 5		
29				10·33 8	10·80 5	10·65 6
July 7				10·30 4	10·75 4	10·53 5
8				9·95 4	10·50 5	10·30 6
9				10·12 4	10·77 5	10·41 6



*Continued on same line.

The preceding differences demand 13 conditions to be satisfied; these conditions are expressed by the following conditional equations, to which are added the values of the reciprocal weight or $\frac{1}{p}$ for each difference depending on the number $n\ n_1$: for the observed values for latitude in each group, I take $\frac{1}{p} = \frac{10\,(n + n_1)}{nn_1}$

CONDITIONAL EQUATIONS.



$\frac{1}{p}$ = ·268 ·321 ·241 ·118 ·220 ·231 ·277 ·438 1·126 ·540 ·472 ·342 ·257 ·260 ·339 ·704 ·973 ·417 1·672 1·060 1·167 3·734 1·399 ·272 ·513 ·506

Multiplying these equations with the correlates k_1 we form the normal equations as below.

NORMAL EQUATIONS.

k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_{10}	k_{11}	k_{12}	l_{13}	
+5·11	+0·27	+0·59	+0·56	+6·36	+0·51	+0·72	+1·56	+1·01	+0·60	+0·26	−0·26	+0·27	+0·26=0
	+0·61	+0·27								−0·34		+0·27	−0·09=0
		+1·29	0·32	+0·24								+0·27	−0·01=0
			+1·54	+0·78	+2·18	+0·28	+0·44	+4·75	+2·00	+0·87	+0·77		+0·12=0
						+1·78	+2·73						−0·08=0
													+0·20=0
													+0·14=0
													−0·19=0
													−0·19=0
													−0·30=0
											−0·26	+0·51	0·00=0
											+0·77	+1·29	−0·05=0
													−0·05=0

Combination of results for the variation of latitude at Rockville, Md.

Solving, we get

$k_1 = -0.162$	$k_5 = +0.196$	$k_9 = +0.075$
$k_2 = +0.359$	$k_6 = -0.048$	$k_{10} = +0.198$
$k_3 = +0.031$	$k_7 = -0.049$	$k_{11} = +0.230$
$k_4 = -0.055$	$k_8 = +0.170$	$k_{12} = +0.130$
		$k_{13} = -0.060$

and after substituting in the equations of correlates

$v_{2-1} = +.045$	$v_{9-8} = -.018$	$v'_{2-1} = -.044$	$v_{12-10} = -.280$
$v_{3-2} = -.060$	$v_{10-9} = +.009$	$v_{3-1} = -.022$	$v_{14-12} = -.277$
$v_{4-3} = -.005$	$v_{11-10} = -.047$	$v_{4-2} = +.054$	$v_{2-14} = -.062$
$v_{5-4} = +.004$	$v_{12-11} = -.041$	$v_{5-3} = -.082$	$v^{\circ}_{1-14} = +.036$
$v_{6-5} = -.036$	$v_{13-12} = +.013$	$v_{8-6} = +.080$	$v^{\circ}_{2-14} = +.030$
$v_{7-6} = -.048$	$v_{14-13} = +.009$	$v_{9-7} = +.052$	
$v_{8-7} = -.072$	$v_{1-14} = -.016$	$v_{10-8} = -.198$	

The adjusted values of the differences between the groups are as follows:

		″
I—XIV°	= I′—XIV	= +0.555
II— I	= II′— I′	= −0.285
III— II	=	−0.040
IV— III	=	+0.095
V— IV	=	−0.006
VI— V	=	+0.214
VII— VI	=	−0.188
VIII— VII	=	−0.072
IX— VIII	=	+0.172
X— IX	=	−0.191
XI— X	=	−0.107
XII— XI	=	−0.031
XIII— XII	=	+0.003
XIV— XIII	=	−0.121

″

Check: $\Sigma \begin{matrix} +1.039 \\ -1.041 \end{matrix}$

We also have the closing error:

″

For group XIV—.21
For group I—.26
For group II—.35

Taking group IV for reference group as having the greatest number of pairs and observations ($\varphi_{IV} = 39° 05' 10''·39$), and applying the above differences we get the final correction to each group, as below:

