SMITHSONIAN

CONTRIBUTIONS TO KNOWLEDGE.

VOL. XVI.

EVERY MAN IS A VALUABLE MEMBER OF SOCIETY, WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN.—SMITHSON.

CITY OF WASHINGTON:
PUBLISHED BY THE SMITHSONIAN INSTITUTION.
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ADVERTISEMENT.

THIS volume forms the sixteenth of a series, composed of original memoirs on different branches of knowledge, published at the expense, and under the direction, of the Smithsonian Institution. The publication of this series forms part of a general plan adopted for carrying into effect the benevolent intentions of JAMES SMITHSON, Esq., of England. This gentleman left his property in trust to the United States of America, to found, at Washington, an institution which should bear his own name, and have for its objects the "*increase* and *diffusion* of knowledge among men." This trust was accepted by the Government of the United States, and an Act of Congress was passed August 10, 1846, constituting the President and the other principal executive officers of the general government, the Chief Justice of the Supreme Court, the Mayor of Washington, and such other persons as they might elect honorary members, an establishment under the name of the "SMITHSONIAN INSTITUTION FOR THE INCREASE AND DIFFUSION OF KNOWLEDGE AMONG MEN." The members and honorary members of this establishment are to hold stated and special meetings for the supervision of the affairs of the Institution, and for the advice and instruction of a Board of Regents, to whom the financial and other affairs are intrusted.

The Board of Regents consists of three members *ex officio* of the establishment, namely, the Vice-President of the United States, the Chief Justice of the Supreme Court, and the Mayor of Washington, together with twelve other members, three of whom are appointed by the Senate from its own body, three by the House of Representatives from its members, and six persons appointed by a joint resolution of both houses. To this Board is given the power of electing a Secretary and other officers, for conducting the active operations of the Institution.

To carry into effect the purposes of the testator, the plan of organization should evidently embrace two objects: one, the increase of knowledge by the addition of new truths to the existing stock; the other, the diffusion of knowledge, thus increased, among men. No restriction is made in favor of any kind of knowledge; and, hence, each branch is entitled to, and should receive, a share of attention.

The Act of Congress, establishing the Institution, directs, as a part of the plan of organization, the formation of a Library, a Museum, and a Gallery of Art, together with provisions for physical research and popular lectures, while it leaves to the Regents the power of adopting such other parts of an organization as they may deem best suited to promote the objects of the bequest.

After much deliberation, the Regents resolved to divide the annual income into two parts—one part to be devoted to the increase and diffusion of knowledge by means of original research and publications—the other part of the income to be applied in accordance with the requirements of the Act of Congress, to the gradual formation of a Library, a Museum, and a Gallery of Art.

The following are the details of the parts of the general plan of organization provisionally adopted at the meeting of the Regents, Dec. 8, 1847.

DETAILS OF THE FIRST PART OF THE PLAN.

I. To increase Knowledge.—*It is proposed to stimulate research, by offering rewards for original memoirs on all subjects of investigation.*

1. The memoirs thus obtained, to be published in a series of volumes, in a quarto form, and entitled "Smithsonian Contributions to Knowledge."

2. No memoir, on subjects of physical science, to be accepted for publication, which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

3. Each memoir presented to the Institution, to be submitted for examination to a commission of persons of reputation for learning in the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

4. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision be made.

5. The volumes of the memoirs to be exchanged for the Transactions of literary and scientific societies, and copies to be given to all the colleges, and principal libraries, in this country. One part of the remaining copies may be offered for sale; and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

6. An abstract, or popular account, of the contents of these memoirs to be given to the public, through the annual report of the Regents to Congress.

II. To increase Knowledge.—*It is also proposed to appropriate a portion of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that, in course of time, each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made:—

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, mathematical, and topographical surveys, to collect material for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of articles of science, accumulated in the offices of Government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also explorations, and accurate surveys, of the mounds and other remains of the ancient people of our country.

I. To diffuse Knowledge.—*It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. Some of these reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators, eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch, can procure the parts relating to it, without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:—

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoology, geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

II. TO DIFFUSE KNOWLEDGE.—*It is proposed to publish occasionally separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises to be submitted to a commission of competent judges, previous to their publication.

DETAILS OF THE SECOND PART OF THE PLAN OF ORGANIZATION.

This part contemplates the formation of a Library, a Museum, and a Gallery of Art.

1. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies of the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

2. The Institution should make special collections, particularly of objects to verify its own publications. Also a collection of instruments of research in all branches of experimental science.

3. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found elsewhere in the United States.

4. Also catalogues of memoirs, and of books in foreign libraries, and other materials, should be collected, for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

5. It is believed that the collections in natural history will increase by donation, as rapidly as the income of the Institution can make provision for their reception; and, therefore, it will seldom be necessary to purchase any article of this kind.

6. Attempts should be made to procure for the gallery of art, casts of the most celebrated articles of ancient and modern sculpture.

7. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union, and other similar societies.

8. A small appropriation should annually be made for models of antiquity, such as those of the remains of ancient temples, &c.

9. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art; distinguished individuals should also be invited to give lectures on subjects of general interest.

In accordance with the rules adopted in the programme of organization, each memoir in this volume has been favorably reported on by a Commission appointed for its examination. It is however impossible, in most cases, to verify the statements of an author; and, therefore, neither the Commission nor the Institution can be responsible for more than the general character of a memoir.

The following rules have been adopted for the distribution of the quarto volumes of the Smithsonian Contributions:—

1. They are to be presented to all learned societies which publish Transactions, and give copies of these, in exchange, to the Institution.

2. Also, to all foreign libraries of the first class, provided they give in exchange their catalogues or other publications, or an equivalent from their duplicate volumes.

3. To all the colleges in actual operation in this country, provided they furnish, in return, meteorological observations, catalogues of their libraries and of their students, and all other publications issued by them relative to their organization and history.

4. To all States and Territories, provided there be given, in return, copies of all documents published under their authority.

5. To all incorporated public libraries in this country, not included in any of the foregoing classes, now containing more than 10,000 volumes; and to smaller libraries, where a whole State or large district would be otherwise unsupplied.

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[1] Each memoir is separately paged and indexed.

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THE
GRAY SUBSTANCE
OF
THE MEDULLA OBLONGATA AND TRAPEZIUM.

BY

JOHN DEAN, M.D.

[ACCEPTED FOR PUBLICATION, AUGUST, 1863.]

COMMISSION

TO WHICH THIS MEMOIR HAS BEEN REFERRED.

Brig. Gen. W. A. HAMMOND, U. S. A.
Prof. JEFFRIES WYMAN,

JOSEPH HENRY,
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COLLINS, PRINTER,
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PREFACE.

The principal object in view, in the following memoir, has been to give the entire topography of the medulla oblongata and trapezium, with illustrations from a series of photographs, the negatives of which have been prepared solely by myself, and have in no case received any retouching. Over two years of constant study have been devoted solely to this investigation, the results of which, both descriptive and histological, I have constantly endeavored to render as trustworthy as possible.

It was my original intention to comprise, in the same communication, the anatomy of the pons Varolii, including that part of the human pons corresponding to the trapezium. Such a plan, however, would have been attended with many difficulties, besides a great increase in the number of illustrations, and it has therefore seemed best to present the second part of this paper in a form which I am well aware is quite incomplete, with the hope of extending it at some future time.

A limited number of photographic prints from the original negatives have been prepared by myself for private distribution, and from these negatives other copies may be obtained, which will be supplied, as far as possible, either on direct application to the author or through the medium of the Smithsonian Institution.

For the labor and patience bestowed on the photo-lithographs by Mr. L. H. Bradford, and for the conscientious care and skill with which Mr. J. W. Watts has engraved my histological drawings, I owe and gladly render my most grateful thanks.

JOHN DEAN.
11 Louisburg Square, Boston.

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PART I.

THE FORM AND STRUCTURE
OF THE
GRAY SUBSTANCE OF THE MEDULLA OBLONGATA,
HUMAN AND MAMMALIAN.

CHAPTER I.

MORPHOLOGICAL CHANGES IN THE MEDULLA OBLONGATA OF THE SHEEP.

(1.) THE first change in the form of the gray substance as it passes from the cord to the medulla oblongata, consists in a gradual pushing outwards and forwards of the *posterior* cornua, which are now traversed along the anterior edge of the *caput cornu*, especially at its junction with the *cervix*, by very numerous bundles of longitudinal fibres, forming a beautiful network along the lateral border of the gray substance. At the same time the *anterior* cornua have rapidly diminished in size, being encroached upon by similar longitudinal fasciculi, extending the above mentioned network into the antero-lateral and anterior columns. The network connected with the posterior cornua is traversed by the roots of the spinal accessory, whilst that of the anterior cornua is traversed by the upper cervical, and higher up by the hypoglossal roots. These changes are well shown in Plate I, Figs. 1, 2; Plate XIII, Figs. 1^a, 2^a, the network in the latter figure being further increased by numerous arciform fibres derived from the post-pyramidal and restiform nuclei.

Anteriorly (Plate I, Fig. 1; Plate XIII, Fig. 1^a, P') the fibres of the *pyramids* will still be noticed decussating to a considerable extent; but they have already begun to take a direction parallel with the median line. These latter fibres together with some bundles derived from the arciform plexus, partly running along the middle line, and partly decussating at this point, form the first indications of the raphè, which is shown completely formed in Figs. 2, 2^a, *R*.

The most important changes, however, occur in the posterior portion of the medulla. In Figs. 1, 1^a, it will be noticed that the posterior median fissure is still persistent, reaching quite to the posterior gray commissure, which latter is much thicker than in the spinal cord. On each side of the fissure, very minute tufts may be seen arising from the gray substance; these are the first indications of the network of fibres and cells, which higher up is so very conspicuous, nearly filling the posterior pyramids, and separated from the restiform bodies by a distinct sulcus (Figs. 1, 1^a, *p*). At the side of these little tufts a large and very distinct eminence will be noticed, occupying the remainder of the posterior portion of the cervix cornu, and projecting outwards into the restiform body, into which it sends numerous fibres and cells. These two new bodies, which appear to fulfil a very important part in the organization of the medulla, Clarke has already named the *post-pyramidal* and *restiform nuclei* or ganglia. "They exist in all the mammalia."[1]

The *caput* cornu, meanwhile (Figs. 1, 2, 1^a, 2^a, *b*), has been pushed forwards, and almost separated from the cervix by intervening network, until it nearly reaches the surface of the postero-lateral columns, forming the *tuberculo cinereo* or gray tubercle of Rolando (*b*). The cervix contains many scattered cells of various sizes, collected into several groups near the tufts which are the first indications of the post-pyramidal and restiform nuclei. The *caput* contains only very small cells, scattered about among the longitudinal bundles which traverse it. Numerous large cells are found among the fasciculi forming the fibrous network around the lateral and antero-lateral gray substance, especially in that portion reaching from the entrance of the spinal accessory along the lateral edge of the anterior cornu.

The *tractus intermedio-lateralis* is well marked here, but as we ascend, only a few large cells remain in the outer network, the majority being pushed inwards to form the nucleus of the spinal accessory; it is usually, however, quite possible to trace a continuous line of cells from the entrance of the spinal accessory nearly to the central canal.

The *anterior* cornua are much diminished in size, and contain but few large cells which are already partially collected in two small, round groups (Fig. 1^a, *H*), forming the first indication of the great hypoglossal nuclei.

In the lateral columns near the border of external arciform fibres, a group of large multipolar cells is found (Fig. 1^a, *B*) which become more and more prominent as we ascend, till the level of the vagus is reached, when it is broken up into smaller groups. From its situation in the antero-lateral columns I propose to call this group the *antero-lateral nucleus.* It is penetrated by the fibres of the arciform plexus, both external and internal, with which it is brought into very close connection.

(2.) A little higher up (Plates I, XIII, Figs. 2, 2^a) these changes in form are still more marked; the decussation of the pyramids has ended. The pyramidal columns which in the sheep are very small are now quite distinct; and numerous fibres run parallel to the axis of the medulla, forming with the arciform fibres which decussate with them the raphè (*R*). The principal morphological change is the appearance of the *olivary* bodies (*O*), which, though not particularly well marked in the sheep, are still quite too distinct to be overlooked, as has been done by some anatomists. They are composed of layers of small cells penetrated by the arciform fibres; but I shall reserve the discussion of their more intimate structure for a

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[1] Medulla Oblongata. Philos. Trans. 1858, 240.

subsequent chapter. The olivaries are connected with each other and with the raphè by the arciform fibres, and are also united to the hypoglossal nuclei by bundles of fibres, either directly or by the interposition of cell nuclei.

The *antero-lateral* nucleus (*B*) is now very prominent, from the number and size of its cells. These are mostly stellate, sending their processes in all directions, the group being traversed by the arciform fibres and by fibres derived from the central gray substance, as well as by longitudinal fibres. This group is also united to the caput, and in sections higher up to the remains of the cervix, by the cells formerly scattered throughout the antero-lateral columns, but which are afterwards collected into elongated groups (Fig. 3^a). The *restiform* (*r*, *r*) and *post-pyramidal* (*p*, *p*) nuclei are now much increased in size, and are quite filled with cells of various dimensions and forms, the cells of both nuclei reaching out into and soon entirely filling the posterior and postero-lateral columns.

As we ascend, the nuclei of the hypoglossal and spinal accessory nerves rapidly increase in size and number of cells, the entire substance of the anterior or *hypoglossal* nucleus (*H*) being filled with large stellate cells, with the exception only of that portion which forms on each side the lateral boundary of the central canal. The posterior, *spinal accessory* or *vagus* nucleus (*S*), has also equally increased; its group of large, obovate cells is very conspicuous, the remainder of the nucleus being entirely filled with smaller, scattered cells. The *caput* is mostly filled with granules and smaller nuclei, with a few cells of medium size; numerous cells being scattered throughout the entire lateral and antero-lateral network.

(3.) Still higher up (Plate I, Fig. 3; Plate XIII, Fig. 3^a) the *central canal* which has been hitherto somewhat elongated, of a narrow oval form, changes to a triangular shape with curved sides, the apex pointing forwards, and bridged behind by a thick band of commissural fibres connecting the posterior nuclei, now the nuclei of the vagus roots (Fig. 3^a, *V*). The principal changes to be noticed in this region are the rapid increase in the number of cells forming the *post-pyramidal* (*p*, *p*) and *restiform* (*r*, *r*) nuclei, which fill the entire posterior and postero-lateral columns, encroaching on the caput and thick band of external arciform fibres, with both of which they seem to be connected by numerous bundles of curving or wavy fibres (Fig. 3^a, *a*). A remarkable collection of longitudinal fasciculi is here plainly manifest, which, beginning a little lower down, comes now distinctly in sight just at the entrance of the vagus roots (*l*), separating them into anterior and posterior divisions. The cells of the *antero-lateral* nucleus, instead of being collected into compact groups as below, are somewhat scattered, forming various wavy groups which nearly fill the antero-lateral columns of the medulla (*B*).

(4.) As we continue to ascend (Plates I, XIII, Figs. 4, 4^a) the commissural bridge between the two vagal nuclei is split open, forming the fourth ventricle, on each side of which are situated the nuclei of the hypoglossal and vagal nerves, the anterior portion of the vagus nucleus being especially conspicuous from its crowd of obovate cells.

The longitudinal fasciculi in connection with the vagus nucleus are very prominent, separating the roots into two divisions, the posterior bundles either entering a small nucleus behind the longitudinal fasciculi, or bending around them towards the anterior part of the nucleus. The *restiform* and *post-pyramidal* nuclei are filled with numerous cells, and the latter is closely connected with the vagus nucleus by means of a spur from each, the post-pyramidal body being as it were wedged or dove-tailed into the vagus nucleus. The cells of the *caput* gradually increase in size and number as we ascend, the caput itself being traversed by the vagus roots. The longitudinal fasciculi in connection with the vagus continually increase in size, and are reinforced by another system of bundles (*m*) which appear in that portion of the nucleus from which the auditory nucleus is subsequently developed. The lower part of the raphè constituting the olivary commissure contains many cells, rather larger than those of the olivary bodies, and scattered cells are found throughout the entire length of the raphè, as well as in all parts of the anterior and antero-lateral network. At about this height little nuclei are found connecting the raphè and hypoglossal nuclei with the olivary bodies and antero-lateral nuclei.

(5.) Still higher up (Plates I, XIII, 6, 6^a) the *hypoglossal* nucleus begins to diminish somewhat in size, its cells being smaller and much less numerous, though a considerable number of large cells are still to be seen as long as the nucleus continues distinct. The cells of the *vagus* nucleus are very numerous and the roots very distinct.

Posteriorly we begin to trace the formation of a new nucleus (*A*), in the hinder portion of the vagus, or rather between the vagal and post-pyramidal nuclei. This mass, which is pyramidal in shape, with its longest convex side fitted into the vagus nucleus, its concave side being turned towards, and receiving the post-pyramidal body, becomes the principal nucleus of the *auditory* nerve. The *vagus* nucleus is now much diminished in size, and is thrust forwards and wedged in between the newly formed auditory nucleus and that of the hypoglossal. The new mass contains cells of large size, especially at the apex, which projects into the restiform body and into the posterior border of the caput, with both of which it appears to be connected.

The *restiform* and *post-pyramidal* bodies in this region are thickly studded with large cells, and both the vagal and auditory nuclei are bordered by a network, formed by the passage of numerous longitudinal fasciculi, which continue to increase both in size and number as we ascend (Fig. 6^a, *l*, *m*).

The *caput cornu* through which the large roots of the vagus pass, is thickly studded with cells of medium size. The *antero-lateral* nucleus is still quite conspicuous, but the cells are separated into more distinct groups, intersected in every direction by the arciform and transverse fibres. Cells are also scattered in the network by which the entire edge of the caput is surrounded, embracing with their processes the large bundles of longitudinal fibres which traverse it. The olivary bodies have now obtained their maximum development, and soon begin to diminish in size with the diminution of the hypoglossal nucleus and roots (Figs. 6^a, 7^a, *O*). In the upper portions of the medulla the remains of the olivary lamina seem to be filled with larger cells, which have replaced the small regular cells of the lower portions. They still extend across the raphè through the commissure.

(6.) In the section just above the preceding (Plates I, XIII, Figs. 7, 7^a) the *hypoglossal* nucleus, though still large, contains but few cells, and these very much scattered; no distinct roots can be traced to the surface. The *vagus* nucleus still contains numerous cells, mostly crowded back from the apex. The nucleus has been pushed forwards so that its base no longer lies on the floor of the fourth ventricle, but is separated from it by a commissure of fibres and cells connecting the hypoglossal nucleus with that of the auditory.

The *auditory* nucleus (*A*) is now quite large, pyramidal in form, and has already absorbed the outer portion of the vagus nucleus as well as the post-pyramidal body. It is bordered along its outer edge by a network of fibres, inclosing large and numerous longitudinal fasciculi, forming a very conspicuous fringe, which still higher up is more distinctly separated from the inner portion, forming a very complete border, called by Clarke the "*outer nucleus.*" Both portions of the auditory nucleus contain numerous cells of medium size, obovate and stellate.

The *restiform* body is still crowded with cells, and at its outer edge gives off fringes of fibres reaching into the dark border of longitudinal fibres by which it is now bounded (*k*), the band of external arciform fibres (*a*) being pushed further forwards, and thinned off posteriorly more and more, to make way for the posterior and anterior divisions of the auditory roots, which presently make their appearance.

The *caput* is penetrated by the vagus roots and studded with small cells, particularly near the apex of the vagus nucleus. It is also connected with the restiform body, and with the point of the auditory nucleus, by a network of cells and fibres, and anteriorly with the remains of the antero-lateral nucleus.

The small cells of the olivary bodies have mostly disappeared, except in the immediate vicinity of the raphè. Some cells are still persistent in the locality of the antero-lateral nucleus, while further back and close to the caput a large group is seen, the commencement of a column which steadily increases as we ascend, its somewhat large cells being finally grouped together as the upper olivary bodies (Plates XIII, XIV, *O'*). In (Fig. 7^a) these cells as well as the remains of the antero-lateral nucleus appear to be connected with the posterior portion of the hypoglossal nucleus by radiating fibres.

(7.) Still higher up the principal changes consist in the gradual pushing forwards of the vagus nucleus, which, as it is pushed towards the apex of the great triangular mass formed by the fusion of the vagal, hypoglossal, and auditory nuclei, becomes the nucleus of the glosso-pharyngeal. These changes have been well figured by Stilling (*Textur und Function der Medulla Oblongata.* Erlangen, 1843, Taf. vii, Figs. 1—6). The roots of the glosso-pharyngeal subdivide into many bundles in their course through the caput; some seem to pass into the auditory nucleus, some into their own proper nucleus, whilst some, especially in higher sections, reach forwards as far as the remains of the hypoglossal nucleus.

The *restiform* body is still further reduced in size by the dark border of longitudinal and oblique fibres by which it is surrounded, which has now attained very considerable breadth. The *olivary* bodies have entirely disappeared, with the exception of a few quite large cells which still linger about the raphè near the olivary commissure.

CHAPTER II.

MORPHOLOGICAL CHANGES IN THE MEDULLA OBLONGATA OF MAN.

(1.) In the region of the first cervical nerve the general form of the human medulla has been very well represented by Stilling[1] and by Clarke.[2] The general plan is similar to that observed in the sheep, with slight differences, chiefly due to the nearly circular form of the human medulla, as compared with the more elongated or elliptical form in most of the mammalia, producing a greater concentration of parts, especially in the lower regions, where the contrast is very decided. The *restiform* and *post-pyramidal* nuclei are developed earlier and are much larger in man and the carnivora than in the lower mammalia, and a few other differences occur higher up, which will be noticed presently.

(2.) Figs. 17, 17^a, Plates V, and XIV, show the general arrangement of parts in the vicinity of the decussation of the pyramids. By comparison with Plates I, and XIII, Figs. 1, 1^a, it will be seen that the principal differences consist in a more complete separation of the *cervix* (*d*) and *caput* (*b*), and in the much greater development of the *restiform* (*r*, *r*) and *post-pyramidal* (*p*, *p*) nuclei, which are already very prominent and contain very many cells. The *post-pyramidal* nuclei have expanded backwards into a fan-like network of cells and fibres, nearly filling the post-pyramidal bodies on each side of the posterior fissure. The cells of the *restiform* nucleus are scattered throughout the posterior portion of the cervix, but are mostly concentrated along its outer border, lateral as well as posterior; they are large and easily distinguishable, even with a low power. The cells of the *tractus intermedio-lateralis* (*t*) are still persistent along the outer border of the gray substance, between the anterior and posterior cornua, but are mostly pushed inwards towards the central canal, behind and on each side of which soon appears a large group of cells, constituting the nucleus of the spinal accessory. The *caput cornu* (*b*) contains a few scattered cells, as also does the network extending across to the anterior cornu, which latter contains very numerous large multipolar cells.

The large wings formed by the tractus intermedio-lateralis (*t*), are here plainly seen; they have been called by Reichert[3] the *lateral* cornua (seitliche Stränge oder Hörner). A little higher up, the anterior cornua are still further contracted, and the first indications are seen of the *olivary* columns and of the *antero-lateral* nuclei.

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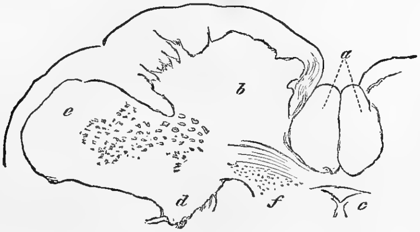
[1] Medulla Oblongata, pl. iv, fig. 1.

[2] Philos. Transactions, 1858, pl. xiv, fig. 23; pl. xv, fig. 19.

[3] Bau des Menschlichen Gehirns. II. Leipzig, 1861.

In the cat the form of the different parts is very nearly intermediate between the human medulla and that of the sheep. It is especially distinguished in this region by the very remarkable size of the *post-pyramidal* and *restiform* nuclei, which are developed to an enormous extent, filling the respective columns (Fig. 1).

Fig. 1.



Posterior cornu from the medulla of the cat, just above the decussation of the pyramids.—*a*, post-pyramidal nuclei; *b*, restiform nucleus; *c*, central canal; *d*, tractus intermedio-lateralis; *e*, caput cornu; *f*, nucleus of spinal accessory.

(3.) In the next section, Plates V, and XIV, Figs. 18, 18^a, the anterior cornua have almost entirely disappeared, and the group of cells constituting the nucleus of the hypoglossal (*H*) has become quite distinct. The nucleus of the spinal accessory (*S*) is plainly seen, as a long tract of cells reaching from the tractus intermedio-lateralis to a point just behind the central canal. The lateral cornu through which the roots of the spinal accessory run, is here quite prominent, and just beyond a line of cells can be traced connecting it with the *antero-lateral* nucleus. Reichert seems to consider the antero-lateral nucleus as simply a pushing outwards of the lateral cornu,[1] but I think this is not the case; it seems to be more probably a distinct group of cells, intimately connected with the development of the internal arciform fibres and appearing at the same time with these.

The commencement of the *olivary bodies* (*O*) is now seen as a somewhat elongated tract of cells along the margin of the pyramids, closely connected with the arciform fibres and with the antero-lateral nucleus. In the substance of the *anterior pyramids*, which are here very large, and from which the raphè is already partially formed, may be seen here and there little nuclei, connected with fibres both transverse and longitudinal (*Kleine Pyramiden-Kerne* of Stilling). (Fig. 18^a, i.)

The posterior portion of the medulla has undergone very considerable development; the *caput* (*b*) is filled with numerous scattered cells, and is connected with the external arciform fibres by little groups of cells, which its numerous radiating

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[1] In his description of Fig. 7, op. cit., he makes the following statement: Die seitlichen Hörner haben ihre Verbindung untereinander und zum Theil auch mit der Centralpartie der grauen Kernsubstanz aufgegeben, sie erscheinen als einzelne unbestimmt begrenzte, in die Seitenstränge des Mantels eingelagerte Flecke die demnach als Durchschnitte von isolirt verlaufenden Strängen anzusehen sind. p. 100.

fibres enter. The *restiform* nucleus (*r*, *r*) is very conspicuous and is entirely filled with cells, some of which are quite large, and along its posterior border numerous tufts of fibres and cells are pushed out into the restiform body (*r*). The post-pyramidal nucleus has become a fan-like expansion of cells and radiating fibres, quite filling the post-pyramidal body (*p*). Both of these nuclei are traversed by the arciform fibres, many of which originate from their cells.

(4.) In the sections next above (Figs. 19, 19^a) we have a decided change in the form of the central gray substance. The *raphè* (Fig. 19^a, *R*) is now completely formed, and has pushed the central canal (*c*) somewhat backwards; the posterior fissure has almost entirely disappeared, and is reduced to a deep sulcus, while the central gray substance is drawn out posteriorly in a very remarkable manner, until it reaches the sulcus. Behind the central canal, and nearly parallel with the sides of the gray substance, are situated two elongated groups of oval and fusiform cells (*S*), which are continued backwards until they nearly meet at the middle line, forming the nuclei of the highest roots of the spinal accessory nerve. This nucleus is somewhat bifurcated by bundles of longitudinal fibres which pierce its apex (*l*), and in the anterior spur some remains of the tractus intermedio-lateralis are still persistent.

The cells of the *antero-lateral nucleus* (*B*) are very numerous, filling nearly the entire antero-lateral columns, and serving to connect the anterior and posterior portions of the medulla, by means of the arciform fibres which traverse this nucleus, and in many cases enter its cells, the processes from which pass in every direction transversely as well as longitudinally. This group is also closely related to the olivary bodies, which are now quite fully developed as a compact coil of small cells imbedded in a mass of fibres, situated on the lateral border of the pyramid outside the hypoglossal roots.

The situation of the olivary bodies (*O*) with respect to the hypoglossal roots, constitutes one of the most striking differences between the human medulla and that of most of the mammalia, and is produced by the great development of the pyramids, as well as of the olivaries themselves, in the human medulla, leaving insufficient room for the hypoglossal roots to pass on the outer side, as is easily done where the development of these bodies is comparatively so slight, as it is, even in animals possessing so distinct olivary convolutions as the carnivora.

On the inner side of the hypoglossal roots, we find in man a large and elongated group of cells (*s*) called by Stilling the *great pyramidal nucleus*, and considered by him, together with the small pyramidal nuclei, noticed above, as the chief source from which the fibres of the pyramidal column proceed. Although some of the transverse bundles by which the pyramids are everywhere pierced, undoubtedly arise from these cells, I entirely agree with Clarke[1] in considering this group (the great pyramidal nucleus) as a portion of the olivary column, the peculiar structure of which the cells assume more and more as we ascend, being often found in the upper part of the medulla (Fig. 23^a), arranged in a little convolution, evidently of the same nature as the larger olivary lamina with which it is connected.

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[1] Philos. Trans. 1858, 244.

The *anterior* portion of the gray substance has become more compact, the little wings, noticed in the sections just below, at the entrance of the hypoglossal roots, have nearly disappeared, and the entire substance of the anterior cornua is filled with large multipolar cells, constituting the *nucleus* of the *hypoglossal.*

On comparing Figs. 19, 19^a, from the human medulla, with Figs. 2, 2^a, from about the same region in the sheep, the dissimilarity seems at first sight considerable. By a closer examination it will, however, be seen that the general plan is quite the same, and we may consider the form of the human medulla, as resulting from a greater concentration of parts around the central canal, together with the much greater development of some portions, especially the pyramidal and olivary columns. Here, as elsewhere, we see that if we should take the medulla of the sheep on each side the middle line, near the point where the restiform nuclei approach the posterior surface, and bring the two points towards each other, almost the same disposition of parts would be produced as is seen in the human medulla, making allowance only for the greater development of certain cell tracts in the latter case, as contrasted with the evident simplification of structural details in the sheep and other of the lower mammalia.

(5.) As we approach the opening of the central canal into the fourth ventricle, the development of the cell groups seen below continually advances, till we reach the level of the *calamus scriptorius* (Figs. 20, 20^a).

Just in front of the sulcus forming the apex of the fourth ventricle (Fig. 20^a, *w*), and on each side of the middle line, are seen the two tracts closely crowded with large multipolar cells, constituting the hypoglossal nuclei (*H*), from which the root-bundles of the hypoglossal (*XII*) may now be seen radiating to the surface of the medulla, between the pyramidal and olivary columns. The whole anterior and antero-lateral substance contains numerous scattered cells and small cell groups, entering everywhere into connection with the arciform fibres; the extremely complicated arrangement of the fibres constituting this plexus has already been very accurately described by Clarke (1858).

Little groups of cells are frequently found just at the entrance of the hypoglossal roots into their nuclei, as also scattered along the raphè, serving to unite the different sets of fibres, transverse, arciform, and longitudinal.

The *olivary* convolutions (*O*) have attained a very considerable development, and the *small pyramidal* nuclei (*i*) are likewise quite conspicuous. The *antero-lateral* nuclei (*B*) have reached their maximum development, being separated into smaller cell groups a little higher up. The *caput* (*b*) is large and distinct, and is closely united to the *restiform* nucleus; they are both crowded with cells, and are connected with the external band of arciform and oblique fibres (*a*) by quite numerous detached cell groups. At about this height the *post-pyramidal* and *antero-lateral* nuclei seem to have reached their greatest development; the commencement of the auditory ganglion, which is formed out of the substance of the first-named nucleus, is seen in sections lying just above, while the antero-lateral nucleus is continually encroached upon by the development of the olivary bodies.

(6.) In the next sections (Plates VI and XV, Figs. 21, 21^a) we have a still greater development of some parts, with a corresponding diminution in others.

The *hypoglossal* nuclei (*H*) are spread out into closely crowded clusters of large, multipolar cells. The *vagal* nuclei (*V*) are considerably developed, and filled with oblong, or obovate cells, the more posterior of which are now closely connected with those of the post-pyramidal nuclei. It is in this posterior cell group (*g*), developed, as Clarke has already pointed out,[1] from the substance of both nuclei, that the first appearance of the auditory ganglion can be traced. The *vagus* nucleus is here bifurcated, as that of the spinal accessory was to some extent, by large bundles of longitudinal fibres (*l*). The restiform nucleus (*r*, *r*) has expanded into a large mass of cells and fibres, nearly filling the entire restiform body and pushing the caput cornu still further forwards.

The *antero-lateral* nucleus (*B*) has diminished in size, a few cell groups alone remaining, crowded between the olivary body and the border of the caput; these groups are still closely connected with the arciform fibres and probably serve to co-ordinate distant parts of the medulla. A group formed at least partially from the antero-lateral nucleus, is seen (Figs. 20^a, 21^a, *n*) arranged in a long layer close to the border of the olivary lamina. This group, called by Stilling the *accessory olivary nucleus*, is evidently similar in structure to the olivary lamina, as has already been pointed out by Clarke. Its position and the number of its layers vary in different sections, as well as in different specimens, and there seems no reason for considering it as in any wise distinct from the olivary body.

At the junction of the restiform nucleus and caput, a network of cells and fibres is pushed out, extending to the border of the medulla (Fig. 20^a, *x*), where a large group of cells is seen closely connected with the band of external arciform fibres; several such groups are pushed out, either from the caput or restiform nucleus, and this tendency seems to increase as we ascend, till the whole restiform body is filled with a mass of more or less compact cell groups, reaching very nearly to the border of the medulla (Figs. 21^a, 22^a). The decussation along the raphè is very marked, and scattered cells are everywhere found mingled with its fibres. The arciform fibres interlace in a much more intricate manner than in the lower mammalia, and are connected with numerous cells and cell groups, which serve either as starting-points for new fibres or as co-ordinating centres.

(7.) In the sections just above (Figs. 22, 22^a) the principal changes are in the posterior portions of the medulla, the anterior and antero-lateral parts undergoing but little change. The *hypoglossal* nucleus is still very large and prominent, the nerve-roots (*XI*) winding in a serpentine course through a part of the olivary lamina, but never entering into communication with it. The great pyramidal nucleus of Stilling (*s*) is here very distinctly seen, as well as the little elongated lamina (*n*) situated just above the olivary body (accessory olivary nucleus of Stilling).

The *vagus* nucleus (*V*) has now reached its maximum development; it appears as a large elongated, pyriform mass, containing a group of densely crowded, obovate cells. From it the vagus roots (*X*) may now be seen proceeding in several very distinct bundles, traversing the caput cornu, which consists of a compact mass of cells connected together by wavy bands of fibres. The apex of the nucleus is quite

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[1] Philos. Transactions, 1858, and Proceedings of the Royal Society, 1861.

deeply bifurcated by the longitudinal fasciculi spoken of above (*l*), and sends forward one of its spurs into the substance of the post-pyramidal body. Between the post-pyramidal nucleus and that of the vagus a new body has arisen, apparently developed out of the substance of both nuclei. This new body (Fig. 22, *A*), the formation of which has been described very accurately by Clarke,[1] becomes the principal nucleus of the auditory nerve, and is at first intimately connected both with the post-pyramidal and vagal nuclei. It presents the usual pyriform or triangular shape assumed by the other nuclei, and contains numerous scattered cells of varied form and dimensions. It seems to be inserted like a wedge between the vagus nucleus and that of the post-pyramidal body, the latter being partially blended with it and partly pushed aside, and is already pierced to some extent by little bundles of longitudinal fibres (*m*), appearing in the section as dark spots, which continually increase as we ascend, forming eventually a very remarkable marginal network, containing numerous cells, many of which are of large size, and embrace the longitudinal fasciculi in all directions with their processes.

(8.) These changes are still more evident higher up (Figs. 23, 23^a), and have been exceedingly well figured both by Stilling[2] and Clarke[3]. The *vagus* nucleus (*V*) is here rapidly thrust forward by the extension of the nucleus of the auditory, and soon becomes the nucleus of the glosso-pharyngeal, which is simply an upward extension of that of the vagus, between which and the glosso-pharyngeal it is impossible to fix any definite boundary.

The remains of the *hypoglossal* nucleus are quite conspicuous, and the place of the root is occupied by transverse, radiating fibres (*XII'*), running apparently into the hilus of the olivary body, but consisting mostly of obliquely ascending bundles of hypoglossal roots which are cut off by the plane of section.

The nucleus of the *auditory* (*A*) is now considerably extended, and sends out a spur or process into the post-pyramidal body, by means of which it is also brought into connection with the restiform nucleus, as well as with the caput. The bundles of longitudinal fibres (*m*) by which the auditory nucleus is bounded on its postero-lateral margin, rapidly increase in size and number, and in the sections just above (Figs. 24, 24^a), we find them arranged in a wide band or network along the outer edge of the auditory nucleus, of which they constitute the outer portion (*A'*), containing among the meshes of the network numerous very large multipolar cells.

(9.) The little nucleus of the *glosso-pharyngeal* is here seen (Fig. 24^a, *G*) thrust very far forward by the extension of the auditory nucleus, which quite overlies the remains of the vagus nucleus; it is entered by the glosso-pharyngeal roots (*IX*) in several distinct and wavy bundles.

In this part of the medulla (Figs. 24, 24^a) the entire outline is changed from the circular or somewhat crescentic form presented below, to one much more elongated along the posterior boundary; the restiform columns being drawn apart laterally from the middle line or raphè, so that the nuclei which in the lowest part of the

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[1] Philos. Transactions, 1858, and Proceedings of the Royal Society, June, 1861.

[2] Medulla Oblongata. Atlas, pl. vii, figs. 1—6.

[3] Philos. Trans. 1858, pl. xvi, figs. 31, 32; pl. xvii, fig. 36.

medulla were arranged with respect to the central canal much as in the spinal cord, are now spread out upon a very long base forming the extended floor of the fourth ventricle.

The upward extension of the hypoglossal nucleus still contains numerous small cells, from which is subsequently developed the *fasciculus teres*, forming the nucleus of the abducens and facial nerves. The *restiform* body no longer presents the same appearance as in lower sections, but consists interiorly of a large group of cells (*r*, *r*) the remains of the restiform nucleus, from which as a common centre, a mass of fibres radiate in an obliquely ascending course, becoming more and more horizontal as we approach the cerebellum, which the restiform body, as is well known, finally enters.

Winding around the outer border of the restiform body is seen the posterior division of the auditory nerve (*VIII'*), containing, as noticed by Stilling, numerous little cells (*z*) near its entrance into the medulla. The *caput* is still prominent and contains numerous cells, connected by a small group with the large nucleated mass from which the glosso-pharyngeal and auditory roots arise. The whole antero-lateral and anterior substance of the medulla in this region, contains numerous cell groups, some of considerable size, and small cell groups are very often found scattered among the decussating fibres of the raphè. The *olivary* columns have here reached their greatest development, and begin immediately to diminish in size, as is also the case with the anterior pyramidal columns, giving place to the extremely complicated plexus of fibres constituting the pons Varolii, many of which are intimately connected with and to some extent developed from the little cell groups so constantly found at different points in the substance of the pyramids (Fig. 24^a, *i*).

CHAPTER III.

THE HYPOGLOSSAL NUCLEUS AND ROOTS.

The Nucleus.—Stilling[1] was the first to point out the true origin of the hypoglossal roots, from the two groups of nerve cells which make their appearance just above the upper cervical nerves, in front of the central canal, extending laterally to a considerable distance on each side. These groups seem to be a continuation of the cell columns from which the anterior spinal roots arise, being situated within what is evidently the posterior portion of the anterior cornua, the anterior portion of which has already been broken up into an open network by the passage of numerous longitudinal fasciculi, to such an extent that the portion in the immediate vicinity of the central canal, together with a branching wing on each side the raphè, alone remains distinct.

The form of the hypoglossal nucleus as it appears just above the decussation of the pyramids, is nearly pyramidal, with its apex directed forwards towards the roots, varying but slightly in those mammalia I have examined, from its shape in man, the only difference arising from the greater general concentration of structure in the human medulla. These slight differences will be readily seen by comparing Figs. 17, 18, 19, 20, 21, 22, Plates V and VI, from the human medulla, with the corresponding sections from the sheep, Plates I, II, Figs. 1, 2, 3, 4, 5, 6.

Higher up the nucleus increases somewhat in size, and is gradually pushed slightly backwards and outwards, changing its form somewhat, becoming almost square close to the *calamus scriptorius* (Plates I, II, Figs. 4, 5; Plate VI, Fig. 21), and having attained its greatest development, gradually diminishes in size, reassuming presently its former pyramidal shape, finally becoming covered over by the auditory ganglion. Fig. 7, Plate II, shows the last remains of the hypoglossal which in Fig. 8 is completely merged in the auditory nucleus.

The oval cell groups which occupy already a large portion of the nucleus on each side of the middle line, increase rapidly in size and number of cells as they ascend, until their point of greatest development is reached a little above the *calamus scriptorius.*

The cells are mostly quite large, stellate or oblong in shape, and multipolar, resembling in every respect those found in the anterior cornua of the spinal cord, for which they might easily be mistaken.[2]

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[1] Medulla Oblongata. Erlangen, 1843.

[2] The great similarity both in the form of the cells and the general relations which these bear to the roots may be seen by comparing one of the figures from my memoir on the spinal cord (Memoirs of the American Academy, 1861, fig. 4), with pl. x, fig. 37 of the present memoir, the principal difference being solely that the cells of the hypoglossal nucleus are much more closely crowded together

Intermingled with the large multipolar cells are others presenting every variety of form and size, obovate, stellate, and fusiform.

The larger cells measure on an average in their longest diameter, in the sheep $\frac{1}{555}$ to $\frac{1}{500}$ of an inch. In the cat $\frac{1}{1250}$ to $\frac{1}{555}$ of an inch. In the human medulla $\frac{1}{1000}$ to $\frac{1}{666}$ of an inch.

These cells are collected into groups more or less distinct according to the region in which they are observed, and are also connected by their processes in the same manner as I have shown to be the case in the anterior cornua of the spinal cord, though from the cells being so closely crowded together, the connections are very difficult to trace satisfactorily.

The cell processes are sent out in various directions, both longitudinal and transverse, their general course having been already described by Clarke.[1] Some of them go upwards to cells of the same nucleus, some run backwards and enter the neighboring spinal accessory, or vagal nuclei, or are continuous with the roots of these nerves; a third set decussate at the raphè, and are either continuous with its fibres, or cross over into the opposite nucleus, the two nuclei being thus brought into close connection; whilst a fourth set pass out into the network by which the nucleus is bounded anteriorly and antero-laterally, the network itself containing, as mentioned above, very numerous cells of different form and size. Many of the cell processes, especially those from the anterior part of the nucleus, are continuous with the hypoglossal roots.

The courses pursued by these cell processes will be seen at a glance to be strictly analogous with the general direction which the cell processes follow in the anterior cornua of the spinal cord.

The connection between the hypoglossal nuclei and olivary bodies, by direct fibres and by numerous little cell groups scattered along the raphè and hypoglossal roots, will be noticed in describing the olivary bodies and their accessory nuclei.

The Roots.—In man the hypoglossal roots enter between the olivary column and the anterior pyramid (Plate VII, Figs. 25, 26, 27), penetrating the olivary body in the upper part of the medulla in a serpentine course (Fig. 27), but never, so far as I have been able to ascertain, entering into any immediate connection either with the cells or fibres of the olivaries.

In most of the mammalia the plan is somewhat different, owing to the greatly diminished size of the pyramids and olivary bodies, the latter being situated behind the pyramids on each side of the raphè, allowing the hypoglossal roots to pass outside of them (Plates I, II, and XIII).

The hypoglossal roots in man, after curving around the border of the olivary bodies, or penetrating them in one or more bundles, pursue a direct course to the nucleus, the apex of which they enter; in the mammalia the course is the same, with the single exception that they pass along the outer edge of the olivaries, and only penetrate among the scattering cells near the extreme outer edge.

On reaching the nucleus the greater part of the fibres proceed directly inwards, as do those of the anterior spinal roots, becoming connected with the large groups

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[1] Philos. Trans. 1858

of multipolar cells noticed above. The further course of the roots will be best understood by reference to Plate XI, Fig. 40, representing a transverse section of the hypoglossal nucleus, on a level with the vagus nucleus and just above the *calamus scriptorius*. A portion of the fibres are connected with cells of the outer group (*b*), thus becoming united secondarily with the great bundles of fibres proceeding from the vagus, by which the hypoglossal nucleus is bordered anteriorly (*D*). By far the greater number, however, pass through these border fibres and cells, penetrating the nucleus, until they reach the groups lying in the central and posterior portion (*h*). A few fibres may be seen to leave the bundles, either just before or soon after they cross the border, and pass along with the latter towards the raphè, or else branch out into the anterior columns and join some of the numerous bundles passing towards the raphè, where they decussate with those coming from the opposite side (*c*). It is impossible to trace their further course. Numerous fibres, often forming considerable bundles, may be seen either just as they enter the nucleus, or not unfrequently in its central region, sometimes forming quite a sharp curve (*m*, *m*), and bending back towards deeper lying cells, or towards the nucleus of the vagus, which some fibres from the hypoglossal certainly enter, forming a counterpart to the relation established, as noticed by Clarke[1] and confirmed by my own observations, between some of the hypoglossal roots and those of the spinal accessory.

The decussation of the hypoglossal roots, first pointed out by Kölliker, has recently been denied by Schröder van der Kolk. Kölliker[2] states that there is a "total decussation of the roots of both sides, on the floor of the fourth ventricle, so that those from one nucleus pass over into that of the opposite side." Lenhossek[3] also makes a similar statement with regard to the inner nerve bundles. Clarke[4] states that fibres from the hypoglossal "bend inwards and decussate through the raphè with their opposite fellows."

On the other hand, Schröder van der Kolk,[5] after many investigations on different animals, as well as on the human medulla, was able "to completely satisfy himself that this nerve does not decussate, but is lost entirely in the hypoglossal nucleus, being connected with multipolar cells by numerous fibres." He states, however, that the two nuclei are brought into connection by means of commissural fibres crossing the raphè and derived from the cells on each side.

The question is by no means an easy one to decide; my first attempts at solving it led me to think that Schröder van der Kolk was right in his opinion, but in going over the whole ground again with very great care, and examining specimens from the medulla of man and various animals, prepared by different methods,[6] I could have no doubt that some of the hypoglossal roots certainly decussate directly at the raphè, standing about in equal proportion to the main bundles as do those of

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[1] Philos. Transactions, 1858, 252, 253; pl. xvii, fig. 35.

[2] Mikroskopische Anatomie. II, 459.

[3] Neue Untersuchungen, 32.

[4] Philos. Transactions, 1858, 253.

[5] Medulla Spinalis and Oblongata, 1859, 97.

[6] Especially specimens hardened in chromic acid and made transparent by turpentine, this method seeming to me decidedly the best for tracing the *course of fibres*.

the anterior spinal roots which can be traced into the anterior commissure of the spinal cord.

Some of the fibres of the hypoglossal roots, especially those lying along the inner edge of the bundle nearest the raphè, turn off either just before or immediately after they enter the broad band of marginal fibres, and pursuing the same course, proceed towards the raphè, where they decussate with their fellows from the opposite side. Schröder van der Kolk is undoubtedly right in his assertion that the great loops of decussating fibres figured by Kölliker, and named by Lenhossek *ansa hypoglossi*, are formed not from the hypoglossal roots, but by the band of border fibres described above, which he has clearly shown to be derived from the vagus, and as he has also pointed out, this adds greatly to the difficulty of deciding the question. Most of the fibres forming the hypoglossal roots undoubtedly penetrate deeply into the nucleus, as maintained by Schröder van der Kolk, but a careful and repeated examination especially with high powers, has convinced me that some of them turn aside, and that a direct decussation exists of *a few* at least of the root bundles. In the cat, especially in the lower part of the hypoglossal nucleus, the course pursued by the roots is very distinct, and quite numerous bundles may be traced, accompanying the marginal fibres derived from the spinal accessory to the raphè; higher up the course is somewhat more obscure, as the band proceeding from the vagus is so much broader and more prominent than that from the accessory.

The roots of the hypoglossal are brought into intimate relation with those of the vagus, by means of a group of large multipolar cells, situated just within the marginal band of fibres proceeding from the vagus roots, by which the hypoglossal nucleus is inclosed (Plate X, Fig. 37, Plate XI, Fig. 40, *b*). Most of these cells are grouped together just behind the entrance of the hypoglossal roots, and thrust out some of their processes into the anterior columns, embracing the longitudinal columns, with some of the fibres of which they are perhaps continuous. They are connected by the remaining processes with the marginal fibres derived from the vagus (Plate X, Fig. 37, *B*), and with the hypoglossal roots (*A*), and also send fibres forward which decussate at the raphè. This group further serves to connect the marginal fibres with the deeper lying cell groups in the hypoglossal nucleus.

The hypoglossal and spinal accessory roots are also connected by a corresponding group, but the cells are comparatively few in number, which may probably be accounted for partly by the different respective situations of the nuclei; that of the spinal accessory lying so much more behind the hypoglossal, a more direct connection is doubtless established between them, as is the case between the anterior and posterior cornua of the spinal cord. I have however had no difficulty in making out the little group connecting the hypoglossal with the accessory in the human medulla, and in the cat it is very distinct, containing cells quite large and compactly arranged.

The lowest roots of the hypoglossal are so precisely similar in arrangement and connection to the anterior spinal roots, as to render it somewhat difficult to mark with precision the limit between the highest cervical nerves and the commencement of the hypoglossal.

CHAPTER IV.

THE PASSAGE INTO THE MEDULLA OF THE POSTERIOR VESICULAR COLUMNS AND TRACTUS INTERMEDIO-LATERALIS.

In order to arrive at a clear understanding of the nature of the tract from which the sensitive nerves of the medulla arise, it will be necessary to study carefully the passage into the medulla of the two remarkable columns of nerve cells found in the posterior cornua of the spinal cord, and described by Clarke under the name of *posterior vesicular columns* (*columnæ vesiculosæ posteriores*) and *tractus intermedio-lateralis.* The posterior or sensitive nerve roots of the cord were shown by Clarke[1] and myself to be very intimately connected with the posterior vesicular columns, either directly, or as I have shown to be the case in the lumbar region,[2] after passing through the *longitudinal columns of the cornua.* The tractus intermedio-lateralis which is developed in the dorsal and cervical regions of the cord, seems to be a means of uniting the anterior and posterior cell groups, and serves especially to connect them with the very interesting longitudinal fasciculi, by which the lateral portions of the gray substance are bordered near the junction of the anterior and posterior cornua.

In his last memoir on the spinal cord (1859), Clarke has traced at considerable length the changes which are observed in the *tractus intermedio-lateralis* and *posterior vesicular columns.* Of the latter he states, that in the mammalia, "in the upper part of the cervical region, near the origin of the third pair of nerves, a darker and more defined mass reappears at the base of the cervix cornu. It is composed of cells both large and small, and of bundles of the posterior roots which interlace amongst them. This mass is not distinctly circumscribed like that of the posterior vesicular column in the dorsal region, but is somewhat triangular, with one of its angles directed towards the point of the posterior cornu, another towards the transverse commissure, and the third obliquely forwards and outwards towards the antero-lateral column. It gradually diminishes upwards, and disappears near the first pair of nerves." (*Philos. Trans.*, 1859, 447.)

In the spinal cord of man, as we ascend through the cervical enlargement, "the dark oval masses decrease, and at length disappear; but the spaces which they occupied along the inner halves of the cornua are still interspersed with a multitude of cells, and traversed by the posterior roots. The cells, however, are very much

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[1] Philos. Transactions, 1859.

[2] Memoirs of the American Academy, 1861.

smaller than in the dorsal region; the majority are scarcely larger than those in the middle of the gelatinous substance; but a few of superior size are unequally scattered amongst them. Above the cervical enlargement the dark masses present nearly the same appearance as in mammalia, but they are rather paler, and the cells they contain are of smaller size." (*L. c.*, 450.)

The existence of the *tractus intermedio-lateralis* was first pointed out by Clarke in 1851, and described by him subsequently with great accuracy and detail (1859). This tract, which is situated on the lateral border of the gray substance just at the junction of the anterior and posterior cornua, is said by Clarke to gradually disappear as it ascends through the cervical enlargement, a few scattered cells remaining, which resemble those of the tractus intermedio-lateralis.

"In the upper part of the cervical region, a similar but somewhat larger tract reappears in the same situation, and projects in the same way into the lateral column. It increases in ascending to the third pair of nerves. This tract is traversed by several roots of the *spinal accessory* nerve, in their course forwards to the *anterior* cornu, and contributes with the edge of the posterior cornu to form a beautiful network in the lateral column, through which the nerve enters. There is reason therefore to believe that this tract forms a part of the *tractus intermedio-lateralis.* In the sheep and ox, and probably in all mammalia, a *peculiar* group of cells, which is traversed by the roots of the spinal-accessory nerve, is found in the same situation; and this group in ascending the medulla oblongata, retires inwards to the space behind the canal, and there contributes to form the nucleus which gives origin to the highest roots of the nerve."[1]

The changes which the posterior vesicular columns and the tractus intermedio-lateralis undergo, are very well illustrated in the cat, the two groups being more plainly distinguishable, and their relations more distinctly marked than in any other animal I have examined. At a point near the 2d or 3d cervical nerve, a very distinct, dark, oval mass of cells is seen (Cervicalkern of Stilling),[2] situated rather further inward than the posterior vesicular column in the upper part of the cervical enlargement, but so closely resembling it in form and general relation to the surrounding fibres, that no doubt can exist of this group being an upward extension of the column. Along the posterior edge of the cervix will be noticed numerous scattered cells. The tractus intermedio-lateralis in this region is very distinct, and is continued outwards along the course of the spinal accessory, forming a projecting mass of gray substance, and is brought into close relation with the longitudinal fasciculi by which the cervix and caput are separated. In the wood-cut, Fig. 2, showing the posterior cornu a little higher up, the group representing the posterior vesicular column is larger, but rather less distinctly circumscribed (*a*); it is closely connected with the tractus intermedio-lateralis (*f*), the cells of which are very numerous, and are continued along the lateral edge of the cervix around the

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[1] Philos. Transactions, 1859, 451, also 458.

All these facts have been verified by my own observations, but as they were already so excellently stated by Clarke, I have preferred to give them in his words.

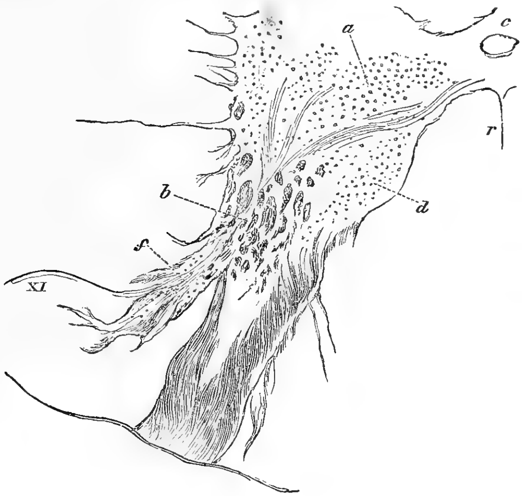
[2] Neue Untersuchungen. Description of pl. iv.

longitudinal bundles (*b*), which latter are now surrounded by a network of fibres formed from transverse fibres looping around the fasciculi, together with cell pro-

Fig. 2.

Posterior cornu from the spinal cord of the cat, near the second cervical nerve.—*a*, Cell group representing the anterior portion of the posterior vesicular column, and constituting the principal nucleus of the spinal accessory; *b*, longitudinal fasciculi; *c*, central canal; *d*, cell groups representing the posterior portion of the posterior vesicular column, from which the restiform nucleus is developed; *f*, tractus inte medio-lateralis; *r*, raphè.

Fig. 3.

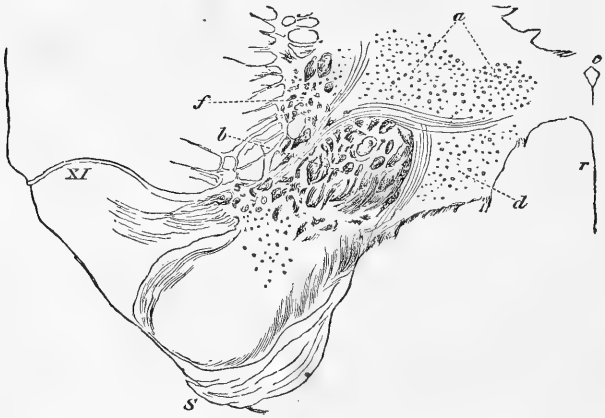


Posterior cornu from the spinal cord of the cat, a little higher than the preceding, the letters corrseponding with fig. 2; *XI*, root of the spinal accessory.

cesses by which they are embraced. In Fig. 3, still higher, the group we have been considering appears to be divided; it is more completely within the limits of the cervix, and consists of two portions, the anterior (*a*), reached by the posterior roots of the spinal accessory (*XI*), constituting together with the cells of the tractus intermedio-lateralis, which are successively pushed further inwards, the posterior nucleus of this nerve; and a posterior group (*d*), which, as will presently be shown, is that from which the post-pyramidal and restiform nuclei are developed.

In Fig. 4, showing the posterior cornu just below the pyramidal decussation, the continuance of this change is strikingly shown. Here the groups are very distinct, the posterior being separated from the anterior by a broad band of fibres which proceed from the spinal accessory towards the posterior commissure. The cells of the tractus intermedio-lateralis have mostly joined the anterior group formed from the posterior vesicular column, and are reached by the posterior roots of the spinal accessory; a few cells belonging to this tract still lingering among the network along the lateral portion of the cornu are seen at *f*. The cervix is almost entirely separated from the caput cornu by very numerous longitudinal fasciculi which pierce the gray substance. In the sheep, the cells of the posterior vesicular columns, with the exception of a few scattered cells, seem to disappear in the region of the first cervical nerve, being replaced by a little group of small, oblong cells, the nucleus of the spinal accessory, formed almost exclusively, however, from the tractus intermedio-lateralis, which is here pushed in towards the central canal; but higher up the cells of the posterior vesicular columns reappear, forming the restiform and post-pyramidal nuclei, and uniting with the above-mentioned group in forming the much

Fig. 4.



Posterior cornu from the spinal cord of the cat, just below the pyramidal decussation. The letters correspond with fig. 2; *S*, posterior spinal nerve root.

larger nucleus of the upper roots of the spinal accessory, the nucleus of which continually increases in size as we ascend towards the vagus.[1]

In man I have usually been able to trace the continuity of these columns into the medulla. The cells of the posterior vesicular columns are often very much scattered, but rarely if ever disappear, and although the nucleus of the accessory, between the first cervical and lowest roots of the hypoglossal, is principally formed from the tractus intermedio-lateralis, it is constantly united to and reinforced by cells from the vesicular column. (Fig. 5.) In the upper part of the spinal accessory nucleus and still more distinctly in that of the vagus, it will be noticed that the nucleus is composed of two distinct cell groups, one anterior, derived chiefly from the tractus intermedio-lateralis, this group apparently serving to receive the anterior roots of these nerves, and to unite them with the hypoglossal nucleus; the other posterior, derived from the posterior vesicular columns, receiving the posterior roots, and united by means of cells with the post-pyramidal and restiform nuclei, which are entirely derived, as we have seen, from the posterior vesicular columns. It will thus be seen that in the medulla, cell groups are formed, which if not direct continuations of the posterior vesicular columns and tractus intermedio-lateralis, are doubtless connected with them, and may certainly be considered as representing them, bearing the same relation to the posterior nerves of the medulla which these columns have been shown to sustain to the posterior spinal roots in the cord. These columns, moreover, though not always so compact and well defined as they are seen to be in the region of the accessory and vagus, may nevertheless be traced continuously throughout the medulla in close connection with the spinal accessory, vagus and glosso-pharyngeal nerves, as well as a part of the auditory and trifacial roots.

Fig. 5.

Posterior cornu from the human medulla.—*a*, Nucleus of the spinal accessory; *b*, caput cornu; *c*, central canal *d*, restiform nucleus; *f*, tractus intermedio-lateralis; *p*, post-pyramidal nucleus.

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[1] In the sheep the nucleus of the spinal accessory seems to be formed more exclusively from the tractus intermedio-lateralis, than it is in the human medulla or in that of the cat.

A moment's reflection suffices to show that by this means a relation is at once established between the nerves of the posterior column of the medulla and the posterior spinal roots, and that the *plan* in both is precisely similar, although the arrangements of parts may at first sight seem to differ. The analogy between the upper roots of the spinal accessory, vagal and glosso-pharyngeal nerves and the posterior spinal roots seems to be perfect; they traverse the caput cornu, and are connected with cell groups which completely correspond with each other, if not in all respects identical, and this analogy is still further established by the relation they form with the motor roots, as we have already had occasion to notice.

Having noticed the relation between the nuclei of the posterior cornua of the spinal cord and those of the medulla, it remains to add a few words with regard to the passage into the medulla of the very interesting columns of longitudinal bundles, which in the cervical region of the cord are shown to be so intimately connected with the tractus intermedio-lateralis. The situation of these bundles in the spinal cord is well seen in the wood-cuts, Figs. 2, 3, 4. In Plate XIII, Fig. 1^a, *l*, the same column is seen, situated close to the entrance of the spinal accessory roots; higher up these bundles are situated just behind the entrance of the roots, and continually increase in size as we ascend (Figs. 3^a, 4^a, 19^a, 20^a, 21^a, 22^a), till the vagus nucleus has reached its greatest development, from which point upwards they gradually diminish and finally disappear, being replaced by a similar collection of longitudinal fasciculi, which are developed behind these in the substance of the post-pyramidal and posterior portion of the vagus nucleus, and stand in close connection with the outer portion of the nucleus of the auditory.

The longitudinal columns in connection with the vagus and spinal accessory nuclei have been noticed by Stilling, Schröder van der Kolk, and Clarke, and appear from their connection in the medulla with the centres, as well as with the anterior and posterior cornua in the spinal cord, to be intimately concerned in co-ordinating and bringing into harmony the different respiratory movements.

The connections of these fasciculi with different parts of the medulla are very striking; as I have shown in various places in the present memoir, they constantly penetrate the meshes of a network of cells and fibres, many of these cells being of very considerable size, embracing the bundles with their processes, and in many cases becoming continuous with them, while, on the other hand, some cell processes are sent transversely in all directions, many of them entering the nuclei (vagal and spinal accessory). It is chiefly in this way, I think, that connection is brought about between the roots and the longitudinal columns, for I have not been able to find any *direct* communication between them, notwithstanding the assertion of Schröder van der Kolk.[1] On the outer side of the longitudinal column in the direction of the caput, many cells are found, some of very large size, serving to connect the column with the caput, through the substance of which fibres descend from the trifacial. The opposite columns are brought into commissural connection by means of radiating fibres, some of which join the marginal bundles passing around

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[1] Medulla Oblongata, 171.

the border of the hypoglossal nucleus and decussating at the raphè, while others pass backward along the floor of the fourth ventricle.

In the following paragraphs Clarke has pointed out very clearly some of the connections established between the tractus intermedio-lateralis and the respiratory tract above. "It has been seen that the cells of the *tractus intermedio-lateralis* are elongated with their processes in a longitudinal direction, and reached by both the *posterior* and *anterior* roots of the *spinal* nerves, and perhaps by the *spinal accessory;* that the latter nerve extends *forwards* to the cells of the *anterior cornua*, which also send some of their processes *longitudinally*, and are reached by the *posterior* roots. Moreover, I have in another memoir shown that, while *one* portion of the *upper* roots of the *spinal accessory* nerve and *one* portion of the *vagus roots* proceed *inwards to their respective nuclei behind the canal*, *other* portions *of both bend forwards to the vesicular network into which the anterior cornu has become resolved.* Again, I have shown, in the same memoir, that some of the roots of the *trifacial nerve descend longitudinally through the caput cornu*, between the transverse roots of the *vagus;* in which course they are probably brought into connection with the *respiratory centres*, and perhaps also, like the *vagus*, with the anterior gray substance of the medulla. These extensive and intimate connections seem to afford an explanation of the mechanism by which impressions made on the vagus and on the incident fibres of the trifacial and spinal nerves, may call into action the whole class of respiratory muscles; and if the tract which I have just described in the upper part of the cervical region be continuous, as it probably is, with the *tractus intermedio-lateralis*, which is reached by the dorsal nerves supplying the intercostal and other respiratory muscles of the trunk, the explanation in question will be still more complete."[1] If to these facts, all of which I have had abundant opportunity to confirm most thoroughly, we add the connections pointed out above of the *vagal* and *spinal accessory nuclei* with the *longitudinal columns*, which are undoubtedly continuous with the *longitudinal fasciculi* in the *spinal cord* separating the *cervix* and *caput cornu*, and standing in close connection with the cells of the *tractus intermedio-lateralis*, from the upward extension of which tract the *spinal accessory* and *vagal nuclei themselves* were shown to be partially formed, we have a series of very extensive and highly interesting connections brought about, the physiological importance of which is at once obvious, though it does not fall within the province of the present communication to do anything more than simply to call attention to them.

My own observations thoroughly confirm all the important facts pointed out by Clarke and Schröder van der Kolk, only differing from the latter in some of the minor details. The main point, however, I consider completely established, that the *respiratory centres* are brought into connection with *descending fibres from the trifacial, forming together a system of descending longitudinal fasciculi connected with columns of cells, continuous with those in the cervical and dorsal regions of the spinal cord*, and thus connected with both *anterior* and *posterior cornua*, serving to bring into action a series of movements, both direct and reflex, the importance of which can hardly be over-estimated.

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[1] Philos. Transactions, 1859, 451.

CHAPTER V.

THE VAGUS NUCLEUS AND ROOTS.

The Nucleus.—Stilling[1] was the first to point out the exact locality of this nucleus, and to give an accurate description of its form. The vagal nuclei are, as both Clarke and Stilling have shown, an upward extension of the vesicular columns from which the spinal accessory nerves arise, and in the lower portion of the medulla share so closely the characteristics of the latter, that it is quite impossible to determine any line of demarcation.

The roots of the vagus appear to be first given off, soon after the central canal opens into the fourth ventricle, and the two nuclei, which are at first joined by the transverse commissure forming the posterior boundary or roof of the central canal, are shortly after entirely separated, and lie on each side of the hypoglossal nuclei on the floor of the ventricle.

The form of the vagus nucleus is much the same as that of the hypoglossal, with the exception that it is bifurcated at the apex, forming two spurs or processes, between which run numerous thick and very conspicuous longitudinal fasciculi, which are the upward extension of those penetrating the spinal accessory nucleus. Most of the nerve roots appear to be given off from the inner process, a few only passing from the outer or posterior spur, which is brought into very close connection with the post-pyramidal and restiform nuclei, into which it is as it were wedged, forming in the upper part of the medulla a starting point for numerous arciform fibres (Plate XIII, Fig. 6^a).

The changes in form which the vagal nuclei undergo as they ascend are but slight, and may be readily studied in Plate XV from the human medulla, and in Plate XIII from that of the sheep.

The changes in position of the nuclei have already been sufficiently dwelt upon in the chapters on the morphology of the medulla, the most important of these changes consisting in the gradual development of a new pyramidal mass formed partly out of the substance of the vagus, and partly from the post-pyramidal nucleus, by means of which the nucleus of the vagus is pushed more and more forwards, till it becomes blended with the mass now constituting the great pyramidal nucleus of the auditory, the base of which forms almost the entire floor of the fourth ventricle.

The cells of the vagus nucleus closely resemble those of the spinal accessory, being rather more oval or fusiform than those of the hypoglossal. They are exceed-

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[1] Medulla Oblongata.

ingly numerous, especially in the anterior portion of the nucleus, where they are very closely crowded together. The larger cells are found chiefly in the anterior and antero-lateral portions, in the neighborhood of the hypoglossal nucleus and near the entrance of the vagus roots; those lying further inwards, more especially in the posterior and postero-lateral portions of the nucleus and in the neighborhood of the caput cornu and post-pyramidal nucleus are mostly quite small and are oblong or fusiform in shape.

The cells measure as follows, the measurements being made on their longest diameter and as near as possible to the point where the nucleus attains its greatest development. In the medulla of the sheep, the cells in the anterior part of the nucleus measure from $\frac{1}{666}$ to $\frac{1}{444}$ of an inch, and in the posterior portion $\frac{1}{2000}$ to $\frac{1}{1000}$ of an inch. In man $\frac{1}{1333}$ to $\frac{1}{666}$ of an inch, the smaller cells measuring not more than $\frac{1}{4000}$. In the cat, about $\frac{1}{1333}$ of an inch.

The group of cells represented in Plate X, Fig. 38, is from the anterior portion of the vagus nucleus; *V*, the bundle of vagus roots, many of which pass inwards to the cell group. Intermingled with the larger cells are very numerous smaller ones, and many of exceedingly small size with numberless single nuclei (not represented in the figure) are found scattered throughout the entire substance of the nucleus. It is quite impossible to determine the nature of these very small cells; they closely resemble those found in the posterior cornua of the spinal cord, and some of them are probably fragments of larger nerve cells, or cells which are still undeveloped, whilst many doubtless belong to the connective tissue.

The cell processes pass out in various directions, both transversely and longitudinally; many of them are directly continuous with the nerve roots, whilst others run in the direction of the neighboring hypoglossal nucleus, and are continuous either with processes from its cells, or with the nerve-roots themselves (*A*, *A*), thus forming connections analogous to those which I formerly demonstrated between the anterior and posterior cornua of the spinal cord.[1] A third set send their processes transversely into the antero-lateral columns, embracing the numerous longitudinal fasciculi which pass upwards in the bifurcation of the nucleus. Many cells serve also to connect the nucleus with the caput cornu, establishing thereby a possible relation between the vagus and the trifacial, the nucleus of which has been shown by Clarke to send descending fibres into the numerous longitudinal bundles by which the caput is pierced, a statement which I have been able thoroughly to verify. Other processes pass backwards, and serve to connect the roots as well as the anterior portions of the nucleus with the deeper lying parts, and also directly or through the intervention of cells, with the post-pyramidal and restiform nuclei.

As mentioned above, the vagus nucleus seems to consist of two more or less distinct portions (Plates XIII, XV). The anterior portion, divided from the posterior by the great bundles of longitudinal fibres (*l*), is for the most part occupied by a very large and closely crowded group of cells (*V*) with which many of the vagus roots are connected; the posterior part of the nucleus contains but very few cells, mostly of exceedingly small size, its substance being chiefly made up of fine fibres

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[1] Memoirs of the American Academy, 1861, 10.

crossing each other in every direction, intermingled with nuclei and granules, and forming an inextricable web closely resembling the structure of the *substantia gelatinosa* in the spinal cord.

The union of this portion of the nucleus with the post-pyramidal and restiform nuclei appears to be very intimate, numerous fine fibres passing between them. Along its apex fibres also pass forwards, some winding among the longitudinal bundles, others curving around and becoming arciform fibres, whilst quite a large tuft pass anteriorly into the caput cornu. Some fibres uniting with bundles which apparently turn off from the nerve-roots, loop around the longitudinal fasciculi in every direction, forming a network of fibres containing a few cells, and closely resembling the network formed around the numerous longitudinal bundles in the neighborhood of the tractus intermedio-lateralis as figured by Clarke in the cervical region of the spinal cord.[1] This network is continued anteriorly and antero-laterally out towards the caput, and backwards towards the restiform body.

From the postero-lateral or intermediate portion of the nucleus, we have the following classes of fibres produced. 1st. Bundles which proceed from the interior portion and pass directly outwards as radiating fibres, winding among the longitudinal bundles or turning off with the arciform fibres. 2d. Bundles which turn off at a more or less acute angle and pass forwards to join the bundles decussating at the raphè. 3d. Very numerous bundles serving to connect the nucleus with the *post-pyramidal* and *restiform nuclei*, and with the *caput cornu*. 4th. Fibres joining cells in the anterior portion of the nucleus.

Along the back of the nucleus constant indications are met with of single fibres and bundles cut across by the plane of section, many of which are evidently ascending bundles; some of them turning off from their longitudinal course and passing through the nucleus as transverse fibres, serve probably to connect various parts of the nucleus with the lower portions of the medulla.

The nucleus is bordered posteriorly by a thick band or commissure of fibres, which is especially distinct in the upper regions of the medulla; some of its fibres turn downwards and others upwards, but quite a regular band may be traced along the posterior border of the hypoglossal nucleus to the raphè, where it meets and decussates with a similar band coming from the nucleus of the opposite side, not only serving to connect the posterior portions of the vagal nuclei, but also co-ordinating to some extent the post-pyramidal and restiform nuclei.

The Roots.—Clarke has given a very accurate, though brief, description of the general course pursued by the vagus nerve.[2] As stated by him, the bundles pass through the caput cornu on their inward course, penetrating the longitudinal fasciculi derived from the root of the trifacial which are inclosed in its substance. I have not, however, been able to trace any *direct* communication between them, the roots of the vagus passing directly onwards, pursuing apparently an unbroken course. Stilling[3] states that the roots of the vagus pass both before and behind, as well as

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[1] Philos. Trans. 1859.

[2] Philos. Transactions, 1858, 253.

[3] Medulla Oblongata, 37.

through the *substantia gelatinosa*, and this is perhaps true in the lowest sections (Fig. 3^a), in which it is, however, probable that the roots passing in front of the caput cornu are the uppermost of the spinal accessory. In sections higher up, all the roots *penetrate* the caput, a circumstance which Stilling was the first to point out as proving the resemblance between the vagus and posterior spinal roots.

The roots of the vagus enter the anterior spur of the nucleus, just in front of the great bundles of longitudinal fasciculi, which separate it from the posterior process, their fibres being distributed much on the same plan as those of the accessory. Their course can be studied in Plates X, XI, Figs. 38 and 40. A portion of the fibres belonging to the great bundle of roots (*V*), enter deeply into the nucleus, becoming sooner or later united with cells which are very numerous and much crowded together (Plates XIII, XV, 3^a, 4^a, 6^a, 21^a, 22^a). Another portion of the roots, as will be seen in Fig. 40, turn backwards and pass out among the longitudinal bundles (*H*), or form loops around them, while some pass still further back into the posterior spur. Of the bundles which pass *forwards*, without entering the cells of their own nucleus, Clarke makes the following statement: "A separate bundle turns *inwards*, and after sending forwards in succession a number of single returning fibres, which wander through the network of the lateral column, proceeds through the side of the hypoglossal nucleus, where its fibres mingle with those of the hypoglossal nerve—I may almost affirm that some at least are continuous with the cells. Such is the course I have repeatedly observed in man; and in the sheep and ox I can show, without any difficulty, that while some of the fibres of the last mentioned *inner* bundle are apparently continuous with those of the hypoglossal nerve, others pass inwards to decussate at the raphè."[1]

On the other hand, Schröder van der Kolk[2] has endeavored to show that there is no *direct* decussation either of the sensitive or motor nerve roots of the medulla, but that the decussation of both is produced through the *intervention of cells.*

This statement is, I think, incorrect in regard to the spinal accessory and vagus roots, the course of which I have had repeated opportunity of studying in very many specimens, both from the human medulla and that of various mammals.

The course of the spinal accessory roots has been described and figured with very great accuracy by Clarke,[3] with whose observations my own have agreed very fully,[4] proving to my entire satisfaction, that while a part of the roots enter the nucleus and proceed directly towards the cells, quite a large bundle turns forwards, and passing in front of the hypoglossal nucleus, for the most part without entering cells, decussates at the raphè with a similar bundle from the opposite side.

The same is true of the vagus roots, but here the bundles turning forward to decussate are much larger and more conspicuous than is the case with those proceed-

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[1] Philos. Transactions, 1858, 253—4.

[2] Medulla Spinalis and Oblongata, 96, 185.

[3] Philos. Transactions, 1858, pl. xviii, fig. 35.

[4] A sketch drawn from one of my own specimens was so exact a reproduction of Clarke's figure in all important particulars as to render the publication of it, as well as of my own observations on the course of the spinal accessory roots, quite superfluous.

ing from the accessory. A glance at Figs. 38 or 40 will show large bundles of the vagus roots taking this course, and the same is also true in the human medulla, where this course is very evident, though perhaps not quite so distinctly made out as in the sheep.

These large bundles turning forwards from the vagus roots, appear to be composed of fibres which may be divided into three classes according to the course they pursue while passing towards the raphè. 1st. An uppermost layer (Plate XI, Fig. 40, *D*), which passing along the edge of the hypoglossal nucleus for a short distance and then turning outwards, pursue a wavy course among the longitudinal bundles of the antero-lateral and anterior columns; some of them may be traced to the raphè (*c*), while many of them are soon lost sight of. 2d. The next set pass along the hypoglossal nucleus, forming a complete marginal border; the fibres cross the hypoglossal roots with which they frequently interlace, and proceeding onwards still along the edge of the nucleus, are sometimes joined by a few fibres from the hypoglossal roots which they accompany to the raphè. (See page 16.) 3d. This set is composed of the deepest lying fibres; these pass through the hypoglossal nucleus at various depths, many as far back as the middle of the nucleus, and some even through its posterior portion. Some of the fibres composing the two last sets enter cells in the hypoglossal nucleus, and are thereby brought into indirect relation with the hypoglossal roots. (Fig. 38.)

The further course of the fibres after decussating is not easy to make out, and although I have carefully studied very many specimens in the endeavor to ascertain their destination, I can only briefly state that while many are immediately lost sight of in the anterior columns, some are seen passing along the raphè anteriorly for some distance, soon, however, curving outwards into the anterior portion of the medulla, probably becoming longitudinal fibres. A few seem to bend backwards, and pass along the raphè posteriorly, either entering the hypoglossal nucleus, or passing still further backwards towards the posterior commissure of the opposite side, along which they may sometimes be traced.

The posterior commissure, or marginal border of fibres forming the floor of the fourth ventricle, is chiefly derived from the posterior portion of the vagus nucleus, though occasionally reinforced by fibres from the nucleus of the hypoglossal. I have had repeated opportunity of verifying the truth of Clarke's statement quoted above (p. 27), in regard to the connection of cells in the hypoglossal nucleus with fibres derived from the vagus roots, as well in the human medulla as in various animals.

A very remarkable cell group located just at the point where the marginal bundles passing forwards from the vagus cross the hypoglossal roots, intended apparently to connect the two, in the same manner as the anterior and posterior spinal roots are united, has been described in the section on the hypoglossal roots. (p. 16.)

It is a question of great interest to ascertain, if possible, whether, as is the case with the spinal roots, any of the vagus fibres are *directly* continuous with those of the hypoglossal, but it is extremely difficult to decide this point with accuracy. I have repeatedly thought that I could make out a direct continuity between single fibres from the anterior bundles of the vagus and some of the hypoglossal roots, especially those which turn backwards. Clarke seems to have traced a similar continuity between some of the fibres of the hypoglossal and spinal accessory nerves, stating that some of the fibres of the latter nerve "may be traced even to the cells of the hypoglossal nucleus, where apparently they form loops of continuation with the fibres of the hypoglossal nerve."[1]

If such be the truth, we have in the medulla three classes of nerve fibres, analogous to those I pointed out formerly as existing in the spinal cord,[2] viz:—

(1) Vagus (spinal accessory) and hypoglossal roots which arise from or terminate in cells in their respective nuclei.

(2) Vagus (spinal accessory) and hypoglossal roots meeting in cells.

(3) Vagus (spinal accessory) and hypoglossal roots directly continuous.

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[1] Philos. Transactions, 1858, 252.

[2] Mem. American Academy, 1851, 349.

The three classes referred to are as follows: (1.) Anterior and posterior roots which arise from or terminate in anterior or posterior cells. (2.) Anterior and posterior roots which meet in cells near the central part of the gray substance. (3.) Anterior and posterior roots which are directly continuous.

CHAPTER VI.

THE GLOSSOPHARYNGEAL NUCLEUS AND ROOTS.

The form and development of the glossopharyngeal nucleus, and the general course of its nerve-roots in the human medulla, have been described by Stilling[1] with very considerable accuracy. More recently Clarke[2] has given a detailed description of the course of the fibres within the nucleus, to which but little remains to be added.

The course of the glossopharyngeal roots, and the distribution of their fibres within the nucleus resembles very strikingly the course and distribution of the vagus roots as described above, and the connection between these two nuclei is very close, the nucleus of the vagus passing gradually forwards as that of the auditory makes its appearance, until the three nuclei (hypoglossal, vagus and auditory) are fused as it were into one mass, the remains of the vagus nucleus now constituting one of the sources from which the glossopharyngeal roots are derived. The transition, however, between the vagal and glossopharyngeal roots or nuclei is so gradual, that it is quite impossible to point out any exact line of demarcation.

In the sheep the glossopharyngeal roots pass inwards in two or three bundles, which, after crossing the arciform plexus, often subdivide into as many as six or eight smaller ones, penetrating the caput cornu on their way to the nucleus. In the cat and in man the main bundles, usually not more than two or three in number, pass inwards without subdividing, till they reach the apex of the nucleus (Plate VI, Fig. 24) which a portion of them enter, other portions of the bundles diverging, and the fibres spreading out in various directions either forwards or backwards, passing, as Clarke has noticed, among the longitudinal fasciculi which adjoin the margin of the nucleus. Some of the fibres pass into the loose network formed from the remains of the posterior pyramid, others pass forwards towards the remains of the hypoglossal nucleus. Some of the fibres, as mentioned above, proceed directly inwards, joining the group of rather large cells which constitutes the remains of the vagus nucleus. The cells near the apex are mostly very small, but further inwards, near the back of the little nucleus, measure about $\frac{1}{1333}$ to $\frac{1}{800}$ of an inch in length; in the human medulla they are mostly obovate or fusiform, resembling the vagus cells, and are evidently connected with a portion of the glossopharyngeal roots.

As in the case of the vagus, a large anterior bundle is formed, which turns off at or near the apex of the nucleus, and as described by Clarke, "turns inwards round

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[1] Medulla Oblongata.

[2] Philos. Trans. 1858.

the summit of the antero-lateral column, and passing through the most anterior and largest cells, sends forward a series of returning loops, first through the antero-posterior bundles along the inner border of the *caput cornu posterioris*, and then in succession through the network of the lateral column as it makes its way towards the raphè; but in this course its fibres lie side by side with those which have been already described as proceeding from the antero-lateral column to decussate through the raphè with their opposite fellows, so that it becomes almost impossible to identify them and ascertain if they share in the decussation; that they do so, however, is rendered extremely probable by the fact that in birds *all* the fibres of the eighth pair of nerves, of which the highest correspond to the *glossopharyngeal*, may be distinctly seen to decussate through the raphè, after passing through and around their nuclei."[1]

In the cat the course of this anterior bundle is very distinctly seen, and I have several specimens showing the anterior division as it passes along the margin of the nucleus towards the raphè, where it decussates with a similar bundle from the other side. As the bundle turns forwards at the apex of the nucleus, it gives off a few fibres which enter among the cells, some of which they undoubtedly join, and in its course along the border of the nucleus, a few fibres are seen at intervals turning inwards towards the deeper lying cells, while on the outside of the bundle fibres constantly turn off, forming loops or joining the numerous radiating fibres which everywhere penetrate the anterior and antero-lateral columns; a part of these pass across the anterior columns to the raphè with some of the radiating fibres, but most of them are soon lost sight of, and probably pass upwards with the longitudinal fasciculi. A portion of the middle roots may be traced forwards, as stated by Clarke, to the group of large cells occupying the place of the *fasciculus teres* and representing the continuation of the hypoglossal nucleus; and fibres are also seen to turn off from the anterior bundle towards the same group.

In the cat the decussation at the raphè is very distinct, quite as much so as in the case of the vagus; but in the sheep and especially in man, I have had much difficulty in tracing the course of the anterior bundle, for the reasons which Clarke has given in the passage quoted above. In the cat, however, the entire course of the glossopharyngeal roots is very distinct and easily made out.

In Plate IX, Fig. 33, the upper roots of the glossopharyngeal may be seen passing through the caput cornu in the medulla of the cat. Plates II and XIV, Figs. 8, 8^a, from the sheep, and Plates VI and XV, Figs. 24, 24^a, from the human medulla, also illustrate the course and appearance of the glossopharyngeal roots.

Schröder van der Kolk has supposed that a connection exists between the trifacial and glossopharyngeal, from the fact that the latter passes through the caput, but as in the case of the vagus, I have found no evidence of any direct communication between the glossopharyngeal roots and the bundles which descend through the caput from the fifth nerve.

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[1] Philos. Transactions, 1858, 255.

CHAPTER VII.

THE OLIVARY BODIES IN MAN.

The resemblance between the convoluted folds of the *corpora olivaria* and the *corpus dentatum* of the cerebellum, could hardly fail to attract the attention of many anatomists. This resemblance, pointed out by Reil,[1] Prochaska,[2] and Gall,[3] the latter, however, seeming to have overlooked the convoluted structure, has been very plainly shown by Rolando,[4] who makes the following statement. "Il résulte de mes observations, qu'il n'existe presqu' aucune diversité, relativement à la structure, entre les éminences olivaires et les corps dentelés du cervelet. En effet, si on suit les coupes qu'ils offrent tant les uns que les autres, il est facile de se convaincre que la lame jaunâtre et dentelée est disposée autour du noyau, de manière qu'il en résulte une bourse aplatie, dont le col ouvert et un peu rétréci est tourné vers la ligne médiane et en arrière, s'il est question des eminences olivaires; tandis que si on parle des corps dentelés du cervelet, la dite lame jaunâtre est plus plissée, et forme une bourse plus longue et presque ronde, dont le col, plus ouvert et plus large, serait retourné en avant et vers le 4^e ventricule."

The resemblance pointed out above, and the probability that the same general plan exists in all cases where this peculiar convoluted structure is found, at once invest the study of the minute anatomy of the olivary bodies with very great interest, from the light thus likely to be thrown on the analogous structure of the hemispheres of the cerebrum and cerebellum.

The external and internal form and relations of the olivaries, as seen in transverse sections, have been well described by several observers, among whom Clarke[5] certainly deserves first mention, both for the extreme accuracy and detail of his descriptions. The subject is by no means an easy one, but after going over the whole ground very carefully, and studying very many different preparations, I find that my own observations are *entirely in accordance with his in every important particular.*

As pointed out by Clarke, the olivary column is developed amongst the network into which the anterior cornu is resolved. This is evident by reference to Plate XIV, Fig. 18^a, where the origin of the olivary bodies is seen just behind the pyramid, and close to the course of the hypoglossal roots, as an elongated, somewhat rounded collection of cells (*O*), scattered at first among the arciform fibres with

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[1] Archiv für die Physiologie, IX, 490.
[2] De Structura Nervorum.
[3] Gall et Spurzheim, Système, 198.
[4] Recherches anatomiques. Magendie, Journal de Physiol. IV, 336.
[5] Philos. Transactions, 1858.

which they appear to be closely connected. In longitudinal sections, the lower portion of the olivary column presents a similar appearance, consisting of successive layers of scattered cells, separated from each other by thick bundles of transverse fibres, penetrating the column in every direction. Higher up, the cells are more and more compactly arranged, soon becoming collected into a convoluted lamina, the form of which has so often been drawn and described.

The principal changes in the general form of the olivary bodies are well shown in Plates VII and XV. In Plate VII, Fig. 25, a section is seen soon after the full development of the convolution is attained, at a point just above the opening of the fourth ventricle, some additional details being given in Plate XV, Fig. 20^a.[1] The olivary body, which in the preceding figure, 19^a, consisted of a closed convolution in the centre of a large fibrous mass, is now an open series of folds, with very numerous transverse fibres radiating towards the centre or hilus, across which the hypoglossal roots pass; the fibrous mass within and around the lamina still however predominating. In Fig. 26, Plate VII, the convolutions have become much deeper and closer, the course of the fibres proceeding from the interior is much more distinct, and many of them may now be seen passing directly forwards, towards the raphé, where they decussate with their fellows from the opposite side, forming a commissure between the two olivary bodies. In this course they are joined by numerous arciform fibres, which everywhere surround and penetrate the olivaries, forming an exceedingly complicated plexus radiating from the posterior portion of the medulla.

From this stage upwards, the principal changes consist in the rapid increase in number and size of the convolutions, which soon occupy nearly the entire mass of the olivary column (Plates VII and XV, Figs. 27, 28, 22^a, 23^a, 24^a). In the outline figures (Plate XV) I have merely attempted to *indicate* the relation of the arciform fibres to the lamina, these fibres forming so intricate a plexus as they pass through the convolutions of the lamina, either joining cells or passing onwards towards the decussation at the raphè, that anything more than the *merest indication* of their course would have required the use of many additional figures on a much larger scale than those given.

In the neighborhood of the olivary bodies will be noticed several smaller nuclei, occasionally assuming the convoluted form to some extent. These bodies, called by Stilling[2] the *accessory olivary nucleus* (Oliven-Nebenkern) and *larger pyramidal nucleus* (grosser Pyramiden-Kern), have been shown by Clarke[3] and Schröder van der Kolk[4] to be similar in structure to the olivaries, and are undoubtedly groups of similar cells, more or less removed from the main body, but identical in structure and relations. Moreover, as Schröder van der Kolk has pointed out, the so called

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[1] Figs. 20, 20^a and 25 are from the same section; Fig. 26 is from a section a *very little* higher than Figs. 21, 21^a; Fig. 27 is also from a section a little higher up than Figs. 22, 22^a, but they may be regarded as representing substantially the same level; Figs. 23, 23^a, and 28 are from the same section.

[2] Medulla Oblongata, 30, 31.

[3] Philos. Transactions, 1858, 243.

[4] Medulla Oblongata, 133.

pyramidal nucleus is not everywhere isolated, but, on the contrary, as will be seen from my own figures (Figs. 21^a, 22^a, 23^a, 24^a, *s*), is in some places closely connected with the lamina and in others separated from it, while in some cases it is divided into three or four little groups, some of which, though doubtless connected more or less with the pyramids, are still evidently offshoots from the olivary lamina. The accessory olivary body of Stilling seems to be a sort of intermediate group between the cells of the antero-lateral nucleus and the olivary lamina, and in sections from the upper part of the medulla (Figs, 23^a, 24^a) it is replaced by the cells of the former nucleus and by large multipolar cells lying in the same situation.

As we ascend towards the pons, the hilus of the olivary bodies becomes successively more and more contracted, the folds of the lamina increasing somewhat in depth, but diminishing rapidly in number, until, finally, the lamina is reduced to much the same state as at its outset, becoming a closed coil of cells and fibres, which soon entirely disappears, leaving only a few scattered cells to mark its situation in the antero-lateral network which is now much encroached upon by the rapidly increasing fibres of the pons Varolii.

The cells of the olivary lamina are quite small, measuring about $\frac{1}{1666}$ to $\frac{1}{1333}$ of an inch, agreeing very closely with Clarke's measurement ($\frac{1}{1300}$—$\frac{1}{1600}$); they are very numerous and are quite uniform in size. My measurements of the average thickness of the lamina vary much in different specimens, the smallest measurement being about $\frac{1}{200}$ of an inch, and the largest $\frac{1}{80}$ of an inch; in the same medulla I have however found but very little variation, either in longitudinal or transverse sections.

Each olivary body is joined to its opposite fellow by a transverse commissure of fibres decussating at the raphè, by means of which they are brought into very close connection, as has already been pointed out by several authors. These commissural fibres may be well seen in Figs. 25, 26, 27, and 28, and especially in Fig. 29, but I have nowhere found such a strongly marked band without any intermingling of longitudinal fibres, as is represented by Lenhossek,[1] and I cannot fail to agree with the criticism of Kölliker[2] on Lenhossek's description of the olivary commissure. The fibres which serve to connect the olivaries, are for the most part as stated by Kölliker, a direct continuation of the inner bundles of arciform fibres, which, as was shown above, penetrate the olivary lamina at varying angles, a portion entering cells, and the remainder forming a most intricate and complicated plexus with the fibres derived from the cells of the lamina. Both of these sets of fibres, viz., those entering cells and those passing among the cells, are, many of them at least, continued forwards towards the raphè, forming a very beautiful network around the numerous longitudinal bundles which pass upwards in the anterior part of the medulla on each side of the median line. Some of these fibres turn upwards, accompanying the longitudinal bundles, but very many of them may be seen to decussate at the raphè, forming a commissural connection between the opposite sides of the medulla. At the same time, however, it must be borne in mind, that while some of these decussating fibres do undoubtedly originate in the cells of the olivary lamina and

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[1] Neue Untersuchungen. Wien, 1859, pl. ii, fig. 2.

[2] Gewebelehre, 1862, 320.

form a true olivary commissure, they are constantly accompanied by the arciform fibres, which here, as elsewhere, decussate in so great number, connecting the various parts of the medulla with those of the opposite side.

Schröder van der Kolk[1] and Lenhossek[2] have described at considerable length a large and well marked bundle, called by the latter "*pedunculus olivæ*," serving to connect the olivary body with the hypoglossal nucleus, with the roots of which it is nearly parallel. "These fibres arise from the gray substance of the olivary body, and form a tolerably large bundle, which does not differ much in thickness from the roots of the hypoglossal, and which we can follow uninterruptedly into the nucleus of this nerve. The fasciculi in question appear not to perforate the olivary body, as they do not appear on the other side; but they arise, as can be easily shown, from the ganglionic cells of the olivary body itself. They pass through the hilus, and are collected in bundles, which run into the hypoglossal nucleus."[3] I have nowhere been able to find such bundles as are figured by Schröder van der Kolk (*op. cit.*, Fig. 14, Plate v), or by Lenhossek (*op. cit.*, Fig. I, Plate ii), with their fibres spreading out like a brush into the hilus, my own observations on this point being very closely in agreement with those of Kölliker.[4] As stated by him, the roots of the hypoglossal do not always run in front of the olivary bodies, but frequently penetrate the lamina at a greater or less depth, and often pursue a wavy or zigzag course before emerging (Figs. 26, 27, 21^a, 22^a). It of course often happens that such bundles are cut off, and may easily be mistaken for fibres originating in the hilus, and when we take into consideration the slightly ascending course of the hypoglossal roots, which may be easily demonstrated in longitudinal sections, the probability becomes very great that the bundles seen in the upper part of the medulla apparently terminating in the hilus (Figs. 22^a, 24^a) are mainly cut off bundles of hypoglossal roots which emerge lower down.[5]

The fibres from the hilus and from the cells of the lamina pass in every direction, both forwards towards the raphè, and transversely towards the posterior portion of the medulla, contributing to form the very beautiful and complicated network with which the entire anterior and antero-lateral portions of the medulla, between the nuclei on the floor of the fourth ventricle and the olivary bodies, is filled. The cells found in this network are mostly single, though sometimes collected into little groups which serve to unite the distant parts of the medulla, and seem especially intended to connect the olivary bodies with the hypoglossal nucleus, perhaps also with that of the spinal accessory, though I have never been able to trace any direct communication between this and the olivary column, notwithstanding the assertion of Schröder van der Kolk.