		″			″
Correction to group	IV	·000	and to group	III	+ ·095
	V	+ ·006		II	+ ·055
	VI	— ·208		I	— ·230
	VII	— ·020		XIV°	+ ·325
	VIII	+ ·052			
	IX	— ·120			
	X	+ ·071			
	XI	+ ·178			
	XII	+ ·209			
	XIII	+ ·206			
	IV	+ ·327			
	I′	— ·228			
	II′	+ ·057			

From these corrections, when applied to the individual results in each group respectively or more conveniently to the mean value of each group as tabulated on the tables marked $A_{,,}$ $B_{,,}$ $C_{,,}$, and combined according to weights, we get the final daily mean value for each day of observation as below. Column headed n gives the number of pairs observed each night; the next column of figures the seconds of the resulting latitude φ_1 or the combined result from two or more nights; in the last column the number of observations n_1 is added for convenience of plotting the results, as properly grouped, in order to equalize number of observations for suitable short intervals of days.

Date.	$\varphi = 39° 05'$	n	φ_1	n_1	Date.	$\varphi = 39° 05'$	n	φ_1	n_1
1891.	″		″		1891.	″		″	
June 13	+10·58	16	10·65	31	Aug. 22	+10·43	8	10·43	8
15	·73	15			Sept. 1	·46	15	10·38	31
23	·74	14			3	·31	16		
24	·91	15	10·90	59	7	·35	9		
25	·84	15			9	·51	15	10·39	65
27	11·11	15			10	·42	20		
July 5	10·81	15	10·77	28	12	·28	21		
6	·72	13			13	·11	2		
10	·46	16	10·42	32	14	·49	21	10·44	38
12	·37	16			15	·41	15		
21	·45	16	10·43	29	17	·31	21		
22	·40	13			18	·44	15	10·43	66
27	·58	15			19	·54	15		
29	·44	16	10·52	37	21	·46	15		
31	·61	6			23	·63	15		
Aug. 7	·52	14			24	·12	14	10·36	44
9	·49	14	10·51	43	25	·32	15		
10	·53	15			26	·32	15		
11	·12	4			28	·35	15	10·34	44
14	·62	2	10·43	26	30	·35	14		
15	·48	19			Oct. 3	·54	15	10·42	45
17	·38	1			5	·30	15		

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Date.	$\varphi = 39°05'$	n	φ_1	n_1	Date.	$\varphi = 39°05'$	n	φ_1	n_1
1891.	″		″		1892.	″		″	
Oct. 9	+10·42	15	10·42	45	Mar. 16	+10·26	8	10·38	31
14	·36	16			19	·32	11		
15	·34	15	10·30	61	20	·27	12	10·36	39
16	·23	15			21	·43	11		
17	·25	15			23	·50	5		
22	·02	5	10·23	20	24	·49	9		
23	·30	15			28	·38	12	10·45	25
24	·05	15			29	·60	4		
28	·17	15	10·22	45	April 4	·70	11	10·65	19
29	·43	15			9	·59	8		
30	·52	15			11	·57	12		
31	·05	1	10·34	46	12	·54	12	10·61	32
Nov. 1	·36	15			13	·77	8		
2	·15	15			16	·63	6		
6	·05	15			19	·67	2	10·80	21
7	·20	15	10·15	45	23	·90	13		
9	·21	15			26	·74	13		
17	·56	6	10·31	20	27	·79	6	10·84	36
18	·20	14			29	11·01	4		
20	·36	15			30	10 92	13		
23	·23	15	10·24	45	May 3	·73	9		
24	·13	15			4	·94	9	10·75	31
29	·11	15			5	·63	13		
30	·49	4	10·23	34	7	·76	13		
Dec. 1	·29	15			8	·79	13	10·77	39
4	·27	6	10·42	20	9	·76	13		
5	·48	14			16	·63	14		
8	·49	14			17	·47	10	10·57	26
9	·72	14	10·57	41	19	·71	2		
10	·49	13			23	·83	14	10·73	25
13	·51	14	10·36	28	24	·61	11		
18	·22	14			25	·73	14	10·68	28
28	·36	14	10·29	28	28	·63	14		
30	·22	14			30	·57	14		
1892.					June 1	·64	12	10·64	41
Jan. 7	·40	12			2	·71	15		
8	·49	5	10·28	29	6	·72	13	10·60	32
16	·08	12			11	·51	19		
20	·15	11			12	·50	17	10·49	33
21	·25	12	10·20	47	13	·48	16		
24	·12	12			15	·44	12		
25	·26	12			16	·45	1	10·52	20
28	·40	3	10·10	15	17	·67	7		
31	·02	12			20	·49	18		
Feb. 10	·06	4	10·38	16	21	·57	4	10·58	41
13	·48	12			23	·67	19		
15	·18	12	10·31	23	25	·45	14		
17	·45	11			26	·23	5	10·52	38
Mar. 10	·51	4			29	·65	19		
12	·60	7	10·38	31	July 7	·58	13		
14	·30	12			8	·31	15	10·45	43
					9	·49	15		