At points where the hypoglossal roots cross the olivary lamina, it becomes very difficult to decide whether or not any connection is brought about between the

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[1] Medulla Oblongata, 164.

[2] Neue Untersuchungen, 34.

[3] Schröder v. d. Kolk, l. c. 134.

[4] Gewebelehre, 1862, 321.

[5] This opinion is further confirmed by the figures given by Stilling and Clarke, in which no such bundles as are represented by Lenhossek are to be found. (See Stilling, Medulla Oblongata, pls. v and vi, and Clarke, Philos. Trans. 1858, figs. 29, 30, 31, 32, and especially fig. 36.)

nerve-roots and the cells of the lamina; processes from the cells cross the root-bundles in every direction, and I have occasionally been able to trace fibres derived from these cells, running parallel to the roots and apparently accompanying them for some distance towards the nucleus, but I have never been able to satisfy myself that there is any direct connection between the hypoglossal roots themselves and the cells of the olivaries, not even where the roots pass directly through the lamina.

The fibres derived from the hilus, or even from the cells of the lamina, which I have been able to trace continuously for any considerable distance in a course parallel with the hypoglossal roots, are very few in number, not at all corresponding to the very large bundles represented by Lenhossek, which had they existed could hardly have escaped the observation of Stilling and Clarke. That the hypoglossal nuclei are, however, connected to some extent with the olivary bodies, by fibres and by the network of cells in the anterior part of the medulla, admits I think of no doubt, and will be still more evident when we examine presently the arrangement of these cell groups in the medulla of the sheep.

In longitudinal sections the olivary bodies present a very beautiful appearance, the convolutions being compact and numerous; this is especially evident in Fig. 30, Plate VIII, representing a longitudinal section through the olivary body, in a direction nearly parallel to the hilus. A series of such sections presents several striking points; in the outermost, the convoluted lamina has the appearance of a closed circle or ellipse, from which various other foldings radiate, filling up the whole interior, but as we approach the hilus, the lamina opens at the bottom (Fig. 30), into which some of the great bundles of longitudinal fibres turn, often quite abruptly, radiating in every direction towards the centre of the olivary body. At different heights small bundles of longitudinal fibres turn off from the main bundles, running some upwards and some downwards towards the convolutions, which they often cross, proceeding towards the interior, though not unfrequently joining cells of the lamina.

In sections cut at right angles to the raphè (Figs. 31, 32), the appearance is somewhat different. Near the surface of the olivary body (Fig. 31), the longitudinal columns are seen ascending on each side of the raphè in a perpendicular course, in the midst of which the olivary body seems to be thrust, as it were, the folds of the lamina branching off from a stem of transverse and oblique fibres, like the branches from a tree; nearer the centre of the olivary body (Fig. 32) the folds of the lamina are very distinctly seen, and as the plane of section has in this case gone somewhat obliquely across the thickest portion of the convolutions, the lamina appears nearly double the thickness of that in Fig. 30, though these two specimens were from the same medulla.

In longitudinal sections made in this direction, the internal arciform fibres pursuing a course at right angles to the raphè (Fig. 29) can often be traced for a considerable distance, and may plainly be seen curving upwards and downwards to become longitudinal fibres, just as the longitudinal fibres on the other hand turn off and radiate towards the interior of the lamina; in this way it is highly probable that a series of loops is formed, serving, as is so often the case in the spinal cord, to connect parts lying at different heights.

Various authors have attempted to trace the course of the fibres within the olivary bodies, and their relations to the cells of the lamina, but with little success, with the single exception of the very complete and accurate description given by Clarke.[1] The subject is an exceedingly difficult one, but after studying a large number of preparations, both colored and uncolored, in which the course of the fibres was as clear as possible, I am satisfied of the *entire accuracy* of Clarke's description in *all particulars*. The only point remaining was to ascertain whether the structure was the same in longitudinal as in transverse sections.

Fig. 39, Plate XI, represents one of the folds of the lamina as seen in a longitudinal section (Fig. 30), in which the arrangement of cells and fibres is strikingly the same as that represented by Clarke (*Philos. Trans.* 1858, Plate xv, Fig. 25) in connection with which it will be well to study it. From the longitudinal bundles which proceed upwards in the vicinity of the raphè (Fig. 30), forming the very beautiful network seen in transverse sections (Fig. 29), numerous bundles turn off at varying angles, especially in the lower part of the medulla, radiating towards the convolutions of the lamina. The course of one such bundle as it enters the fold is seen in Fig. 39, Plate XI. The main bundle (*A*) enters the convolution just as Clarke has described and figured the course of similar bundles in transverse sections. (1st.) The inner fibres constituting the axis of the bundle proceed directly inwards to the apex of the fold, where they spread out more or less towards the cells of the lamina, with the processes of which many of them are continuous, while others radiate and pass among the cells in the most varied directions. These fibres sometimes cross over the lamina and pursue an onward course towards more distant convolutions, or pass still further forwards to the anterior portion of the medulla, nearly parallel to the surface of which a folded portion of the lamina is disposed (Fig. 30). The fibres passing through the lamina pursue a transverse course for a very short distance, but soon turn upwards or downwards, joining the longitudinal marginal fibres which run along the anterior surface of the medulla, forming quite a thick band in connection with the arciform fibres with which they are interwoven.

(2d.) The external fibres of the bundles are very divergent, some of them terminate in cells lying near their course, but by far the greater number traverse the lamina either singly or in bundles; the latter are sometimes very conspicuous (*C*, *C*), partly crossing over and partly joining the next lying bundle, entering the neighboring lamina in a course opposite to the one we have been considering. Some of the cells belonging to the next fold of the lamina are represented at (*D*), the lamina folding around the bundle (*B*) at each extremity, just about where the letters (*B*, *B*) stand, so that the bundle (*B*, *B*) which constitutes the outer bundle to one fold of the lamina, becomes in its turn the inner bundle of the next two, such bundles as (*C*, *C*, *C*) uniting them, or, as is frequently the case, passing still further onwards to more distant folds of the lamina. These bundles follow so varied courses, and cross and interlace in so many directions, that any description, however careful, must of necessity be exceedingly indefinite.

It is evident that fibres from *all* the different nuclei of the medulla pass among

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[1] Philos. Transactions, 1858, 244.

the cells of the olivary bodies, and in many cases are doubtless continuous with their processes, so that the probability deduced by Clarke, from the study of transverse sections, viz., that "the *olivary bodies* are co-ordinating centres for the different ganglia or nuclei of the *medulla oblongata*," derives additional strength from the study of the laminæ in the beautiful convolutions in which we find them arranged in their longitudinal course.

The olivary bodies are connected most intimately with the great system of *longitudinal fibres* running on each side of the raphè, by means of which parts lying *above* and *below* are brought into co-ordination. The *two sides of the medulla* are also united by the intimate relation existing between the olivary bodies and the arciform fibres, as well as by means of the olivary commissure; while posteriorly the olivaries receive radiating fibres from the *nuclei lying along the floor of the fourth ventricle*, to which they are still further united by means of the internal and external bundles of arciform fibres, which bend around them and also enter them, forming such an intricate plexus in the antero-lateral portions of the medulla (Plate XV). Their relations with the *antero-lateral nuclei* are very close and intimate, as also with the *caput cornu*, and in the anterior portion of the medulla, fibres are everywhere seen turning off, especially in longitudinal sections, towards the *outer layer of marginal fibres.*

Whether or not it is true, as Todd and Bowman have surmised, "that the olivary bodies constitute the essential portion or *nucleus* of the medulla oblongata, that on which its power as an independent centre depends,"[1] it is evident that they are very largely concerned in the *co-ordination* of action, bringing into harmony the most distant parts of the medulla, and appearing to stand, in connection with the system of arciform fibres, much in the same relation to the nuclei of the *medulla oblongata*, as the cerebellum and fibres of the pons Varolii do to the nuclei of that part of the central nervous system to which they belong.

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[1] Physiological Anatomy, I, 267.

CHAPTER VIII.

THE OLIVARY BODIES OF MAMMALIA.

THE structure of the olivary bodies in the mammalia has received but little attention hitherto, and their existence has been entirely denied by some authors. Schröder van der Kolk and Clarke have given the only accurate description of the structure and connections of these bodies, and the results of their observations are both interesting and important. As already pointed out by both these authors, the situation of the olivaries is different in most of the mammalia from their position in man, lying directly behind the anterior pyramids between the raphè and hypoglossal roots; the latter running along the outer edge of the olivary bodies, instead of passing on the inner side, as is the case in man. In the sheep, the structure of the olivary bodies is reduced to a very simple type (Plate XIII, Figs. 2^a, 3^a, 4^a, 6^a, 7^a, and the corresponding figures Plates I and II, also Fig. 5); in this latter figure the olivary is seen to consist of a folded lamina, the convolutions of which are very few in number when compared with those in the human medulla.

The laminæ are united by a transverse commissure across the raphè, similar to that described in man, and contain numerous, rather small, oblong or fusiform cells, measuring about $\frac{1}{1333}$ to $\frac{1}{1000}$ of an inch on their longest diameter. The lamina is everywhere penetrated by regular, wavy bundles of fibres, between which the cells are arranged in layers, some of the fibres being evidently continuous with their processes. Just behind the pyramids, on each side of the raphè, the fibres, which are mostly derived from the arciform plexus, are arranged in a very regular manner, often forming beautiful, wavy bands which sweep through the olivary bodies, and cross at the raphè. In Figs. 5, 6, 6^a is seen the greatest development of the olivaries which is attained in the sheep, and even here the convoluted appearance is very slight, consisting only of three or four foldings, which are very much larger in proportion to the whole size of the olivary body than in the human medulla; while lower down (Figs. 2^a, 3^a) no indication of folding is visible, the cells being arranged in layers between bundles of arciform fibres. The form of the olivary body in the sheep, and the course of the arciform fibres as they pass through it, has been very well drawn by Clarke (*Philos. Trans.* 1858, Plate xv, Fig. 26).

The simple plan of structure of the olivary body in the sheep is well seen in longitudinal sections, where it appears to be inserted or thrust like a wedge between the external and internal bundles of longitudinal fibres which diverge very sharply at the point where the olivary first makes its appearance, the external bundles running in front along the curved surface of the medulla, while the internal fibres pursue their vertical course behind the olivary body, turning off at various angles to penetrate the lamina, joining the cells here or passing among them to more distant parts. The olivary column is terminated above by a group of large, multipolar cells scattered in the network about the raphè, which have replaced the smaller olivary cells, and measure about $\frac{1}{800}$ to $\frac{1}{400}$ of an inch in diameter.

The connection between the olivary bodies and the nuclei of the hypoglossal is much more apparent in the sheep than in man. Little bundles of fibres are constantly seen running from the nucleus on each side the raphè and close to it towards the olivary body, and these bundles are commonly studded throughout their entire course with small scattered cells and little cell-groups. In some specimens the hypoglossal nucleus on each side of the raphè sends out a little pointed promontory of some length containing cells, and along the raphè cell-groups are formed on each side at regular intervals, exactly opposite each other, connecting the hypoglossal nuclei with the olivary bodies (Figs. 2^a, 6^a, 7^a), while branching off from the apex of the hypoglossal nucleus, similar little cell-groups are found, connecting it with the antero-lateral nucleus (Figs. 4^a, 19^a).

In the cat and the carnivora generally, the anterior pyramids are deeper, and approach more nearly to the human type, the olivary bodies are much more fully developed and present a more decidedly convoluted form, which is occasionally very marked; they are still, however, as in the sheep, situated just behind the pyramids, close to the middle line, the hypoglossal roots running on the outside. Their position may be seen in Plate IX, Fig. 33, though as this section is from the upper part of the medulla, they have already begun to diminish in size and in the number of convolutions. The cells of the lamina in the cat are quite small, measuring about $\frac{1}{2000}$ of an inch in diameter; they appear to follow more closely the direction and form of the convolutions than in the sheep, being arranged within the lamina much in the same way as in man, while in the sheep, as stated above, the cells follow more nearly the direction of the arciform fibres, the layer of cells often crossing the lamina at right angles with the direction of the folding.

Schröder van der Kolk[1] has stated, that in all animals the inferior olivary bodies are situated within the limits of the hypoglossal roots, but this does not appear to be strictly true, since in the sheep we find distinct traces of the convolution after the disappearance of the hypoglossal roots (Fig. 7^a), and in the cat, this is also distinctly seen to be the case (Fig. 33), evident remains of the olivary body, still showing the convoluted structure, being found on a level with the roots of the glossopharyngeal. The same is true in the human medulla, the convolutions are distinctly seen in Fig. 24^a, and can be traced for a considerable distance above, as may be seen by reference to Stilling's admirable plates (Pons Varolii, Plate i). I have not been able to trace any direct communication between the accessory or vagal nuclei and the olivary bodies, nor any direct connection with the hypoglossal roots, though the latter often pass directly through the outer portion of the olivaries.

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[1] Medulla Oblongata, 164. His deductions seem to have been principally founded on external measurements, which of course are liable to error.

CHAPTER IX.

THE ANTERO-LATERAL NUCLEUS.

THE only notice which I find of this important and interesting column is contained in a brief description given by Clarke, stating that in the mammalia, " on the outer side of each olivary body, and separated from it by a groove which lodges the hypoglossal nerve, is another vesicular column of nearly the same length, but broader externally. Above, it blends as a flattened band with the trapezium, close to the origin of the facial nerve, which arises from the side of the latter; and below, it is continuous with a distinct fasciculus of the lateral column. From its side and that of the olivary body, the broad band of arciform fibres crosses the medulla to reach the posterior columns; but within, it is traversed by a network or plexus, formed by the interlacement of these fibres with those remaining from the anterior cornu, and inclosing the longitudinal bundles of the lateral column. Amongst this network lie the cells, which are larger than those of the olivary body, and more irregular in shape. They are oval in different degrees, or pyriform, fusiform, crescentic, club-shaped, triangular, or variously stellate, and give off processes which nearly encircle the longitudinal bundles, and contribute to form the meshes. All these appearances may be very distinctly observed in the sheep, ox, or cat. In man a similar structure was found, but owing to the difference in the shape of the medulla, it lies behind, instead of at the side of the olivary bodies, and is not so prominent externally; the cells also are rather less than those of the mammalia."[1]

This column of large cells, which, from the variety of its connections, would seem to be of very considerable importance, I have called the *antero-lateral nucleus.* It is developed in the antero-lateral portion of the medulla, just above the decussation of the pyramids, among the great bundles of arciform fibres which are here so conspicuous. The cells vary, as stated by Clarke, both in form and size, but are mostly quite large, measuring, in the sheep, from $\frac{1}{800}$ to $\frac{1}{400}$ of an inch in the principal group; while behind, a smaller group of very large cells is often found, connecting the main nucleus with the caput cornu, some of the cells of which measure $\frac{1}{400}$ to $\frac{1}{266}$ of an inch in diameter. The cells composing the body of the nucleus are disposed in a compact group, through which the arciform fibres radiate in various wavy bundles, forming an intricate network around the longitudinal fasciculi, which are embraced in every direction by the cell-fibres. The large cells, mentioned above, sometimes appear as a distinct group, just on the anterior border

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[1] Philos. Transactions, 1858, 246.

of the caput cornu, but are more commonly an offshoot from the main nucleus, with which they are evidently closely connected (Figs. 2^a, 3^a, 4^a, 6^a). In the cat the cells of the antero-lateral nucleus are very conspicuous and well defined, they are collected into a group in the same situation as in the sheep, but form a rather more open plexus or network with the arciform fibres, many of which are distinctly seen to be continuous with their processes. As cell-processes also pass in many different directions transversely as well as longitudinally, this group doubtless serves to connect the arciform fibres with the other parts of the medulla, constituting apparently an accessory nucleus to each olivary body.

Its connections with the caput cornu have already been pointed out; and connections are also established between this nucleus and that of the hypoglossal, and with the vagal and spinal accessory nuclei; with the two latter sometimes directly, and sometimes through the caput. The connections established between the antero-lateral nucleus and that of the hypoglossal are often very striking. They are especially evident in the sheep, in which I have often noticed the formation among the border fibres of the hypoglossal nucleus, of a little cell-group, sometimes thrust out along the course of the roots for a considerable distance, and joined by scattered cells to quite a large, elongated group of stellate and oval cells, which are evidently a prolongation obliquely inwards of the antero-lateral nucleus (Fig. 4^a). Along the raphè on each side, little cell-groups are found at varying distances, each of which is usually provided on the opposite side with its exact counterpart, and these little groups are apparently entered by numerous fibres from the arciform plexus, which have just passed through the nuclei mentioned above.

In the human medulla the antero-lateral nucleus is quite conspicuous (Figs. 18^a, 19^a, 20^a, 21^a, 22^a, 23^a); the cells are rather smaller than in the sheep, measuring about $\frac{1}{1000}$ to $\frac{1}{400}$ of an inch. The relations between the antero-lateral nucleus and the other portions of the medulla, are the same in man as those described above in the sheep, and its changes in form and situation have been sufficiently dwelt upon in Chap. II, on the morphology of the human medulla.

By comparing Figs. 6^a, 7^a with Fig. 8^a (all from the sheep) it will be seen that the groups of very large cells, which will be subsequently shown to be the origin of the upper olivary bodies, are evidently developed from the remains of the antero-lateral nuclei, so that it is extremely probable that the *antero-lateral nucleus* is, in the lower part of the medulla, *accessory to the olivary column*, and that it is continued upward into the *trapezium*, where it is developed into the *upper olivary body*, the structure and relations of which will be described subsequently.

PART II.

THE FORM AND STRUCTURE

OF THE

GRAY SUBSTANCE OF THE TRAPEZIUM, MAMMALIAN.

CHAPTER I.

MORPHOLOGICAL CHANGES IN THE TRAPEZIUM OF THE MAMMALIA.

(1.) The most striking feature in the upper part of the medulla oblongata, is the development of the *auditory* nucleus, which is conspicuously presented in two distinct masses, an *inner* or *anterior* portion formed from the remains of the underlying nuclei, together with the new pyramidal mass, which, as we have seen in the foregoing chapters, is formed partly from the vagal and partly from the post-pyramidal nucleus, and an *outer* or *posterior* portion, consisting of a remarkable network inclosing in its meshes numerous longitudinal bundles, formed from the outer part of the post-pyramidal and inner portion of the restiform nucleus. The outer network is closely connected with the entire mass of the restiform nucleus, by numerous bundles of transverse fibres radiating from the network and traversing the dark mass of longitudinal bundles constituting the restiform body, which now forms the outer border of the medulla; a part of these radiating fibres are connected with the posterior auditory root, while another portion join the arciform plexus.

The *glossopharyngeal* nucleus is still somewhat distinct, and is situated in a depression near the apex of the anterior portion of the auditory nucleus, where it is entered by numerous bundles of nerve-roots, traversing the caput cornu. In the cat the roots of the glossopharyngeal are very distinct (Plate IX, Fig. 33), passing into the small, transparent nucleus, which is crowded with quite large cells, especially numerous near the posterior part. A portion of the glossopharyngeal roots do not enter at the apex, but pass along the posterior margin of the nucleus, entering farther back, spreading out both anteriorly and posteriorly in the posterior part of the nucleus.

The inner portion of the *restiform* nucleus contains many large multipolar cells, and is closely connected with the network forming the outer portion of the auditory nucleus. Both portions of the *auditory* nucleus, as well as the *caput cornu*, contain many scattered cells, mostly small.[1]

Numerous bundles of fibres proceed from the anterior portion of the nucleus near the raphè, taking the same direction as those noticed in the lower part of the medulla, serving to connect the olivary bodies with the motor nuclei; these fibres are also connected with the few remaining cells which are the uppermost of the lower olivary column (Plate XIV, Fig. 8^a, *e*). The upper olivary bodies (*O′*) are now quite distinct, consisting of large and numerous multipolar cells, the processes from which in connection with transverse and arciform fibres, form a rather open network, inclosing numerous longitudinal bundles in its meshes.

(2.) Higher up (Figs. 8, 8^a, and 33), the nucleus of the glossopharyngeal becomes distinctly fused with that of the auditory, the apex of the *anterior* auditory nucleus projecting into the caput. The *posterior* portion of the nucleus (Fig. 8^a, *A′*) is very large and distinct, and has already absorbed nearly, if not quite, the whole of the restiform nucleus. It is connected with the longitudinal fibres of the restiform body (*r*) by numerous curved and radiating bundles (*r′*), and is entered at its apex by the *anterior* division of the *auditory root* (*VIII*), which is at first a small bundle, passing through and apparently connected to some extent with the arciform fibres. The *posterior auditory root* (*VIII′*) is very large and well defined, and is connected with the posterior portion of both divisions of the nucleus.

TRAPEZIUM

(3.) As we approach the trapezium the plexus of external arciform fibres which has gradually diminished in the sections below, till it appears as a very thin band at times hardly distinguishable beyond the extremity of the caput (Fig. 8^a), quite suddenly enlarges (Fig. 9^a), and is now seen as a very thick and constantly increasing marginal band of fibres, which, as Clarke has pointed out, "proceed out of the restiform bodies and auditory ganglia, and sweep round the extremity of the caput cornu to the back of the anterior pyramids, to decussate across the raphè. As they pass the ganglion, or auditory nerve, they receive fibres from it."[2] In Figs. 8^a, 9^a, the course and origin of these fibres may be plainly seen, as well as their connection with both auditory roots.

(4.) In Plate XIV, Fig. 9^a, from a section just above the commencement of the trapezium, the *posterior auditory root* (*VIII′*) has reached its greatest development, and sends out from its substance numerous radiating bundles into the restiform body. Some of these apparently pass out with or join the anterior root; the majority, however, cross the root and become external arciform fibres, the number of which constantly increases as we ascend towards the pons Varolii, forming a very thick and compact marginal band, completely bounding the antero-lateral and anterior

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[1] My observations on the formation and development of the auditory nucleus agree so entirely with the description given by Clarke (Proceedings of the Royal Society, 1861), as to appear almost like a direct quotation of the particulars he has there given.

[2] Proceedings of the Royal Society, June, 1861

portions of the medulla, and decussating behind the pyramids at the raphè, with fibres derived from the opposite side. The posterior root of the auditory often contains at its entrance into the medulla a few scattered cells, which are less conspicuous in the sheep than they are either in the cat or in man. They may generally, however, be plainly seen, and were described by Stilling, in man, as a little ganglion, similar to those found on the posterior spinal roots. In the cat, the posterior root of the auditory is very large and conspicuous (Plate IX, Fig. 34); its pyriform swelling is very evident, containing numerous cells and fibres, the latter winding among the small cells in a somewhat spiral or serpentine course, resulting apparently from the obliquely ascending course which the posterior auditory roots take as they wind around the restiform body.

As the posterior root proceeds in its course, winding in a broad band round the posterior border of the restiform body, the cells which are scattered among its inner fibres become more and more numerous; they are principally oval or fusiform in shape, elongated in the direction of the fibres. As the roots pass the *flocculus*, with which the medulla is here connected, the cells increase in number and size, and the broad band of nearly parallel fibres soon expands, entering the posterior portion of the auditory nucleus, through which many of its fibres penetrate to the anterior portion.

The *anterior root* (*VIII*) is also quite well developed, entering close to the posterior, which a part of its fibres accompany, the majority, however, immediately diverging and passing on the inner side of the restiform body, which is thus completely grasped, as it were, by the two roots. In Plate IX, Figs. 33, 34, the development of the *anterior auditory root* in the cat is well seen: the roots lie at first just behind those of the glossopharyngeal, from which it is often somewhat difficult to distinguish them. At the point where the anterior roots cross the external band of arciform fibres, a little ganglion or group of cells is developed, in close connection with the roots, the root-bundle often splitting, a part of the fibres going on each side and completely inclosing this little group.

The network constituting the *outer nucleus* of the *auditory* contains very large and numerous multipolar cells, sending their processes in all directions around and among the longitudinal and transverse fibres of which the network is composed. The cells fill the entire network, extending from the apex at the entrance of the anterior roots, back towards the cerebellum, as far as the entrance of the posterior root, and reaching forwards into the anterior portion of the nucleus, along the back of which a group is formed sending out numerous fibres into the cerebellum. Both nuclei of the auditory are joined to the caput by numerous radiating fibres, some of which penetrate the caput and pass outwards as internal arciform fibres.

The *fasciculus teres* (*T*) which becomes the nucleus of the sixth and facial nerves, is first seen as a somewhat dark mass on the floor of the fourth ventricle, in that part of the auditory nucleus which represents the upward extension of the hypoglossal; it contains numerous small cells, which increase in size and become more numerous higher up.

In that portion of the anterior columns of the medulla representing the upward continuation of the lower olivary bodies, numerous multipolar cells are found, many of which are of large size, and are connected by their processes with the arciform fibres decussating at the raphè. Scattered cells are also found at various points in the substance of the raphè.

(5.) In the sections just above (Figs. 10, 10^a), the cells representing the lower olivary column are reduced to a little group in the immediate neighborhood of the raphè. The *upper olivary* bodies in the sheep, are now seen as compact masses, resembling those found in the carnivora, though not quite so large proportionally or so distinctly convoluted. The cells have diminished in size, but the arrangement of fibres is much more distinct and orderly. In the cat, the large cells found in the lower part of the upper olivary column soon disappear, the open network being cut in upon more and more by the wavy bundles of the trapezium, and are replaced by smaller cells arranged in a distinctly convoluted lamina.

The *roots* of the *abducens* or sixth pair of nerves (Fig. 10^a, *VI*), are now quite easily distinguishable, running inwards in two or three tolerably thick bundles to the nucleus, which is more distinctly seen a little higher up, the course pursued by the roots of the abducens as well as by those of the facial being slightly ascending. The commencement of the nucleus may, however, be seen in Fig. 10^a, *T*, partly separated from the anterior portion of the auditory nucleus, in a position exactly corresponding to the upward extension of the hypoglossal nucleus. The roots of the sixth form a remarkable exception to the usual course of the nerve-roots, *bending backward* to enter their nucleus just before they reach the floor of the fourth ventricle, instead of running *towards the median line* as do the roots of all the other nerves.

The *facial* first makes its appearance as a somewhat wavy band of fibres, running directly inwards towards that portion of the auditory nucleus which is close to the caput, and then bending forwards towards the *fasciculus teres*, which constitutes the common nucleus of the sixth and seventh pairs. It rapidly increases in size till it is seen as a thick and broad band of fibres (Figs. 10, 10^a, 11, 12, 13 and 36), running inwards towards the nucleus, and crossed, as it passes along the anterior margin of the auditory nucleus, by very numerous wavy bundles of fibres passing out into the antero-lateral columns (Plates XIV and XVI, Figs. 10^a, 12^a, and 44). The entire space between the fibres of the sixth and seventh nerves is studded with little cells (Figs. 10^a, 12^a), which are also frequently found throughout the entire antero-lateral network, serving to unite all the various nuclei, by means of the arciform and transverse fibres with which their processes are connected. Not unfrequently little groups of cells are found at the foot of the facial (Fig. 10^a, *v*), and at various points among the external arciform fibres, the latter being the first appearance of the numerous cell-groups from which the fibres of the pons Varolii are subsequently developed.

The *auditory nucleus* contains many very large, multipolar cells, especially in the network and postero-lateral portion. In the cat (Plate IX, Fig. 35), the network of the outer nucleus is very much developed, the restiform body being often quite hidden beneath the fibres of the network, which is crowded with very large cells reaching forward into the substance of the anterior part of the nucleus, and backwards in a straight line into the substance of the cerebellum. Large bundles of fibres following the course of the posterior root may be traced from the *flocculus* towards the back of the nucleus, crossed by bundles coming down from the cerebellum towards the apex of the nucleus.

(6.) In Plate XVI, Fig. 12^a, the projection formed on the *posterior auditory root*, as it emerges from the medulla, is still conspicuous, but the fibres of the root have very much diminished in number. The ganglionic enlargement consists partly of numerous longitudinal or oblique fibres, intermixed with others running in a transverse direction; the latter, which are derived from the posterior parts of the medulla, cross the fibres of both divisions of the auditory root and pass onward as part of the external band of arciform fibres so conspicuous throughout the trapezium. As we ascend, the projection still continues to be conspicuous (Plate IV, Fig. 13), but the posterior root-bundles continually diminish in number and presently disappear. The prominence is filled with numberless very small cells, round and obovate, measuring about $\frac{1}{2000}$ to $\frac{1}{800}$ of an inch in diameter. In sections still higher up the cells diminish in size, the prominence appearing more and more like an extension of one of the cerebellar folds filled with small cells and granular nuclei.

In the cat the group of cells placed on the back of the auditory root forms a very conspicuous prominence, seen in Plate IX, Fig. 35, as a dark mass lying along the roots, and separated by a deep sulcus from the *flocculus*. The cells become more and more numerous as we ascend, and are often found intermingled with the roots themselves. After the level of the facial roots is attained (Fig. 36), the mass is brought into close contact with the folds of the flocculus, and the cells are seen to be evidently of a similar nature to those found in the convolutions of the cerebellum, only in a somewhat denser and larger mass. The structure of the *caput* in this region is somewhat peculiar. Instead of consisting of a loose fibrous mass containing scattered cells, as is the case in the lower regions of the medulla, it is here divided into several rounded masses, five or six in number, closely crowded with cells of moderate size, very much resembling the appearance of those masses in the lower part of the trapezium which were shown to be the commencement of the upper olivary bodies. The caput is very early brought into connection with the anterior part of the auditory nucleus by several rather thick bundles of fibres, and its whole substance appears to be closely connected with both portions of the auditory nucleus.

(7.) As we ascend, the *restiform columns* are continually encroached upon more and more by fibres radiating from both roots of the auditory, which penetrate and almost conceal them (Plate IV, Fig. 13). They are, at the same time, pushed backwards together with the auditory nucleus, by the formation and enlargement of the nucleus of the abducens and facial, and by the contraction of the lateral boundaries of the fourth ventricle, until, as Clarke[1] and Stilling[2] have both shown, they are ultimately thrown backwards into the cerebellum, together with the posterior portion of the auditory nucleus.

The *anterior root* of the *auditory* seems to consist, in the upper part of the trapezium, of two quite distinct divisions (Figs. 12, 12^a, 13); a compact bundle proceed-

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[1] Proceedings of the Royal Society, June, 1861.

[2] Pons Varolii.

ing inwards to the anterior portion of the nucleus, accompanied by numerous small bundles which enter the loose network constituting the outer portion of the nucleus, while another division diverges, and winding around the outer edge of the restiform body, enters the posterior portion of the nucleus in company with the posterior roots. The connection between the *auditory* nucleus and the *cerebellum* is now very conspicuous (Plate IV, Fig. 13, Plate XVI, Figs. 12^a and 44); numerous bundles which proceed from the cerebellum pass down through the nucleus and enter the medulla, radiating in all directions in the anterior and antero-lateral network, and a portion of these fibres are also continuous with cell-processes in the postero-lateral portion of the nucleus.

The connection between the *upper olivary* bodies and the *facial* nucleus is very evident in the upper part of the trapezium, and will be referred to subsequently. The groups of large cells near the facial, figured by Schröder van der Kolk (Medulla Oblongata, Fig. 20, *o*), and another group found near the outer edge of the caput, are evidently of the same nature as the upper olivary bodies.

(8.) In the upper part of the course of the facial, the nucleus has entirely disappeared (Plate IV, Figs. 14, 15, 16 and Plate XIV, Fig. 16^a), and the roots are seen in two or three very large bundles, whose entire course can be traced inwards to the longitudinal columns on each side of the middle line, called by Stilling the "*constant roots of the trifacial.*" These columns are inclosed by the root-bundle, a portion of the fibres of which seem to abruptly terminate here; the remainder can, however, be traced onward to the raphè where they are seen to decussate with their fellows from the opposite side. Throughout their entire course the facial roots are crossed at various points by fibres radiating from the auditory nucleus, many of which proceed from the cerebellum either directly or after passing through cells.

(9.) The longitudinal columns on each side the raphè near the floor of the ventricle (Fig. 12^a, *j*, Fig. 44), referred to above, have been described by Stilling as the "*constant roots of the trifacial,*" and by Schröder van der Kolk as "*roots of the auditory.*" I have not been able to discover any connection between these columns and the trifacial or auditory roots, and in the chapter on the facial nerve, I have endeavored to show, that a portion of the facial roots probably descend in these columns to the underlying nucleus. With the exception that they are intermingled with descending facial roots, these columns seem to be simply bundles belonging to the general system of the longitudinal postero-lateral columns, from which they are separated to some extent by the facial roots on their way to the raphè, but to a still greater extent, especially in front, by the curving fibres which sweep out from the auditory nucleus.

(10.) In sections from the upper part of the trapezium the chief changes noticeable consist in the gradual disappearance of the nerve-roots we have been considering, as well as of the upper olivary bodies (Plate XIV, Fig. 16^a). The external arciform fibres constituting the border of the trapezium have increased very much in number as we approach the pons Varolii. The upper olivary bodies (O') are very much reduced in size, appearing now as simple rounded masses, containing a few small cells, almost hidden by the wavy bundles of arciform fibres.

The roots of the facial (Fig. 16, 16^a, *VII*) are reduced to a few small bundles, which are collected together as they pass the anterior border of the remains of the auditory nucleus, forming quite a broad bundle which may be traced onward to the raphè where it decussates with its fellow from the opposite side. As we pass upward the roots constantly diminish in number, and are presently replaced by the small or motor root of the fifth nerve, the nucleus of which appears to be an upward extension of the motor column from which the facial, abducens and hypoglossal roots are derived

The *caput cornu* steadily increases in size and in the number of its cells, contributing with the remains of the auditory nucleus to form the principal nucleus from which the sensitive fibres of the fifth or trifacial nerve originate. The remains of the auditory nucleus have at this height passed backwards towards the cerebellum, together with the restiform columns (Fig. 16^a, *r*). The little group of cells lying close to the remains of the auditory root is still persistent, and is now seen to be in very close connection with the flocculus.

(11.) The changes which are observable still higher up, in the form and structure of the gray substance, are chiefly produced by the development of the pons Varolii and the formation of the nucleus of the trifacial, the *motor* roots of which are derived apparently from the upward extension of the *fasciculus teres*, and its *sensitive* roots from a large pyramidal nucleus, composed of the *caput cornu* together with the upward extension of the *auditory ganglion.*

CHAPTER II.

THE AUDITORY NUCLEUS AND ROOTS.

The Nucleus.—In the preceding chapters on the morphological changes in the medulla and trapezium, it has been shown that the auditory nucleus is developed, as Clarke had already demonstrated,[1] between the outer horn of the vagus nucleus and the post-pyramidal body, as a small triangular mass, apparently formed from the substance of the two neighboring nuclei, with both of which it is very closely connected. It sends out numerous fibres into the restiform body, which cross each other at various angles, interlacing among and around the numerous longitudinal fasciculi which pass upwards along the outer border of the nucleus, thus forming an open network which is very much developed in the upper parts of the medulla, where it is closely connected with the remains of the restiform nucleus, forming what Clarke has called the outer portion of the auditory nucleus.

The inner mass or principal nucleus of the auditory, enlarges till the nucleus of the vagus is pushed quite forwards, the outer portion or network at the same time increasing, till it occupies a very considerable portion of the restiform column. The next stage is that in which the auditory nucleus together with the glossopharyngeal and hypoglossal nuclei, seem to be fused into one mass (Plates II and XIV, Figs. 8, 8^a), the glossopharyngeal distinguishable mainly by its more transparent substance, appearing as a separate nucleus near the apex of the broad triangular mass. From that portion of the triangle which is the continuation of the nucleus of the hypoglossal, fibres run out in the direction formerly taken by the hypoglossal roots (Fig. 8^a), and form considerable bundles accompanied by cells sometimes scattered and sometimes collected into groups, often quite filling the antero-lateral portions of the medulla and apparently serving to connect the transverse and arciform fibres with the neighboring parts.

The large triangular nucleus is now filled with numerous cells, mostly of rather small size, but larger near the apex and in the network or outer portion of the nucleus. As we approach the trapezium, the outer network becomes more and more developed, extending far out into the restiform column and containing numerous very large cells (Figs. 9, 9^a). Anteriorly or towards the raphè, the remains of the hypoglossal nucleus become more and more separated from the mass by the gradual pushing backwards of the auditory nucleus, its situation being almost

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[1] Philos. Trans. 1858. Proceedings of the Royal Society, 1861.

entirely covered by a remarkable fringe of fibres emanating from the anterior border of the auditory mass (Figs. 10^a, 11^a), among which are finally developed the cells of the *fasciculus teres* or common nucleus of the facial and abducens nerves.

As the roots of the facial are more and more developed the whole auditory nucleus is thrust outwards and backwards, changing form slightly, and sending out a process or bundle of fibres into the caput cornu with which it becomes closely connected. This gradual pushing outwards and backwards of the auditory nucleus, together with the gradual lateral elongation of the whole medulla in this region, continues as the facial makes its appearance, and the connection with the caput becomes more and more intimate, until in the lower part of the pons Varolii the two form together the great nucleus from which the trifacial nerve arises.

As already pointed out by Clarke, the outer portion of the auditory nucleus together with the restiform body, is thrown backward into the cerebellum, numerous fibres from the main nucleus arching over the fourth ventricle, whilst others pass backward into the cerebellum.

The cells of the auditory nucleus present almost every variety in size and form, some of them being exceedingly small, while, as already noticed by Schröder van der Kolk, some are the largest anywhere found, even exceeding in size those of the anterior cornua of the spinal cord. In the lower part of the medulla the cells of the auditory nucleus are mostly small, oval or stellate, with every variety of intervening form, measuring $\frac{1}{2000}$ to $\frac{1}{800}$ of an inch in the sheep, and are interspersed with scattered nuclei and granules with which the entire mass seems filled, resembling those found in the posterior cornua of the spinal cord. Higher up, the anterior part of the nucleus, especially that which represents the continuation of the hypoglossal column, contains the same small cells and nuclei, but posteriorly, near the entrance of the posterior division of the auditory nerve, the cells are at first small, and oval, fusiform or crescentic in shape; a little further inwards they are quite large, some of them being very much elongated, oval, fusiform or semilunar in shape, measuring in the sheep $\frac{1}{800}$ to $\frac{1}{250}$ of an inch in length. In the cat they are smaller, measuring $\frac{1}{800}$ to $\frac{1}{572}$ of an inch. The lateral and postero-lateral border of the main nucleus, together with its contiguous network, contains very many large multipolar and stellate cells, sending out their processes in every direction, especially among the longitudinal bundles which penetrate the network and are inclosed in meshes of fibres formed chiefly from the interlacing processes of these large cells. Some of the cell-processes pass inwards towards the deeper lying portions of the nucleus or towards the cerebellum, while others pass outwards among the longitudinal fasciculi towards the restiform body, where they often form a very complicated system of radiating fibres, connected with the root-bundles and with the longitudinal fibres of the restiform column. Some also pass longitudinally upwards or downwards, and serve to connect different planes of the medulla and trapezium. The cells situated in the outer network of the auditory nucleus are the largest I have anywhere found, measuring in the sheep from $\frac{1}{400}$ to $\frac{1}{220}$ of an inch in diameter, in the cat from $\frac{1}{572}$ to $\frac{1}{266}$ of an inch. In the cat they are especially numerous, quite filling the posterior and postero-lateral parts of the main nucleus as well as the outer network.[1]

At the apex, close to the entrance of the anterior division of the root, a group of cells is found, which are stellate or pyriform in shape and are quite large; they are connected partly with the anterior division of the root, and partly with numerous bundles of radiating fibres which pass from the vicinity of the apex into the caput cornu. All along the anterior border of the nucleus a beautiful fringe of very numerous wavy fibres is seen, passing out into the anterior and antero-lateral columns, derived apparently in part from the deeper lying regions of the nucleus, as well as from the cells along the antero-lateral border.

Stilling[2] has described a small nucleus in connection with the posterior root of the auditory, which he seems to consider analogous to the spinal ganglia attached to the posterior roots. It is situated at first on the outer side of the great bundle of fibres constituting the posterior root of the auditory (Plate XIV, Fig. 9^a, *z*), and consists of very small cells, which are continued upwards in nearly the same locality until the auditory nerve finally disappears (Figs. 10^a, 12^a, 16^a).

In Fig. 10^a this group is seen situated among the arciform fibres, just behind the auditory root; in Plate XVI, Fig. 12^a, it occupies a similar position in the projecting mass, which represents the upward extension of the posterior root, though now mainly consisting of the broad band of arciform fibres constituting the boundary of the trapezium or commencement of the pons Varolii. This little group can often be traced backwards towards the group situated in the posterior part of the auditory nucleus, seen (Fig. 12^a) to be in evident connection with the flocculus, and I have consequently been inclined to consider the little nucleus in question, rather as a rudimentary fold of the cerebellum, which it strongly resembles, than as a specific ganglion on the posterior auditory root; this resemblance is especially striking in the cat, a continuation of the flocculus being apparently folded down along the auditory root (Plate IX, Figs. 35, 36).

Foville,[3] as is well known, has described a connection between the auditory nerve and the flocculus, and at the same time to such an extent with the cerebellum that he has called the auditory a cerebellar nerve (nerf cérébelleux). The connections between the posterior portion of the auditory nucleus and the cerebellum are very striking and complicated, and merit more attention than I have been able to bestow upon them. In order to fully understand the meaning of the different bundles of fibres which everywhere stream out from the back of the auditory nucleus, it would be necessary to carefully trace them into the cerebellum, and to understand very fully their destination within this organ; this of course does not come within the limits of the present paper, but I shall briefly notice a few points which are most easily made out.

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[1] In the medulla of the cat I have been able to count over 60 large cells in a field measuring about $\frac{1}{30}$ of an inch in diameter, and as this was done with a $\frac{4}{10}$ objective without changing the focal adjustment, only those on the same plane were counted.

[2] Bau des Hirnknotens. Jena, 1846, 28.

[3] Traité complet de l' Anatomie et Physiologie du Système Nerveux Cérébro-Spinal, Paris, 1844, 503.

The connection of the auditory nucleus with the flocculus is very evident, as has already been noticed by Schröder van der Kolk, who attributes to it the "particularly large size of the flocculus in the Rodentia, which are possessed of acute hearing."[1] In the cat the flocculus is also very large, corresponding with the great development of the auditory root (Fig. 35, Plate IX), the latter sometimes, especially near its entrance, being quite bent out of its course and pushed in towards the facial by the size of the flocculus (Fig. 36). The connections between it and the auditory are very strikingly evident; just along the posterior portion of the network constituting the outer nucleus of the auditory, a row of large multipolar cells is found, intermingled with which are many of an oval, fusiform or semilunar shape, following each other quite closely and regularly, from which a very beautiful fringe of fibres proceeds, turning over and forming a very regular and conspicuous band which may be traced into the flocculus, where its fibres join the bundles radiating into the convolutions of the cerebellum.

In the sheep (Fig. 12^a, Plate XVI) this connection is easily made out, though not quite so conspicuous as in the cat, where the size and regularity of the cells, together with the formation of thick bands of fibres which are very easily traced, leave no doubt of the fact.

In the upper portions of the medulla, the connection of the whole posterior part of the auditory nucleus with the cerebellum becomes more and more manifest. As we ascend, the outer portion of the nucleus together with the restiform body is gradually thrown backwards into the cerebellum, very numerous fibres from the inner portion of the nucleus arching over the fourth ventricle and meeting those from the opposite side, so that the *valve of Vieussens* together with the *lingula* is inclosed as it were, or overarched by these fibrous expansions, which, as Clarke has shown,[2] pass over the *superior peduncle* to the *inferior vermiform process.*

The fibres from the central and outer portion of the nucleus spread out in every direction into the substance of the cerebellum, especially towards the *corpus dentatum*, and finally (Plate XIV, Fig. 16^a) the nucleus, together with the restiform body, is thrown far back into the substance of the cerebellum. The further destination of these fibres, which, whether derived from the auditory nucleus or the cerebellum, certainly serve to connect the two, and to bring them into very close relation, deserves careful study, but could hardly be entered upon without at the same time studying the anatomy of the entire cerebellum, in order to determine whether the connection is with the larger lobes, or only with those more nearly contiguous. The connection of the large cells near the apex and in the outer network, with the auditory roots, is very easy to demonstrate, as well as their connection with fibres emanating from the restiform body and cerebellum. In Plate XII, Fig. 41, we have a group of large multipolar cells from near the entrance of the auditory roots into the apex of the nucleus, from the medulla of the cat, drawn with all possible accuracy by means of the Camera Lucida. Bundles of entering fibres from the auditory root are seen (A, A, A) running inwards towards the cells, which, as will be seen, take every variety of form and send their processes in many different

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[1] Medulla Oblongata, 115.

[2] Proceedings of the Royal Society, 1861.

directions; some join the numerous bundles (*C*) which either pass into or originate from the cerebellum, or pass into the restiform body; while others join the bundles (*B*) which pass out into the antero-lateral portion of the medulla, forming with other transverse fibres a very beautiful network around the longitudinal bundles.

Fig. 43, Plate XII, represents a group of the very large cells found in the posterior portion of the auditory nucleus of the sheep, showing their connection with the numerous and distinct bundles of fibres which radiate from this part of the nucleus towards the cerebellum.

The Roots.—The auditory nerve, as is well known, consists of two portions, anterior and posterior, which, as Stilling has shown,[1] take a slightly ascending course as traced from without inwards, this course being more oblique in man than in most of the mammalia, the great thickness of the pons pressing the roots downwards, while in some of the lower mammalia in which the pons is very thin, the roots of the auditory nerve may be traced in a direct course to their nucleus.

Clarke has given in a few words an accurate description of the course pursued by the *posterior* division of the auditory root; as stated by him, this portion of the nerve takes its origin from both parts of the nucleus, " and winds outward as a broad convex band over the restiform body. In this course it contains, at first, a few small cells, elongated in the direction of its fibres; but as it proceeds, the cells gradually become larger and more numerous, until at the anterior border of the restiform body it enlarges into a pyriform ganglion, which is crowded with nerve-cells, similar in appearance to those of the inner nucleus. The nerve is also reinforced by fibres radiating from the centre of the restiform body as it winds round the latter."[2]

In Plate XIV, Fig. 8^a, we have the first appearance of the *posterior* auditory root, as a thickened band of fibres proceeding from the group of rather small, oval and fusiform cells in the posterior portion of the nucleus. In Fig. 9^a the fibres are seen arising from a similar group; some of the cells are of considerable size and are arranged mostly with their longer axes turned in the direction of the entering fibres; these cells are also connected with a little group near the flocculus, with which a few of the fibres of the posterior root seem to be connected. As the roots proceed onward through this cell group, it increases in size, and finally spreads out, as noticed by Clarke, into a pyriform mass containing numerous cells (*z*), among which some of the fibres interlace before passing outwards. The fibres from the restiform column, though mostly pursuing a longitudinal course, will not unfrequently be seen turning off at an angle more or less acute to reinforce the posterior root as it winds round it (Figs. 8, 9, 10). In the cat the posterior root is especially large and conspicuous (Plate IX, Figs. 34, 35), the pyriform enlargement being very evident; the fibres which constitute it appear to take a somewhat wavy course, many of them are obliquely ascending or descending fibres, interlacing among the cells at a great variety of angles resulting from the somewhat obliquely curved course taken by the root while winding round the restiform body.

The fibres of the *posterior* root are constantly reinforced by little cell-groups, until they arrive within the nucleus; some of them pass towards the large multi-

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[1] Pons Varolii, 39.

[2] Proceedings of the Royal Society, June 20, 1861.

polar cells of the outer network, through which a few small bundles may be traced for a considerable distance, running around the inner border of the restiform body, and sometimes apparently joining the anterior division of the auditory nerve. By far the greater number, however, pass along the floor of the fourth ventricle, occasionally turning off to join the oval cells near which they pass, until the anterior border of the nucleus is nearly reached, in the neighborhood of the *fasciculus teres* (Plate XVI, Fig. 44). Here they turn off in every direction, joining numerous bundles derived from the cerebellum, as well as those derived from the anterior division of the root, with which they pass across the root of the facial or interlace with its fibres, forming the very beautiful fringe so often spoken of and which may be seen very distinctly in Plate XVI, Figs. 44 and 12^a. These fibres pass into the antero-lateral network between the facial roots and the raphè, some of them probably entering the numerous small cells found in this locality; others may be traced across the abducens roots, interlacing with some of their fibres and then passing onward towards the raphè, where some of these bundles are plainly seen to decussate with those derived from the opposite side.

With regard to the *anterior* division of the root, Clarke states that it "consists of two portions: the principal portion penetrates the medulla beneath the restiform body, and running along the outer side of the caput cornu, enters both parts of the auditory nucleus; the other portion runs backward along the upper border of the restiform body, which it accompanies over the superior peduncle to the inferior vermiform process of the cerebellum."[1] To this account, with which my own observations entirely agree, I shall add a few details. The *anterior* division of the auditory penetrates the arciform plexus in a broad, compact mass of fibres, which soon spread out somewhat, being separated by intervening longitudinal fibres into numerous smaller bundles. A portion of these turn off shortly after passing through the arciform plexus, and joining the posterior division of the root wind round the outside of the restiform body, in which course they are constantly joined and reinforced by other fibres, often very numerous, derived from the restiform body itself (Figs. 9^a, 10^a, 12^a); sometimes these fibres instead of turning off and winding round the outer border of the restiform body, pass directly through its substance (Fig. 10^a). Their ultimate destination cannot be distinguished from that of the fibres belonging to the posterior division of the root which they accompany. These fibres not unfrequently penetrate the restiform body to so great an extent that the latter nearly disappears, seeming almost hidden beneath the network of transverse fibres (Plates III and IV, Figs. 1, 2, 13, and Plate IX, Figs. 35, 36).

The principal portion of the *anterior* division of the root is subdivided into a considerable number of smaller bundles, which pass behind the caput cornu separating it from the restiform body, and enter both portions of the nucleus, just at the apex, where the anterior portion of the nucleus is prolonged laterally to join as it were, the outer network. Through the apex the fibres pass onward, spreading out into an almost inextricable network, crossing at different angles the fibres derived from the restiform body and from the cerebellum.

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[1] Proceedings of the Royal Society, June 20, 1861.

Some of the fibres from the *anterior* division of the auditory enter the cells lying in the immediate vicinity of the apex, the processes from these cells serving to connect the roots with the caput cornu, which is also brought into very intimate relation with this portion of the nucleus by means of wavy bundles of fibres, some of which are apparently continuous with the roots (Plate XVI, Fig. 44). Schröder van der Kolk, who considers the caput cornu as the trunk of the great trifacial nerve, thinks that a connection is established between this nerve and the auditory by means of these fibres radiating from the nucleus of the latter, but this conclusion is I think incorrect. The caput cornu, as has been shown by Clarke, and fully confirmed by my own observations, contains in its substance numerous longitudinal bundles which are descending roots from the trifacial, but is certainly mainly composed of quite distinct cell groups constantly increasing in number as we ascend. I have not been able to trace a direct communication between any of these longitudinal bundles and the fibres radiating from the auditory nucleus, and the latter more probably enter the cells of the caput, which are especially numerous near the upper part of the auditory tract. The nuclei of *all the nerves of the posterior column*, spinal accessory, vagus, glossopharyngeal and auditory appear to be connected with the *caput cornu*, which finally becomes itself a part of the nucleus of the trifacial, and may possibly serve to a certain extent throughout the medulla, to co-ordinate and bring into harmony all these different nerves. Another set of fibres from the anterior division of the auditory enter more deeply into the nucleus, and bend forwards into the antero-lateral network, either with or without passing through cells. Many of these fibres join the numerous bundles coming down from the cerebellum, and pursue the same course, radiating into the antero-lateral network; they cross the facial roots, and occasionally join their course for a short distance, but I have been able to satisfy myself that no *direct connection* is established.

Schröder van der Kolk states that many slender fibres pass from the nucleus of the auditory towards the facial nucleus, "so that no doubt can exist of a connection between these nuclei."[1] Though I have carefully examined many specimens in which the course of the fibres could be studied with great certainty, and have often been able to trace fibres from the auditory nucleus across or even into the substance of the facial nucleus, I have never been able to trace them with certainty into the cells of the latter, and although a connection to *some extent* is quite probable, I have been unable to see any sufficient grounds for so elaborate a theory of the reflex action of the auditory on the facial as is attempted to be established by Schröder van der Kolk (*l. c.*). Many of the fibres from the anterior border of the auditory nucleus may be traced across or behind the *fasciculus teres* to the raphè, where they are either seen crossing directly to the other side, or sometimes passing along the raphè for a short distance before crossing. Some of these fibres are undoubtedly either direct continuations of the anterior and posterior divisions of the root, or fibres derived from the cells entered by these, while others seem to be bundles coming directly from the cerebellum. At any rate by means of these bundles which are very numerous, and in many preparations very easily traced, the

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[1] Medulla Oblongata, 116, 117.

nuclei of the opposite side are brought into very close and intimate connection with each other, as well as with the various bundles traversing the antero-lateral network in the neighborhood of the raphè.

A large portion of the fibres belonging to the anterior division of the root bend backwards, towards the network constituting the outer part of the nucleus; these fibres interlace in every variety of direction among the longitudinal bundles, and very many of them are seen to enter the large multipolar cells; others either directly or after passing through cells, penetrate the deeper lying portions of the nucleus, from whence they turn off in the direction of the *superior peduncle* over which some of them pass towards the cerebellum. The more *anterior* or inner set pass towards the *inferior vermiform process*, the *middle* set inwards in the direction of the *corpus dentatum*, the *outer* or posterior set towards the *flocculus.*

The mass of the nucleus is, however, so large, and the course of the fibres so extremely intricate, and so complicated by the numberless bundles derived from and proceeding to different and often distant parts of the cerebellum, that the determination of the connections of the auditory nucleus and the destinations of its root-bundles becomes one of the most difficult problems in the Histology of the nervous system. The necessary study would, however, probably be well repaid, by the light thus thrown on the nature of the cerebellum, an organ evidently entering into very intimate relations with the great nuclei of the trapezium and pons Varolii.

CHAPTER III.

THE FACIAL NUCLEUS AND ROOTS.

The course pursued by the facial nerve is so exceedingly distinct in most of the mammalia, that we are surprised to meet with difficulty in tracing the roots to their ultimate destination. Schröder van der Kolk has indeed stated that among all the nerves of the medulla, there is not one, the origin of which is so difficult to define with certainty as the facial.[1] As is the case with the auditory, the facial in man, especially in its outer part, is pressed slightly downwards by the great thickness of the pons Varolii, but in those mammalia in which the pons is but slightly developed, the facial pursues an almost directly transverse course, so that the fibres can often be followed inwards as far as the floor of the ventricle.

The facial enters the medulla on the inner side of the caput cornu, and runs in a curving course directly inwards and forwards to the fasciculus teres, which is, as shown above, an upward continuation of the column of large, multipolar cells with which the roots of the hypoglossal were connected lower down. As pointed out by Stilling,[2] the roots of the facial generally form a single bundle, though we sometimes find them separated into two or three fasciculi (Figs. 13, 14, Plate IV), forming thereby a remarkable exception to most other nerves.

Stilling has also noticed a remarkable difference between the upper and lower portions of the facial roots. The lower portion terminate in the nucleus, while the upper roots, without entering the nucleus, pass to the raphè where they decussate with their fellows from the opposite side. In this course they inclose a bundle of fibres which Stilling has considered to be roots of the trifacial, but I cannot discover that the column has any connection with this nerve. In the upper portion of the facial he found no remains of the nucleus, and came to the conclusion that a part of the fibres from this portion of the root turn downwards entering the underlying nucleus, while another portion pass downwards through the raphè to the columns of the spinal cord.[3] This difference between the upper and lower portions of the facial course is very conspicuous in the sheep and cat, as well as in man, the nucleus disappearing almost entirely in the upper portion, and we can at the same time trace the fibres from the facial, passing directly to the raphè. As long as the nucleus is persistent many of the fibres of the facial terminate abruptly, just outside the nucleus, that is, they are cut off, as seen in Plate XVI, Fig. 44, the inward course of the fibres from this point being slightly ascending.

Sometimes a portion of these fibres escape being cut off by the plane of section

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[1] Medulla Oblongata, 109.

[2] Pons Varolii, 39.

[3] *l. c.* 38.

and may be traced inwards, winding among the cells of the nucleus, and apparently becoming continuous with some of the cell-processes. This is especially the case in the human medulla, where a very considerable portion of the fibres may be traced, winding among the cells, and either joining them, or passing onward to the raphè. In the sheep this is rarely to be seen, the fibres of the facial seeming to take a sudden bend just at this point, so that they are cut off quite abruptly by the plane of section. A little higher up (Plate XVI, Fig. 44), the fibres of the facial in the sheep, are seen to pass behind the nucleus, crossing over the roots of the sixth nerve, some of them passing in front of the column of longitudinal fibres (called by Stilling the *constant root of the trifacial*); others passing behind this column to the raphè, where they decussate with those derived from the opposite side; a few may be traced into the nucleus. Still higher up, the whole bundle may be traced inwards to this longitudinal column, where the central portion of the root abruptly terminates, the outer fibres turning off behind and in front of the longitudinal column, which is thus completely encircled by the roots which afterwards pass onwards to the raphè. Those fibres, however, which reach the raphè, seem to be few in number as compared with those which terminate abruptly in the vicinity of the longitudinal column, and even in the upper portions of the facial course (Fig. 16^a), where the whole bundle seems at first sight traceable to the raphè, the number of bundles actually decussating or passing into the raphè, seems so small when compared with the great thickness of the root, that I am inclined to think that many of the fibres do actually turn downwards, passing down in the longitudinal columns on each side of the raphè to the underlying nucleus, justifying in this respect the conclusion of Stilling. I have been confirmed in this supposition, by frequently observing in the columns which Stilling has called the *constant roots of the trifacial* and Schröder van der Kolk *roots of the auditory*, great numbers of fibres obliquely cut across, which are especially noticeable in connection with the abrupt termination of the facial roots just at this point, and I am inclined to consider these columns as, at least, partial channels by means of which the upper portion of the facial roots are conveyed downwards, either to the underlying nucleus or to decussate below in the raphè.

The greater part of the facial roots undoubtedly decussate at the raphè directly, but I was unable to trace their farther course. It is not improbable, however, that they may enter the nucleus of the other side, the cells of which are very numerous on the side nearest the raphè, and send out many fibres in that direction. Schröder van der Kolk is undoubtedly right in the statement, "that no other nerve of the medulla oblongata has such an intimate connection with that of the other side, whether directly or through the intervention of ganglionic cells, as the facial."[1]

The cells of the fasciculus teres are very numerous in the sheep, filling a large space between the roots of the facial and abducens. They are mostly oblong or obovate in form, measuring about $\frac{1}{500}$ to $\frac{1}{400}$ of an inch in their longest diameter, and send out their processes in various directions, mostly, however, either laterally in the direction of the roots, or anteriorly towards the raphè, as well as longitudi

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[1] Medulla Oblongata, 111.

nally. Very numerous bundles proceed from the inner edge of the nucleus, crossing the roots of the abducens, and decussating at the raphè with similar bundles from the opposite side, serving to bring the two opposite nuclei into very close connection. The cells of the anterior portion of the nucleus are more nearly stellate in form, and send out their processes either in the direction of the facial roots, or towards the raphè, or as is very often the case into the antero-lateral network, where they are brought into connection with the upper olivary bodies by little scattered cell-groups and fibres, just as the hypoglossal nuclei were joined to the lower olivaries (Fig. 10^a). In the cat the cells are fewer in number, and more scattered through the antero-lateral network, but are often large, measuring sometimes as much as $\frac{1}{500}$ of an inch in diameter. The connection between the upper olivary bodies and the nucleus of the facial, will be described in a subsequent chapter (Chap. V).

CHAPTER IV.

THE ABDUCENS NUCLEUS AND ROOTS.

THE course and origin of the roots of the sixth pair of nerves have been described by Stilling[1] and Schröder van der Kolk,[2] but their accounts differ very considerably. The general course of these nerve-roots before they reach the nucleus of the facial has been given with sufficient detail in a previous chapter, where it was also shown that they form a remarkable exception in their inward course, to all the other nerve-roots, bending *outward* as they approach the floor of the fourth ventricle, while all the other nerves of the medulla bend *inwards* or towards the raphè, where their fibres decussate to a greater or less extent with those coming from the opposite side. As a natural consequence resulting from their peculiar course, the fibres constituting the abducentes roots do not decussate, at least directly, and if the opposite nuclei are brought into connection it must be either through the intervention of fibres derived from cells, or by means of ascending or descending fibres connecting the nucleus with distant parts, for I have not been able to trace *any* fibres turning inwards towards the raphè.

According to Stilling the roots of the sixth nerve end in the same nucleus to which we have traced the roots of the facial, making this large group of cells a common nucleus for the two motor nerves of the trapezium. Schröder van der Kolk, on the other hand, does not admit that the abducens takes its origin from the same nucleus as the facial, and remarks that it would be very singular if two nerves so distinct in their action should arise from a common nucleus. This observation would seem to have but little weight, since we constantly find in the medulla, nerves very distinct in their action arising from the same column, the nucleus of the one changing so imperceptibly into the nucleus of the other, that it is entirely impossible to state with any approach to accuracy when or how the change takes place. Schröder van der Kolk states that the roots of the sixth penetrate those of the facial, after passing through the nucleus, and terminate on the floor of the fourth ventricle. Their further course he seems to have been unable to trace, but surmises that they may probably turn upwards, entering into close connection with the nucleus of the oculomotor nerve which is situated above.

According to my own observations, the roots of the sixth pair of nerves pass directly inward, in two or three somewhat curving bundles, which pursue a slightly ascending course until they nearly reach the floor of the fourth ventricle (Plates III and IV, Figs. 11 and 15, Plate XVI, Figs. 12^a and 44). As they pass along the

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[1] Pons Varolii, 36 and 153.

[2] Medulla Oblongata, 120 et seq.

inner or anterior edge of the nucleus, a few fibres are seen turning off to enter the large multipolar cells found here. This I have frequently observed in the sheep, especially in preparations hardened by means of chromic acid, in which the course of the fibres can be traced with great certainty. The majority of the fibres, however, pass onward and presently cross the roots of the facial, their further course often becoming much obscured by these roots, as well as by the very numerous bundles passing down from the cerebellum through the back of the auditory nucleus and now radiating into the anterior network (Plate XVI, Fig. 44). I have, however, several specimens from the medulla of the sheep, in which the entire course of the root-bundle can be traced. It appears to be as follows: the bundle, after passing along the anterior border of the nucleus, and sending a few fibres into its cells, as stated above, bends around the nucleus, many of its fibres entering the large, stellate and oval cells situated along the posterior margin. Some fibres penetrate more deeply into the posterior part of the nucleus and enter cells. I have also thought that I could trace a few fibres as far back as the groups of large oval cells lying along the back of the auditory nucleus, and which are entered by the roots of the posterior division of the auditory as well as by fibres from the cerebellum. Some of the fibres from the sixth nerve certainly pass along the floor of the fourth ventricle for a considerable distance, but I was entirely unable to determine their ultimate destination, as they are constantly united to the bundles derived principally from the cerebellum, from which it is impossible to distinguish them.

It would seem on theoretical grounds quite possible that there may exist, as stated by Schröder van der Kolk, some connection between the nuclei of the abducens and oculo-motor nerves, and that some of the fibres from the abducens, which are lost sight of as they pass along the floor of the ventricle, may become ascending fibres passing upward to the nucleus of the oculo-motor. The attempt to determine this would, however, have carried me beyond the limits assigned to the present communication, and as I have been desirous to avoid anything approaching to theoretical consideration I shall leave this point for future investigation.

The cells in the posterior part of the nucleus, which are entered by the abducens, are similar in appearance and size to those described in connection with the facial. They are stellate, oval or fusiform in shape, and measure in the sheep, from $\frac{1}{800}$ to $\frac{1}{400}$ of an inch in diameter.

CHAPTER V.

THE UPPER OLIVARY BODIES.

THE nuclei within the mammalian trapezium, situated anteriorly on each side of the raphè, resembling in form and structure the olivary bodies of the medulla, were first pointed out by Clarke,[1] and subsequently described quite fully by Schröder van der Kolk.[2] They make their appearance in the upper part of the medulla, at a point near where the lower olivaries first diminish in size, in the situation formerly occupied by the cells of the antero-lateral nucleus. The cells of this group have, however, diminished very much in number prior to the appearance of the upper olivary bodies (Plate XIII, Figs. 6^a, 7^a), and in the cat they sometimes almost entirely disappear. By comparing Plate XIII, Figs. 6^a, 7^a with Plate XIV, Fig. 8^a, it will be seen that the upper olivary group is developed in a position exactly corresponding to that of the antero-lateral nucleus below, of which it may therefore be considered an upward extension, serving in the lower part of the medulla, as it were, as an accessory nucleus to the *lower olivary column*, and closely connected at the same time with the *caput cornu*, as well as with the *nuclei* of the posterior columns (*glossopharyngeal*, *vagal* and *spinal accessory*).

In the first stage of its development as an independent nucleus (Plate XIV, Fig. 8^a), the upper olivary body appears as a group of large, stellate, multipolar cells, measuring in the sheep from $\frac{1}{800}$ to $\frac{1}{400}$ of an inch in diameter, in the cat from $\frac{1}{1333}$ to $\frac{1}{800}$ of an inch. These cells are very numerous, especially in the cat, and are quite uniform in size when measured on the same plane; in the lower part of the nucleus they are quite large, but rapidly diminish in size as we approach the trapezium. At first they are arranged in a loose network, formed by the interlacement of their processes around the numerous longitudinal bundles of the anterior network. The cell-processes appear to run in every direction, being continuous before and behind with the transverse fibres radiating from the central gray substance, and laterally with the arciform fibres, in addition to which other processes are sent out above and below to join the longitudinal bundles. The meshes formed in this way are exceedingly numerous and intricate, and the development of anything like the regular convolution of a true olivary body is very gradual. The mass is still connected by little cell-groups with the caput cornu, as was the case with the antero-lateral nucleus, and is also joined more or less to the central and anterior portion of the great auditory nucleus, especially to that portion from

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[1] Proceedings of the Royal Society, 1857.

[2] Medulla Oblongata, 162 et seq.

which the *fasciculus teres* is subsequently developed, by numerous bundles of fibres, along which cells of medium size are frequently scattered.

Higher up (Plate XIV, Fig. 9^a), the outer border of arciform fibres has increased in breadth and in the number of bundles, and reaches backwards to the upper olivary bodies which are penetrated by the internal arciform fibres in a wavy course, the cells being quite regularly disposed among the fibres constituting the plexus, and thus becoming gradually arranged into a somewhat convoluted form.

From this region upwards the principal changes consist in the development of a still more convoluted arrangement of the cells and fibres, the cells being finally separated into two or three distinct masses, forming a lamina, which, in the sheep, is folded in a manner much more nearly resembling the convoluted lamina of the human olivaries, than the structure of the lower olivary bodies in the medulla of the same animal. In the cat, as noticed above, the structure of the lower olivary bodies approaches the human type more than in the sheep, and we find a coincident development of the upper olivaries, the structure of which is quite complicated (Plate XII, Fig. 42).

Schröder van der Kolk has already pointed out the striking differences which exist between the different classes of mammals in the development of the upper olivaries. He found the greatest development in the Carnivora, less in the Rodentia, and still less in the Herbivora; these bodies being so slightly developed in the ass as to be easily overlooked. These observations are quite in accordance with my own; the upper olivary body in the sheep consists of two or three distinct spherical bodies rather than a connected and convoluted lamina: on the other hand, in the rabbit the convoluted lamina is very distinct, and often quite uninterrupted, and in the cat the convolutions are very decided (Plate XII, Fig. 42, Plate IX, Fig. 36).

In the sheep the upper olivary body consists of a mass of small cells which rarely exceed $\frac{1}{1333}$ of an inch in diameter, varying in form from oblong or oval, to stellate; they are multipolar, their processes being everywhere continuous with the numerous bundles which either penetrate or radiate from the interior of the mass. The olivary body is completely surrounded by fibre-bundles chiefly radiating or turning off from the arciform plexus, many of the fibres of which penetrate the mass, forming a somewhat similar system of fibres alternating with layers of cells, to that noticed in the lower olivary bodies of the sheep. Sometimes a central bundle may be noticed in the interior of the mass, from which fibres radiate in all directions, but the type of structure is usually exceedingly simple.

As the great bundles of external arciform fibres forming the *trapezium* sweep down from the restiform body and posterior portion of the medulla, after crossing the roots of the facial, they pursue a wavy course (Fig. 10^a), in which they are joined by numberless deeper lying bundles. The more external of these sweep around the olivary body, many separate bundles turning off and curving quite around the mass, either penetrating its interior or completely surrounding it, till the upper side is reached, where the bundle frequently turns still more and enters the central portion of the mass, radiating in the same manner as the bundles which enter the convolutions in the lamina of the human olivaries.

In the rabbit the upper olivary body is represented by a very complete convolution, presenting three or four turns, entered and penetrated by the arciform fibres both external and internal as well as by numerous transverse and radiating fibres. In the mouse the upper olivaries consist of a wavy mass of quite large and numerous cells.

The structure of the upper olivary body is especially distinct in the cat, and I have, therefore, given an accurate representation of the entire mass, the outline being drawn by a power of about 20 diameters, to which some details were added as seen by higher powers (Plate XII, Fig. 42).

In this figure it will be noticed that the lamina is convoluted, and arranged much on the same general plan as in the lower olivary bodies of the same animal or of man. The bundles which surround the entire mass and radiate among the foldings of the lamina, are principally derived from the external and internal fibres of the arciform plexus. These bundles surround the outside of the olivary body pursuing a beautiful wavy course, and turn off at varying angles to enter different portions of the lamina, the cells of which are everywhere brought into connection with the fibres. As these bundles approach the inner or posterior side of the mass, they are joined by other bundles derived from the radiating fibres proceeding from the posterior gray substance, some of which seem to connect the olivaries with the *fasciculus teres* or nucleus of the facial and abducens. These bundles sometimes form quite large stems (Plate XII, Fig. 42, *D*), and are well seen in Plate IX, Fig. 36, where the general situation and relations of the olivary body to the surrounding parts is also well shown. The course of the fibres within the folds of the lamina bears much resemblance to that in the lower olivaries in man; in the cat it may be briefly described as follows:—

1st. The entire mass is surrounded by a broad marginal band (Plate XII, Fig. 42, *B*, *B*), principally derived from the arciform plexus (*A*, *A*), from which, however, single fibres and sometimes considerable bundles constantly pass off, penetrating the lamina, and either entering cells, or passing onward to join deeper lying bundles with some of the fibres of which they appear to be continuous, or else entering still more distant folds of the lamina (some of these fibres are seen at *C*, *C*). In its course around the margin of the olivary body the band is frequently joined, especially on the upper side, by fibres derived from the posterior gray substance.

2d. Traced from within outwards their course is as follows: (1). The fibres from the centre of one of the bundles (*D*) penetrating the lamina, proceed forwards, either joining cells or passing directly across the lamina, often curving around and joining the marginal band or crossing its fibres nearly at right angles, soon becoming lost among the fibres of the arciform plexus. (2). Those fibres forming the external portion of the bundle (*D*), penetrate the lamina and diverge more and more, radiating in all directions among the cells, some of which they enter, the remaining fibres passing outward into more distant folds of the lamina, or into the parts surrounding the olivary body, usually joining ultimately the bundles of the arciform plexus. From the anterior part of the olivary body numerous fibres radiate transversely into the trapezium, crossing its wavy bundles at right angles, and often forming quite a thick stem, which may be traced like the nerve roots to the outer limits of the medulla (Plate XVI, Fig. 12^a, *y*).

Schröder van der Kolk[1] has deduced from the connections between the upper olivary body and the nucleus from which the facial arises, the theory that the upper olivary body is a sort of accessory nucleus to the facial, establishing the same relation between them which he supposes to be established between the hypoglossal and the lower olivary body. A connection between these nuclei undoubtedly exists to some extent in those mammalia which I have examined, but the chief and by far the most important connection of the olivaries, both upper and lower, is with the arciform fibres, and I am therefore inclined to think that the upper olivary bodies, like the lower, are co-ordinating centres for the different nuclei lying in the same region with them, with all of which they are brought into more or less intimate relation by means of the plexus of arciform as well as transverse fibres with which they are connected. Within the human pons Varolii a collection of cells is found near the facial, undoubtedly representing the upper olivary body of the mammalia, but in man, the office of co-ordination would seem to be chiefly fulfilled by the numerous scattered cell-groups, which are so frequently found in the meshes of the intricate plexus of fibres constituting the pons Varolii.

Several other cell groups are found, both on the outer and inner side of the upper olivary bodies, and very many cells are found scattered throughout the whole anterior and antero-lateral network. Among these groups, the largest and most constant are, one on the inner side of the olivary body in the vicinity of the roots of the sixth nerve, consisting of stellate, multipolar cells of moderate size, and another on the outer side of the olivary body, near the entrance of the facial roots (Figs. 10^a, 12^a, *v*), consisting of quite large multipolar cells, and sometimes, as noticed by Schröder van der Kolk, forming two distinct groups, the cells of which become more and more numerous, and at the same time are pushed inwards as we reach the upper part of the course of the facial, continuing to increase both in size and number as we approach the fifth nerve, to the motor root of which, I suspect, this group is related as well as to the facial.

METHODS OF PREPARATION.

Among all the different and numerous methods of preparing specimens of the medulla for microscopic examination, I have found none at all comparable to the methods given by Clarke (*Philos. Trans.* 1859), and I have therefore availed myself exclusively of these, with some slight modifications. Specimens colored by a solution of carmine in glycerine[2] have often been used for special purposes; but for the general study of the *course and destination of fibres*, I have found specimens hardened in chromic acid and made transparent by Clarke's method, particularly well suited. These specimens have usually been immersed for a few weeks in a solution of chromic acid, of about the strength given by Clarke (1859), and subsequently put

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[1] Medulla Oblongata, 165.

[2] Mem. of the American Academy, 1861.

into alcohol, by which means the specimens are hardened, without becoming so brittle as is often the case if they are kept for a long time in a solution of chromic acid or of bichromate of potash. I have also continued the use of copal-varnish in the place of Canada balsam as recommended in a former paper (*Spinal Cord*, 1861), as it still seems to me on many accounts more advantageous than the balsam.

The preparation of specimens for photographic use required some modification of the methods employed, since here the object in view was to obtain as much contrast of structure as possible, rather than that extreme transparency required for the use of higher powers. The sections, for this purpose, were immersed for a short time in very strong alcohol, and after careful washing placed in chloroform, where they shortly become semi-transparent; they are then placed on a slide on which a couple of drops of copal-varnish have been put, so that the section lies on the surface of the varnish: as the chloroform evaporates the varnish takes its place, and the section is kept soft for about twenty-four hours by adding at intervals either varnish or chloroform, or both, according to the degree of transparency required; a little practice only being necessary to attain any desired result. The varnish is then slightly softened by warming the slide over a lamp and the preparation covered with a thin glass as usual.

The methods employed in photographing the specimens were simple, and will readily be understood by those versed in the details of ordinary photographic manipulation. My apparatus consisted of a brass adapter, the tube of which fitted closely into the body of the microscope (Smith and Beck's first class), so that after removing the eye-piece and draw-tube I was enabled to attach the microscope very firmly to a common photographic camera. After a variety of experiments with different sources of illumination, I found the direct sunlight the only one on which I could rely with any degree of certainty, and although it will often appear that much time is lost in waiting for an entirely unclouded day, still, so far as my own work was concerned, I found that I lost much more time in endeavoring to work in uncertain weather. The common plane mirror may be used for reflecting the sunlight, or what is still better, the right angle prism which accompanies Smith and Beck's microscope. The objective with which the accompanying photographs were taken was a three inch, and I was able to enlarge the field of illumination to a considerable extent, by introducing directly behind the stage, as suggested by my friend Prof. Rood, a double convex lens, the focal distance of which measured a little less than the distance between the object and the back diaphragm of the objective; the exact focal length of the lens is, however, practically of little importance, and by diaphragming the lens to some extent, the central spot of light, should one appear, may be removed without sensibly diminishing the field. Whatever the power used may be, whether high or low, too much care cannot possibly be expended on careful and perfect illumination, not only in obtaining the greatest *amount* possible, but also in so modifying it according to the character of the object as to obtain the greatest degree of contrast between different parts, and this not only visually but also actinically, which of course is only to be determined by careful and repeated experiment.

The Wet Process was the one used for the majority of the photographs, the Dry

Process presenting difficulties which render it in some respects less suitable. In using as low an objective as a three inch, the first difficulty encountered is in adapting the collodion to a light which is so extremely brilliant as the direct sunlight reflected in the manner described above, it may therefore be well to give the formula used. In so brilliant a light not only is an ordinary collodion altogether too rapid, it being almost impossible to cover the lens quickly enough, but the resulting negative is excessively thin, and destitute of that intensity which is requisite in order to give a clear and brilliant print.

The pyroxyline used was chiefly the French (Poulenc-Wittman), and the plain collodion prepared as follows:—

Alcohol (.805)	10 ounces.
Ether (.725)	10 "
Pyroxyline	300 grains.

The iodizing solutions were prepared as follows, the formulæ being taken from Hardwich (*Manual of Photographic Chemistry*, 1861).

No. 1. (*Potassium Iodizer.*)

Iodide of Potassium	135 grains.
Alcohol (.816)	10 ounces.

No. 2. (*Bromo-Iodizer.*)

Bromide of Ammonium	40 grains.
Iodide of Ammonium	90 "
Iodide of Cadmium	90 "
Alcohol (.816)	10 ounces.

Two separate portions of the plain collodion were iodized with No. 1 and No. 2 respectively, in the proportion of two parts of iodizer for six parts of plain collodion, and the iodized collodion mixed after a few days, in the proportion of $\frac{1}{3}$ or $\frac{1}{4}$ of No. 2 with No. 1. The resulting collodion gave the best results after keeping from two to six months; it had then acquired a decidedly red color, and gave a thin, very even film, giving pictures remarkably free from imperfections of any sort, and though exceedingly insensitive for common purposes, requiring in the brilliant light of the microscope an exposure of only 8 or 10 seconds, which is much more easy to manage than any shorter time. The film was sensitized in the ordinary Nitrate Bath, *prepared with distilled water*, the strength being about 40–45 grains. For developing the picture, I have preferred the use of pyrogallic acid to the ordinary developer prepared with sulphate of iron, as I have found it much more controllable than the latter, and giving with more certainty the requisite degree of intensity. I have prepared it as follows:—

Pyrogallic Acid	1½ grain.
Acetic Acid, No. 8	30 minims.
Distilled Water	1 ounce.

The picture required no re-development, and I invariably made it a rule to throw away any picture which after the first development appeared deficient in intensity, as any attempt to re-develop injured very much the finer details of the picture. The fixing solution consisted of the usual saturated solution of hyposulphite of soda.

Major Russell's *tannin* process, is in many respects very well adapted for the purposes of microscopic photography; by modifying the collodion and developer we may obtain almost any desired result, and I sometimes employed it, though not so much as I undoubtedly should, had I known earlier how to control the strong tendency to solarization and thinness, of negatives obtained by the tannin process by means of direct sunlight reflected through a low objective. This control is best attained by using a large proportion of bromide in the collodion, in order to diminish the excessive intensity and hardness of the tannin negative, and a very large proportion of citric acid in the developer.

The formula for collodion which seemed to me to give the best results with the dry process was as follows:—

Bromide of Cadmium	40 grains.
Iodide of Ammonium	22 "
Collodion	8 ounces.

The plates were prepared as usual, and immersed in a solution of tannin (15–20 grains to the ounce).

The developer is made from the two following solutions:—

No. 1.—	Pyrogallic Acid	72 grains.
	Alcohol	1 ounce.
No. 2.—	Nitrate of Silver	20 grains.
	Citric Acid	120–180 "
	Water	1 ounce.

Fifty minims of No. 1 are diluted with two ounces of water, and a few drops of No. 2 added to the quantity necessary to develop a plate. The resulting pictures are very full of detail, and the great convenience of the dry process will not fail to be a very strong recommendation to the microscopist, who may by this means have a stock of sensitive plates on hand ready for use at any moment. Figs. 30, 31, and 32 were taken by the dry process, and are certainly not surpassed in detail and delicacy by any of the others.

EXPLANATION OF THE PLATES.

PLATES I–IX are sections from the medulla, magnified about 7 diameters, as seen with a three inch objective.

PLATE I.

FIG. 1. Section of the medulla of the sheep, just above the spinal cord, showing the partial decussation of the pyramids from which the raphè is already formed, and the first appearance of the hypoglossal roots.

FIG. 2. Transverse section from the same, a little higher up, showing the formation of the olivary bodies, the hypoglossal roots, the restiform and post-pyramidal nuclei.

FIG. 3. Transverse section from the same medulla, showing the enlargement of the central canal, and the complete formation of the hypoglossal and vagal nuclei.

FIG. 4. Transverse section from the same, still higher, showing the opening of the central canal into the fourth ventricle which is now completely formed, and on each side of which are seen the vagal and hypoglossal nuclei.

PLATE II.

FIG. 5. Transverse section from the medulla of the sheep, showing the central portion on each side of the raphè. In front are seen the narrow pyramids and behind the olivary bodies; posteriorly on the floor of the ventricle lie the hypoglossal and vagal nuclei. The course of the hypoglossal roots is very plainly seen.

FIG. 6. Transverse section at about the same height, showing the same nuclei with their roots, and the commencement of the auditory nucleus.

FIG. 7. Transverse section, a little higher up; the hypoglossal roots are now no longer visible; the vagus nucleus has reached its maximum development and is already pushed forward by the formation of the auditory nucleus which has attained considerable size. The vagus roots are very distinctly seen, forming several quite large bundles which traverse the caput cornu.

FIG. 8. Section from the same medulla, still higher, showing the development and formation of the anterior and posterior portions of the auditory nucleus, with the posterior auditory roots.

PLATE III.

FIG. 9. Section from the medulla of the sheep, showing the auditory nucleus and roots together with their connections with lobes of the cerebellum.

FIG. 10. Transverse section from the same medulla, showing the further development of the auditory nucleus and anterior root of the auditory, together with the facial nucleus and root. The fibres from the anterior auditory root which penetrate the restiform body, joining the posterior root of the auditory, are especially well shown in this figure.

Fig. 11. Section from the same medulla, a little higher up, showing the antero-lateral portions. On each side of the raphè are seen the roots of the sixth or abducens, and a little further outwards is seen the facial root passing inwards towards its nucleus. Between the two roots is seen one of the upper olivary bodies.

Fig. 12. Section showing the postero-lateral portion of the same specimen of which the antero-lateral portion is given in Fig. 11. In the upper right hand corner is seen a portion of the flocculus. The formation and development of both roots of the auditory, as well as of the fibres radiating through the restiform body and serving to connect them, are well shown in this figure. The very numerous bundles passing from the posterior portion of the auditory nucleus back into the cerebellum are very conspicuous in the upper part of the figure.

PLATE IV.

Fig. 13. Transverse section from the sheep, showing the postero-lateral portion of the medulla. The restiform body is now pushed backwards towards the cerebellum, and the posterior auditory root is seen to be intimately connected with the flocculus. The connection between both portions of the auditory nucleus and the cerebellum is very conspicuous. In the lower part of the figure part of the facial course is seen, the root being now very large and distinct.

Fig. 14. Antero-lateral portion of the same specimen as the preceding figure, showing the course of the facial roots towards their decussation at the raphè as well as the development of the upper olivary bodies.

Fig. 15. Section from the same medulla, a little lower down than the preceding, showing the central portions on each side the raphè. The form of the fourth ventricle at this height is well seen, with the projecting lingula or *linguetta laminosa* derived from the cerebellum. The course and destination of the nerves of the sixth pair are well seen, and anteriorly the broad band of wavy fibres constituting the trapezium.

Fig. 16. Transverse section from the medulla of the sheep, still higher up, showing the gradual disappearance of the facial roots, just before the root of the fifth is developed. The broad band of fibres constituting the pons Varolii is seen in front.

PLATE V.

Fig. 17. Section of the human medulla just at the decussation of the pyramids.

Fig. 18. Transverse section from the same, a little higher up, showing the formation of the raphè and the hypoglossal and spinal accessory nuclei.

Fig. 19. Section from the same medulla, still higher, in which the nuclei are very conspicuous, the central gray mass being elongated posteriorly in a very remarkable manner. The restiform and post-pyramidal nuclei are very conspicuous, and anteriorly the olivary bodies have made their appearance.

Fig. 20. Transverse section from the same medulla, still higher up, showing the formation of the fourth ventricle, and the complete development of the hypoglossal and vagal nuclei.

PLATE VI.

Fig. 21. Transverse section from the human medulla, showing the further development of the nuclei and olivary bodies.

Fig. 22. Transverse section from the same medulla, showing the complete opening of the fourth ventricle, along the floor of which lie the hypoglossal, vagal and auditory nuclei, the latter just making its appearance on the outer side of the vagus nucleus.

Fig. 23. Section from the same, still higher up, showing the blending into a single mass of the nuclei seen in Fig. 22, the vagus nucleus being pushed outwards towards the apex of the mass.

FIG. 24. Section from the same medulla, still higher up, showing the formation of the auditory and glossopharyngeal nuclei.

PLATE VII.

FIGS. 25, 26, 27 and 28 are from the human medulla, and show the gradual development of the olivary bodies as seen in transverse sections and their relations to the hypoglossal roots. Fig. 25 is from the same section as Fig. 20: Fig. 26 is from a section a little higher up than Fig. 21: Fig. 27 is also from a section a little higher than Fig. 22: Fig. 28 is from the same section as Fig. 23.

PLATE VIII.

FIG. 29. Transverse section from the human medulla, showing the central part with the raphè and the olivary commissure, from the upper part of the medulla.

FIG. 30. Longitudinal section through the human olivary body, showing the convolutions of the lamina or *corpus dentatum.* The section is made obliquely inwards in a direction nearly parallel to the hilus, through the most dense portions of the lamina.

FIG. 31. Longitudinal section through the human olivary body, the section being made at right angles to the raphè, showing the outermost portions of the lamina. *a, a,* the raphè.

FIG. 32. Longitudinal section through the olivary body in the same direction as the preceding, but further inwards, showing the convolutions of the gray lamina cut through in a somewhat oblique direction. *a, a,* the raphè.

PLATE IX.

FIG. 33. Transverse section of the medulla of the cat, showing the auditory and glossopharyngeal nuclei.

FIG. 34. Section from the same medulla, a little higher up, showing the very large, posterior auditory root and the nucleus.

FIG. 35. Section from the same medulla, still higher up, showing both divisions of the auditory root, as well as the connection between the nucleus and the cerebellum, with the formation of the upper olivary bodies.

FIG. 36. Section from the same medulla on a level with the facial roots, showing the roots of the sixth pair, the facial and auditory nerves together with their nuclei. Anteriorly the upper olivary bodies are seen, and the broad wavy bundles constituting the trapezium.

PLATE X.

FIG. 37. Group of cells from the anterior portion of the hypoglossal nucleus of the sheep, magnified 120 diameters, from a transverse section. *A, A, A,* bundles connected with the hypoglossal roots: *B, B, B,* bundles derived from the vagus roots, passing along the outer margin of the nucleus on their way to the raphè: *D,* fibres derived from the hypoglossal roots, passing into the deeper portion of the nucleus and curving backwards towards the vagus nucleus.

FIG. 38. Group of cells from the vagus nucleus, from a transverse section of the medulla of the sheep, magnified 120 diameters. *V,* bundle of fibres constituting the vagus roots, some of which are seen to turn inwards towards the cells and deeper lying parts of the nucleus, while others sweep around the margin of the hypoglossal nucleus in the direction *A, A.*

PLATE XI.

Fig. 39. One of the convolutions of the lamina of the human olivary body, from a longitudinal section, magnified 120 diameters, showing the cells of the lamina and their relations to the fibres. *A*, fibre-bundle penetrating the convolution, sending out its fibres among the cells: *B*, *B*, bundle surrounding the fold of the lamina: *C*, *C*, bundles passing from the central bundle *A* through the lamina towards distant convolutions: *D*, a few scattered cells of the neighboring convolutions.

Fig. 40. Transverse section through the hypoglossal and vagal nuclei, from the sheep, magnified 20 diameters, some details being subsequently added with higher powers. *A*, *A*, *A*, the hypoglossal roots: *R*, the raphè: *X*, the apex of the fourth ventricle: *V*, the vagus roots: *D*, bundles derived from the vagus, sweeping round the margin of the hypoglossal nucleus on their way to the raphè, where many of them decussate with those from the opposite side: *H*, longitudinal fasciculi: *b*, group of cells situated in the anterior portion of the hypoglossal nucleus, in close connection with the hypoglossal roots and with the marginal fibres derived from the vagus. This group is represented in Fig. 37. *c*, marginal fibres derived from the vagus, passing to some extent into the antero-lateral columns: *m*, *m*, fibres derived from the hypoglossal roots curving backwards towards the posterior part of the nucleus: *e*, posterior commissure, on the edge of which is seen the epithelial layer: *h*, posterior cells of the hypoglossal nucleus: *v*, cells of the vagus nucleus.

PLATE XII.

Fig. 41. Group of cells from the auditory nucleus of the cat, magnified 120 diameters; from a transverse section near the entrance of the auditory root. *A*, *A*, *A*, fibres derived from the auditory root, some of which may be traced towards cells: *B*, curved fibres and bundles, some of which are derived from the root, radiating into the antero-lateral network: *C*, fibres coming down from the cerebellum.

Fig. 42. Upper olivary body of the cat, from a transverse section, magnified about 20 diameters. *F*, part of the facial root: *A*, *A*, bundles from the external arciform plexus: *C*, fibres from the arciform plexus penetrating the fold of the olivary lamina: *B*, bundles surrounding the folds of the lamina and also penetrating them: *D*, fibres derived both from the transverse and internal arciform fibres, forming as it were a stem to the olivary body, radiating subsequently within the lamina, with the cells of which these fibres are intimately connected.

Fig. 43. Group of cells from the postero-lateral portion of the auditory nucleus of the sheep, magnified 120 diameters. The bundles represented in this figure are mostly derived from the cerebellum, with which this part of the nucleus is intimately connected.

Plates XIII, XIV, XV, and Fig. 12^a, Plate XVI, are outlines representing the situations of the principal cell nuclei, and a few other details of the photographs given in the preceding plates of which they bear corresponding numbers. The lettering is the same in all the figures.

a—border of external arciform fibres.

b—caput cornu posterioris.

c—central canal.

d—cervix cornu.

e—little cell group thrust out from the hypoglossal nucleus.

f—cells in the anterior spur of the vagus nucleus.

g—cells in the posterior spur of the vagus nucleus.

h—anterior cornu.

i—small pyramidal nuclei.

j—longitudinal columns (Stilling's constant root of the fifth).

k—border of longitudinal fibres, just above which the posterior division of the auditory root appears.

l—longitudinal fasciculi passing through the vagal and accessory nuclei.

m—posterior longitudinal fasciculi.

n—accessory olivary nucleus (Stilling).

p—post-pyramidal body.

r—restiform body.

p, *p*—post-pyramidal nucleus.

r, *r*—restiform nucleus.
s—great pyramidal nucleus (Stilling).
t—tractus intermedio-lateralis.
v—cell-group at foot of facial root.
w—fourth ventricle.
x—cell group pushed out from the restiform nucleus.
y—lower stem of olivary body.
z—cell group at foot of the posterior auditory root.
r′—fibres radiating through the restiform nucleus.
A—inner portion of the auditory nucleus.
A′—outer " " " " "
VIII—anterior auditory root.
VIII′—posterior " "
B—antero-lateral nucleus.
O—lower olivary bodies.
O′—upper olivary bodies.
H—hypoglossal nucleus.
XII—hypoglossal roots. *XII′*—roots cut off by plane of section.
S—spinal accessory nucleus. *XI*—spinal accessory roots.
V—vagus nucleus. *X*—vagus roots.
G—glossopharyngeal nucleus. *IX*—glossopharyngeal roots.
T—fasciculus teres, nucleus of sixth and seventh pairs of nerves.
VII—facial roots. *VI*—abducens roots.
R—raphè. *P*—anterior pyramids.
P′—fibres decussating to form the raphè.
D—flocculus. *K*—lingula or linguetta laminosa.
F—fibres of the pons Varolii.

PLATE XVI.

Fig. 44. Transverse section from the medulla of the sheep, from a preparation hardened by chromic acid, magnified about 11 diameters, some details being added by the use of higher powers, showing the course of the fibres constituting the roots of the facial, abducentes and auditory nerves within their respective nuclei. The location of the different cells has been omitted to avoid confusion, this being sufficiently shown in the smaller outlines, especially Fig. 12ᵃ from about the same height. *VI*, roots of the abducens nerve: *VII*, facial roots: *VIII*, anterior division of the auditory roots: *VIII′*, posterior division of the same roots: *a*, external arciform fibres: *b*, caput cornu: *D*, a fold of the flocculus: *B*, bundles derived partly from the flocculus and partly from the posterior division of the auditory root, on their way around the restiform body towards the nucleus: *r*, restiform body: *A*, bundles derived from the cerebellum passing down into the nucleus: *t*, fasciculus teres or nucleus of the abducens and facial: *R*, raphè.

Fig. 45. Epithelial cells from the fourth ventricle of the sheep, from the same preparation. *a*, rounded cells, from the side walls of the ventricle. *b*, cells near the calamus scriptorius, just behind the raphè. *c*, cells at the apex of the ventricle, exactly behind the raphè, magnified 450 diameters.