The columns headed φ_1 and n_1 were added as more convenient for graphical representation than the daily values; they contain 52 weighted means depending on 1789 observed values for latitude, and are represented on the accompanying diagram. (Illustration No. 4.)

The main feature of the representation is a decided minimum latitude towards the close of the year 1891 and apparently two epochs of high values of latitude, one of which, however—that about April, 1892—is probably due to some unknown disturbances affecting the observations. Besides this there are two large and systematic declines in the resulting latitudes which in magnitude greatly surpass the minor irregularities of the ordinary zigzag lines of variability. It cannot be supposed that these features are due to real changes in latitude; about this, however, corroborative evidence can be had as soon as the results for changes in the latitude of San Francisco shall have become known.

The probable error of observation for latitude for the period covering the best part of the series—*i. e.*, from July to November—is as follows:

	″
For group III,	± 0·17
For group IV,	± 0·17
For group V,	± 0·17

embracing together 544 observations, and for the period, unfavorable for observation—*i. e.*, from November (in part) to February, inclusive—the probable error of a single observation for latitude becomes

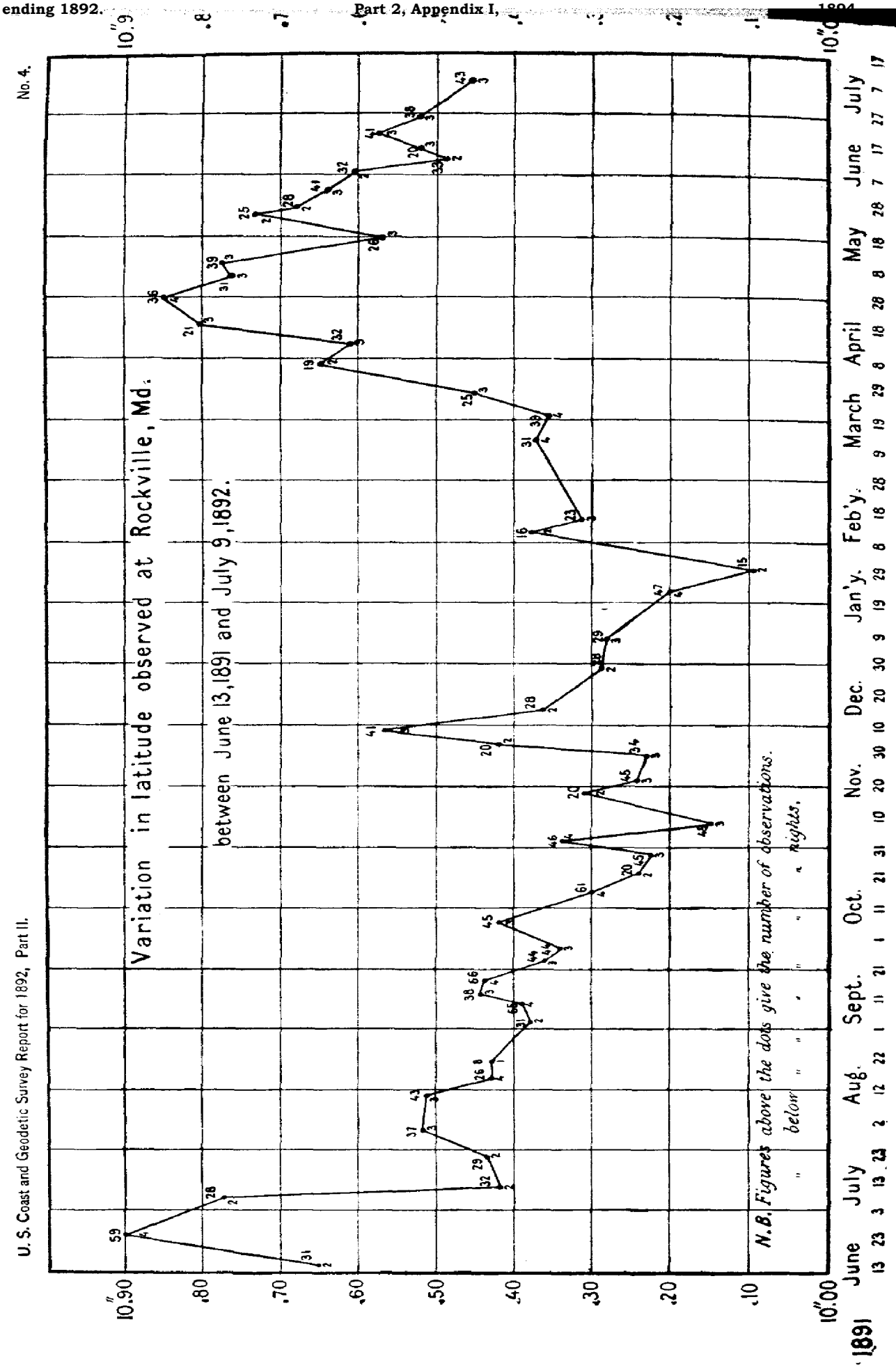
	″
For group VI,	± 0·21
For group VII,	± 0·22
For group VIII,	± 0·26
For group IX,	± 0·20