Fig. 12ᵃ. Outline of Figs. 11, 12, Plate III. *W*, *W*, fibres radiating towards the cerebellum, some of which overarch the fourth ventricle, while others pass back towards the corpus dentatum and outwards towards the flocculus: *M*, fibres connecting the back of the auditory nucleus with the flocculus. The remaining lettering of this figure is the same as that used for Plates XIII, XIV, XV.

Each division of the scales annexed to the preceding figures represents the $\frac{1}{100}$ or $\frac{1}{1000}$ of an inch.

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Plate. I.

Fig. 1.

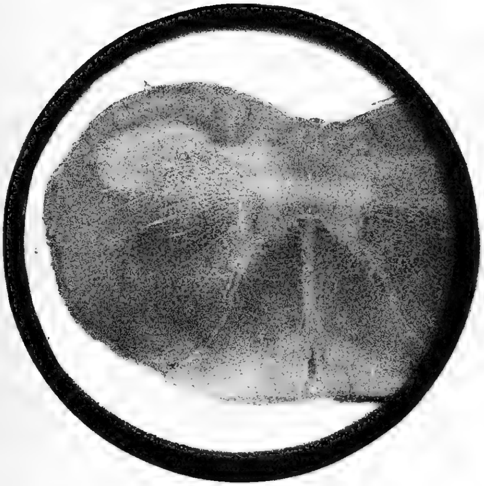


Fig 2.

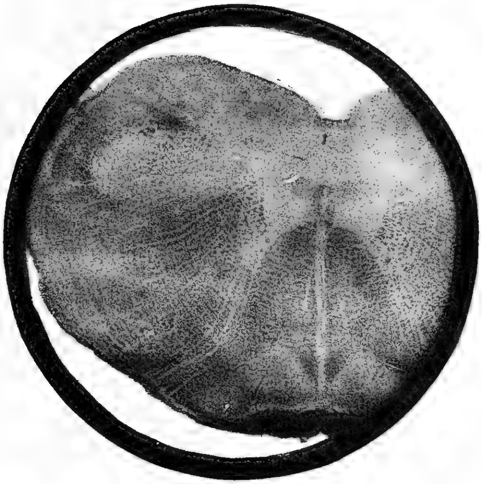


Fig. 3.

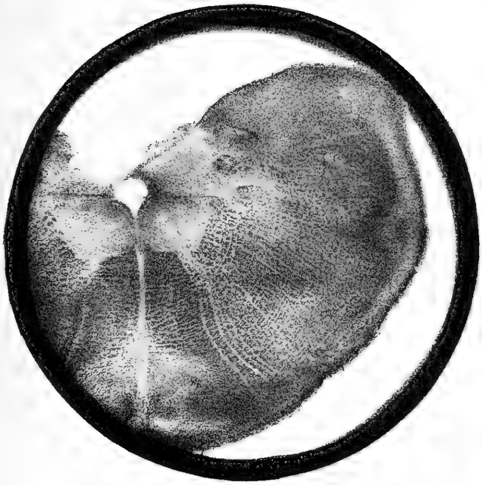
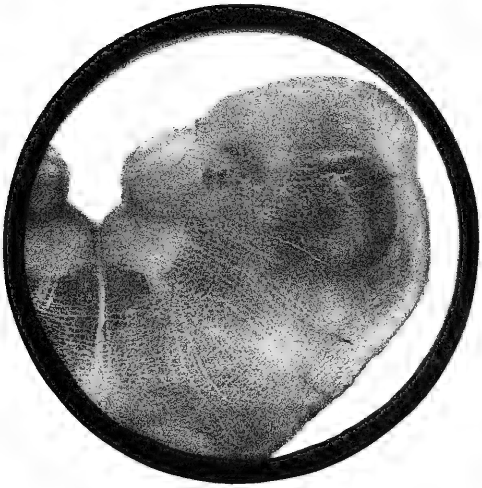


Fig 4.



Photographed by J. Dean.

Photo-Lith. by L.H. Bradford.

Plate II.

Fig 5

Fig. 6

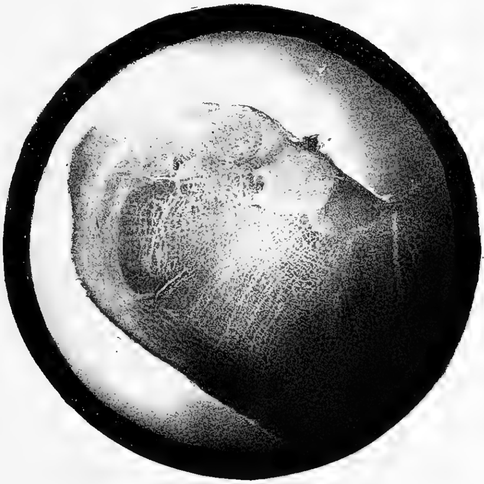


Fig 7.

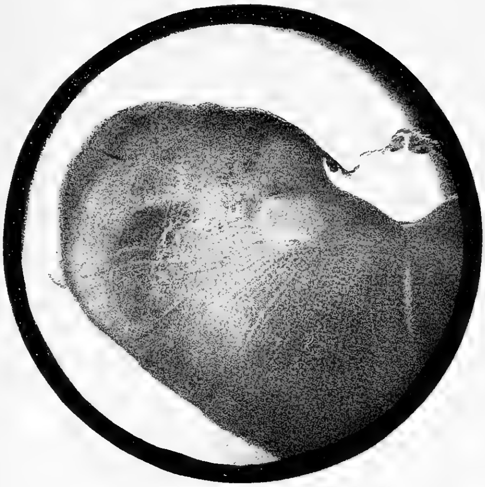


Fig 8

Photographed by J. Dean

Photo Lith by L. H. Bradford.

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Photographed by J. Dean

Photo-Lith. by L. H. Bradford

Fig. 13.

Fig. 14.

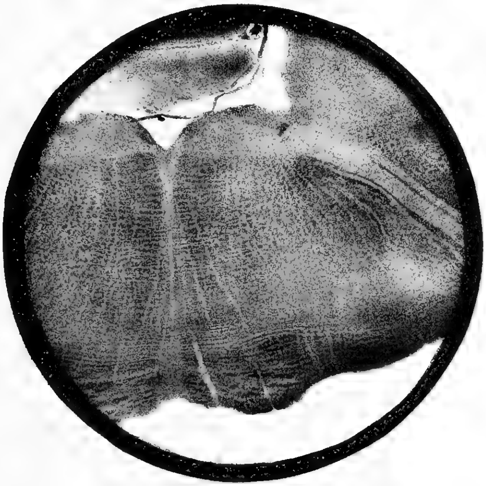
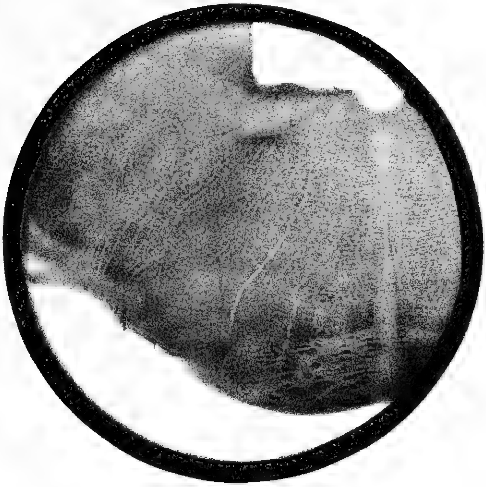


Fig. 15.

Fig. 16.



Photographed by J. Dean

Photo Lith by I. H. Bradford.

Plate V

Fig. 17

Fig. 18

Fig. 19

Fig. 20.

Photographed by J. Dean.

Photo-Lith by L. H. Bradford.

Plate VI.

Fig. 21

Fig. 22.

Fig. 23.

Fig. 24

Photographed by J. Dean.

Photo-Lith. by I. H. Bradford.

Plate VII.

Fig. 25

Fig. 26

Fig. 27

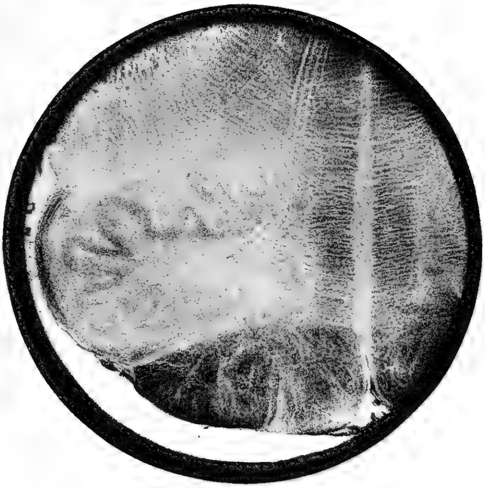
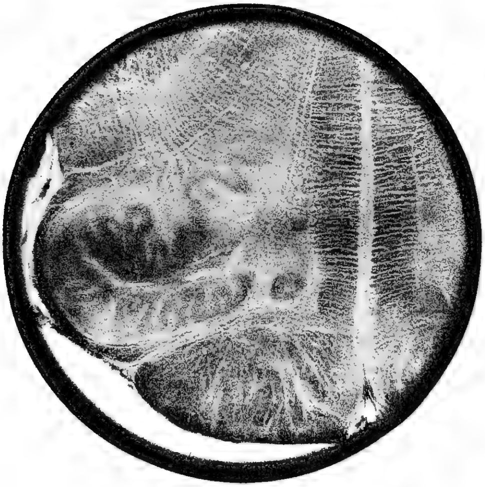


Fig. 28



Photographed by J. Dean.

Photo-Lith. by L.H. Bradford.

Plate VIII.

Fig 29

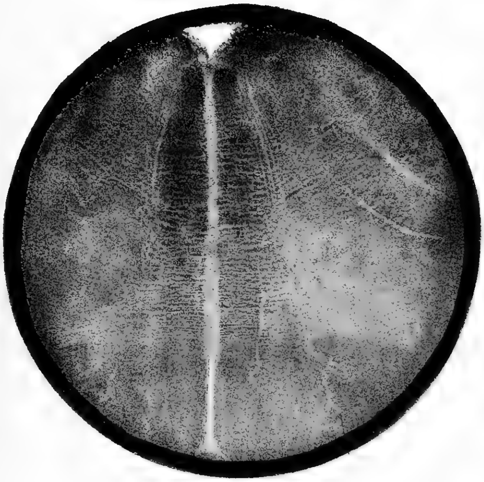


Fig. 30

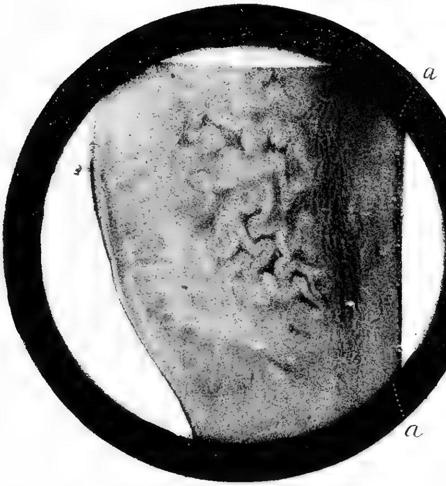


Fig 31.

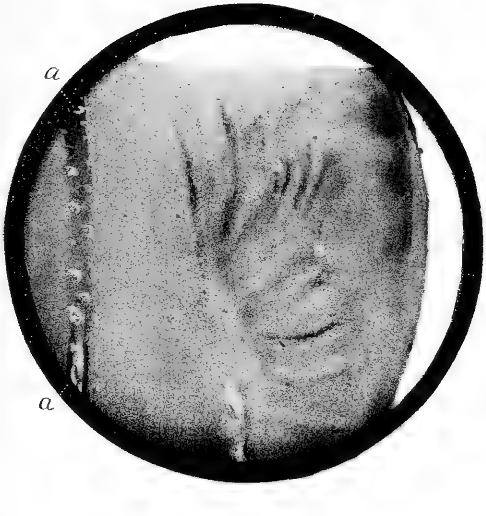
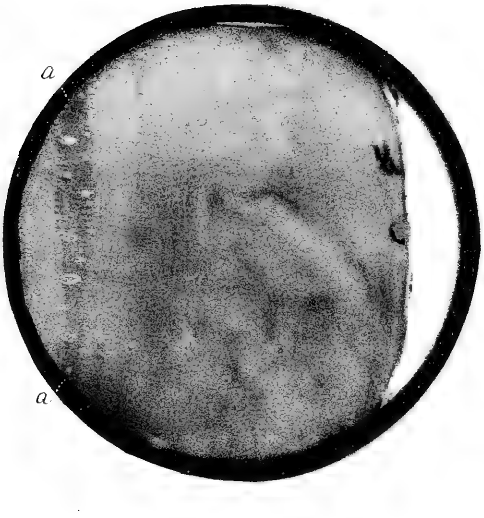


Fig 32

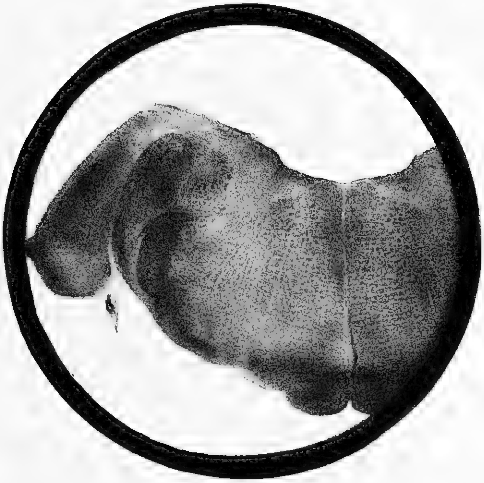


Photographed by J. Dean

Photo-Lith by L. H. Bradford.

Fig 33.

Fig. 34.



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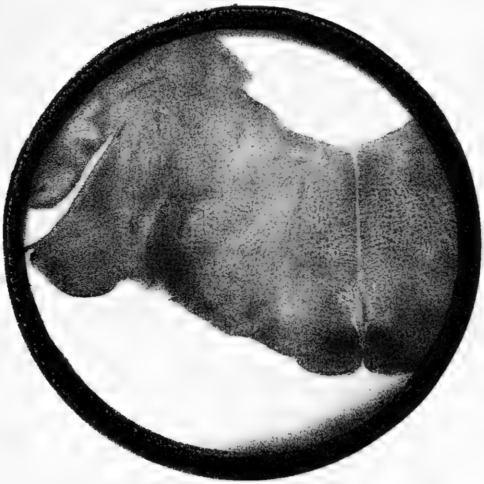


Fig. 36.

Photographed by J. Dean

Photo-Lith by I. H. Bradford.

Fig 37

Fig 38

Fig 39

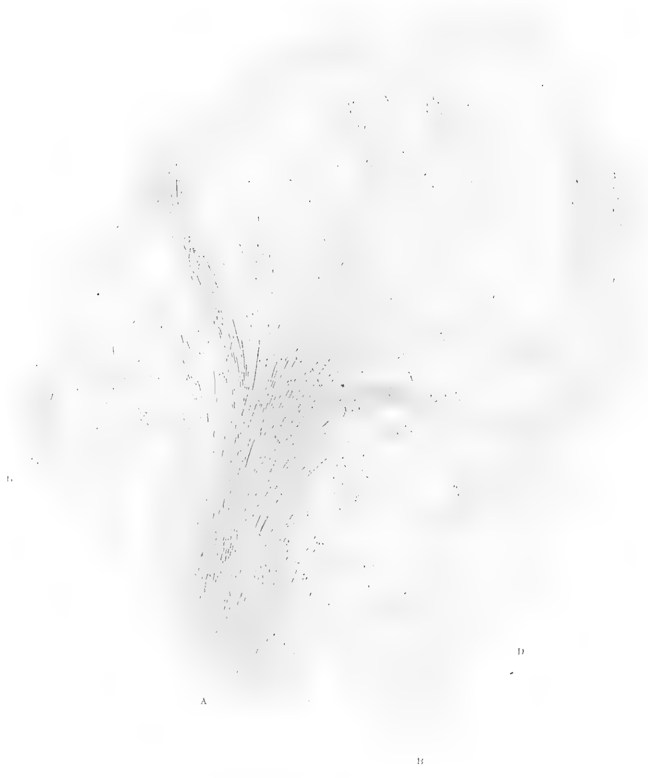


Fig 40

Fig. 11

Fig. 13 120×

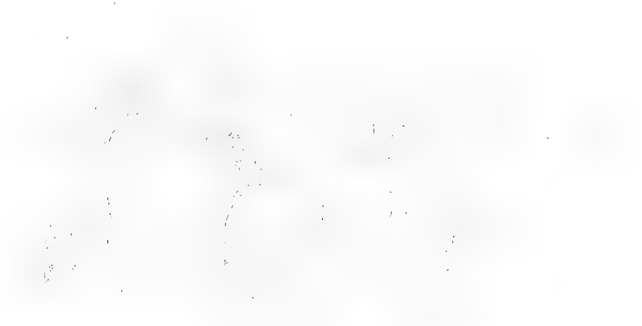
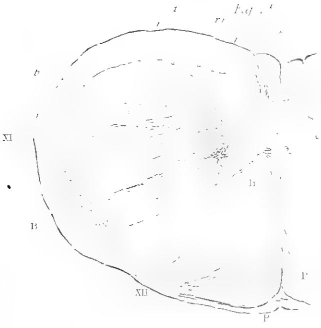


Fig. 12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b
XI
h
B
F
XII
P


R
XII
F
G

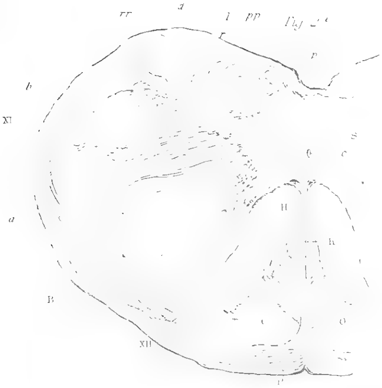
rr
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Fig 2a
b
XI
a
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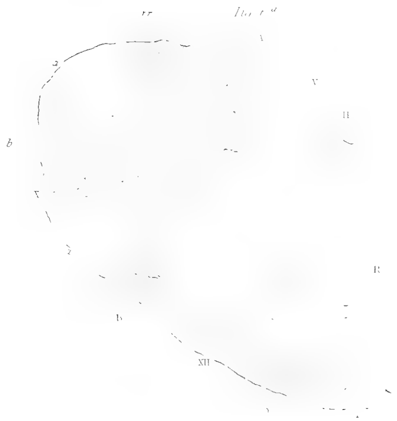
rr
V
H
b
R
XII


Fig 3a
V
H
X
R
XII
F

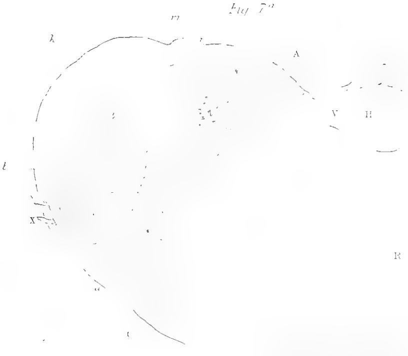
Fig 7a
rr
A
V
H
b
X
R

Fig 8a

Fig 9a

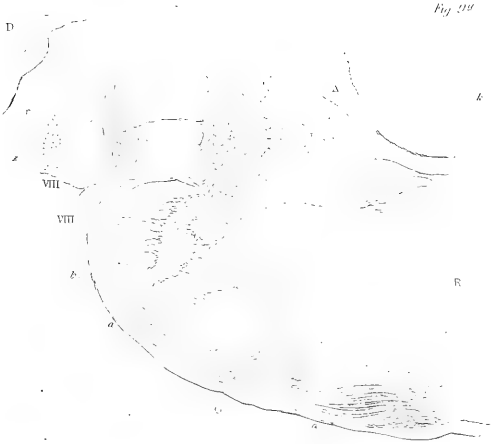

Fig 10

Fig 16a

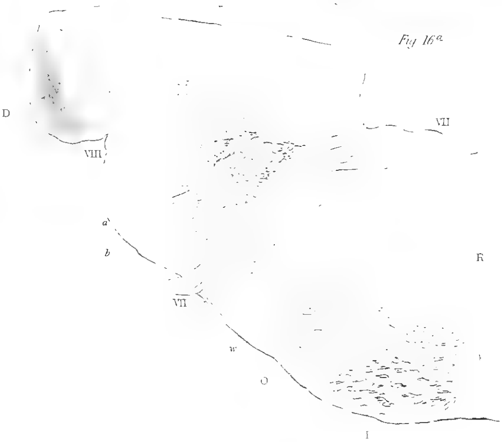

Fig 17a

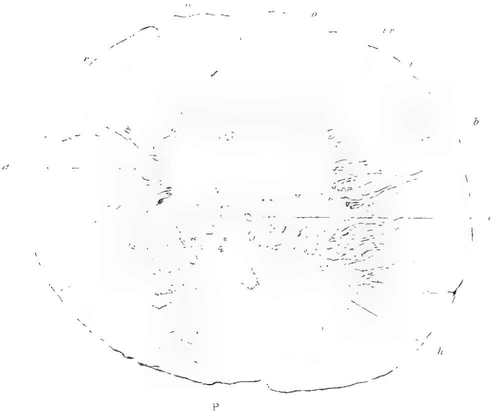

Fig 15'

Plate XV

Fig 19a

Fig 20a

Fig 21a

Fig 22a

Fig 23a

Fig 24a

J Dean ad nat del

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Fig. 44

11× . 01"

Fig 45

Fig 46

240× 001'

J Doan ad nat del

J W Watts Sc

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.
204

RESULTS

OF

METEOROLOGICAL OBSERVATIONS

MADE AT BRUNSWICK, MAINE, BETWEEN 1807 AND 1859.

BY
PARKER CLEAVELAND, LL. D.,
PROFESSOR IN BOWDOIN COLLEGE.

REDUCED AND DISCUSSED,

AT THE EXPENSE OF THE SMITHSONIAN INSTITUTION,

BY
CHARLES A. SCHOTT,
ASSISTANT U. S. COAST SURVEY; MEMBER AM. PHIL. SOC. PHILA.

[ACCEPTED FOR PUBLICATION, DECEMBER, 1866.]

CONTENTS.

(Illustrated with 8 small diagrams.)

INTRODUCTION.

BETWEEN the years 1807 and 1859 inclusive, meteorological records were made with great regularity by the late Prof. Parker Cleaveland, of Bowdoin College, at Brunswick, Me., and after his death were given in charge of the Smithsonian Institution for reduction and publication. The observations, though evidently not intended by their author to be of a strictly scientific character, were yet found sufficiently valuable to warrant the expenditure of considerable labor in preparing them for the press. They were accordingly placed in the hands of Mr. Charles A. Schott, who has deduced from them, at the expense of the Smithsonian Institution, the results and conclusions given in the following pages.

Brunswick, Me., is on the Androscoggin River, about twenty-five st. miles N. 40° E. of Portland. The college is in latitude 43° 54′.5 and in longitude 69° 57′.4 west of Greenwich. The ground around Prof. Cleaveland's residence is very nearly 74 feet above high-water mark.

The observations were made three times a day, and (as we are informed by a member of the family) at the hours 7 A. M., 1 P. M., and 6 P. M. The observer was frequently assisted by his brother, particularly during the latter years. The records relate to the following subjects: indications of the thermometer and barometer, direction of the wind, state of the weather, amount of rain and snow, character of clouds, occurrence of thunderstorms, fogs, frost and hail, earthquakes, auroras, etc.

The regular series of observations commences with November, 1807; and is complete with exception of the record of the year 1853. The barometric observations were found of less value for scientific purposes for want of a recorded temperature of the mercury; this, however, was nearly uniform, since the instrument was suspended in a room, heated in winter.

JOSEPH HENRY,
Secretary S. I.

SMITHSONIAN INSTITUTION,
March, 1867.

RESULTS

OF THE

METEOROLOGICAL OBSERVATIONS MADE AT BRUNSWICK, MAINE.

ATMOSPHERIC TEMPERATURE.

The temperature of the air was observed three times a day, at the hours 7 A. M., 1 P. M., and 6 P. M., between November, 1807, and December, 1859, inclusive. The record of the year 1853 is missing. Otherwise there are but a few omissions. The record of the period August, 1856, to May, 1857, is in many places damaged by fire, though mean values, which were written on slips of paper, are preserved in many instances. Table I contains the daily mean values of the temperature *uncorrected* for diurnal variation, and expressed in degrees of Fahrenheit's scale. When but one or two observations were found recorded in a day, the missing numbers were supplied by interpolation; this had judiciously been done by Prof. Hopkins by paying attention to the diurnal variation as well as to the readings of the days preceding and following at the hour required; these cases, however, are not numerous.[1] When no observations are recorded for several days in succession, not exceeding six, however, the omission was supplied by simple interpolation; all numbers thus obtained are distinguished in the table by brackets ( ). A few other defects, extending over a month and fraction of a month, were remedied by the insertion of the daily means resulting from the whole series of over 50 years; these means are inclosed within rectangular brackets [ ].

Daily maxima and minima of temperature are recorded for January, February, and March, 1807, and again between November, 1807, and January, 1818; this last record is rather irregular. The instrument used was a Sykes' thermometer, exposed on the northern side of the building, five feet from the ground. The locality was at first bare of vegetation, but in the course of time shrubbery and trees grew up.

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[1] The daily and monthly means were made out by Prof. Hopkins, who had also commenced transcribing monthly maxima and minima, and collected statistical information respecting wind, weather, and rain.

TABLE I.—MEAN DAILY TEMPERATURE (uncorrected).

Mean Temperature in November.

Day of month.	1807.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.
1	37°.0	39°.3	39°.0	24°.0	49°.3	48°.3	35°.0	40°.2	41°.0	44°.6	44°.2	55°.0	35°.5	41°.7
2	37.8	46.0	42.8	25.7	44.8	44.0	36.2	34.7	45.8	43.3	31.8	47.2	48.9	42.3
3	44.2	43.2	54.0	25.8	43.8	47.5	40.0	32.5	45.2	52.7	32.8	39.3	48.3	44.0
4	45.0	36.2	34.5	23.5	39.8	39.0	46.3	37.8	43.7	55.7	31.2	41.3	46.2	43.2
5	47.3	36.7	32.5	31.7	38.8	52.0	41.8	41 0	50.5	55.1	36.0	44.3	41.7	40.7
6	41.3	41.6	27.2	38.7	43.5	40.8	40.4	43.5	49.3	50.7	39.5	49.4	36.2	41.1
7	42.4	34.2	36.3	35.5	47.2	33.8	42.3	39.7	44.3	46.3	54.1	58.7	45.7	37.9
8	38.1	35.3	23.0	31.5	48.8	37.2	43.3	40.8	29.2	48.3	44.8	50.7	33.7	39.0
9	41.0	40.3	27.7	34.3	51.7	35.2	45.7	40.0	43.3	47.7	47.2	42.2	33.8	42.8
10	33.3	54.7	40.5	35.7	46.4	43.8	55.7	45.5	55.8	35.8	57.0	43.3	39.0	25.3
11	32.3	36.2	33.5	45.8	37.5	43.2	57.0	45.3	35.5	33.2	54.3	43.0	36.9	25.0
12	49.0	34.6	21.0	39.7	36.5	38.3	36.8	37.7	24.5	32.3	56.2	40.5	47.5	21.0
13	33.5	42.3	30.6	42.2	42.2	33.7	35.0	51.2	25.2	31.2	44.3	39.5	42.3	26.0
14	24.0	39.8	36.5	47.3	42.0	37.3	32.7	52.7	30.7	34.7	36.5	42.2	29.8	31.3
15	27.3	36.1	35.5	53.7	37.2	34.5	29.0	39.5	34.0	45.2	41.3	54.7	33.2	28.0
16	30.3	37.5	32.4	51.0	36.2	37.3	33.4	36.7	32.7	37.2	39.3	50.5	31.7	36.0
17	21.8	40.8	29.5	35.8	49.0	34.7	31.7	49.2	39.8	47.0	30.0	41.7	45.0	27.2
18	25.2	32.4	37.5	30.0	30.5	31.7	30.3	50.3	34.2	54.2	35.2	38.4	41.7	34.3
19	41.8	29.2	30.2	44.0	33.8	29.3	45.7	43.7	37.6	56.2	37.2	34.7	43.2	40.2
20	34.2	28.8	25.9	51.7	22.1	27.0	42.0	37.2	39.7	55.7	33.3	33.3	35.7	36.2
21	30.7	35.2	23.3	32.3	32.2	33.2	38.0	38.3	41.7	40.7	30.8	35.7	40.7	41.2
22	36.0	38.2	24.2	32.5	38.0	29.2	33.7	33.0	42.2	23.3	27.2	36.3	31.0	36.8
23	30.2	38.4	19.5	27.7	34.9	34.8	42.6	39.8	39.0	30.0	27.8	34.8	30.5	38.8
24	32.0	31.5	19.3	24.0	38.7	48.3	40.7	37.0	34.0	30.7	16.2	34.2	32.3	40.5
25	28.3	25.5	27.8	32.2	24.1	26.3	48.0	26.7	40.0	27.3	23.0	29.3	40.5	46.7
26	30.0	21.8	33.8	36.0	21.2	26.5	40.7	30.8	30.7	17.5	29.1	44.5	37.7	42.2
27	41.5	24.8	36.0	48.7	32.0	41.5	35.3	30.8	28.3	33.8	33.1	36.1	40.8	15.8
28	46.3	27.0	30.2	38.0	38.8	32.7	32 2	31.2	37.2	19.5	31.7	38.8	32.1	15.8
29	32.8	29.5	27.5	33.0	32.0	39.3	28.8	19.5	41.3	21.0	37.2	41.8	28.6	21.5
30	29.2	38.9	22.0	38.8	40.2	29.8	26.8	30.9	44.8	35.8	38.0	31.2	32.5	13.5
Mean,	35.46	35.87	31.12	36.36	38.43	37.01	38.90	38.56	38.73	39.55	37.34	41.79	38.12	33.88

Day of month.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.
1	46.5	38.8	41.0	19.1	49.7	51.0	36.0	49.0	36.7	58.0	47.7	44.7	33.7	34.7
2	38.7	33.1	42.7	21.2	53.3	58.7	33.0	50.3	43.0	51.2	52.0	56.0	45.0	36.7
3	40.5	33.3	31.2	18.8	39 3	44.0	41.3	51.7	44.7	45.7	46.7	46.7	34.7	35.0
4	50.8	30.7	37.7	23.7	41.3	28.7	35.0	54.7	46.7	51.8	45.3	46.5	25.7	42.5
5	41.3	36.3	33.3	31.5	33.0	26.7	36.0	55.7	42.3	49.0	49.3	51.0	30.5	48.0
6	39.0	38.3	24.7	42.7	42.3	33.0	21.7	49.7	38.0	50.3	42.7	40.3	37.3	41.7
7	48.3	41.0	30.9	37.3	51.3	48.0	27.7	44.7	40.7	51.3	44.3	43.8	42.7	38.0
8	45.7	42.8	25.8	35.2	49.7	39.7	30.0	50.3	41.7	54.3	41.0	32.3	47.3	39.0
9	38.3	36.5	27.5	32.0	49.0	31.7	33.3	37.3	41.3	54.0	42.7	30.7	57.8	39.3
10	45.8	35.8	35.3	36.3	36.7	48.3	18.0	36.7	50.3	48.3	44.7	46.0	51.3	50.3
11	38.2	44.7	31.3	36.2	31.3	33.0	20.0	45.0	36.0	47.0	55.0	48.7	46.0	39.0
12	48.7	51.3	28.0	26.0	29.0	39.7	43.7	32.0	33.7	48.3	47.7	35.7	55.0	40.7
13	38.0	37.5	29.0	21.7	31.3	26.7	54.7	25.7	30.3	47.3	46.3	45.3	43.0	31.7
14	42.2	40.8	24.1	35.2	52.7	27.3	35.7	27.7	38.0	46.0	44.5	30.7	43.3	48.0
15	35.8	42.8	32.7	36.7	36.3	34.0	30.3	31.7	38.3	51.0	45.7	21.0	54.5	24.7
16	33.3	35.2	20.3	35.4	39.3	34.7	29.3	28.0	51.0	56.0	46.0	30.3	38.3	27.3
17	35.7	39.0	15.6	39.2	41.0	55.3	28.0	30.0	54.0	55.0	44.0	42.7	34.0	25.2
18	36.5	30.0	21.1	28.5	31.3	56.0	28.7	38.1	55.0	54.3	47.7	48.3	35.3	37.0
19	35.7	42.3	23.0	27.3	13.7	28.7	28.7	26.3	52.7	44.7	43.7	49.5	34.7	38.3
20	33.7	37.7	(29.8)	34.8	30.0	27.3	28.7	42.3	29.3	46.3	42.0	45.3	24.0	42.0
21	33.2	35.7	36.7	32.3	30.5	26.3	25.3	34.3	33.7	38.3	36.0	27.7	28.0	39.3
22	32.5	29.7	36.4	36.0	28.7	22.0	27.3	35.7	32.0	42.7	30.7	29.7	42.0	36.7
23	38.7	34.2	27.8	42.7	15.0	23.0	26.0	40.0	49.3	38.8	41.7	39.7	45.0	44.3
24	31.7	28.5	27.3	29.2	32.7	27.3	23.3	30.0	22.3	36.0	38.7	35.5	39.5	38.2
25	39.5	25.2	24.7	31.8	27.0	23.7	20.0	32.0	21.7	34.0	38.0	32.3	34.2	36.7
26	30.8	32.3	36.0	30.5	33.3	43.3	9.0	32.0	38.0	37.0	34.3	41.7	31.0	30.7
27	24.8	31.3	35.7	43.3	25.3	52.3	28.0	27.0	35.3	37.0	32.0	43.7	28.7	29.0
28	23.7	37.5	22.7	26.0	36.0	29.7	33.3	39.7	26.7	39.0	31.7	38.3	27.7	35.7
29	23.7	40.6	12.0	27.3	32.3	28.0	35.7	41.7	36.7	29.2	29.3	39.7	26.3	42.7
30	21.2	44.7	9.0	22.8	33.0	29.3	44.0	36.3	38.7	23.1	23.0	24.7	24.5	43.3
Mean,	37.06	36.92	28.44	31.35	35.68	35.91	30.72	38.20	39.27	45.78	41.80	39.58	38.01	37.83

TABLE I.—*Continued.* Mean Temperature in November (continued).

Day of month.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.
1	35°.3	29°.7	46°.7	29°.7	51°.7	52°.0	58°.3	47°.3	31°.3	39°.3	50°.7	36°.3	49°.3
2	39.3	39.0	44.3	45.8	48.7	47.3	58.3	42.7	47.7	42.7	51.0	44.3	48.5
3	49.0	37.7	44.3	51.7	41.8	47.0	48.7	40.7	36.0	41.2	55.0	50.2	51.5
4	50.7	39.0	44.3	56.6	37.5	49.5	44.0	43.3	31.0	44.2	59.0	52.0	52.0
5	61.7	36.3	50.7	58.5	37.7	47.0	46.3	46.3	30.3	35.0	52.7	46.0	46.0
6	41.7	37.3	52.7	51.7	45.8	51.7	42.0	45.7	31.3	36.3	41.3	51.7	39.7
7	35.0	37.3	44.3	46.4	45.7	48.0	43.3	47.7	29.3	36.7	43.8	43.0	37.3
8	47.7	35.3	45.0	53.7	43.7	49.2	37.3	37.7	30.7	40.8	46.0	48.0	43.2
9	50.0	36.3	45.3	50.7	38.5	57.0	37.0	40.3	31.0	39.8	49.3	44.8	44.3
10	42.3	46.0	44.3	35.3	39.6	51.3	35.3	45.0	31.7	35.7	42.3	47.0	45.3
11	42.7	45.0	41.0	32.2	42.5	49.0	38.7	40.0	34.3	36.0	38.3	46.7	37.3
12	41.3	48.3	42.7	41.8	42.2	51.2	37.3	37.0	31.7	39.0	34.5	48.0	37.3
13	31.3	48.0	39.3	52.7	44.7	47.5	38.3	36.0	25.0	44.3	33.7	42.3	38.3
14	34.7	39.7	30.3	56.7	50.3	43.0	39.0	41.3	26.7	34.3	46.3	40.3	34.7
15	42.0	40.7	33.3	42.2	59.5	49.3	39.0	43.3	23.7	32.3	37.3	42.0	35.0
16	54.7	40.7	28.0	46.1	49.7	41.7	33.3	37.3	37.3	38.3	40.7	44.8	33.0
17	45.3	38.7	38.7	40.3	53.3	39.0	32.2	38.7	41.0	39.2	40.8	41.2	39.3
18	44.3	28.7	43.0	38.2	56.8	39.3	31.7	49.7	45.3	43.3	44.5	39.7	44.3
19	42.3	27.0	44.3	38.7	41.5	37.0	37.7	35.0	38.2	27.2	47.2	46.7	36.0
20	49.3	34.0	43.3	36.2	41.2	36.3	32.7	37.7	34.5	30.7	46.5	43.3	29.0
21	44.7	44.3	44.3	35.7	33.3	34.7	34.0	34.3	33.7	33.2	42.7	38.7	37.3
22	35.0	46.7	46.0	41.0	32.8	32.7	38.0	29.3	38.3	39.3	33.0	38.7	36.2
23	16.7	39.0	46.0	27.3	32.3	34.0	42.3	26.7	38.3	41.0	48.0	42.7	37.0
24	22.0	32.0	47.3	16.5	43.0	39.3	39.3	34.3	37.3	33.3	28.3	31.7	52.0
25	25.0	21.7	45.0	19.5	59.0	40.7	36.3	35.0	35.7	17.0	25.7	29.0	53.3
26	25.3	25.7	28.7	21.7	27.9	36.3	31.0	33.0	33.5	20.2	30.0	23.0	44.8
27	10.0	27.0	33.0	32.0	36.0	31.0	30.0	34.0	21.7	20.7	52.3	32.2	29.7
28	27.0	33.0	29.3	36.0	38.6	24.3	24.0	19.7	29.2	13.0	24.0	36.0	27.0
29	26.0	26.3	45.7	21.6	40.8	38.7	24.0	22.0	26.5	17.7	17.2	33.0	19.0
30	10.7	25.3	47.1	42.0	41.7	49.0	30.0	26.3	11.8	24.5	24.7	31.5	11.8
Mean,	37.44	36.17	41.96	39.94	43.25	43.46	37.98	37.58	32.47	33.87	40.89	41.13	38.98

Day of month.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Means.
1	45.2	33.2	43.7	45.0	42.7	- -	61.0	48.3	39.0	43.0	51.7	38.3	42.5
2	41.0	38.7	47.8	47.7	50.3	- -	48.3	50.3	49.0	42.3	46.3	38.7	44.0
3	40.5	46.3	49.3	47.3	48.8	- -	46.7	40.3	54.0	40.3	39.7	31.7	42.8
4	39.5	46.7	52.3	35.3	41.2	- -	38.7	40.0	52.7	34.7	36.7	31.7	41.9
5	45.2	42.0	47.0	35.7	43.7	- -	23.7	35.3	36.7	35.3	44.0	36.7	41.8
6	41.3	44.7	54.8	31.3	34.3	- -	31.3	42.0	27.3	52.0	41.3	37.7	
7	37.5	51.3	40.2	31.3	37.3	- -	46.7	46.0	38.7	44.7	39.7	30.0	
8	30.3	47.7	38.2	38.7	38.8	- -	37.0	47.3	49.3	40.7	42.7	39.7	
9	35.3	48.8	40.7	40.3	35.0	- -	23.0	41.7	40.7	47.7	41.3	44.0	
10	21.3	47.0	38.0	30.3	31.8	- -	31.3	42.0	30.7	51.3	39.3	43.0	
11	20.7	44.0	45.7	26.7	33.7	- -	48.7	45.0	31.0	34.3	28.0	37.0	
12	29.8	47.3	41.3	24.7	37.0	- -	52.7	43.0	34.7	38.7	24.7	29.7	
13	27.0	48.3	36.7	29.3	39.2	- -	55.7	43.8	35.7	47.0	28.3	48.0	
14	27.8	49.7	34.3	26.7	32.2	- -	50.0	41.3	34.3	23.0	27.3	35.0	
15	38.7	39.2	40.7	34.3	27.7	- -	36.3	45.0	30.0	24.7	25.0	31.7	
16	36.2	37.3	45.3	29.7	35.0	- -	38.3	50.3	34.7	32.7	25.3	34.0	
17	42.7	41.7	43.0	28.3	35.7	- -	36.0	29.3	(35.0)	38.0	35.0	42.3	
18	33.7	40.7	40.3	30.7	37.5	- -	44.0	28.7	[38.1]	37.7	42.3	48.0	38.9
19	28.2	43.7	40.0	27.3	32.8	- -	38.0	29.0	[36.5]	46.0	36.7	49.7	37.4
20	32.5	40.2	33.2	30.8	31.0	- -	31.0	19.7	[34.7]	35.0	29.7	42.3	35.6
21	32.3	43.7	34.2	34.2	28.7	- -	30.0	22.7	[34.4]	23.3	34.3	21.7	34.3
22	34.7	39.7	33.8	40.7	27.0	- -	30.7	22.7	[33.1]	30.7	35.7	34.3	34.0
23	31.7	46.7	27.0	33.8	32.0	- -	33.7	22.7	[33.7]	39.7	30.3	28.7	34.7
24	35.0	43.5	29.0	40.3	21.7	- -	37.0	22.0	[31.9]	24.0	37.3	29.0	32.8
25	45.8	43.7	33.0	31.7	37.0	- -	52.0	28.0	[31.4]	13.0	30.3	23.3	32.3
26	38.3	52.5	34.0	30.7	39.2	- -	43.7	42.7	[31.5]	15.3	31.7	37.7	32.5
27	28.0	41.5	34.7	30.3	48.8	- -	37.0	30.3	[31.9]	28.3	31.0	30.0	33.0
28	24.3	35.0	32.3	30.3	35.8	- -	32.0	40.3	[30.4]	33.7	31.7	31.0	31.3
29	37.3	37.7	34.3	34.3	32.7	- -	33.0	27.3	[30.0]	40.0	30.7	28.7	30.8
30	47.3	37.0	37.3	27.0	31.3	- -	38.3	25.0	[30.0]	35.0	22.0	34.7	31.0
Mean,	34.97	43.31	39.41	33.59	35.99	- -	39.52	36.40	36.03[1]	35.73	34.67	35.60	

[1] Values within [ ] equal mean of 51 years, less 0°.9 to bring out the monthly mean.

TABLE I.—*Continued.* Mean Temperature in December.

Day of month.	1807.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.
1	31°.7	34°.2	22°.0	31°.5	39°.3	29°.2	45°.3	29°.6	16°.3	28°.7	35°.5	27°.4	36°.9	15°.5
2	36.0	33.7	36.5	26.7	36.4	27.0	35.8	30.8	14.2	11.7	35.2	27.0	35.6	18.8
3	46.2	35.8	35.2	25.1	32.7	22.2	19.5	26.3	31.5	9.3	36.0	27.2	20.8	31.3
4	31.2	46.3	33.4	30.3	37.5	17.8	32.2	20.3	40.1	15.3	24.7	25.8	27.7	28.7
5	26.5	29.2	37.5	28.3	38.8	43.3	29.8	23.0	22.7	22.0	20.8	29.9	18.2	31.8
6	30.3	17.8	42.7	31.3	50.3	31.5	38.7	17.1	24.5	30.2	22.7	47.2	27.0	33.5
7	23.9	11.5	50.3	31.5	41.9	25.2	36.8	21.5	37.8	36.8	18.7	32.3	34.3	20.8
8	21.3	8.9	31.0	30.7	39 8	31.5	36.2	22.2	16.2	39.3	18.8	15.8	41.3	30.7
9	34.2	16.8	33.7	25.3	27.5	31.5	35.4	17.8	13.3	14.3	33.0	35.8	45.0	25.2
10	35.2	29.2	35.8	32.3	23.3	23.3	29.7	14.3	6.8	13.8	30.7	24.8	22.3	20.7
11	35.7	28.7	31.8	21.0	32.5	19.6	25.5	21.8	10.3	19.8	18.7	22.4	19.7	8.0
12	31.5	38.7	29.8	18.7	33.3	16.0	23.8	29.0	30.7	34.7	17.9	21.7	23.5	9.5
13	31.4	25.2	30.6	18.8	24.5	30.8	26.7	23.3	24.8	37.8	22.2	-17.2	24.7	9.1
14	35.7	13.2	36.7	20.8	13.8	28.8	30.6	17.5	19.5	33.7	33.3	22.2	29.5	23.7
15	32.5	17.9	31.2	12.1	9.7	23.3	28.5	22.3	26.3	18.0	38.2	17.3	34.7	28.0
16	24.7	18.7	21.3	31.0	26.7	19.7	24.1	28.0	28.5	8.3	20.2	22.0	41.4	7.5
17	20.8	16.3	23.3	16.0	25.2	21.8	35.8	33.5	32.2	10.5	24.2	2.5	33.7	10.7
18	36.9	16.0	18.7	7.1	35.8	27.3	30.0	22.5	28.4	24.8	27.5	6.2	26.8	18.0
19	24.3	45.3	28.8	22.2	36.0	34.5	30.0	24.3	20.7	14.5	31.0	11.8	27.7	26.8
20	10.3	50.2	37.3	26.7	9.0	20.7	21.2	7.2	15.0	13.3	24.3	23.3	39.7	35.7
21	27.3	27.7	27.5	22.8	15.7	15.5	8.3	14.3	20.8	17.7	13.2	32.3	35.0	27.0
22	29.7	27.3	35.0	32.3	25.9	14.7	20.3	25.4	20.0	6.2	8.3	24.0	33.2	17.3
23	22.9	37.2	16.2	22.1	32.0	24.2	29.0	33.9	27.7	23.0	14.9	9.7	37.3	2.3
24	20.2	35.7	13.0	19.8	11.3	32.3	28.5	28.4	39.7	31.7	24.4	15.7	33.7	7.2
25	11.8	15.2	41.0	25.8	10.5	15.4	9.7	7.1	28.0	36.2	40.8	21.3	11.8	9.0
26	16.3	15.5	43.3	16.7	24.1	2.7	9.0	0.2	21.3	39.5	29.2	25.0	14.8	2.0
27	32.1	19.8	38.8	11.7	23.8	7.8	10.7	16.5	18.7	39.7	25.2	9.0	12.5	6.3
28	32.7	23.8	22.8	33.8	13.8	17.5	29.0	16.8	17.5	31.7	34.2	22.0	23.0	2.5
29	30.5	28.8	20.2	42.2	17.0	27.8	30.3	25.2	15.0	32.2	36.0	25.0	8.0	18.8
30	29.2	20.8	14.7	35.8	25.7	34.5	29.2	30.2	16.8	17.3	32.9	28.0	2.3	23.0
31	31.9	28.7	18.8	21.1	27.0	24.0	19.7	33.0	21.5	23.6	35.5	29.2	10.7	20.2
Mean,	28.55	26.23	30.29	24.88	27.11	23.92	27.00	22.03	22.80	23.75	26.71	22.62	26.84	18.37

Day of month.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.
1	14.3	58.3	(15.5)	22.8	43.7	42.7	34.7	26.7	39.7	34.0	25.0	21.5	39.0	38.0
2	30.3	31.3	(22.0)	39.7	44.0	25.0	37.3	37.7	44.7	36.0	14.3	22.3	38.7	40.3
3	38.8	24.7	(28.5)	42.0	40.3	13.7	26.7	41.7	26.0	42.7	18.0	30.3	39.0	35.0
4	36.7	15.0	35.0	37.0	32.3	20.0	26.7	44.0	14.7	50.3	17.3	39.5	31.7	26.0
5	36.8	25.0	35.8	13.0	30.0	14.7	24.0	32.3	37.0	43.3	15.7	21.0	38.3	33.0
6	27.5	17.7	26.3	30.3	21.3	34.0	23.3	39.7	37.3	30.7	20.3	25.7	32.8	44.3
7	29.7	15.0	37.7	32.0	18.3	41.3	40.7	33.3	42.0	32.3	15.3	23.0	28.0	39.0
8	32.0	32.2	18.3	27.0	16.7	40.7	33.0	38.0	45.7	33.3	10.3	42.2	31.0	31.3
9	36.8	26.7	13.0	24.7	44.0	48.7	27.7	42.5	29.7	38.2	19.3	41.2	45.3	26.7
10	23.5	36.3	18.6	26.8	14.7	53.0	28.0	37.8	23.7	38.0	16.3	36.7	38.0	14.7
11	26.0	25.5	24.3	23.7	18.7	35.3	34.3	37.3	31.0	35.3	20.0	33.0	28.0	33.3
12	18.0	24.7	21.7	19.7	10.3	31.3	27.0	38.0	48.0	29.2	19.3	32.0	25.0	16.7
13	25.3	21.3	24.7	38.3	—12.0	30.7	21.3	37.7	33.3	30.5	·14.0	16.0	26.7	30.0
14	24.0	33.7	22.5	29.0	18.3	24.0	42.0	45.5	34.7	29.7	13.7	23.0	23.0	10.7
15	15.7	25.8	26.3	16.3	17.7	26.7	39.7	29.0	45.0	51.0	10.3	22.8	27.7	4.7
16	5.7	8.2	25.0	16.0	37.0	32.0	20.0	31.7	35.3	34.7	15.3	24.7	26.2	22.3
17	25.3	29.0	27.0	17.0	48.3	38.7	19.0	41.7	28.0	25.3	24.3	33.8	31.8	6.3
18	32.3	11.7	19.4	40.3	47.7	28.3	11.3	12.3	21.7	23.5	2.7	40.3	30.7	18.7
19	19.3	37.3	(28.9)	38.0	37.3	19.0	15.3	7.0	30.0	29.3	14.8	29.7	26.3	25.7
20	9.3	26.3	38.3	34.7	34.0	15.7	14.0	25.3	32.0	30.7	12.7	18.8	25.7	30.3
21	28.8	19.3	23.2	32.0	21.2	23.0	13.3	23.7	45.7	28.6	28.5	14.5	26.5	15.0
22	27.3	18.7	12.3	31.7	9.0	22.3	7.3	6.0	21.0	11.5	—3.7	18.3	32.7	11.7
23	13.7	3.3	28.7	14.7	6.0	11.0	6.0	31.8	28.0	14.0	9.0	12.8	26.7	24.0
24	14.0	11.7	29.5	21.3	20.0	6.3	12.0	25.8	41.7	25.0	33.3	20.7	30.2	19.0
25	21.0	16.0	17.3	31.0	40.3	—1.0	31.0	32.2	49.7	47.3	26.7	32.7	29.7	19.3
26	16.8	18.7	10.0	23.3	34.3	22.7	10.0	25.2	42.0	44.7	11.8	20.7	31.3	6.3
27	16.3	17.0	16.4	28.0	14.0	30.7	13.7	25.7	33.7	39.2	15.7	22.7	24.7	16.0
28	25.0	17.8	30.7	22.0	31.0	2.7	18.0	21.7	41.3	40.7	11.2	19.8	16.3	12.7
29	—0.7	17.7	26.5	32.7	31.7	—2.7	20.7	30.3	38.3	36.3	19.3	20.0	20.7	14.8
30	0.5	15.0	27.7	32.7	27.3	2.7	15.0	31.3	40.0	35.7	20.3	8.0	15.3	23.0
31	15.3	10.7	36.3	32.3	36.7	13.3	25.3	11.0	42.7	43.5	7.3	38.0	37.3	24.3
Mean,	22.42	22.30	24.75	28.07	26.91	24.08	23.17	30.40	35.58	34.32	16.08	26.00	29.92	23.00

Table I.—*Continued.* Mean Temperature in December (continued).

Day of month.	1835.	1836.	1837..	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.
1	16°.3	31°.0	44°.0	39°.0	43°.3	25°.0	24°.7	32°.0	19°.0	32°.0	34°.3	26°.7	31°.2
2	4.7	17.0	45.7	44.3	42.8	25.8	32.0	23.7	28.7	21.2	22.7	23.3	48.8
3	19.3	24.3	46.0	36.2	40.6	34.7	31.0	33.3	24.2	16.7	12.5	36.0	39.3
4	29.3	30.0	41.0	26.3	47.7	19.3	44.7	31.7	28.3	30.8	16.3	31.8	29.2
5	32.3	41.7	37.0	45.3	45.3	19.0	37.3	35.7	33.0	32.3	31.3	26.7	30.5
6	7.8	35.7	32.7	36.3	47.5	15.3	30.0	23.0	12.7	28.7	16.0	17.0	31.2
7	4.8	17.7	38.0	35.0	46.3	30.7	28.0	22.3	25.0	40.3	12.5	17.7	22.7
8	11.7	19.7	41.7	43.8	44.0	38.0	26.7	28.0	24.0	18.8	20.3	38.0	28.3
9	22.3	25.0	30.7	19.8	50.6	39.7	41.7	25.0	24.3	18.7	29.7	34.7	41.7
10	15.3	44.7	28.0	22.0	46.7	45.7	40.7	25.7	26.2	23.8	20.7	23.7	51.3
11	12.3	43.0	35.0	27.0	42.7	32.0	44.0	25.7	30.7	9.7	—2.2	26.7	52.8
12	24.3	38.0	29.0	39.0	47.7	30.0	38.7	21.7	24.7	22.3	1.0	22.3	34.7
13	29.3	39.3	28.3	14.1	45.2	46.7	32.0	14.0	9.0	22.0	5.5	17.8	45.2
14	33.7	45.0	24.3	33.8	42.3	43.0	41.7	24.7	21.8	31.0	27.2	19.7	43.2
15	8.0	18.5	22.3	36.9	41.0	40.0	38.7	26.7	32.2	27.7	34.5	14.8	44.0
16	—7.0	17.3	21.3	19.2	39.0	45.0	36.7	32.0	24.0	18.8	29.0	17.2	19.5
17	3.3	22.7	19.3	19.5	32.8	33.7	22.3	22.3	17.0	8.7	25.2	15.5	25.0
18	6.5	28.2	43.0	33.2	22.7	23.0	25.0	21.0	21.3	6.7	35.7	27.7	19.2
19	10.7	17.7	37.3	23.7	26.0	30.7	18.5	12.7	25.2	9.7	35.8	28.7	26.8
20	24.7	23.7	23.3	19.2	23.3	29.7	14.7	15.7	28.2	7.2	21.2	27.2	21.3
21	37.0	44.7	19.7	29.0	26.7	30.7	15.3	27.3	27.7	6.8	24.7	15.5	5.8
22	29.7	17.0	11.3	36.5	24.7	22.2	14.0	43.3	28.3	27.3	11.8	17.7	8.3
23	21.3	12.7	21.3	37.7	32.6	20.3	11.0	20.7	24.2	40.3	8.7	18.5	15.7
24	18.3	25.7	37.0	10.8	38.8	21.7	42.7	7.3	30.0	26.7	9.3	14.3	25.7
25	38.7	19.3	39.0	23.7	36.3	10.5	28.3	20.0	30.7	27.0	19.3	29.8	22.8
26	40.0	41.7	39.0	36.7	35.7	7.7	17.0	28.0	24.0	37.0	19.3	16.8	13.7
27	37.7	13.7	34.0	18.0	35.3	22.4	21.0	31.0	25.2	33.8	14.7	28.8	4.3
28	18.3	6.3	38.3	15.0	41.7	25.3	29.7	20.0	30.3	20.2	25.5	31.7	16.7
29	18.0	22.7	35.0	40.7	36.3	31.0	32.0	9.7	29.3	12.6	24.5	15.0	25.8
30	29.3	1.3	41.7	13.2	20.1	33.7	32.7	32.3	26.7	25.3	30.7	13.3	38.8
31	27.3	—1.7	43.3	10.2	18.3	31.3	33.0	26.0	33.3	29.0	15.2	29.3	43.2
Means,	20.18	25.27	33.15	28.49	37.54	29.15	29.84	24.59	25.45	23.00	20.42	23.37	29.25

Day of month.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Means.
1	32.3	40.0	35.8	25.2	36.7	- -	19.3	32.0	22.5	42.3	10.7	38.7	31.0
2	42.0	18.7	30.3	25.0	36.0	- -	18.7	41.7	23.0	30.0	23.7	44.3	
3	38.5	28.7	26.3	25.3	37.8	- -	18.0	41.3	29.0	33.3	34.0	16.0	
4	33.5	28.3	33.3	29.3	42.0	- -	35.3	36.0	21.0	21.7	18.7	6.3	
5	34.7	30.7	35.8	22.0	43.0	- -	15.7	29.0	19.3	17.3	18.0	24.3	
6	25.7	30.7	31.5	17.3	43.3	- -	19.0	28.3	- -	15.7	26.7	31.3	
7	20.0	20.7	21.0	20.7	43.8	- -	28.0	34.0	- -	31.0	18.0	40.3	
8	35.7	20.7	21.7	30.7	50.0	- -	18.7	30.7	- -	33.0	30.7	25.7	
9	36.3	18.0	25.8	26.0	38.7	- -	14.3	29.0	- -	28.0	15.0	5.0	
10	30.0	34.2	28.2	23.0	44.3	- -	35.7	35.3	- -	33.7	12.3	18.3	
11	35.2	20.3	19.3	6.8	34.0	- -	35.7	23.3	- -	14.5	27.7	13.3	
12	28.7	21.2	31.7	12.3	37.0	- -	15.3	15.3	- -	14.7	10.0	20.7	
13	32.7	25.2	10.5	25.8	38.3	- -	18.0	21.0	- -	29.3	13.7	2.0	
14	41.0	22.3	15.3	8.0	20.7	- -	37.0	24.3	- -	35.3	32.3	5.0	
15	41.3	21.8	25.0	13.5	13.2	- -	35.3	25.3	- -	25.3	35.3	18.7	
16	28.2	38.7	27.0	21.7	18.8	- -	38.3	37.7	- -	29.3	29.0	12.3	
17	38.3	38.3	31.3	1.0	30.0	- -	13.8	33.3	- -	31.3	21.0	14.0	
18	36.3	20.7	14.0	3.5	29.8	- -	15.3	26.3	- -	41.0	3.0	26.7	
19	42.3	13.3	3.7	11.0	19.5	- -	5.7	24.0	- -	33.3	5.3	29.0	
20	30.3	32.0	18.3	24.7	33.5	- -	—1.6	18.7	- -	18.3	28.0	30.0	
21	21.0	33.0	13.2	14.0	19.7	- -	9.7	22.3	- -	18.0	22.0	27.0	
22	4.0	17.2	13.3	5.3	5.0	- -	—7.3	37.7	- -	34.7	27.3	23.0	
23	9.0	28.7	9.0	10.7	18.3	- -	—4.2	41.0	- -	24.7	12.3	21.7	
24	12.5	26.3	6.0	14.7	33.7	- -	19.0	36.0	- -	28.0	10.3	17.3	
25	33.8	23.5	14.0	9.5	33.7	- -	31.3	14.2	- -	10.0	8.0	12.0	
26	26.8	3.0	19.3	0.0	27.8	- -	38.7	18.3	- -	8.7	13.7	10.3	
27	12.3	17.2	25.3	—0.3	22.7	- -	38.3	13.3	- -	7.0	30.3	12.0	
28	27.7	15.0	23.3	35.7	37.5	- -	30.0	20.3	- -	25.3	21.7	—0.7	
29	27.3	22.0	11.3	40.7	30.5	- -	34.3	4.0	- -	20.3	6.3	—1.3	
30	30.3	21.3	5.3	33.3	20.3	- -	16.0	15.7	- -	22.3	—4.7	7.7	
31	24.3	14.7	5.7	38.3	11.2	- -	20.3	12.3	- -	26.3	14.7	17.3	
Mean,	29.20	24.06	20.38	18.54	30.67		21.34	26.53	21.14[1]	25.28	18.55	18.33	

[1] This mean was found preserved in the record, like that of the preceding month.

TABLE I.—*Continued.* Mean Temperature in January.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.
1	12°.1	26°.0	19°.6	12°.4	34°.8	23°.5	22°.3	27°.3	22°.8	30°.3	27°.7	38°.3	13°.5	3°.2
2	5.8	24.5	17.7	28.0	43.2	36.2	24.2	31.7	20.7	35.5	27.7	33.7	5.7	8.5
3	10.3	16.5	20.3	14.2	32.0	36.7	3.0	37.5	16.2	27.7	31.4	21.7	9.8	9.5
4	7.9	7.0	37.8	9.8	35.2	26.3	—0.2	22.3	12.8	42.7	25.5	25.3	21.3	13.3
5	9.2	9.7	29.7	27.0	33.7	23.7	7.2	18.5	16.2	17.8	16.9	10.3	21.7	8.2
6	14.7	17.7	29.0	32.3	30.3	23.2	8.2	17.7	24.3	19.0	22.5	21.3	10.5	12.3
7	16.2	24.3	35.3	41.7	33.3	31.5	25.5	6.0	20.3	19.8	35.6	15.0	12.3	15.2
8	15.5	24.5	11.8	36.3	32.1	1.6	14.5	16.7	10.5	16.0	21.0	6.7	12.0	11.8
9	17.3	8.5	26.8	34.7	14.8	7.3	15.8	29.5	3.5	24.7	16.5	25.7	10.0	16.3
10	6.0	25.0	26.9	26.3	12.0	17.0	18.3	27.7	7.0	33.0	21.0	39.7	18.0	23.3
11	16.2	19.6	41.3	21.3	16.0	11.4	29.7	35.3	2.5	28.1	11.0	35.3	21.3	11.3
12	31.8	18.3	16.0	26.8	10.0	26.0	33.0	17.8	11.5	11.6	16.7	32.2	22.7	18.5
13	18.8	0.2	21.3	11.3	16.0	31.3	24.2	7.8	8.5	—2.2	14.8	21.2	12.7	21.8
14	9.3	—1.2	28.3	9.4	10.0	7.0	16.0	14.2	10.5	3.7	22.5	0.0	21.0	9.7
15	8.7	8.0	30.2	10.5	25.3	5.8	23.5	19.7	2.5	1.2	24.0	6.3	23.0	15.8
16	8.6	15.6	30.2	20.2	—4.8	13.5	26.8	19.3	14.0	10.0	27.0	24.3	19.0	18.8
17	31.3	14.2	31.8	29.8	—6.7	31.8	27.3	24.8	43.7	15.2	26.6	26.7	17.0	6.3
18	43.3	14.8	34.8	1.5	—9.7	18.8	28.3	18.2	35.3	39.2	(26.1)	41.3	19.0	5.0
19	32.0	19.9	—8.7	13.0	—5.8	28.2	28.8	27.5	30.5	4.5	27.5	38.0	16.7	11.0
20	16.2	32.8	—7.5	35.2	—3.3	18.8	23.7	36.3	26.7	9.8	22.7	28.3	15.3	17.5
21	21.5	19.8	—2.1	25.1	1.3	25.9	18.2	31.3	30.2	16.3	9.5	26.3	11.7	25.2
22	30.0	16.3	7.4	23.6	—4.8	16.0	9.0	18.5	34.7	10.7	27.0	36.7	16.7	[19.2]
23	37.2	27.5	17.2	2.4	15.5	19.2	14.3	19.3	31.8	10.0	2.3	39.7	19.3	[18.5]
24	35.8	19.4	12.3	1.0	9.6	3.3	32.3	17.8	36.8	21.3	5.7	41.3	13.3	[18.6]
25	15.8	14.2	14.8	9.7	21.5	22.7	30.8	21.3	23.3	23.0	8.9	30.3	14.3	[21.2]
26	19.4	14.7	9.2	16.8	36.8	14.2	26.2	17.0	12.2	23.8	18.7	31.0	9.3	[23.2]
27	40.2	18.8	11.3	19.7	30.2	4.5	19.7	—1.2	17.0	5.5	27.3	33.3	21.7	[22.3]
28	21.3	16.2	13.8	19.2	14.3	10.7	29.2	5.2	22.0	—4.9	27.0	30.7	14.0	[21.6]
29	13.9	19.8	3.0	23.5	10.2	19.7	19.0	3.7	26.3	—0.8	26.3	2.3	28.3	[21.3]
30	19.0	24.2	6.9	32.0	25.3	—9.1	23.0	7.4	25.3	2.7	—1.3	31.3	31.3	[20.6]
31	28.3	23.2	15.0	33.8	29.0	6.2	—0.8	—12.3	22.5	6.5	3.5	8.3	25.0	[20.1]
Mean,	19.82	17.42	18.78	20.91	17.33	17.84	20.03	18.84	20.07	16.18	19.98	25.89	17.12	15.78

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	14.2	2.0	11.3	32.0	35.3	33.0	17.7	22.0	20.7	46.7	18.3	43.3	34.3	12.7
2	35.8	22.7	11.3	25.0	33.0	21.3	31.3	5.5	21.3	32.0	10.0	31.7	26.0	9.3
3	13.0	23.0	16.3	8.0	29.7	18.7	41.0	—7.7	31.7	32.0	17.0	36.2	30.0	—0.3
4	2.3	12.0	25.8	3.7	28.0	13.7	26.0	—7.3	41.0	38.7	7.3	48.0	13.7	—5.3
5	—5.3	3.7	27.3	9.7	0.0	3.3	34.7	0.0	29.0	50.2	26.3	46.3	16.0	6.3
6	7.0	2.3	36.3	36.0	3.0	22.7	32.7	10.5	27.3	31.8	30.2	43.7	12.0	0.7
7	5.0	—1.8	20.0	4.7	22.3	18.7	37.7	30.8	28.7	32.3	21.0	26.0	12.5	3.0
8	25.7	12.0	23.7	5.3	35.0	19.7	23.7	19.7	28.3	22.7	20.0	22.7	18.3	16.5
9	25.0	13.7	25.5	14.3	39.7	18.3	14.3	28.0	22.3	16.7	42.0	31.0	23.0	20.5
10	—3.3	33.0	36.8	11.7	44.3	27.7	16.7	1.0	39.0	14.0	34.8	30.3	27.3	17.3
11	—9.7	7.7	19.7	17.0	42.3	26.7	30.7	—4.3	4.7	22.7	34.0	13.0	12.0	20.7
12	25.3	4.7	25.3	15.3	27.0	25.3	37.7	9.0	0.0	24.7	16.0	11.8	24.7	24.0
13	18.3	2.7	31.7	17.7	19.7	23.7	39.0	16.3	4.3	7.5	24.3	23.7	25.7	29.7
14	—6.7	—4.3	33.3	27.7	28.0	21.3	27.7	31.0	20.3	15.0	27.3	26.0	22.0	35.3
15	14.3	9.4	9.7	37.7	35.3	23.0	25.3	41.7	28.0	16.3	35.3	4.5	12.0	42.3
16	6.7	18.0	19.3	24.3	30.7	22.7	14.7	36.7	30.7	26.3	42.7	39.7	14.7	42.0
17	—4.3	17.8	15.8	33.0	22.7	3.8	24.7	38.0	40.3	23.3	38.2	—1.5	28.3	39.5
18	14.3	25.0	13.2	17.3	17.0	—2.5	23.2	32.0	16.0	17.7	42.0	24.7	43.2	29.5
19	30.0	39.8	14.8	17.3	13.0	1.0	17.7	34.0	13.0	22.0	46.5	—10.2	25.5	22.7
20	35.7	31.7	14.0	18.7	17.0	—1.3	23.3	27.7	36.3	9.3	40.0	22.0	32.7	27.7
21	31.5	33.2	15.3	18.3	20.0	2.3	5.0	30.0	13.3	11.7	35.0	41.0	9.7	29.3
22	41.0	30.8	8.3	9.7	14.3	7.0	7.3	27.8	18.3	15.3	19.3	39.8	4.0	38.3
23	8.3	31.0	5.3	4.7	20.3	15.0	10.7	29.3	27.7	14.0	18.0	35.5	2.3	36.0
24	—5.0	14.3	3.3	9.0	29.2	14.3	12.0	30.3	4.3	11.0	39.3	36.3	10.0	22.7
25	—0.7	22.5	15.3	17.7	21.7	16.3	22.5	15.3	15.0	10.0	38.0	31.5	8.0	26.7
26	11.7	33.8	29.5	29.0	5.0	25.3	37.7	25.7	8.0	21.7	4.8	20.2	33.3	39.7
27	31.0	33.5	23.6	30.3	7.2	34.7	25.7	26.0	14.0	22.0	—0.5	18.0	15.0	38.7
28	24.7	34.7	16.3	25.3	29.0	40.0	33.3	26.3	9.7	17.3	4.3	23.3	11.0	36.0
29	34.3	27.0	22.9	33.0	23.7	27.3	25.7	14.7	1.0	23.7	19.0	10.3	7.0	34.3
30	21.3	17.8	27.8	20.0	6.8	19.0	18.3	7.7	2.0	19.7	26.0	24.7	22.7	31.3
31	14.8	22.2	24.3	16.7	—15.9	19.7	31.5	7.7	1.7	22.7	36.3	13.7	31.7	46.3
Mean,	14.75	18.58	20.12	19.03	22.07	18.12	24.83	19.61	19.56	22.28	26.23	26.04	19.63	24.94

TABLE I.—*Continued.* Mean Temperature in January (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	27°.7	11°.3	44°.3	13°.0	13°.7	26°.7	14°.7	11°.0	32°.3	29°.0	10°.8	37°.3	42°.3
2	33.7	19.3	44.0	21.8	14.1	30.3	37.7	7.3	29.3	22.0	36.3	27.7	39.2
3	24.3	11.3	53.3	39.2	12.7	14.7	4.7	21.2	21.0	15.8	35.3	32.0	30.2
4	19.7	3.7	41.0	37.5	18.4	7.3	10.7	8.0	29.0	30.7	24.2	26.0	34.8
5	28.0	5.3	44.7	33.2	26.7	6.5	12.0	16.3	13.3	31.8	24.3	40.8	22.0
6	20.3	30.7	46.7	28.9	29 2	34.0	10.0	28.7	17.0	13.2	25.2	33.5	14.7
7	24.7	31.3	46.3	39.4	31.3	44.7	39.0	34.0	15.8	18.0	30.7	32.3	3.0
8	20.8	27.3	48.2	43.1	26.7	47.7	21.3	45.3	8.7	25.0	29.0	19.3	7.0
9	21.0	20.0	32.7	22.5	34.2	37.3	35.0	48.0	—0.2	29.5	27.3	15.7	36.3
10	35.7	18.0	34.8	43.2	37.5	28.3	30.5	44.3	5.3	27.2	13.0	22.3	—3.8
11	40.7	28.3	17.0	44.0	25.0	31.0	27.0	45.0	11.3	22.8	17.3	15.0	—2.5
12	42.7	29.0	25.5	45.5	17.0	34.7	26.0	41.0	10.5	22.7	16.3	11.3	10.0
13	39.8	16.3	33.7	30.9	25.5	31.0	3.0	40.0	33.0	14.0	19.7	18.0	17.8
14	38.0	5.3	36.3	31.1	21.3	29.3	25.3	37.0	14.0	7.3	19.0	23.3	37.0
15	27.3	6.7	41.3	13.7	18.3	27.0	32.3	31.0	8.0	7.3	27.3	28.5	44.2
16	10.3	4.7	37.0	22.6	5.0	26.3	11.7	21.7	12.3	19.3	30.2	37.0	37.3
17	15.7	11.7	49.7	28.6	10.7	33.8	26.7	16.3	35.5	20.0	14.0	6.0	34.3
18	17.0	17.7	32.7	38.9	5.3	25.3	36.7	33.3	29.8	13.3	1.0	9.2	26.2
19	21.0	20.3	30.8	44.7	25.8	13.7	33.3	39.0	11.0	5.0	3.5	22.0	6.7
20	20.3	20.0	25.7	16.0	32.6	23.0	32.7	46.0	1.7	16.3	10.3	7.0	15.8
21	13.0	19.7	26.8	26.8	33.8	31.4	45.7	39.3	2.0	21.0	19.5	10.7	35.2
22	42.7	31.0	22.3	12.2	17.8	30.3	26.7	43.0	5.7	26.0	4.7	2.0	19.0
23	18.7	23.0	29.7	17.0	21.3	22.3	9.0	34.3	20.5	24.0	18.2	20.8	19.7
24	13.7	12.3	37.7	4 3	21.8	31.7	6.0	36.3	29.5	30.5	20.0	31.2	11.5
25	23.7	1.7	41.7	33.3	16.7	36.0	25.0	25.7	5.3	44.7	33.3	15.0	33.0
26	15.3	—1.7	47.7	50.5	16.0	39.3	32.0	24.3	—7.3	30.3	33.8	17.3	35.7
27	15.0	10.0	41.0	42.0	17.2	43.0	31.0	27.3	—6.3	27.7	14.7	18.0	34.0
28	12.3	37.7	40.8	28.8	19.0	39.0	22.3	31.7	—5.3	31.0	23.7	10.0	32.3
29	6.3	27.7	31.8	21.2	34.0	31.7	39.3	22.3	—0.2	35.7	17.7	12.3	33.3
30	28.3	34.0	12 0	25.3	39.2	33.7	41.7	22.7	1.8	19.7	35.7	22.0	32.8
31	33.7	36 0	15.7	22.3	32.2	32.0	43.0	33.7	—0.2	3.3	30.7	8.2	22.8
Mean,	24.24	18.92	35.89	29.73	22.58	29.64	25.53	30.84	12.39	22.07	21.52	20.38	24.58

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	17.3	12.2	15.0	31.7	- -	26.8	- -	11.0	- -	29.7	34.0		
2	1.5	15.7	2.0	22.7	- -	23.2	- -	10.7	- -	25.3	21.3		
3	5.5	14.2	13.2	17.3	- -	17.3	- -	24.7	- -	22.0	3.0		
4	7.7	22.3	5.3	24.8	- -	32.7	- -	12.3	22.7	26.0	8.3		
5	9.8	23.3	—1.0	30.2	- -	37.5	- -	—1.7	11.0	29.7	27.0		
6	20.5	14.0	9.0	30.8	- -	35.0	- -	9.0	0.3	2.3	25.3		
7	15.3	14.2	11.2	26.0	- -	9.0	- -	2.9	8.0	8.0	31.3		
8	12.3	22.2	13.0	14.0	- -	13.7	- -	23.0	2.0	1.0	15.7		
9	17.0	15.3	18.0	16.3	- -	1.8	- -	—1.7	12.3	19.0	—8.3		
10	7.2	18.0	31.7	28.7	- -	1.7	- -	2.3	17.0	27.0	—17.0		
11	—0.2	14.3	32.5	31.2	- -	13.2	- -	13.3	17.3	32.0	—20 7		
12	6.2	36.8	28.0	23.8	- -	37.0	- -	12 3	9.3	36.0	—8.7		
13	27.3	19.0	27.2	9.7	- -	38.0	- -	22.0	15.3	21.3	5.7		
14	39.7	10.5	28.8	12.8	- -	30.3	- -	23.3	13.7	27.0	13.0		
15	28.0	20.8	35.0	21.3	- -	21.0	- -	23.5	7.0	26.3	26.3		
16	25.7	22.7	34.0	—6.8	- -	17.5	- -	23.0	7.0	39.7	25.7		
17	33.3	24.7	38.0	0.0	- -	28.2	- -	28.3	20.0	30.3	22.3		
18	—0.9	33.7	18.0	1.5	- -	16.2	- -	24.3	—11.3	21.7	11.3		
19	4.3	27.3	6.3	—0.3	- -	17.7	- -	20.3	6.7	22.7	24.0		
20	14.2	24.8	21.7	—7.3	- -	19.5	- -	10.3	13.7	28.3	30.3		
21	26.0	20.5	22.3	10.5	- -	22.8	- -	11.7	24.0	36.3	39.0		
22	2.0	31.7	13.3	4.7	- -	5.7	- -	17.0	16.7	22.0	38.7		19.2
23	19.2	32.5	16.7	10.7	- -	6.0	- -	18.0	—18.3	22.3	6.3		18.5
24	29.0	17.5	29.7	20.5	- -	6.0	- -	15.0	—8.0	25.7	7.7		18.6
25	36.5	38.0	26.8	24.8	- -	—6.8	- -	—0.7	9.3	38.0	26.3		21.2
26	39.2	32.7	24.0	35.1	- -	4.7	- -	11.7	10.3	43.0	30.0		23.2
27	17.0	32.7	14.0	13.8	- -	18.3	- -	21.0	35.7	43.3	24.0		22.3
28	13.3	32.2	12.0	25.3	- -	2.3	- -	12.3	34.3	29.0	23.3		21.6
29	26.3	27.3	38.0	37.0	- -	—7.3	- -	23.0	36.0	28.0	23.0		21.3
30	23.7	18.0	—4.0	28.2	- -	1.7	- -	23.0	29.3	31.3	26.3		20.6
31	2.5	13.0	—8.3	14.5	- -	32.7	- -	14.3	14.7	15.3	12.3		20.1
Mean,	16.68	22.64	18.48	17.85	- -	16.86	- -	14.81	13.75	26.12	17.00		

TABLE I.—*Continued.* Mean Temperature in February.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	18 0.	1821.
1	40°.0	18°.3	20°.0	32°.8	28°.0	25°.2	15°.3	17°.2	33°.8	4°.0	5°.7	11°.3	—6°.0	47°.5
2	32.7	27.3	9.0	27.4	25.0	9.2	40.2	22.2	24.2	16.0	12.7	29.3	1.3	30.8
3	20.2	3.2	9.0	25.0	34.3	9.8	28 7	19.7	21.5	21.3	21.7	31.3	7.7	32.8
4	35.2	2.4	18.4	24.7	37.3	21.5	0.3	22.5	22.5	5.5	34.3	35.7	12.0	26.4
5	33.2	4.3	30.0	29.0	29.8	34.5	—0.3	17.0	23.2	—4.5	33.0	34.0	4.7	16.3
6	33.3	15.5	18.8	22.5	4.5	31.8	22.5	18.0	14.7	9.7	18.7	20.0	35.7	13.3
7	30.8	15.0	21.5	27.0	30.8	38.2	15.2	17.8	28.5	27.7	16.1	22.3	37.0	31.7
8	27.5	2.7	29.4	28.1	44.3	39.3	30.5	12.0	7.3	25.8	29.0	39.0	28.0	18.5
9	30.4	3.6	27.3	26.3	31.3	34.8	14.3	20.5	—0.8	19.5	6.3	46.7	14.3	24.7
10	30.3	3.1	—1.7	28.0	29.5	34.3	21.5	16.7	8.7	28.5	— 5.3	48.7	12.3	36.0
11	33.7	8.2	11.0	29.3	20.7	31.5	33.2	17.0	21.7	3.8	—2.7	38.0	26.5	30.8
12	34.2	7.2	32.5	23.2	7.0	31.3	21.7	20.3	38.7	2.8	4.2	23.3	30.3	36.2
13	36.0	17.2	28.0	37.7	13.0	32.3	22.7	13.2	13.5	5.5	11.4	14.0	42.0	43.0
14	35.0	25.6	16.8	22.7	24.3	18.0	24.2	8.7	5.0	—2.3	28.3	23.3	38.0	26.3
15	27.3	16.5	20.2	26.3	37.0	26.8	26.8	21.0	—1.3	—2.2	20.5	36.3	40.7	29.7
16	13.8	12.7	30.8	19.0	14.3	13.9	28.3	24.0	8.5	4.8	—1.9	35.7	40.0	18.3
17	11.8	12.3	28.2	21.2	13.3	19.2	39.0	22.9	20.3	9.5	5.2	30.0	40.7	31.5
18	13.8	35.9	32.6	16.3	28.2	22.3	45.0	10.5	27.0	20.8	25.3	13.3	41.0	23.4
19	9.6	24.7	42.5	17.7	23.0	8.7	35.3	19.7	30.3	23.3	13.2	23.8	19.3	32.2
20	10.8	17.0	41.3	13.7	12.8	4.8	35.5	19.5	33.7	27.3	14.7	30.5	28.3	42.2
21	24.8	20.5	38.7	8.7	12.3	16.7	30.8	34.7	27.0	31.0	38.2	34.2	27.0	34.5
22	30.7	31.3	28.3	6.8	24.2	33.7	30.3	20.0	31.8	40.0	13.8	31.3	28.3	28.5
23	20.3	19.3	27.3	8.7	14.2	22.5	30.3	11.0	33.0	33.7	17.0	31.0	36.0	22.0
24	21.5	12.5	33.3	10.5	5.8	26.5	39.8	13.5	28.5	22.8	15.3	19.3	30.8	16.8
25	20.0	23.2	37.5	25.3	5.8	35.7	35.8	27.3	37.8	18.3	29.0	27.5	36.3	17.7
26	17.9	23.3	40.0	36.0	29.5	7.6	26.0	33.0	36.0	16.2	8.5	31.3	40.0	28.9
27	27.3	25.3	23.3	35.6	4.2	10.0	27 3	27.2	27.0	14.3	16.7	35.3	43.3	18.7
28	33.7	25.6	18.7	41.5	9.3	17.7	29.8	36.8	37.0	28.1	43.7	31.0	41.3	21.1
29	43.5				7.0				40.3				25.7	
Mean,	27.08	16.13	25.48	23.94	20.74	23.50	26.79	20.14	23.43	16.20	16.85	29.56	27.68	27.85

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	17.3	11.3	7.9	23.7	—13.8	22.3	28.8	7.3	9.3	27.3	22.0	16.7	32.0	28.7
2	17.3	8.1	2.0	14.0	1.3	21.7	35.0	16.3	13.3	30.7	31.0	10.8	30.3	16.7
3	18.0	14.4	11.7	14.0	20.0	33.3	39.7	22.7	13.0	23.0	39.0	12.8	28.3	3.3
4	29.0	21.4	27.7	3.0	13.0	10.0	38.8	13.7	20.3	36.7	34.2	16.0	39.3	—2.0
5	18.0	8.8	—13.3	13.3	27.7	13.0	32.5	9.3	5.7	20.3	10.8	17.0	33.7	9.0
6	25.0	3.2	9.7	32.3	34.3	15.0	35.2	17.3	1.0	23.5	6.8	25.0	25.0	32.0
7	4.7	2.7	19.7	39.7	28.7	22.0	42.2	23.3	—0.7	23.3	19.7	21.0	6.0	29.7
8	5.3	6.2	27.0	5.3	35.9	28.7	31.0	31.7	12.0	20.7	16.2	14.2	8.0	6.0
9	22.6	13.1	23.0	6.0	35.0	11.7	38.5	36.7	15.0	20.7	8.7	24.3	18.3	12.7
10	17.8	16.5	31.2	25.7	35.7	19.3	37.5	24.7	30.3	19.5	19.8	34.3	28.0	10.3
11	9.8	26.7	43.7	23.3	41.0	11.0	21.0	23.7	36.0	22.8	22.2	16.3	37.0	13.0
12	14.1	26.8	29.7	32.3	24.3	—0.9	9.3	13.7	6.7	18.5	44.0	23.0	8.3	21.3
13	11.2	23.7	9.3	23.3	17.5	20.3	25.7	10.3	10.3	19.3	34.8	19.7	20.0	29.7
14	8.2	20.2	26.3	23.0	18.3	20.0	18.7	11.7	6.7	20.7	28.0	27.5	32.0	26.3
15	12.3	25.7	28.5	28.3	11.0	7.0	21.0	24.3	4.0	23.0	36.0	19.2	37.8	8.3
16	21.3	15.3	30.5	32.0	10.7	42.3	36.3	23.0	14.7	33.7	10.8	22.7	44.0	20.7
17	39.8	0.3	31.2	25.3	27.3	31.3	35.7	26.0	25.0	41.3	10.7	31.3	31.7	28.7
18	25.9	19.5	29.0	38.3	21.7	31.7	43.0	18.3	30.7	18.3	24.3	42.0	30.7	33.3
19	23.1	0.0	14.3	17.0	19.3	18.7	44.7	18.7	33.3	37.0	28.0	37.0	39.7	35 0
20	23.2	6.5	29.3	3.7	20.3	9.0	39.7	16.7	43.7	28.0	34.0	37.3	43.0	29.0
21	38.2	24.3	34.0	17.7	32.3	29.3	43.7	17.0	41.7	14.3	25.7	15.5	36.5	36.7
22	37.6	29.0	24.4	31.3	29.7	31.7	22.3	22.0	44.0	36.0	18.7	32.0	39.7	42.3
23	18.5	17.5	16.7	29.7	22.3	22.3	20.3	10.3	37.0	34.3	37.0	26.7	37.3	35.7
24	27.2	9.7	16.0	27.0	29.7	18.7	31.7	18.7	36.0	15.3	4.3	9.0	40.7	27.3
25	16.6	23.3	14.3	35.7	27.0	33.7	28.3	29.0	40.3	22.7	12.5	12.0	31.3	33.7
26	22.0	20.3	24.8	23.0	42.7	41.7	31.0	30.3	40.3	31.3	30.3	11.4	26.8	26.7
27	33.2	29.0	36.3	19.7	32.0	41.0	42.0	17.0	35.3	38.3	25.0	36.7	25.3	15.7
28	37.5	7.3	27.3	27.7	27.3	40.7	35.3	22.7	21.7	40.3	39.2	10.5	34.3	13.3
29			23.3				31.7				39.3			
Mean,	21.24	15.39	21.92	22.69	24.18	23.10	32.42	19.87	22.18	26.25	24.59	22.27	30.18	21.92

Table I.—*Continued.* Mean Temperature in February (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	23°.0	37°.3	26°.3	21°.1	29°.0	25°.7	31°.3	35°.3	13°.5	0°.0	3°.8	6°.7	27°.3
2	—6.7	29.7	20.3	25.2	23.7	19.0	32.0	21.7	24.7	—2.2	23.8	19.0	31.7
3	3.3	9.3	23.3	29.3	20.0	32.7	44.3	13.0	25.7	5.7	32.3	36.1	33.3
4	0.7	23.0	23.5	21.2	13.8	20.7	48.7	22.7	18.7	2.0	32.5	31.7	35.7
5	8.7	28.7	20.0	11.8	14.2	27.7	42.0	26.7	21.8	16.3	35.5	22.0	30.7
6	9.7	37.3	26.0	15.2	36.0	27.7	33.0	34.3	27.8	17.7	25.2	34.3	26.2
7	9.7	37.0	27.0	8.5	48.3	32.0	37.7	21.0	25.7	8.7	29.3	29.7	27.0
8	29.3	37.0	37.7	38.4	44.0	28.7	31.3	14.0	27.5	7.0	18.7	32.3	19.3
9	29.3	33.3	34.0	19.7	45.4	27.7	8.0	11.7	16.0	15.7	2.7	38.8	16.7
10	28.7	35.7	31.9	15.2	45.7	33.0	19.3	5.3	3.0	18.7	3.8	33.3	18.3
11	22.0	36.3	24.9	24.7	40.8	29.4	36.0	32.0	12.3	19.0	9.5	31.0	6.3
12	17.7	37.7	28.5	23.9	38.2	15.7	40.3	26.7	11.5	35.7	10.3	19.3	11.7
13	27.5	17.7	36.0	28.0	43.7	21.0	35.7	19.3	19.7	2.7	11.3	14.5	24.0
14	21.3	21.3	35.3	37.0	29.7	12.0	38.0	12.3	33.3	6.3	14.0	15.2	23.3
15	9.7	42.7	19.7	46.5	41.7	16.0	11.3	13.7	15.8	27.0	9.5	22.2	25.7
16	2.3	40.0	20.0	47.0	23.3	23.0	34.0	11.0	24.7	29.7	12.7	6.3	27.7
17	8.3	14.0	10.7	40.9	37 3	23.0	23.0	10.0	26.8	33.5	15.7	21.3	23.3
18	7.2	17.3	19.7	35.9	36.0	12.7	25.7	8.0	7.2	32.7	10.0	20.8	24.7
19	6.7	27.0	22.3	32.0	48.7	31.0	43.7	14.3	23.7	30.3	10.7	18.8	27.7
20	26.2	39.3	18.2	41.7	51.0	20.7	20.7	30.3	29.3	37.7	18.0	20.7	32.0
21	38.7	41.7	20.0	44.8	50.7	41.0	27.0	20.0	28.3	38.7	28.2	8.0	38.0
22	40.5	40.0	26.2	45.7	45.7	25.7	26.3	25.0	36.7	41.3	24.0	14.0	38.0
23	36.3	33.0	27.3	41.1	49.7	33.7	28.7	12.0	24.7	34.8	22.7	13.0	38.3
24	41.0	40.3	25.7	46.4	41.8	9.0	35.7	10.0	8.0	40.0	18.3	11.8	25.3
25	32.7	36.7	17.3	42.3	32.0	24.0	18.3	19.7	19.0	36.7	15.0	16.3	14.3
26	14.2	32.3	9.9	44.2	40.2	34.0	25.3	27.3	21.0	36.3	5.3	17.3	14.2
27	15.7	38.0	20.5	44.8	35.5	37.0	33.0	22.3	28.3	35.0	4.0	24.7	26.3
28	12.3	33.0	31.3	44.0	41.3	40.7	33.7	30.3	31.3	25.7	10.7	35.0	9.3
29	18.7				41.7				34.0				30.6
Mean,	18.43	32.02	24.42	32.73	37.59	25.85	30.84	19.64	22.07	22.59	16.34	21.93	25.06

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	10.5	33.7	4.7	15.7	- -	36.5	16.0	9.0	44.6	16.3	18.0		
2	19.2	18.5	22.0	25.2	- -	34.3	14.3	14.7	26.0	32.3	9.7		
3	19.3	25.0	21.3	17.0	- -	9.5	20.0	4.0	17.6	37.0	12.0		
4	19.0	2.7	25.3	20.5	- -	0.3	9 3	3.7	36.0	36.7	28.7		
5	24.2	—2.2	30.0	37.2	- -	—3.0	—5.0	11.0	26.0	23.7	26.0		
6	3.5	2.0	13.7	32.8	- -	6.0	—13.7	14.7	38.3	20.0	23.0		
7	13.8	16.3	—1.0	39.0	- -	5.0	—10.0	20.7	44.7	25.7	16.7		
8	10.3	26.8	—7.2	19.0	- -	13.0	9.0	21.7	47.7	26.3	13.7		
9	18.8	39.7	—0.3	27.3	- -	35.8	12.0	14.7	30.3	21.3	32.0		
10	2.7	43.0	28.2	34.3	- -	30.8	16.0	6.0	27.3	32.0	24.0		
11	10.0	34.3	38.5	41.3	- -	3.8	20.3	26.0	9.0	2.3	4.3		
12	1.8	25.8	14.8	35.2	- -	12.3	16.7	37.7	0.7	5.3	12.7		
13	6.2	25.7	17.7	17.0	- -	22.3	20.3	—3.7	38.7	14.7	11.3		
14	6.3	30.0	37.3	14.7	- -	32.3	28.0	3.0	42.7	16.7	18.0		
15	4.8	37.0	42.3	13.7	- -	30.8	40.3	9.0	43.3	20.3	23.0		
16	—0.8	19.2	33.3	31.7	- -	34.8	41.3	23.7	41.3	16.7	29.7		
17	7.5	24.2	24.0	12.0	- -	17.5	35.7	23.0	45.0	11.3	28.0		
18	7.2	31.8	31.3	10.3	- -	21.7	36.7	12.7	54.7	14.0	30.0		
19	3.2	38.0	24.7	—0.7	- -	17.3	36.3	17.3	31.7	12.0	36.0		
20	8.0	26.7	34.3	7.3	- -	4.7	37.3	23.0	24.7	14.7	36.0		
21	14.0	37.0	33.3	16.7	- -	13.3	36.3	30.0	31.7	29.0	22.0		
22	24.3	20.3	27.3	31.0	- -	23.0	35.7	28.7	32.0	19.7	21.7		
23	32.8	18.3	34.3	34.0	- -	22.3	31.7	34.0	32.7	6.7	29.0		
24	37.0	29.0	37.7	38.3	- -	13.7	3.7	22.3	39.3	14.3	33.7		
25	33.7	38.7	37.7	40.7	- -	3.3	6.3	23.0	51.3	32.0	13.7		
26	33.7	41.7	30.2	31.7	- -	20.7	11.3	26.0	26.7	27.7	2.0		
27	29.7	34.3	31.0	18.7	- -	27.3	12.3	24.0	18.0	27.3	23.3		
28	32.2	20.7	38.3	28.3	- -	19.0	15.7	23.3	31.3	40.7	36.3		
29				24.0	- -			25.0					
Means,	15.46	26.36	25.17	24.61	- -	18.17	19.07	18.21	33.33	21.32	21.94		

February, 1867.