embracing together 407 observations.*

The average value for the whole series is ± 0″·20 nearly. Comparatively this may be regarded as rather a large value; it may be attributed mainly to the circumstance of the use of three in the place of one micrometer thread, since there was evidence to show that the distances between the threads did not remain invariable. There is also liability to error in recording the particular thread used. The nature of suspected systematic errors, notably those affecting the results of December and January, has so far eluded scrutiny, but is probably related to a feature of obscure origin which may produce a systematic difference in the results of all pairs observed on two consecutive nights, as on September 23–24, when each of 14 pairs gave a latitude in defect on the second night, with an average difference of 0″·51.

The unexpected rise of the latitude in April and the subsequent sharp decline was accentuated by the introduction of the adjusted

*From the 1789 observations on 146 nights it has been found that the mean error of a single determination for latitude is ± 0″·25. Since the results in column ϕ, depend upon eight to sixty-six single results, their mean errors are within ± 0″·03 and ± 0″·09.—*Edwin Smith.*—[Added Nov. 9, 1892.]


No. 4.
Variation in latitude observed at Rockville, Md.
between June 13, 1891 and July 9, 1892.
N.B. Figures above the dots give the number of observations.
" below " " " " nights.
U. S. Coast and Geodetic Survey Report for 1892, Part II.
1891
1892
June July Aug. Sept. Oct. Nov. Dec. Jan'y. Feb'y. March April May June July

Combination of results for the variation of latitude at Rockville, Md.

differences between the groups, and hence may be referred, at least in part, to a weak connection of several of the groups.

A further concentration of latitude values by months leads to the following normals:

Date.	φ	n	Date.	φ	n
1891.	″		1892.	″	
June 21	10·81	90	Jan. 20	10·21	91
July 17	10·53	126	Feb. 14	10·34	39
Aug. 12	10·47	77	Mar. 20	10·39	95
Sept. 17	10·39	288	April 18	10·73	108
Oct. 17	10·30	171	May 15	10·71	149
Nov. 14	10·25	190	June 14	10·56	205
Dec. 15	10·43	117	July 8	10·45	43

If we suppose the period of the latitude variation to be 430 days, hence the daily angular motion of the pole of rotation $n = 0^{\circ}\cdot837$, and l = the longitude of this pole west of the place at an arbitrary epoch t_0, here January 1, 1891, then the variation in latitude $\delta\varphi$ may be expressed by $\delta\varphi = \varphi - \varphi_0 = a \cos(nt - l)$, where φ_0 = mean latitude $= 10''\cdot47$ and φ = latitude at the time t.

Using Cauchy's method we get the expression

$$\delta\varphi = + 0''\cdot20 \sin(nt - 5^{\circ})$$

which places the minimum at November 24, 1891.*

Perhaps it will be best to defer further consideration of the observed variability of the Rockville latitude until the results of the other two stations observed during the same time shall have become known.

C. A. S.

* It seems likely that a second term, probably of an annual period, will be needed for the expression of the variation in latitude.—C. A. S.—[Added Nov. 9, 1892.]