TABLE I.—*Continued.* Mean Temperature in March.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.
1	40°.1	39°.8	29°.0	41°.7	10°.5	25°.2	22°.7	38°.3	36°.3	19°.2	49°.7	38°.7	28°.3	35°.5
2	27.2	21.7	31.0	33.6	6.8	28.0	30.0	38.7	34.3	22.3	44.8	27.2	17.0	28.0
3	32.8	16.7	22.7	25.3	10.3	20.0	27.2	41.2	39.3	19.7	37.5	17.7	14.7	27.2
4	40.9	17.1	35.6	33.2	12.3	33.0	11 8	38.8	23.5	36.3	33.7	31.7	19.7	21.3
5	46.4	39.3	30.0	37.3	31.8	32.0	7.0	44.7	30.8	35.7	29.3	29.7	41.3	18.2
6	20.3	25.7	17.0	30.0	30.0	3.7	10.3	46.7	29.8	35.8	12.5	31.3	36.3	18.5
7	19.0	15.8	18.3	25.5	17.7	14.0	31.3	33.5	29.3	42.0	10.8	12.8	24.7	26.5
8	27.2	33.5	30.7	24.9	18.2	21.7	37.7	29.7	17.5	28.3	24.8	15.0	17.0	25.6
9	34.8	22.0	37.0	37.7	25.2	21.7	39.5	35.5	13.6	33.3	35.0	22.3	21.7	29.0
10	38.3	31.0	32.8	35.7	24.0	26.2	37.3	36.8	26.7	35.8	31.8	26.0	34.7	43.5
11	34.8	7.3	31.7	35.7	35.2	37.8	34.5	40.0	26.0	28.5	35.0	27.0	21.0	31.7
12	21.8	30.7	31.2	38.5	24.2	20.2	36.3	40.3	31.3	17.6	40.7	36.7	18.2	33.3
13	26.2	18.7	30.0	42.5	17.7	26.3	20.8	33.3	28.7	19.8	46.5	35.3	34.0	38.7
14	29.8	13.7	36.8	38.1	18.2	17.7	20.0	35.0	39.2	22.5	45.8	17.7	35.8	41.2
15	25.3	30.8	26.7	41.3	19.7	22.2	28.8	38.0	17.5	28.2	42.0	18.3	33.7	38.7
16	35.5	35.7	20.5	44.5	31.0	24.5	36.0	27.2	24.5	27.5	30.8	25.2	35.0	40.3
17	34.2	[35.6]	23.3	41.8	34.7	34.3	29.8	22.7	19.3	28.3	26.3	27.3	32.7	37.5
18	34.1	[33.5]	29.7	35.0	21.3	37.7	38.5	(26.2)	6.3	35.3	28.0	26.0	33.5	15.3
19	38.3	[33.5]	30.8	37.2	16.8	33.5	37.3	29.7	14.6	20.0	30.6	31.0	34.6	9.7
20	32.1	[35.1]	37.3	44.1	23.0	28.5	32.2	17.5	23.5	18.2	38.7	35.5	39.5	23.4
21	34.1	[33.7]	36.5	45.7	34.2	24.0	25.0	13.2	32.1	32.8	39.3	26.7	34.8	40.8
22	34.1	[32.2]	36.0	35.3	38.5	28.0	26.8	16.1	20.8	36.8	39.7	24.7	30.1	31.2
23	41.8	[35.7]	37.0	49.7	31.2	42.0	24.0	26.7	23.7	37.8	37.3	36.0	28.1	35.8
24	39.6	[37.0]	38.0	50.5	29.5	25.5	24.5	36.2	35.3	37.0	42.8	36.0	47.2	37.7
25	40.6	[35.2]	36.5	40.5	28.0	13.3	24.5	36.5	31.7	43.3	41.9	32.2	48.7	33.2
26	38.2	[35.6]	33.3	33.0	40.2	21.0	31.8	25.3	38.2	30.2	28.6	35.0	46.9	36.9
27	47.8	[35.1]	38.8	32.7	41.7	30.7	49.0	34.5	39.3	29.7	31.5	23.2	41.3	36.4
28	34.2	20.8	41.5	31.9	37.8	38.4	40.0	39.5	39.7	35.3	31.2	17.7	43.3	22.7
29	30.2	34.7	37.3	33.3	33.3	42.3	38.2	29.3	22.8	33.0	32.8	26.8	34.4	29.0
30	40.6	26.4	27.7	38.0	34.0	39.2	43.7	32.2	25.5	36.2	41.7	33.2	25.3	30.9
31	37.2	36.7	29.5	36.8	34.5	38.7	47.7	33.3	38.6	39.1	42.3	36.6	28.0	41.8
Mean,	34.11	29.04	31.39	37.12	26.18	27.45	30.46	32.79	27.73	30.50	34.97	27.76	31.65	30.98

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	45.0	9.7	13.3	38.0	29.3	30.7	19.3	20.6	17.7	43.3	18.7	8.7	38.3	14.7
2	43.1	19.0	14.7	38.7	33.3	27.7	33.3	25.0	23.7	42.7	22.5	17.0	31.7	16.7
3	42.7	6.7	31.3	41.0	33.0	12.7	39.0	23.7	25.0	44.0	45.7	4.3	20.5	15.3
4	40.3	3.0	38.7	39.0	33.0	14.0	38.3	40.0	39.3	44 0	35.3	10.0	22.3	22.7
5	38.9	29.5	40.3	37.0	37.5	20.7	28.7	42.0	32.7	48.0	38.0	10.0	42.0	24.0
6	45.7	41.7	33.7	40.3	38.2	30.7	32.3	21.7	42.3	41.3	37.3	15.7	45.7	27.3
7	32.0	30.5	41.7	40.3	29.3	39.7	33.3	21.7	46.3	42.0	27.7	13.7	39.7	29.3
8	19.8	27.5	40.0	39.3	30.3	33.0	22.7	24.3	41.3	26.7	24.0	33.8	42.8	32.7
9	17.7	30.5	30.7	40.0	37.3	36.7	37.7	32.3	20.7	30.0	31.2	38.3	28.3	29.7
10	26.9	18.0	29.7	35.3	36.8	41.0	41.3	38.0	36.0	37.0	48.3	28.7	22.3	33.3
11	34.3	20.4	31.9	30.7	35.5	35.3	35.7	40.3	39.7	37.0	41.0	30.7	40.0	37.0
12	37.0	30.5	(33.9)	38.7	29.3	40.5	37.0	34.7	28.7	43.7	42.2	41.0	42.7	34.0
13	22.7	25.6	35.8	43.3	33.0	45.0	38.7	40.0	39.3	42.0	48.3	34.7	30.7	45.0
14	25.8	26.5	32.7	38.3	28.0	29.7	37.7	19.3	46.0	38.3	21.7	27.3	29.0	39.0
15	31.5	31.7	32.3	41.3	31.0	31.0	26.7	17.3	27.0	39.0	23.0	42.0	35.0	43.7
16	36.8	22.3	20.3	42.3	37.7	32.7	29.0	24.3	31.0	45.3	38.5	32.0	36.3	47.7
17	33.7	30.7	27.0	41.0	23.3	33.0	31.3	33.7	42.0	38.0	38.3	33.0	38.7	34.0
18	38.8	31.8	26.3	41.0	18.7	35.7	37.3	31.7	44.7	27.7	24.0	40.0	43.0	22.3
19	30.4	36.3	28.7	37.0	28.3	45.0	41.2	36.0	38.2	37.0	23.0	46.3	47.0	33.3
20	38.2	30.7	34.0	49.3	36.0	30.0	40.3	36.0	41.0	31.3	32.0	45.3	44.7	36.0
21	34.3	27.7	16.7	31.0	37.7	27.0	38.7	37.0	40.7	28.7	41.7	46.2	39.3	38.0
22	32.2	24.3	(23.2)	26.3	39.0	38.0	25.7	29.3	47.3	44.3	26.3	49.8	23.7	20.8
23	35.1	34.8	29.9	34.0	42.0	42.0	37.7	34.0	27.3	47.7	36.5	48.3	32.7	23.7
24	33.5	49.7	34.7	40.7	43.3	28.0	36.3	38.7	37.3	50.2	45.3	41.3	35.7	25.7
25	35.3	31.7	37.3	30.0	37.3	30.7	43.3	36.0	35.3	49.7	47.8	43.8	38.0	22.7
26	41.5	33.3	37.8	32.0	35.3	46.3	40.3	31.7	33.0	47.0	46.3	44.7	29.0	34.8
27	36.0	41.3	38.1	30.0	31.3	51.3	39.0	41.0	36.0	38.0	28.8	33.3	24.3	45.0
28	42.0	36.0	38.7	29.3	36.3	53.0	50.7	49.0	41.7	42.5	31.3	29.3	37.0	33.7
29	32.5	39.7	40.5	32.7	40.0	30.0	43.0	51.3	43.7	41.3	33.7	33.5	49.0	33.7
30	30.5	36.5	42.7	40.7	25.7	31.0	42.0	48.0	43.3	50.0	37.5	38.7	20.3	35.3
31	31.8	30.6	39.5	41.3	27.3	35.3	44.3	43.0	43.0	51.5	48.0	45.7	24.0	42.0
Mean,	34.38	28.65	32.13	37.42	33.37	34.09	36.19	33.59	36.48	40.92	34.94	32.48	34.84	31.70

TABLE I.—*Continued.* Mean Temperature in March (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	36°.3	12°.3	34°.8	42°.5	39°.2	45°.3	36°.0	30°.3	37°.0	25°.5	6°.3	20°.7	17°.0
2	22.3	12.7	30.2	45.2	46.7	42.3	42.7	22.7	38.3	29.3	11.0	18.0	14.0
3	15.0	20.7	34.0	22.0	43.0	42.3	46.7	18.0	39.0	37.7	18.8	20.7	21.0
4	29.0	25.7	39.5	18.3	47.7	33.7	46.0	19.7	27.7	29.6	33.0	26.7	20.7
5	38.0	28.0	37.5	22.7	47.7	21.0	36.0	23.0	17.3	35.3	37.7	28.7	25.0
6	23.8	28.7	46.7	28.8	42.3	26.7	30.7	23.0	28.0	35.3	27.7	27.5	19.7
7	25.7	43.3	42.0	43.2	33.2	42.3	33.7	22.7	26.3	33.3	23.2	25.5	27.7
8	28.7	44.0	41.0	41.7	32.7	34.7	33.3	27.7	34.7	33.7	29.0	37.0	40.7
9	26.0	46.3	36.3	45.3	43.3	33.3	44.7	29.3	41.3	36.5	34.8	27.3	43 0
10	40.0	45.7	39.2	34.0	39.5	34.6	37.7	30.0	30.0	31.3	25.3	26.3	28.7
11	40.0	45.3	49.8	30.8	28.0	32.3	32.0	36.7	34.0	23.3	29.3	22.0	26.0
12	19.2	44.3	48.3	43.8	28.0	24.3	22.0	34.7	35.0	23.0	38.0	19.7	25.5
13	19.3	52.0	41.1	44.7	33.5	33.3	30.3	34.7	40.7	34.7	46.0	20.8	39.7
14	38.0	53.0	45.2	47.5	31.7	34.0	34.0	32.3	39.0	32.3	43.0	25.3	19.0
15	30.3	38.0	50.8	37.2	35.0	23.0	35.0	34.3	27.0	31.7	37.0	26.3	12.2
16	24.5	40.3	50.3	43.5	40.7	23.0	35.3	31.7	32.3	22.0	32.0	19.7	7.3
17	29.0	35.3	44.7	40.8	42.7	22.3	45.7	35.0	33.3	17.3	34.2	20.0	21.0
18	35.3	49.7	39.7	42.0	42.0	31.0	43.3	38.0	36.0	26.3	30.7	26.3	25.3
19	22.2	40.0	40.3	41.3	46.3	45.3	48.3	36.3	24.7	20.7	38.5	31.0	24.0
20	24.9	31.7	47.0	31.0	44.8	50.7	43.3	36.0	33.3	28.0	50.7	30.7	39.1
21	27.3	38.7	47.0	40.3	42.6	43.7	36.7	28.3	33.3	21.3	42.5	41.3	45.7
22	33.0	42.3	40.8	41.7	32.0	39.0	32.7	26.0	23.3	26.3	39.0	23.7	39.7
23	38.3	53.0	48.3	45.3	34.3	41.3	30.7	26.3	24.5	34.3	36.3	29.0	30.0
24	31.7	46.7	51.0	44.3	34.5	39.7	31.7	32.3	30.7	41.3	38.0	35.3	29.0
25	36.3	47.7	40.0	39.9	37.3	41.0	35.0	32.0	36.7	33.0	36.3	37.3	34.0
26	32.7	46.3	41.7	39.5	34.0	43.7	34.3	29.0	38.0	30.0	40.3	38.3	40.3
27	39.3	45.3	36.0	55.0	45.7	49.7	42.0	33.3	21.0	43.0	42.0	39.0	35.3
28	42.7	48.7	34.3	46.8	51.0	45.3	37.3	39.0	31.0	36.8	42.0	22.7	38.0
29	35.2	48.3	46.0	41.1	52.7	33.0	37.7	34.0	37.3	35.3	40.3	22.3	43.3
30	40.0	34.3	45.0	38.3	50.3	24.7	41.3	33.7	20.3	43.0	40.0	22.7	43.0
31	42.3	39.0	41.8	42.7	50.7	26.3	36.7	35.7	22.0	41.7	40.0	26.0	44.7
Mean,	31.17	39.58	42.27	39.40	40.44	35.58	37.18	30.50	31.39	31.39	34.29	27.08	29.64

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	37.3	34.7	21.7	23.7	- -	29.2	22.0	27.0	19.3	41.7	12.7		28 4
2	23.8	29.5	34.7	20.3	- -	37.3	24.7	24.0	17.3	31.7	10.0		27.6
3	16.8	12.3	31.3	12.3	- -	31.3	36.0	20.7	25.3	20.7	13.3		
4	18.7	12.3	28.7	20.0	- -	39.2	29.0	19.7	36.0	19.0	28.3		
5	19.3	15.3	37.2	28.0	- -	34.0	36.0	23.0	32.7	15.3	26.7		
6	22.3	35.8	40 2	28.0	- -	26.3	42.0	26.0	36.3	13.3	34.0		
7	32.0	38.0	39.7	29.0	-	26.0	22.3	19.7	22.3	13.7	29.7		
8	32.0	35.7	24.7	30.8	- -	31.0	23.3	24.3	19.7	20.3	22.7		
9	32.0	29.5	28.7	40.0	- -	37.3	29.0	6.7	27.7	24.7	29.7		
10	26.0	21.8	28.3	39.0	- -	39.0	22.3	—2.0	22.3	24.3	24.3		
11	26.8	28.0	32.0	38.3	- -	36.7	30.3	13.3	18.7	26.7	28.7		
12	29.0	25.7	18.7	41.7	- -	33.0	30.3	6.3	29.7	27.3	41.0		
13	35.7	34.3	15.5	45.7	- -	47.3	29.7	22.7	22.3	24.7	42.7		
14	31.2	45.3	17.7	35.3	- -	34.0	22.7	27.7	38.7	31.0	39.0		
15	34.0	42.7	41.3	41.3	- -	34.7	26.7	32.7	33.0	39.3	41.3		
16	37.7	32.8	26.7	39.0	- -	42.7	37.7	31.7	42.7	42.0	36.7		
17	39.0	30.3	26.7	35.7	- -	35.7	34.0	30.3	43.3	44.3	36.7		35.6
18	40.5	32.0	30.0	37.0	- -	17.0	37.7	33.7	39.7	48.7	38.3		33.5
19	28.3	19.7	32.3	40.3	- -	18.3	29.0	27.7	45.0	38.7	42.3		33.5
20	38.7	23.0	36.7	27.3	- -	22.3	35.3	39.0	40.7	36.7	29.7		35.1
21	44.3	27.3	40.3	24.0	- -	17.3	27.3	32.7	34.7	43.0	35.0		33.7
22	32.3	33.3	37.3	36.0	- -	19.7	23.7	35.3	33.0	35.0	32.7		32.2
23	28.7	32.7	35.7	29.3	- -	34.7	25.3	34.3	37.3	28.7	35.7		35.7
24	36.0	33.7	36.0	36.3	- -	35.7	38.0	31.7	45.0	33.3	37.0		37.0
25	35.7	29.3	34.7	40.3	- -	22.0	20.3	32.3	44.7	36.0	32.7		35.2
26	39.7	32.0	31.0	42.0	- -	20.3	36.3	31.7	43.0	34.0	36.3		35.6
27	39.3	34.7	43.3	40.7	- -	20.3	33.7	32.7	45.0	38.7	42.3		35.1
28	39.3	34.0	42.7	42.0	- -	20.3	24.3	20.7	45.0	39.7	39.3		
29	44.3	37.0	36.7	31.0	- -	21.7	31.0	23.3	45.0	46.0	41.7		
30	50.7	36.5	40.8	26.3	- -	26.0	39.3	28.0	41.3	44.7	39.3		
31	52.3	38.7	44.0	37.0	- -	33.5	40.7	25.3	46.3	43.7	36.0		
Mean,	33.77	30.58	32.74	33.57	- -	29.83	30.33	25.18	34.61	32.47	32.16		

TABLE I.—*Continued.* Mean Temperature in April.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.
1	41°.7	47°.0	33°.0	36°.8	36°.0	35°.3	43°.0	33°.5	42°.3	40°.3	37°.0	26°.7	36°.2	35°.2
2	42.7	42.0	37.0	29.1	39.7	31.9	45.3	28.7	38.3	44.7	38.3	35.7	29.7	37.8
3	42.2	39.0	33.5	37.8	40.5	39.8	43.0	34.0	32.2	44.7	38.0	43.0	24.6	30.7
4	43.2	44.3	34.7	43.7	37.7	36.2	41.5	37.8	37.5	38.8	41.9	42.7	29.8	30.3
5	40.2	34.3	39.3	39.3	39.2	40.0	46.3	41.8	42.5	37.2	32.0	43.8	34.9	36.4
6	43.3	37.4	39.8	41.7	38.5	45.7	46.9	37.5	45.0	38.3	38.0	39.2	37.3	38.1
7	42.7	35.9	51.3	36.3	34.7	43.2	39.7	42.7	38.2	37.8	44.2	31.9	33.4	44.7
8	36.8	30.8	42.5	43.0	38.3	44.5	41.3	36.0	39.6	41.3	39.3	39.6	42.5	43.5
9	39.0	32.1	34.3	43.5	36.0	39.3	42.7	39.0	48.7	39.3	40.2	33.4	36.7	38.3
10	35.7	35.2	40.2	45.7	43.2	53.3	44.7	40.8	28.8	45.2	41.0	32.7	33.2	38.8
11	36.3	43.2	44.0	41.7	47.7	36.2	47.0	42.0	29.8	32.9	45.2	37.2	39.7	39.7
12	40.2	39.7	47.2	40.5	34.8	35.5	41.3	44.5	34.0	37.5	48.6	41.9	43.2	34.3
13	47.0	37.7	38.3	39.7	35.2	38.3	41.0	48.2	40.3	43.0	43.0	48.3	43.2	40.7
14	48.7	38.3	49.0	52.7	38.8	53.7	44.7	33.4	41.7	45.3	43.1	47.8	42.0	47.9
15	45.7	41.3	50.3	49.2	42.5	48.0	38.8	35.0	35.2	42.0	45.7	50.3	44.1	45.5
16	41.9	43.2	47.7	52.0	44.7	41.7	43.8	45.7	35.8	44.5	37.4	47.0	39.8	36.5
17	42.6	49.2	44.7	56.5	45.3	42.7	45.2	42.0	38.7	51.2	46.8	43.7	47.8	37.2
18	45.3	56.3	52.0	57.5	55.8	42.5	39.3	45.0	39.7	34.0	38.7	34.2	55.7	36.2
19	53.7	44.0	55.8	53.9	52.7	46.3	42.8	42.0	39.3	33.0	44.4	32.8	58.9	40.8
20	53.8	43.8	56.2	50.3	49.5	50.3	38.9	47.7	44.5	41.2	41.1	41.7	58.2	45.8
21	50.5	51.0	53.3	49.7	42.3	51.7	42.5	47.0	44.0	42.7	40.8	49.0	57.8	45.0
22	46.8	53.7	45.5	42.4	39 2	45.5	46.3	44.8	42.3	39.8	40.6	46.7	44.3	44.7
23	46.1	51.8	45.2	44.8	46.3	43.2	44.2	39.3	47.2	49.7	43.7	47.7	54.8	47.7
24	42.9	53.3	47.0	43.6	42.2	38.8	34.0	43.3	47.5	38.3	49.0	45.8	47.5	49.7
25	48.3	45.0	57.3	47.0	48.7	44.0	34.7	40.0	49.7	39.8	51.7	47.0	52.5	45.5
26	42.8	43.3	54.2	48.2	47.2	53.2	66.2	53.2	51.0	42.3	54.2	39.0	48.3	47.8
27	54.0	40.3	49.3	52.5	46.7	56.6	62.5	62.8	49.8	49.0	50.0	40.5	45.8	48.0
28	54.3	38.7	55.2	49.8	41.3	51.0	52.3	52.7	57.3	48.7	45.8	47.3	51.0	45.3
29	62.3	46.5	49.3	51.2	43.8	43.7	47.2	40.6	52.7	49.8	48.5	56.0	50.5	48.7
30	51.6	51.0	49.0	49.8	43.0	45.0	52.8	43.5	63.2	52.0	47.5	58.7	50.2	52.1
Mean,	45.40	42.98	45.87	45.66	42.36	43.90	44.67	42.15	42.56	42.16	43.18	42.37	43.78	41.76

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	39.6	43.7	35.0	40.3	40.3	34.3	39.3	47.0	50.3	49.7	49.8	51.0	41.0	4[illegible].7
2	31.0	41.8	43.3	39.3	41.0	52.3	39.7	39.7	47.7	49.0	37.3	49.3	47.0	47.3
3	39.8	40.0	44.3	36.3	38.7	61.7	45.7	44.3	47.7	44.7	40.5	48.7	43.7	44.7
4	35.7	29.7	48.0	44.3	49.3	58.0	37.0	41.7	44.5	46.7	32.7	45.7	41.3	37.3
5	35.5	26.3	43.1	44.4	41.6	63.3	41.3	45.3	43.3	48.0	30.3	47.7	41.0	38.7
6	31.3	38.0	44.7	48.7	36.2	58.7	39.0	42.5	45.3	48.0	30.3	49.7	47.3	42.8
7	38.7	45.3	36.0	49.0	37.2	49.3	35.7	42.3	44.3	54.0	39.0	50.0	45.5	41.0
8	43.3	45.0	37.7	46.7	38.7	46.0	41.3	45.7	46.3	41.5	27.3	46.7	49.3	47.3
9	33.2	36.1	42.7	48.7	43.3	46.0	41.3	45.7	52.0	44.6	27.3	48.7	51.7	54.0
10	34.2	31.7	42.3	60.0	31.5	56.0	48.7	39.3	52.8	42.7	41.0	48.3	46.0	47.3
11	42.2	31.0	41.7	52.0	21.3	60.3	44.0	48.7	41.0	47.3	44.3	44.3	50.8	44.3
12	39.6	30.7	43.2	42.0	24.0	54.3	41.0	46.3	45.0	35.0	49.0	42.0	61.0	45.3
13	37.2	40.3	(42.3)	47.7	38.3	53.3	34.3	46.0	41.3	42.7	54.0	41.5	61.7	44.7
14	36.7	39.3	41.3	39.3	41.7	55.3	37.7	49.3	46.0	43.8	43.7	47.7	51.3	38.7
15	38.2	35.3	40.7	56.7	54.0	46.7	41.3	49.8	54.8	56.0	42.8	33.7	67.2	35.7
16	38.2	44.3	40.7	65.3	40.7	48.0	45.7	48.3	57.7	48.0	41.0	39.7	56.7	42.3
17	40.6	47.3	(41.8)	61.0	46.3	42.3	45.0	58.0	55.7	48.0	38.3	41.3	55.3	35.0
18	41.2	52.3	(42.8)	61.7	51.0	36.0	47.7	50.7	51.0	55.7	44.7	51.0	45.3	31.3
19	39.7	43.7	(44.0)	57.0	48.2	34.7	48.3	46.7	68.0	58.0	45.3	46.0	44.7	39.7
20	40.0	48.0	45.0	43.7	48.0	36.0	38.7	48.3	69.7	54.0	38.8	63.0	49.7	46.7
21	40.7	44.5	48.3	36.0	48.0	48.3	42.3	52.7	71.3	48.7	45.0	52.0	49.7	45.0
22	41.3	36.7	46.7	48.3	41.0	54.3	42.7	49.3	77.3	48.8	42.8	50.0	43.8	48.7
23	37.0	45.7	(47.3)	58.3	39.7	43.3	45.0	53.3	64.3	48.0	35.0	39.7	39.3	44.7
24	43.1	38.3	48.0	53.7	43.2	40.7	44.3	44.7	45.0	55.0	40.8	38.7	40.7	44.0
25	45.2	41.4	49.0	61.7	46.3	45.3	44.7	45.7	42.3	46.0	47.7	45.7	37.7	46.3
26	49.2	53.0	52.7	65.3	49.3	45.0	39.7	41.7	57.3	49.7	62.2	44.7	40.7	46.5
27	44.3	40.7	49.0	68.7	51.0	47.0	40.0	46.7	49.3	56.0	62.3	47.0	41.7	51.3
28	49.3	42.7	47.0	56.3	46.7	53.0	52.7	47.7	56.7	46.3	40.3	55.0	48.3	41.7
29	54.2	43.0	48.3	50.7	44.0	46.0	55.0	52.0	58.7	44.3	46.7	69.7	48.0	47.7
30	54.7	42.8	47.7	57.7	47.7	40.0	53.3	47.3	66.0	52.7	48.0	66.3	50.7	50.7
Mean,	40.49	40.62	44.16	51.35	42.27	48.52	43.08	46.89	53.09	48.46	42.44	48.14	47.93	43.97

TABLE I.—*Continued.* Mean Temperature in April (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	47°.7	44°.7	42°.5	47°.7	47°.7	41°.0	25°.3	37°.7	26°.3	43°.0	36°.0	23°.7	43°.8
2	45.3	42.0	42.0	45.7	43.3	41.0	41.7	29.7	31.7	39.3	38.3	33.7	35.3
3	41.7	46.0	42.8	42.7	48.2	37.0	52.0	35.0	33.0	32.7	40.7	36.3	33.7
4	43.3	42.7	49.8	54.8	51.0	45.0	37.3	32.7	53.7	35.0	36.0	37.7	38.7
5	35.3	45.7	50.5	52.7	49.5	47.0	34.7	39.3	43.0	29.7	44.3	39.7	42.7
6	34.3	51.0	52.2	50.3	43.3	40.9	43.0	41.3	41.7	32.3	50.0	39.7	39.3
7	37.7	51.3	49.2	64.7	37.0	42.0	48.3	43.3	43.3	37.3	48.3	36.0	37.3
8	41.7	50.3	47.8	47.9	40.3	42.3	38.0	46.0	48.0	33.7	49.7	43.3	43.0
9	49.0	51.3	52.0	41.0	43.3	42.3	41.3	48.0	53.3	33.2	39.0	41.7	49.0
10	43.3	51.0	52.5	51.4	51.0	35.3	42.7	42.7	55.0	35.0	42.3	36.0	47.3
11	31.0	54.0	45.2	60.0	55.7	39.0	51.3	44.0	50.0	37.0	49.5	30.3	46.7
12	27.0	57.3	46.2	53.3	53.0	37.7	43.0	43.3	46.0	34 0	43.7	32.3	44.0
13	36.0	51.7	52.3	45.7	54.2	31.8	44.0	45.7	58.0	35.7	39.3	36.3	39.7
14	41.0	48.0	37.7	43.0	52.7	41.0	41.0	53.3	64.0	41.8	38.0	40.7	42.2
15	43.3	55.3	40.7	43.7	57.4	42.7	44.3	51.7	53.3	43.3	37.3	41.0	49.3
16	43.3	44.7	34.0	47.8	54.7	42.2	45.3	53.3	46.7	38.2	39.3	34.0	49.3
17	43.3	50.0	44.0	49.3	59.0	45.0	43.3	46.3	48.7	38.7	47.7	35.3	44.0
18	47.3	53.7	47.0	48.7	61.0	48.7	44.7	47.3	36.7	44.7	50.7	31.7	37.3
19	50.7	48.7	51.0	62.3	54.3	36.8	41.3	48.3	36.7	43.5	51.8	32.3	35.0
20	44.7	51.7	45.2	46.8	54.3	41.7	48.3	47.7	50.7	36.7	48.0	45.7	40.7
21	50.3	48.7	44.7	46.4	48.7	42.0	51.3	52.3	52.0	48.3	53.7	41.7	46.3
22	39.3	47.7	50.8	51.8	50.8	46.3	62.7	51.0	56.3	56.3	47.3	50.7	52.7
23	40.7	53.3	40.2	58.2	65.0	45.7	52.0	47.0	47.7	50.7	56.0	37.3	48.0
24	46.0	54.3	38.8	60.0	68.0	58.0	51.3	50.0	50.3	54.3	55.7	38.0	50.0
25	35.3	49.7	44.9	61.5	66.7	42.0	54.0	51.3	53.3	51.3	39.7	40.0	44.3
26	42.7	59.7	42.1	58.3	64.3	47.7	45.0	53.7	54.0	42.0	47.6	49.0	48.0
27	51.0	61.3	59.3	64.2	48.5	46.7	45.7	48.7	41.5	43.0	56.0	45.3	48.0
28	47.7	61.7	59.3	53.2	52.5	49.3	49.3	52.0	51.3	51.0	54.7	35.8	50.3
29	43.0	61.7	58.3	55.0	52.7	55.3	47.0	46.0	50.3	44.0	53.0	36.7	46.7
30	52.7	57.0	53.0	51.0	62.7	43.3	48.3	49.7	47.3	47.3	47.0	44.7	49.2
Mean,	42.52	51.53	47.19	51.96	53.02	43.23	45.25	45.94	47.46	41.10	46.02	38.22	44.06

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	34.0	42.3	41.3	38.0	- -	37.0	41.0	31.0	52.7	45.0	35.0		39.9
2	30.7	45.3	36.7	34.7	- -	31.7	19.0	32.0	22.7	45.3	36.0		38.6
3	40.0	47.0	43.0	31.7	- -	25.3	26.0	38.3	31.7	52.3	37.0		
4	51.8	33.3	42.7	35.0	- -	32.3	32.0	43.7	41.3	44.3	33.7		
5	45.7	31.0	40.3	33.7	- -	40.0	42.7	44.7	50.0	48.7	28.0		
6	42.7	33.7	45.8	33.3	- -	46 7	42.3	41.0	53.7	45.3	30.7		
7	44.3	38.0	46.7	38.3	- -	40.0	37.7	44 7	40.7	31.3	38.7		
8	49.0	43.7	43.7	39.3	- -	34.7	37.7	48.3	41.0	40.7	42.0		
9	43.7	25.7	44.5	38.0	- -	37.3	40.3	45.7	48.0	40.7	37.7		
10	38.0	29.7	47.3	42.8	- -	38.3	42.0	44.3	45.0	46.0	33.3		
11	41.3	34.0	38.7	43.0	- -	37.0	41.3	39.3	55.3	41.0	33.3		
12	42.3	35.0	33.2	39.3	- -	34.7	39.7	43.3	49.3	42.0	37.0		
13	43.3	38.3	36.0	38.0	- -	36.7	39.7	28.7	51.7	44.0	43.0		
14	35.3	33.5	38.0	41.0	- -	31.3	36.3	41.0	46.7	44.0	37.3		
15	25.0	28.7	48.3	33.5	- -	33.3	47.0	48.3	47.0	52.0	38.7		
16	26.8	28.7	38.3	36.7	- -	33.3	45.7	41.7	42.7	55.7	36.7		
17	36.3	29.0	40.0	43.0	- -	35.7	49.0	48.3	39.7	48.7	39.7		
18	37.0	30.7	36.7	40.8	- -	35.3	53 3	45.7	47.3	48.0	40.7		
19	38.3	37.7	38.0	42.7	- -	42.7	50.0	43.7	48.3	44.7	43.3		
20	42.0	41.3	36.0	40.7	- -	43.3	45.3	41.7	47.3	47.7	43.3		
21	38.3	43.0	40.0	43.0	- -	42.7	47.7	39.7	43.3	37.7	43.3		
22	39.0	43.7	47.7	43.2	- -	42.7	48.0	45.3	46.0	47.3	44.3		
23	41.0	49.0	51.7	46.7	- -	45.0	46.7	48.3	48.3	44.3	43.0		
24	47.3	39.0	49.0	45.8	- -	42.0	54.7	52.3	54.7	47.7	44.0		
25	42.3	48.7	48.0	47.0	- -	42.7	50.7	52.3	51.3	45.7	44.0		
26	43.3	57.0	48.7	49.7	- -	46.3	42.0	44.3	49.3	42.3	39.0		
27	37.5	51.8	50.7	47.3	- -	49.0	43.0	49.7	48.0	39.0	44.0		
28	42.7	53.3	46.3	43.3	- -	42.7	38.3	49.3	50.7	40.3	42.7		
29	49.0	53.7	49.3	47.2	- -	40.0	38.0	51.3	46.3	49.7	46.7		
30	44.3	55.3	49.0	47.7	- -	49.0	43.7	49.7	46.0	46.3	51.7		
Mean,	40.42	40.03	43.18	40.81	- -	38.95	42.02	43.92	46.20	44.92	39.25		

TABLE I.—*Continued.* Mean Temperature in May.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816	1817.	1818.	1819.	1820.	1821.
1	59°.2	48°.0	58°.7	43°.3	44°.0	47°.5	54°.3	48°.7	59°.3	58°.0	53°.4	59°.5	60°.2	56°.7
2	53.9	51.0	54.7	47.7	43.7	45.7	45.8	45.0	42.8	58.3	55.3	47.7	49.3	60.0
3	55.6	52.7	49.5	53.5	40.0	42.3	38.7	39.2	56.3	57.7	51.6	60.8	46.8	53.5
4	55.5	50.5	50.7	53.0	38.0	43.6	48.8	43.3	44.2	46.3	47.6	65.5	55.8	51.3
5	55.0	45.6	48.6	56.5	37.2	51.5	48.8	51.7	44.8	47.0	49.0	62.3	51.3	38.6
6	52.5	56.3	46.7	57.8	44.5	49.0	49.2	49.8	54.5	53.2	53.2	56.3	55.7	39.5
7	52.8	53.3	42.6	61.2	44.8	47.5	47.5	46.7	53.5	57.7	52.0	49.7	56.2	51.3
8	43.7	50.2	50.0	56.2	49.5	40.6	53.2	37.8	50.2	57.0	55.5	53.5	54.7	57.3
9	49.1	51.3	52.0	54.7	47.3	46.8	52.5	49.2	45.2	55.0	57.4	52.6	48.8	59.3
10	49.6	49.2	53.5	50.0	47.8	54.3	49.9	50.3	48.3	52.2	56.7	51.8	57.8	54.1
11	50.7	49.3	52.0	51.8	46.3	52.2	53.8	52.5	52.2	58.0	56.3	49.3	65.5	50.0
12	45.1	50.3	50.8	59.2	48.5	50.0	54.5	54.7	46.0	50.0	50.3	48.7	55.8	60.7
13	47.5	46.7	53.2	51.8	54.8	46.7	54.5	53.8	53.3	41.7	56.4	50.7	55.7	59.8
14	49.4	48.0	49.0	52.3	52.3	45.0	51.8	45.2	46.5	49.5	57.3	50.7	55.5	57.2
15	53.6	47.3	50.0	52.8	51.0	45.0	47.7	47.8	43.4	48.8	58.7	57.3	60.2	56.1
16	55.3	52.0	50.3	59.0	44.8	48.7	47.3	54.0	51.3	45.0	56.3	56.3	55.3	61.8
17	46.1	54.3	49.0	53.5	52.7	54.8	55.2	51.2	46.0	51.0	55.1	50.2	51.7	59.7
18	49.6	59.6	55.3	54.5	39.7	47.5	59.0	53.7	46.3	49.5	59.2	52.3	50.4	53.0
19	50.9	63.1	59.7	57.7	46.7	42.8	64.8	39.3	54.7	55.5	48.4	50.7	53.1	55.3
20	61.4	63.3	57.3	51.0	51.5	49.0	62.7	45.8	60.5	50.3	47.4	53.7	51.6	52.7
21	53.3	62.7	53.7	50.8	51.4	54.4	56.7	56.7	59.9	59.0	52.5	62.7	56.9	57.3
22	48.8	58.3	56.7	57.7	48.2	52.6	61.3	61.7	63.0	55.5	55.7	54.2	58.7	53.0
23	56.0	62.5	57.5	59.5	55.0	54.2	60.8	59.3	44.2	57.8	58.2	56.5	67.9	56.6
24	54.0	61.0	62.9	54.1	55.0	60.3	60.2	57.7	48.0	62.3	70.0	50.2	60.6	59.2
25	46.5	67.0	68.3	55.6	56.7	64.6	69.2	62.3	51.5	59.7	74.2	52.6	53.1	59.0
26	48.7	61.0	67.8	61.0	55.3	52.5	72.5	61.3	(52.6)	54.8	71.5	50.2	45.7	55.2
27	55.3	56.7	66.7	62.7	49.7	55.8	65.2	59.7	(53.7)	47.7	70.8	43.7	50.5	61.3
28	54.3	54.8	71.8	52.3	50.7	54.3	62.2	61.3	(54.8)	46.0	66.5	52.7	53.0	73.3
29	52.3	51.0	64.3	52.8	60.0	61.7	64.5	63.3	(55.9)	49.5	70.2	59.5	57.5	62.5
30	62.5	59.7	56.7	51.9	62.1	62.0	54.5	62.7	(57.0)	47.7	72.2	59.0	54.1	66.9
31	64.1	61.7	55.8	57.8	60.0	63.3	53.0	56.7	(58.0)	46.9	66.7	59.0	53.5	66.5
Mean,	52.65	54.79	55.36	54.69	49.32	51.16	55.50	52.36	51.54	52.50	58.23	54.17	54.93	56.73

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	53.3	42.2	48.7	50.3	37.3	35.3	56.3	56.0	58.0	53.3	42.3	57.0	53.7	48.3
2	58.3	33.3	49.3	43.0	52.0	38.3	53.7	58.7	59.0	57.0	46.2	58.7	53.7	50.3
3	53.5	56.7	50.7	46.0	50.3	47.0	53.3	51.3	62.5	60.3	53.0	50.7	55.3	53.0
4	45.8	51.7	60.3	51.7	71.0	60.3	63.0	46.3	67.7	54.0	46.0	54.0	56.7	50.7
5	48.3	36.7	66.0	48.7	48.0	54.7	57.7	59.3	67.7	52.2	49.8	52.3	51.0	45.7
6	48 2	37.3	62.7	54.7	56.3	56.3	55.7	69.3	64.7	52.7	50.3	53.3	43.7	46.3
7	51.2	52.5	54.0	59.0	56.3	52.3	61.3	61.3	56.7	56.7	48.0	64.7	45.3	52.2
8	52.3	38.3	59.7	54.7	52.7	52.7	55.0	57.7	54.3	54.7	53.7	68.0	55.7	48.3
9	49.9	41.3	56.0	51.0	55.7	57.7	60.7	64.0	49.7	55.3	62.7	59.2	53.7	50.0
10	50.3	43.0	46.0	61.7	58.7	57.7	57.0	52.3	51.7	46.7	57.5	49.0	49.3	54.3
11	52.7	47.7	47.3	55.7	56.3	41.3	55.0	59.0	55.7	52.7	55.7	53.0	51.0	58.3
12	55.0	51.7	47.0	65.7	57.0	39.7	55.3	54.7	66.0	64.0	65.2	60.3	51.3	59.7
13	57.2	53.7	54.7	64.3	77.3	47.0	62.0	51.3	59.3	61.3	61.8	61.7	49.0	50.3
14	59.3	45.3	46.3	60.3	74.0	55.3	55.7	59.3	59.7	63.5	63.3	57.0	47.7	48.7
15	59.2	53.7	48.7	56.7	79.0	55.0	56.3	61.7	60.0	61.7	66.3	63.7	42.7	46.0
16	55.3	58.3	52.0	54.0	86.2	59.3	53.2	62.0	58.7	61.3	67.0	62.0	49.3	49.0
17	57.8	49.0	48.0	56.3	79.7	64.0	60.7	61.7	57.0	63.3	62.0	63.3	52.0	49.7
18	59.2	59.7	51.7	62.3	58.7	61.0	61.3	(63.8)	56.3	63.0	59.3	69.3	60.7	54.7
19	59.3	63.3	51.7	62.3	51.0	53.7	60.5	(65.7)	62.7	58.8	51.3	68.0	74.7	61.3
20	59.3	66.3	50.7	60.3	50.0	60.0	50.0	(67.9)	64.3	52.0	49.7	47.7	61.3	70.3
21	58.4	67.3	43.3	67.8	66.0	51.3	48.0	(69.9)	57.7	59.7	50.3	53.3	62.0	56.7
22	60.0	51.2	54.7	65.7	66.3	51.0	47.7	(72.1)	55.8	64.7	46.7	67.7	62.7	54.7
23	68.2	52.7	60.3	65.7	62.0	45.7	67.3	(73.8)	(56.1)	67.0	47.3	62.3	46.0	56.0
24	60.7	52.7	55.3	69.7	58.3	55.0	59.7	75.7	56.5	56.3	48.0	59.7	55.3	62.3
25	53.8	52.7	54.3	69.7	68.0	63.0	61.7	77.2	56.3	56.3	44.8	62.0	59.0	68.0
26	56.5	47.3	46.7	62.3	67.2	68.3	59.0	71.3	59.2	60.3	48.8	56.3	56.0	69.7
27	60.7	51.0	56.3	61.7	58.2	72.7	56.3	70.3	62.6	55.0	46.3	61.7	59.3	65.0
28	73.3	49.7	64.0	55.0	49.0	69.3	58.2	72.5	63.9	64.8	55.0	64.0	56.0	61.7
29	68.0	55.5	56.3	67.0	54.0	58.0	63.0	53.8	64.7	71.0	63.5	61.7	50.3	59.3
30	63.4	56.8	57.0	69.0	63.7	55.7	63 0	58.6	63.6	74.0	58.0	59.7	50.7	69.8
31	63.9	49.3	57.5	67.3	(68.2)	61.0	55.0	62.0	59.6	77.0	60.7	63.3	54.3	63.7
Mean,	57.18	50.57	53.46	59.36	60.91	54.81	57.49	62.59	59.59	59.70	54.21	59.51	53.84	55.91

TABLE I.—*Continued.* Mean Temperature in May (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	67°.0	43°.3	57°.7	59°.3	64°.2	49°.0	54°.3	45°.7	55°.7	53°.5	55°.3	43°.2	53°.3
2	66.0	60.0	62.3	62.2	60.3	53.3	51.3	49.3	59.3	51.3	53.0	47.0	49.3
3	51.0	66.0	50.9	61.3	64.3	43.3	49.3	54.3	61.3	56.0	56.7	45.0	46.3
4	49.7	51.3	50.8	47.7	54.0	42.7	56.3	50.7	53.3	57.3	55.5	46.0	57.7
5	49.3	50.0	47.7	54.3	46.3	49.7	56.7	43.0	56.3	54.7	60.0	53.0	53.0
6	48.7	51.0	53.2	56.3	57.0	46.0	60.7	52.0	58.2	50.0	51.3	54.0	49.8
7	57.3	51.0	57.0	45.7	54.7	53.3	46.0	56.7	58.3	51.0	52.7	50.7	57.3
8	53.7	54.3	61.3	50.3	55.0	54.3	54.0	57.0	56.8	40.0	53.3	53.5	61.7
9	55.0	54.3	60.7	60.6	52.0	55.0	46.7	56.7	59.3	45.3	56.0	65.3	54.7
10	60.0	50.3	55.9	56.3	54.3	53.5	51.7	53.0	48.7	46.0	56.3	59.3	53.0
11	68.3	68.3	53.3	56.2	54.7	48.8	56.0	53.0	48.0	69.5	48.8	63.5	47.7
12	63.3	64.3	59.3	56.0	58.0	48.0	51.7	58.7	57.3	70.8	50.0	52.3	48.3
13	37.0	56.3	60.3	59.7	60.2	50.0	52.0	55.3	54.7	59.0	50.7	49.0	58.3
14	43.7	67.7	64.2	58.8	64.7	50.3	50.3	55.0	51.0	60.3	58.0	57.3	54.3
15	54.3	58.3	69.0	67.0	59.0	50.7	57.0	62.0	54.7	60.3	61.0	56.3	55.0
16	62.0	54.7	67.2	59.7	63.7	53.3	55.7	72.7	61.7	42.0	63.0	59.3	59.0
17	72.3	57.3	67.2	64.7	70.0	49.3	56.0	62.0	55.0	44.5	65.3	56.7	58.3
18	70.3	63.3	51.3	64.0	82.2	46.0	63.7	56.7	47.2	49.7	59.0	47.7	69.0
19	63.0	57.7	54.0	69.3	67.1	49.7	57.3	62.3	52.0	58.2	42.3	53.0	68.8
20	56.7	62.7	66.7	69.0	64.1	57.0	52.0	63.3	49.7	56.3	49.7	57.3	69.7
21	57.3	71.0	67.7	62.7	65.3	63.0	55.3	62.7	52.5	59.3	45.7	54.0	55.8
22	50.0	63.0	62.7	61.7	65.3	64.7	59.3	65.0	50.0	57.2	52.3	48.5	49.2
23	30.0	63.7	72.0	60.3	63.7	60.0	62.0	60.3	55.0	55.0	55.3	60.2	57.3
24	33.0	66.0	68.7	54.0	66.7	71.3	58.0	54.3	62.7	49.7	59.0	54.8	49.0
25	46.7	60.0	67.7	59.3	68.3	68.7	60.3	56.7	50.3	49.8	58.3	54.0	56.7
26	44.3	58.3	62.3	68.0	71.3	60.0	59.7	57.0	47.0	48.0	63.2	55.3	63.3
27	46.0	60.7	64.3	66.8	79.7	66.2	57.3	57.7	52.0	58.0	53.0	58.0	55.3
28	49.3	59.0	65.7	65.3	83.3	62.7	58.0	54.0	58.3	61.7	52.7	62.7	57.7
29	66.7	63.0	69.0	62.5	73.7	62.7	59.7	59.7	63.3	53.0	51.7	56.3	54.3
30	59.0	70.7	65.8	63.2	68.3	60.0	54.0	54.3	59.3	47.7	50.0	55.5	57.3
31	58.8	68.7	74.0	64.7	67.3	60.0	61.0	54.7	55.7	48.7	50.8	56.8	55.3
Mean,	54.51	59.57	61.61	60.26	63.80	54.92	55.58	56.65	54.95	53.67	54.52	54.37	56.00

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	63.0	52.7	45.0	46.3	- -	48.0	43.3	51.7	49.3	53.0	47.7		51.9
2	44.5	43.7	47.0	48.3	- -	58.3	49.3	43.7	49.0	53.3	55.3		51.6
3	44.0	46.7	47.5	46.5	- -	52.7	48.0	45.0	61.7	45.3	50.3		
4	53.7	44.0	51.7	47.3	- -	45.0	49.0	43.0	49.7	53.7	52.3		
5	47.7	44.7	41.8	58.0	- -	50.7	56.3	42.3	53.3	59.0	56.7		
6	45.5	43.0	41.0	61.5	- -	32.0	55.7	51.7	59.3	55.7	56.0		
7	51.2	55.0	44.7	63.0	- -	38.0	47.0	47.7	56.0	58.0	63.3		
8	52.0	52.0	49.0	63.0	- -	48.3	53.3	48.0	57.3	58.0	69.7		
9	49.3	45.3	48.7	60.0	- -	54.7	45.7	42.3	60.0	55.0	45.0		
10	51.5	46.7	55.0	59.7	- -	58.3	47.0	43.0	60.7	56.7	45.3		
11	51.0	46.3	53.7	54.3	- -	59.0	51.3	42.7	46.0	52.0	42.7		
12	51.7	49.0	52.2	50.0	- -	56.7	51.7	55.3	47.3	55.0	44.7		
13	57.0	58.3	58.3	51.0	- -	60.0	53.7	48.3	54.7	55.3	55.0		
14	52.0	50.8	64.7	44.3	- -	52.3	55.0	47.0	56.7	52.0	50.7		
15	46.7	49.7	56.3	55.0	- -	60.3	55.3	53.3	50.7	54.3	51.0		55.4
16	52.2	52.7	53.3	56.8	- -	63.0	63.0	57.0	52.0	50.3	48.3		56.6
17	51.0	57.7	51.3	56.3	- -	60.7	56.3	54.0	49.3	51.0	51.7		56.3
18	51.7	50.0	55.0	55.5	- -	57.0	56.3	58.3	53.3	51.3	53.3		56.5
19	56.0	50.3	53.3	54.7	- -	61.3	57.0	53.0	53.7	54.3	52.0		56.6
20	63.0	51.3	50.0	54.7	- -	58.5	55.0	59.7	49.7	48.3	56.0		56.6
21	57.8	50.0	58.5	54.3	- -	62.3	42.3	55.3	49.0	42.0	47.3		56.7
22	49.2	52.7	56.3	64.3	- -	59.0	43.3	58.3	60.6	50.0	51.7		56.9
23	58.3	54.7	59.7	66.7	- -	57.2	47.3	63.0	62.3	58.7	52.0		58.3
24	42.3	52.0	56.7	52.8	- -	58.3	54.7	53.3	69.7	60.0	56.3		57.7
25	51.5	51.0	57.5	57.8	- -	59.0	62.0	51.0	70.0	54.0	61.3		59.2
26	56.3	49.7	59.0	50.3	- -	60.0	48.7	46.0	66.7	58.0	57.3		57.8
27	63.0	55.0	66.7	52.3	- -	64.7	55.0	54.0	58.0	61.0	61.3		58.9
28	56.8	50.5	64.7	57.7	- -	66.3	58.7	53.7	62.0	51.3	58.0		59.5
29	61.8	54.0	49.0	54.3	- -	62.7	57.0	55.3	60.7	55.3	57.7		59.5
30	61.5	49.3	51.7	60.3	- -	64.7	62.3	50.7	63.7	53.0	53.7		59.3
31	52.0	55.3	56.0	56.3	- -	51.2	64.0	45.3	59.7	57.0	52.3		59.0
Mean,	53.09	50.45	53.39	55.28	- -	56.13	53.05	50.74	56.62	53.84	53.42		

TABLE I.—*Continued.* Mean Temperature in June.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.
1	50°.5	50°.8	58°.6	64°.8	61°.9	60°.5	59°.3	51°.2	59°.0	51°.2	58°.2	54°.7	60°.7	57°.3
2	64.2	52.3	64.3	72.3	60.3	(62.1)	61.7	60.0	62.3	56.3	65.8	62.8	67.5	59.2
3	66.4	57.7	62.2	64.7	53.7	63.3	61.2	57.8	63.3	56.6	70.7	63.3	68.7	66.0
4	61.2	61.2	66.3	59.5	50.7	65.9	64.5	63.0	48.5	59.9	68.3	68.5	65.9	70.4
5	84.0	57.6	57.8	56.4	61.5	65.5	61.7	54.8	63.0	57.0	66.3	74.7	62.0	72.6
6	77.2	59.6	56.5	57.7	64.8	62.5	55.0	51.3	44.8	63.7	67.1	73.8	60.3	78.7
7	58.7	56.9	53.8	59.7	61.5	61.9	55.7	55.0	43.5	58.7	67.4	70.7	61.2	74.7
8	60.7	59.1	53.2	53.3	62.3	63.0	56.8	57.3	43.5	56.2	51.3	68.5	63.2	64.8
9	65.8	56.8	47.7	57.0	67.7	65.8	60.0	62.7	47.3	54.9	58.8	68.6	56.3	63.0
10	68.3	57.5	50.8	58.2	57.2	63.3	59.7	61.7	48.2	61.3	62.6	69.2	54.2	67.5
11	67.2	56.0	54.3	60.3	53.9	57.5	63.3	67.3	51.2	59.8	70.3	60.3	58.5	67.2
12	64.2	65.1	62.8	63.0	58.7	59.8	66.3	70.0	54.4	60.3	71.1	57.8	57.3	65.0
13	58.5	67.7	61.1	59.7	54.3	54.9	68.0	65.8	57.7	63.2	69.6	61.3	61.2	65.2
14	52.1	66.3	66.0	59.3	56.3	63.7	62.8	60.0	51.5	65.8	59.9	69.5	67.3	57.7
15	64.8	66.0	66.0	70.2	63.7	61.7	69.0	65.0	55.0	54.7	67.2	70.0	65.6	57.7
16	62.5	68.8	69.5	72.7	59.0	60.2	70.0	66.2	58.3	50.8	65.3	66.7	66.2	66.2
17	70.4	63.2	69.5	68.5	59.3	63.5	60.3	71.3	59.3	57.3	63.0	75.5	65.0	68.0
18	50.8	58.7	63.3	59.5	59.2	71.0	65.2	65.7	58.8	61.3	60.2	74.7	61.5	67.5
19	59.2	70.1	65.0	59.2	67.0	61.7	68.0	59.7	69.8	60.6	66.2	75.7	69.5	68.7
20	50.7	66.2	69.3	70.3	64.0	61.8	65.8	71.7	59.7	66.0	69.1	61.5	74.7	71.7
21	58.1	69.3	66.0	74.8	62.0	55.2	64.3	70.3	67.0	69.8	77.0	67.3	84.5	70.7
22	61.7	57.0	65.8	78.6	63.0	58.7	64.5	74.0	79.2	69.2	73.3	70.2	84.3	71.3
23	68.8	69.7	65.0	67.5	65.3	59.8	57.5	66.3	77.0	66.4	71.0	67.3	78.2	71.0
24	61.7	78.8	70.7	59.0	62.7	65.0	59.2	62.7	82.7	63.3	71.7	60.8	66.5	81.7
25	69.7	71.8	73.1	64.7	60.8	59.3	56.2	67.3	58.8	64.6	77.8	63.5	64.4	81.2
26	73.1	69.6	68.3	69.0	64.5	59.0	63.0	66.2	59.8	62.5	75.8	64.2	66.3	77.2
27	72.1	67.8	67.4	65.0	57.8	63.3	62.7	68.0	56.3	57.3	76.2	73.5	65.3	67.8
28	65.3	71.6	70.3	56.5	64.3	71.7	63.8	71.0	66.3	63.3	79.8	73.7	69.0	69.0
29	65.9	65.7	70.8	60.7	61.7	64.8	67.8	74.3	58.3	58.7	79.0	71.1	70.0	70.5
30	66.4	63.2	71.2	65.2	60.0	69.5	67.2	70.2	60.7	49.7	77.7	65.0	74.0	75.0
Mean,	64.00	63.45	63.56	63.57	60.64	62.53	62.68	64.26	58.84	60.00	68.58	67.51	66.31	68.80

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	62.7	(53.1)	83.5	68.0	72.7	52.3	58.0	53.7	58.7	82.0	62.0	70.7	63.0	68.0
2	63.7	(57.2)	69.0	64.7	71.3	61.0	61.3	58.0	65.0	73.3	56.0	53.3	63.0	71.0
3	65.7	61.0	62.7	66.3	77.0	66.7	58.7	61.7	67.7	65.0	46.3	55.7	57.0	66.0
4	61.0	59.3	61.3	61.7	69.7	73.3	56.7	69.0	66.6	68.0	53.3	58.0	64.3	68.7
5	57.7	67.8	63.7	58.3	59.0	74.7	60.0	74.3	65.7	72.8	54.7	64.3	59.3	70.2
6	62.0	66.5	72.3	64.5	65.0	76.3	70.0	66.7	59.2	74.3	57.2	64.0	63.7	67.0
7	59.0	61.8	66.3	75.0	71.3	73.0	68.7	68.3	62.7	72.3	59.2	61.7	59.7	60.3
8	64.3	56.2	62.0	82.3	74.3	72.7	75.0	67.3	62.7	71.5	55.7	58.0	69.3	63.0
9	67.5	53.0	60.3	82.3	77.8	70.0	62.3	68.7	68.0	73.3	56.3	52.3	71.3	72.8
10	71.4	50.7	60.7	88.0	74.7	60.0	63.3	67.7	62.7	80.0	56.3	55.7	71.3	60.3
11	67.7	56.0	61.0	84.0	72.8	63.7	58.0	67.7	65.2	75.3	62.2	59.0	65.3	62.3
12	67.7	57.0	58.0	62.5	59.0	75.0	63.3	67.0	66.6	73.0	72.7	62.7	63.3	57.0
13	55.3	61.3	57.7	61.7	58.7	68.7	65.3	67.0	65.0	74.7	63.7	64.7	63.3	77.0
14	58.2	65.3	52.0	67.0	72.0	64.0	76.3	71.0	69.3	76.7	65.7	69.7	60.3	65.7
15	61.7	59.3	54.3	67.7	72.3	53.7	73.3	75.0	73.2	70.0	71.0	68.0	63.3	62.3
16	78.7	62.0	52.3	69.3	64.7	56.0	72.7	73.0	72.7	65.7	63.3	69.0	58.7	63.0
17	64.3	74.0	61.7	69.3	72.3	65.0	69.0	73.3	66.0	71.0	72.0	64.3	63.3	64.7
18	59.0	74.7	66.0	65.7	73.0	61.7	76.3	76.3	63.8	77.3	64.0	64.3	56.3	65.3
19	58.3	82.0	63.3	69.7	71.3	67.7	75.3	70.7	67.7	75.3	59.3	64.0	61.0	67.3
20	62.0	60.0	58.0	72.7	69.3	62.7	73.3	69.3	58.0	79.2	62.3	59.7	66.3	61.0
21	66.1	51.0	59.0	75.3	63.3	60.7	74.0	68.3	60.2	73.7	69.3	63.0	64.7	60.0
22	68.1	56.4	58.0	71.8	66.0	61.0	71.7	65.7	62.3	72.3	73.3	65.7	67.3	59.7
23	68.0	61.1	61.3	68.0	61.3	58.0	71.7	65.3	65.7	62.0	75.2	68.0	72.3	60.0
24	64.0	61.1	63.3	70.7	61.3	66.0	82.3	67.7	68.0	63.0	66.7	58.7	65.0	67.2
25	60.0	67.0	72.0	57.3	68.0	63.7	68.3	63.3	71.3	69.0	62.8	55.0	68.7	70.3
26	69.8	67.7	71.7	63.3	69.0	61.3	62.7	71.3	75.0	66.7	67.3	62.3	71.0	69.8
27	67.7	63.0	73.7	70.3	73.0	56.3	73.0	72.3	65.7	66.7	68.7	60.7	66.3	63.7
28	68.5	69.0	69.0	69.3	73.0	68.7	74.3	65.0	70.0	69.0	70.3	67.0	68.7	64.0
29	74.5	66.2	72.3	72.7	72.3	72.3	77.0	64.3	72.3	71.7	66.2	69.7	58.7	68.3
30	66.0	66.3	74.0	74.7	73.3	74.3	71.7	64.0	70.0	76.3	71.3	73.7	63.0	65.3
Mean,	64.68	62.22	64.00	69.79	69.30	65.34	68.78	67.76	66.21	72.05	63.47	62.75	64.32	65.36

TABLE I.—*Continued.* Mean Temperature in June (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	62°.5	65°.7	74°.3	57°.0	57°.8	58°.3	59°.0	51°.7	61°.0	63°.0	60°.8	52°.0	47°.7
2	64.0	74.3	62.2	57.7	61.5	64.0	62.3	51.7	64.7	64.0	64.2	62.0	58.7
3	61.0	63.3	70.0	62.0	58.7	58.3	61.3	55.0	57.0	67.0	69.0	60.2	63.5
4	65.7	74.0	71.5	66.3	68.0	65.3	65.0	57.3	60.0	72.7	72.3	56.3	61.0
5	65.3	72.7	64.3	58.2	73.3	67.0	69.3	61.0	60.0	66.5	69.7	60.3	62.8
6	67.7	76.0	73.7	60.2	72.7	64.7	60.7	53.0	59.0	63.0	64.2	61.3	56.0
7	66.3	78.3	64.0	71.5	69.3	70.3	54.7	58.0	64.0	61.3	61.7	64.3	56.7
8	69.0	72.7	73.3	76.7	72.3	76.7	61.2	60.3	56.3	65.3	61.7	63.8	57.2
9	75.7	74.0	75.7	73.7	76.0	61.7	56.0	55.0	55.7	79.5	63.3	57.2	54.0
10	66.7	56.3	80.1	75.6	79.0	71.3	61.0	65.7	59.7	76.0	67.3	63.0	61.3
11	69.0	65.7	84.7	73.3	83.7	68.3	45.7	56.3	53.0	64.7	69.0	63.3	67.3
12	72.0	71.3	88.3	59.7	83.5	69.0	56.3	63.3	56.7	64.3	63.0	62.3	50.0
13	67.3	71.7	88.0	63.0	67.7	67.3	61.0	63.3	55.3	71.3	61.5	62.3	50.7
14	66.0	69.3	78.5	69.1	70.0	70.0	69.3	63.7	58.3	62.0	67.7	65.7	61.5
15	67.0	70.0	80.2	72.0	68.7	64.0	64.7	60.7	59.7	62.0	76.3	51.0	65.8
16	63.0	70.3	84.7	62.0	69.3	67.7	67.0	57.0	65.7	66.0	63.7	62.5	70.3
17	57.3	60.7	81.3	69.0	70.3	70.0	71.7	61.3	70.3	61.8	64.0	64.7	65.0
18	59.0	68.7	73.7	72.8	73.2	70.0	49.7	65.0	69.3	62.0	71.3	64.0	66.7
19	67.3	74.7	71.0	67.7	67.0	62.7	68.0	63.8	69.5	63.8	60.8	59.3	72.2
20	65.0	68.0	72.0	71.8	67.0	58.3	71.7	74.0	74.0	64.0	58.7	55.7	65.3
21	61.7	71.3	77.0	65.7	67.7	70.0	69.0	73.7	62.0	64.5	50.7	52.7	68.3
22	54.3	63.0	78.0	64.7	75.4	69.3	72.7	77.7	61.3	61.5	53.2	60.5	71.3
23	59.3	81.0	75.0	69.7	74.0	75.0	65.7	69.7	69.7	64.7	57.5	64.2	69.0
24	61.0	68.7	67.7	69.3	78.7	74.7	64.7	66.3	73.0	73.3	61.7	70.3	71.7
25	60.3	77.7	66.8	72.3	69.7	69.3	63.7	72.0	73.3	62.7	62.3	78.3	63.7
26	65.0	72.3	74.7	74.2	73.0	65.3	65.7	67.3	79.0	65.5	59.7	77.0	68.2
27	58.7	76.3	74.5	75.9	67.0	75.7	66.0	77.0	69.7	62.8	58.3	79.7	65.7
28	74.3	76.0	70.0	68.0	74.3	74.0	59.0	76.0	68.3	61.0	73.3	70.7	69.0
29	67.7	72.3	76.3	74.3	79.0	78.0	64.0	75.7	64.4	63.0	70.7	63.7	67.7
30	66.3	79.3	71.2	72.7	78.0	78.7	68.7	73.0	63.3	54.3	69.3	67.2	63.7
Mean,	64.86	71.18	74.75	68.19	71.55	68.50	63.84	64.17	63.77	65.14	64.22	63.18	63.06

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	55.0	54.3	55.8	59.2	- -	58.0	64.0	58.7	61.0	58.0	51.3		59.9
2	61.0	59.0	54.7	61.7	- -	61.3	63.3	63.7	68.0	62.7	59.3		62.4
3	64.8	57.7	57.3	62.3	- -	60.3	60.7	68.3	64.7	67.7	57.0		62.3
4	63.5	59.0	60.0	61.0	- -	61.0	57.0	64.3	64.7	65.3	47.0		63.1
5	58.3	61.2	58.7	55.5	- -	69.7	60.7	57.7	62.7	72.0	43.3		63.7
6	60.7	68.7	63.3	60.5	- -	65.0	62.7	55.3	61.0	67.7	52.7		63.8
7	61.7	69.0	50.3	60.2	- -	57.8	57.7	54.0	59.7	68.7	56.7		62.5
8	56.3	71.3	50.0	59.7	- -	55.8	59.0	61.7	64.0	75.0	51.0		
9	61.8	71.7	49.7	63.3	- -	67.3	60.7	62.0	64.0	67.0	50.3		
10	61.0	53.7	61.2	63.0	- -	60.7	57.7	67.7	66.3	60.7	51.3		
11	60.5	54.0	61.3	58.8	- -	64.3	62.3	71.0	66.3	69.0	51.0		
12	58.3	65.3	63.0	59.0	- -	67.7	57.3	63.7	68.0	60.3	53.0		
13	61.0	69.0	63.0	62.3	- -	68.3	60.7	61.7	67.7	50.7	51.3		
14	62.7	73.3	61.2	64.0	- -	70.8	60.7	63.3	65.3	56.7	64.7		
15	64.7	64.0	55.3	68.7	- -	67.7	58.3	67.7	62.7	51.7	66.3		
16	74.7	58.2	55.3	81.0	- -	63.2	64.7	64.0	60.7	60.0	67.0		
17	64.7	63.3	56.3	73.7	- -	61.0	62.0	68.0	61.0	63.7	62.0		
18	72.0	72.7	66.0	63.0	- -	63.7	59.3	70.0	53.7	73.3	63.7		
19	78.7	77.3	66.2	67.0	- -	75.0	59.7	62.7	54.3	69.3	64.3		
20	80.3	82.7	70.3	67.3	- -	73.0	56.0	64.0	62.7	69.0	59.7		
21	76.3	72.7	70.7	66.3	- -	64.0	65.3	76.0	65.3	69.7	53.7		
22	82.7	66.7	64.7	60.5	- -	63.8	66.3	80.3	63.7	68.7	58.3		
23	80.7	60.0	59.0	64.3	- -	55.7	70.3	64.7	62.3	72.7	61.0		
24	75.3	69.0	53.5	65.5	- -	65.2	69.3	62.0	61.7	71.3	63.3		
25	72.7	63.7	63.3	60.0	- -	67.0	67.7	60.3	69.0	72.0	61.7		
26	68.7	63.7	64.0	67.3	- -	61.7	68.3	73.7	69.0	69.3	65.0		
27	67.3	68.3	67.3	69.5	- -	66.7	71.0	71.7	67.0	71.7	69.0		
28	62.0	69.3	65.2	67.3	- -	65.0	72.0	67.2	65.0	75.3	68.3		
29	56.7	64.7	71.7	70.5	- -	67.3	78.7	81.7	68.7	72.0	76.3		
30	64.3	72.7	71.7	71.7	- -	63.7	78.3	73.0	61.7	70.7	63.3		
Mean,	66.27	65.87	61.00	64.47	- -	64.38	63.72	65.99	63.65	66.72	58.77		

March, 1867.

TABLE I.—*Continued.* Mean Temperature in July.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816	1817.	1818.	1819.	1820.	1821.
1	77°.3	63°.2	64°.2	58°.7	60°.2	72°.7	70°.7	68°.8	61°.0	62°.0	68°.8	68°.2	74°.7	69°.8
2	59.3	66.6	62.5	70.7	60.5	71.8	71.5	74.2	65.6	67.0	71.5	69.8	68.7	71.2
3	61.2	60.7	66.6	81.5	70.2	70.3	66.7	68.0	64.8	69.3	63.5	64.2	73.0	65.3
4	59.8	60.3	62.2	80.3	74.0	69.3	71.7	66.2	61.3	64.2	65.8	66.3	75.8	62.8
5	70.2	58.8	69.3	79.7	72.0	73.7	69.1	65.6	69.0	68.2	68.1	61.7	89.5	62.8
6	65.2	60.5	67.3	83.7	66.8	63.7	65.3	65.5	63.3	67.7	73.2	66.9	81.2	61.7
7	68.8	66.0	71.1	67.7	68.7	66.7	62.8	66.0	57.2	68.8	69.7	66.3	82.0	62.2
8	67.3	61.9	66.0	62.4	62.0	71.0	63.2	72.7	60.2	66.9	75.2	72.2	78.3	60.5
9	63.1	62.3	66.0	64.5	56.1	70.0	65.7	68.8	58.7	65.3	79.5	74.3	74.2	65.3
10	71.5	62.1	65.3	63.2	60.3	66.7	66.5	74.8	65.2	62.7	73.7	81.2	75.7	61.0
11	66.1	65.8	64.2	59.6	56.2	65.0	59.8	78.0	62.7	64.0	82.8	78.7	76.3	61.3
12	75.4	(63.6)	73.2	57.7	62.2	65.0	60.5	73.7	69.5	71.8	82.3	74.3	73.3	67.3
13	69.2	60.8	66.2	65.2	65.3	63.7	59.3	80.2	69.0	69.0	75.8	69.2	80.2	67.2
14	69.8	67.7	62.6	67.5	70.3	64.0	72.5	72.0	66.7	64.1	74.7	72.3	75.3	69.3
15	67.2	69.7	62.3	67.0	63.8	64.5	74.3	68.7	65.3	66.0	65.6	71.2	69.0	70.3
16	74.4	64.3	61.3	70.5	64.2	66.0	73.2	64.3	65.8	68.3	69.4	69.3	75.5	70.5
17	76.0	63.5	59.0	67.3	63.7	65.7	71.2	73.2	67.7	72.0	74.2	75.3	75.0	68.7
18	74.0	53.6	60.0	68.0	64.2	62.0	68.0	74.0	65.2	78.3	73.4	74.2	73.8	72.8
19	63.5	56.2	66.7	68.0	67.7	64.2	65.5	74.2	64.3	79.0	69.8	67.0	75.8	69.3
20	62.8	54.8	69.2	69.7	70.7	70.8	63.0	77.2	69.2	77.3	66.1	71.0	73.7	69.2
21	67.6	64.8	68.7	72.0	66.3	70.3	61.5	78.7	70.0	66.3	54.4	69.9	69.2	70.7
22	71.8	64.4	67.3	72.8	64.7	66.2	66.7	72.7	67.7	59.8	72.1	70.8	74.2	70.7
23	76.1	66.5	61.0	66.0	66.5	64.3	67.7	72.0	64.8	68.7	74.3	74.4	72.8	70.7
24	67.1	61.3	66.3	63.2	66.3	67.3	67.8	71.7	67.5	64.0	72.1	75.2	72.8	68.2
25	62.4	61.2	68.3	65.7	66.8	73.0	71.0	72.0	66.0	66.3	68.7	75.0	78.0	69.7
26	63.6	66.8	67.5	65.7	69.2	65.2	67.0	62.7	68.5	68.5	72.0	74.3	78.7	71.3
27	70.1	59.7	62.8	71.7	66.9	64.7	65.3	63.3	67.3	69.3	69.2	66.2	78.0	72.3
28	69.8	64.8	66.2	64.3	70.2	67.0	70.8	70.7	62.7	67.7	75.3	69.3	82.3	72.5
29	68.4	64.7	64.3	64.2	65.0	71.8	69.8	78.7	64.2	72.7	73.3	76.7	82.0	65.0
30	61.8	65.7	66.7	78.2	59.3	70.0	71.0	74.0	65.5	66.6	72.9	79.8	85.7	75.8
31	72.1	68.5	71.7	74.2	67.5	68.2	71.7	72.2	66.8	66.7	72.6	84.0	86.5	87.7
Mean,	68.35	62.93	65.89	68.72	65.41	67.57	67.36	71.44	65.24	68.00	71.62	71.92	76.83	68.49

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	78.8	79.0	73.3	71.0	74.7	75.7	75.7	65.8	73.3	76.0	80.0	76.0	64.3	59.0
2	73.6	82.2	73.3	70.7	75.3	80.3	68.7	68.0	73.3	77.0	78.2	73.5	69.3	68.7
3	65.4	75.9	74.0	73.0	79.7	68.7	69.3	66.3	64.3	83.7	79.7	73.5	68.0	74.3
4	71.8	71.5	66.0	77.0	73.7	78.7	72.3	66.0	70.7	82.0	71.3	72.3	72.7	74.7
5	71.5	73.6	69.3	72.3	75.3	76.7	76.0	56.0	68.3	82.0	69.2	73.0	74.3	74.7
6	74.7	62.4	77.0	73.0	74.7	73.3	77.0	69.3	73.8	78.2	74.3	72.0	73.7	70.8
7	79.8	80.5	73.3	70.3	79.7	72.3	75.7	72.5	71.7	77.0	61.8	72.7	74.3	70.3
8	57.3	66.9	70.7	76.0	79.7	71.3	79.2	72.3	63.5	74.3	57.5	75.3	81.0	66.2
9	(59.5)	79.0	79.0	76.0	74.3	77.3	72.0	69.3	68.3	74.3	56.2	72.0	82.7	69.0
10	68.3	72.5	68.3	83.7	81.0	73.0	69.7	69.7	70.1	64.0	59.3	70.3	77.7	65.7
11	65.3	72.0	66.0	89.3	87.5	77.3	70.7	70.7	73.3	61.3	57.0	70.7	74.0	69.3
12	62.3	77.7	70.3	85.6	89.3	72.0	68.7	72.3	70.0	69.3	59.8	73.3	74.3	72.3
13	74.3	78.7	71.7	77.3	84.3	78.7	72.7	68.0	71.7	67.7	59.7	74.3	76.0	78.7
14	71.3	72.3	75.0	75.3	74.3	78.3	68.0	72.7	76.0	65.3	64.0	75.3	73.3	80.3
15	70.7	69.4	77.0	79.7	68.0	81.3	68.0	82.3	73.7	70.0	67.0	75.8	76.7	78.0
16	70.8	66.0	67.0	76.0	60.8	80.0	69.3	76.3	83.7	69.7	67.3	71.0	79.7	66.7
17	70.8	68.3	68.7	79.2	71.0	77.7	72.0	76.0	85.3	69.3	66.7	68.7	77.7	73.3
18	82.0	63.3	67.3	72.0	74.0	75.7	74.3	75.7	86.7	70.0	68.7	69.0	68.0	70.3
19	75.1	64.3	70.7	81.7	72.3	79.0	69.0	67.7	78.3	78.7	75.0	68.2	68.7	74.0
20	78.6	59.4	77.0	85.7	73.0	80.0	74.7	71.0	79.7	74.3	74.7	69.0	69.7	77.0
21	75.7	65.0	69.3	86.2	73.0	70.7	74.3	76.0	86.2	79.0	59.0	68.3	70.0	74.5
22	72.3	74.1	79.3	81.8	75.0	62.3	73.0	81.0	86.5	74.7	67.0	80.3	74.7	72.7
23	70.3	67.1	70.7	65.3	74.7	61.3	75.7	76.0	73.0	76.3	67.7	70.3	76.7	77.3
24	71.8	66.2	70.7	80.3	77.7	65.3	78.0	69.7	68.3	80.3	67.2	77.7	72.7	79.0
25	68.6	72.3	69.0	77.3	74.7	65.0	80.0	68.8	67.3	77.0	65.2	68.7	79.3	77.3
26	62.0	65.0	77.2	70.5	74.0	52.0	75.3	70.7	60.7	70.7	67.7	70.3	81.7	70.3
27	64.0	68.8	77.7	70.7	76.3	66.7	77.3	72.0	58.7	72.3	69.3	77.0	75.0	69.3
28	63.3	77.7	69.0	72.5	71.0	72.3	73.0	71.0	61.0	73.3	71.2	68.7	70.3	71.0
29	68.2	70.7	70.0	78.3	71.3	71.0	67.7	74.3	63.3	75.3	68.7	68.7	75.0	65.7
30	68.8	77.0	76.0	70.8	74.8	73.0	70.0	74.1	70.3	72.7	67.7	64.7	67.7	75.3
31	67.0	71.0	72.0	67.7	75.5	73.3	72.0	78.7	70.7	80.0	70.0	67.0	66.7	69.7
Mean,	70.13	71.29	72.11	76.42	75.50	72.91	72.83	71.62	72.26	74.06	67.35	71.86	73.67	72.10

TABLE I.—*Continued.* Mean Temperature in July (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	71°.7	75°.7	74°.3	73°.5	78°.7	76°.0	72°.0	68°.7	61°.0	52°.7	66°.0	69°.2	61°.3
2	72.3	76.0	75.0	76.3	74.3	68.7	78.0	71.3	74.7	62.5	70.7	70.3	63.5
3	64.7	68.3	83.0	75.8	73.7	66.0	73.7	60.7	70.7	59.5	67.0	70.0	59.2
4	63.3	73.0	87.7	79.3	73.3	68.0	76.3	64.7	59.7	67.7	67.3	73.3	65.3
5	77.3	73.3	81.7	71.2	77.7	70.3	71.7	62.3	63.3	69.0	73.2	77.0	63.3
6	78.3	74.3	80.3	74.2	78.5	70.3	73.3	63.0	65.3	74.7	76.3	77.5	61.0
7	81.0	76.3	78.3	71.3	75.3	74.7	65.3	63.0	62.3	77.0	72.0	79.8	58.3
8	82.7	77.3	78.2	73.3	81.2	68.0	71.7	66.7	64.7	76.3	70.3	77.0	62.7
9	77.7	71.0	87.2	74.3	77.0	69.3	67.7	67.0	66.0	66.7	73.7	81.7	62.3
10	67.0	70.3	83.2	77.0	76.3	68.7	67.7	68.0	68.0	66.3	77.3	78.0	64.0
11	68.7	76.0	88.3	76.7	78.3	67.0	70.7	66.3	64.7	74.5	84.3	74.5	73.7
12	67.7	73.0	81.3	74.3	75.7	67.3	71.7	65.7	60.0	73.3	81.7	76.3	73.7
13	71.3	73.0	74.0	73.3	77.7	71.7	78.3	67.7	66.3	64.3	68.7	72.8	73.2
14	71.3	80.3	76.8	75.7	82.0	72.0	77.3	65.7	67.3	69.3	66.3	67.7	71.7
15	65.3	80.0	85.0	76.7	84.7	75.7	78.7	66.7	71.0	71.7	64.7	67.3	68.0
16	65.7	75.3	83.5	76.2	85.7	74.0	75.3	67.3	64.0	76.3	66.3	69.7	66.7
17	65.7	75.7	76.7	78.3	87.0	69.3	77.3	65.7	73.0	72.5	65.7	71.3	64.3
18	69.0	78.0	76.3	80.1	84.0	71.7	78.3	68.7	71.7	70.7	68.0	73.3	70.7
19	75.0	79.0	78.0	81.7	82.0	71.0	77.0	69.7	67.5	65.3	67.3	70.3	71.3
20	77.7	82.7	70.0	84.3	73.3	72.3	82.0	59.7	69.7	70.7	71.0	77.0	73.7
21	75.7	75.3	72.0	77.5	76.0	74.0	68.0	66.3	70.5	75.5	72.0	77.7	74.0
22	70.0	72.0	74.0	78.8	76.0	80.0	67.3	72.7	66.7	72.0	74.3	79.2	71.7
23	70.3	74.3	76.7	80.3	79.3	74.0	72.0	77.3	77.7	70.3	69.3	74.8	66.7
24	70.0	70.7	74.7	79.7	73.3	71.0	79.3	71.0	68.7	65.3	74.7	73.3	67.7
25	70.0	71.7	70.2	78.4	75.0	71.3	65.3	62.7	56.7	64.0	57.7	72.8	66.7
26	66.7	74.0	79.0	79.2	72.7	69.0	70.0	65.0	65.3	67.8	63.0	66.3	73.7
27	71.0	74.3	79.2	75.9	79.7	70.0	71.7	72.7	64.0	62.5	66.7	62.0	68.3
28	70.0	73.0	83.7	75.5	75.3	68.0	70.3	68.3	65.7	65.3	74.0	62.3	70.7
29	68.9	72.7	89.4	77.7	79.8	65.0	74.7	79.0	67.7	67.0	67.7	63.0	69.3
30	63.7	76.0	85.5	78.2	78.3	72.0	74.7	63.0	67.5	66.3	73.7	63.0	68.7
31	69.0	69.0	76.0	72.7	78.0	70.3	57.0	66.7	68.3	70.3	72.3	63.5	62.7
Mean,	70.92	74.57	79.45	76.69	78.07	70.86	72.72	67.19	66.76	68.63	70.42	72.00	67.35

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	63.3	65.3	69.0	66.0	- -	68.3	77.3	64.7	59.0	63.0	58.3		69.1
2	61.0	62.0	71.5	63.3	- -	70.7	76.0	66.7	59.3	70.0	61.3		70.2
3	60.0	60.3	69.3	62.0	- -	80.7	74.7	65.0	60.7	68.7	66.0		
4	64.3	67.3	56.7	73.7	- -	80.3	72.7	71.3	61.7	69.3	57.0		
5	66.3	74.7	63.7	72.0	- -	82.2	72.0	63.3	66.3	65.0	61.0		
6	68.3	75.0	69.5	67.3	- -	72.3	72.0	65.3	64.3	69.0	63.3		
7	71.7	68.3	65.0	66.7	- -	74.3	67.0	63.3	74.7	73.3	61.7		
8	72.7	66.7	62.0	69.8	- -	73.7	64.7	65.3	64.3	81.0	68.7		
9	72.3	68.0	61.8	75.3	- -	73.0	64.3	55.7	66.0	69.7	70.3		
10	71.7	70.0	68.7	81.3	- -	70.3	65.3	65.0	69.7	70.3	73.3		
11	81.3	67.3	72.0	71.5	- -	69.0	67.7	69.3	71.3	75.3	71.0		
12	81.3	72.7	70.7	75.0	- -	65.7	71.0	63.0	77.7	56.3	77.3		
13	84.3	67.0	68.3	67.3	- -	66.0	71.0	72.3	74.7	65.7	78.3		
14	69.7	68.3	66.7	71.7	- -	65.7	69.0	75.0	71.7	74.3	70.7		
15	62.7	71.0	66.7	72.0	- -	65.3	72.7	73.0	73.7	68.7	68.7		
16	64.8	72.7	71.3	70.8	- -	70.3	72.7	75.0	70.7	69.3	68.7		
17	67.0	72.3	74.3	67.3	- -	68.7	82.7	76.0	66.0	72.3	74.7		
18	69.5	71.3	74.7	66.5	- -	74.8	77.7	73.7	71.0	73.3	71.7		
19	70.0	71.0	72.0	68.3	- -	74.2	83.7	71.7	72.0	67.7	69.7		
20	72.7	67.3	72.0	71.7	- -	77.0	70.7	68.7	72.0	71.7	71.0		
21	69.0	73.2	73.7	76.2	- -	75.7	67.7	66.7	72.7	72.7	61.0		
22	73.7	76.7	72.3	79.2	- -	75.0	63.3	64.3	72.3	70.0	64.0		
23	73.3	76.7	74.3	72.5	- -	74.3	68.0	71.3	61.3	64.0	63.0		
24	69.0	73.3	73.3	69.7	- -	77.0	70.0	76.7	63.7	52.3	65.0		
25	67.7	74.3	73.7	69.8	- -	73.0	74.7	82.7	68.3	62.7	62.3		
26	66.3	61.0	73.3	64.0	- -	75.0	76.0	81.3	71.3	64.7	63.3		
27	76.7	64.3	71.0	69.7	- -	72.0	69.7	83.0	73.3	67.7	63.0		
28	72.7	65.2	66.0	65.3	- -	69.0	66.6	81.3	72.3	66.0	69.0		
29	71.0	70.7	59.0	72.0	- -	70.0	70.7	77.3	70.0	71.3	69.7		
30	70.7	74.0	59.8	69.8	- -	75.0	73.3	74.0	66.3	69.7	68.0		
31	72.3	72.8	64.8	72.2	- -	73.2	73.0	75.0	65.7	72.3	65.0		
Mean,	70.30	69.69	68.62	70.32	- -	72.72	71.48	70.87	68.52	68.62	66.94		

Table I.—*Continued.* Mean Temperature in August.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.
1	67°.9	66°.0	69°.2	61°.2	66°.0	72°.5	66°.0	76°.0	70°.3	66°.5	72°.5	85°.0	84°.5	83°.3
2	68.6	66.2	63.5	62.3	69.0	75.3	63.7	67.0	72.3	67.3	71.8	78.0	72.7	80.0
3	67.9	64.8	64.3	69.2	68.0	75.2	65.8	68.3	70.0	68.3	68.1	76.7	69.0	77.4
4	78.3	70.2	65.0	71.5	66.0	75.7	63.3	65.3	63.7	73.7	72.8	70.7	72.3	76.7
5	59.7	68.3	62.7	68.0	69.2	76.0	65.3	67.0	63.8	71.3	75.5	69.7	75.0	77.0
6	63.7	69.1	62.3	60.3	70.0	69.0	63.2	61.8	69.7	64.3	67.3	74.0	70.8	66.2
7	64.5	73.6	64.3	65.5	68.8	72.7	68.0	66.2	70.3	66.7	64.5	74.0	70.8	62.2
8	65.2	73.3	67.3	59.3	68.8	74.5	66.2	65.7	66.3	67.3	76.3	77.2	73.2	62.0
9	63.7	63.7	70.0	58.6	72.3	74.3	66.3	65.0	67.3	71.7	70.0	72.3	75.8	57.3
10	65.3	60.2	71.7	59.5	67.3	69.7	69.2	65.8	68.3	69.5	70.2	73.7	81.2	75.5
11	73.3	62.8	72.3	68.2	58.2	63.3	65.8	61.0	70.3	67.3	72.0	73.3	75.0	83.5
12	68.8	65.8	73.8	65.5	61.0	60.2	73.7	56.0	71.7	59.2	76.3	76.3	77.8	62.7
13	67.5	64.9	67.0	69.2	57.7	65.8	72.2	57.0	72.0	70.0	72.0	76.3	76.5	65.8
14	68.8	67.6	64.3	66.2	58.5	66.0	68.2	64.7	65.7	72.2	71.5	78.0	72.7	81.7
15	59.4	69.5	63.2	65.8	64.5	73.0	59.2	68.5	64.3	74.3	69.3	66.0	71.0	85.5
16	58.0	68.2	62.7	70.3	67.2	68.8	70.2	66.8	74.6	68.2	69.0	68.4	67.0	84.7
17	55.3	65.7	64.8	70.4	59.3	67.5	72.0	67.5	72.8	68.8	60.6	60.9	62.8	83.8
18	64.2	69.2	71.0	74.8	61.7	63.8	66.8	68.6	74.3	78.0	64.5	68.4	66.8	72.3
19	62.7	63.5	66.5	75.7	65.5	63.3	70.0	69.0	75.5	64.3	67.5	67.7	67.3	76.7
20	58.9	69.3	53.5	81.0	71.7	68.3	70.8	66.2	68.2	61.5	69.5	76.0	65.7	73.0
21	61.3	63.8	65.7	81.2	66.2	69.0	59.8	67.0	56.7	64.3	70.3	79.0	62.0	71.0
22	62.5	66.7	66.7	74.8	64.5	64.3	58.4	64.5	58.7	70.2	72.0	72.8	65.2	69.0
23	66.2	(66.5)	69.7	69.8	66.5	69.3	59.2	65.3	60.8	62.3	67.5	68.3	67.8	57.3
24	66.2	(66.2)	71.0	65.2	65.5	68.7	60.0	64.7	64.5	56.7	69.0	60.9	70.2	60.8
25	76.4	(65.9)	69.0	68.7	69.3	63.3	64.3	58.7	59.7	59.5	68.8	63.7	67.0	58.7
26	71.6	65.6	71.7	66.0	65.3	61.9	55.2	64.7	57.8	61.0	68.5	61.7	67.8	63.0
27	67.3	64.2	70.7	66.8	61.8	64.7	57.7	71.3	63.7	65.5	68.8	63.7	69.7	66.3
28	57.2	72.6	69.8	63.3	61.3	67.3	55.3	67.8	56.7	61.0	65.5	60.0	66.5	64.3
29	61.3	65.2	70.7	65.3	69.0	69.5	64.3	65.2	60.0	65.3	72.3	67.8	66.0	61.8
30	61.3	64.7	69.3	71.6	67.3	67.5	68.0	70.7	61.5	65.7	66.7	62.3	69.0	69.0
31	59.2	66.5	58.5	71.5	53.8	74.2	67.0	64.2	59.2	64.0	66.4	64.3	72.3	73.0
Mean,	64.91	66.75	66.84	67.97	65.24	68.85	65.06	65.72	66.14	66.64	69.26	70.55	70.61	71.05

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	66.7	(70.8)	68.8	70.7	70.0	73.0	71.3	66.3	67.0	74.0	72.7	69.0	68.7	75.7
2	69.3	70.9	70.3	70.3	66.7	75.3	73.3	69.7	70.3	75.0	72.3	61.7	71.7	65.3
3	75.0	72.0	70.0	69.0	64.3	78.0	71.0	70.7	71.0	72.0	74.7	66.3	73.3	63.3
4	72.1	71.3	69.3	70.7	67.3	79.3	74.0	73.7	70.3	69.0	75.7	74.0	77.7	56.3
5	72.0	69.7	69.3	76.0	69.0	75.7	74.7	77.0	63.0	68.0	72.0	71.0	78.3	65.0
6	60.6	(71.3)	68.3	76.0	64.3	84.3	68.3	74.7	69.2	69.0	72.7	68.0	78.3	68.0
7	62.0	73.3	69.3	70.7	75.0	74.7	68.3	78.3	73.0	70.0	71.3	74.3	81.3	65.3
8	56.2	81.0	67.0	82.3	71.0	74.3	72.0	78.0	73.3	71.0	76.5	68.0	70.0	66.3
9	67.6	71.0	65.3	75.0	76.0	70.7	72.3	75.5	73.0	67.3	73.5	57.0	66.7	75.7
10	70.3	68.7	66.0	71.0	73.3	67.0	72.7	77.0	76.3	78.3	71.7	65.3	67.0	75.0
11	77.3	61.2	64.7	66.3	67.7	73.0	72.3	65.3	72.3	73.7	70.0	71.3	73.7	74.0
12	77.0	73.2	63.3	67.7	69.7	66.3	72.7	70.7	73.8	76.3	70.3	70.3	76.0	75.0
13	70.7	73.7	61.0	70.0	66.3	66.3	73.0	74.3	66.7	77.3	72.8	70.0	68.3	72.3
14	69.0	65.8	60.7	79.7	67.0	62.7	72.0	71.3	70.7	77.7	78.3	72.3	64.0	72.0
15	62.5	66.2	69.7	72.3	71.0	62.7	71.0	71.3	74.2	79.3	79.5	68.0	66.7	66.7
16	68.6	67.3	69.7	72.7	70.5	67.0	68.7	68.0	73.5	73.7	69.5	70.0	64.7	65.0
17	67.3	67.4	74.0	69.3	73.7	64.3	67.3	65.7	71.7	73.3	61.3	66.3	67.0	71.7
18	62.2	64.8	71.3	60.0	77.3	69.7	71.3	66.0	71.8	77.3	64.3	65.7	70.0	73.3
19	67.3	65.0	77.7	62.3	75.7	74.0	64.0	71.0	71.0	73.3	58.7	68.0	63.7	70.7
20	69.2	73.7	65.3	53.3	78.0	78.0	63.0	73.3	75.0	79.7	69.3	69.0	59.3	64.3
21	65.0	74.3	70.3	54.3	77.0	72.0	62.0	76.0	69.7	81.7	66.0	69.0	63.7	64.3
22	(64.9)	63.5	67.7	57.0	78.7	63.3	65.7	69.7	67.8	80.0	67.0	69.7	67.7	66.3
23	64.5	60.3	71.3	67.7	69.7	63.3	70.0	73.7	67.3	72.7	72.3	65.7	71.7	66.7
24	64.5	62.1	[67.6]	67.3	74.3	63.7	77.3	73.0	70.7	72.7	67.5	63.7	74.7	65.7
25	68.3	64.9	[67.2]	72.3	76.0	61.0	79.3	73.3	60.8	74.7	55.7	74.7	64.7	67.7
26	67.7	70.9	[66.5]	64.3	69.7	67.3	76.2	66.7	62.3	76.3	64.0	68.3	66.0	63.7
27	63.2	74.0	[66.5]	57.7	70.0	59.7	73.0	66.2	70.0	71.3	66.3	67.0	60.7	71.7
28	63.6	76.5	[65.4]	61.3	69.7	57.7	71.3	66.0	74.3	61.7	68.3	59.3	63.0	70.3
29	67.5	70.0	[66.1]	61.3	75.3	60.3	75.3	69.3	72.3	61.0	68.8	57.2	63.0	72.3
30	60.1	69.1	[66.4]	64.0	74.0	55.3	73.3	71.7	70.7	70.3	68.3	64.0	63.3	72.3
31	62.3	76.8	[66.3]	60.5	62.0	64.0	71.0	73.7	68.0	68.0	65.7	66.3	64.5	70.0
Mean,	66.91	69.70	67.82	67.53	71.30	68.60	71.21	71.52	70.61	73.08	69.58	67.43	68.68	68.77

TABLE I.—*Continued.* Mean Temperature in August (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	72°.3	79°.7	75°.3	76°.3	75°.7	68°.7	59°.0	65°.3	64°.7	68°.0	77°.0	72°.7	72°.0
2	68.7	78.3	77.3	74.7	78.3	74.7	63.3	67.0	73.8	69.0	71.7	69.0	70.0
3	66.7	80.7	78.4	73.8	80.0	74.3	68.0	70.3	68.8	68.7	70.0	70.7	70.0
4	69.7	78.0	80.8	71.5	78.0	80.7	65.7	71.3	69.3	68.0	68.7	70.3	67.5
5	65.0	69.7	84.7	77.0	80.7	80.7	71.3	67.7	68.0	71.7	82.5	70.7	65.7
6	67.3	73.3	76.3	78.5	73.3	73.0	75.3	67.3	71.0	70.2	82.3	60.0	68.0
7	69.3	69.7	76.0	77.7	76.2	70.7	73.3	67.0	66.8	70.7	72.3	60.2	71.3
8	73.3	82.0	81.0	77.4	73.3	73.7	70.3	74.0	68.2	75.7	69.0	64.0	74.3
9	60.7	71.3	77.8	77.8	76.0	73.0	73.0	74.3	68.3	76.3	72.3	63.2	73.2
10	62.3	66.7	76.3	71.0	76.3	76.0	74.0	72.3	73.7	74.7	70.7	69.7	73.7
11	65.3	68.7	74.7	73.7	78.3	70.0	72.0	65.7	65.7	72.3	65.3	73.2	74.3
12	61.8	69.3	78.7	72.0	80.3	72.3	73.0	65.7	64.0	70.8	66.3	74.8	71.7
13	63.0	65.7	77.0	73.2	77.0	74.7	65.3	71.3	64.7	71.3	75.7	71.7	71.3
14	63.3	70.0	68.7	74.1	76.3	68.0	68.0	68.3	66.3	74.0	78.0	71.2	74.3
15	70.3	74.0	72.0	73.7	76.0	68.0	73.0	73.0	68.3	69.7	69.3	67.7	75.0
16	70.7	75.3	73.0	70.0	72.3	67.0	70 7	67.0	66.7	70.0	74.3	66.0	72.7
17	68.0	76.0	74.5	69.7	74.7	74.7	72.3	67.3	69.7	66.0	75.5	72.3	72.3
18	67.7	75.0	69.5	69.8	76.0	74.3	70.0	73.0	72.0	68.2	63.7	71.0	62.3
19	66.7	79.7	70.0	76.8	76.7	73.3	71.3	72.7	66.3	71.0	60.7	66.7	63.2
20	63.7	73.3	69.3	83.0	84.8	76.7	74.0	68.0	71.3	69.7	58.3	64.3	60.0
21	59.7	63.7	74.0	85.7	81.0	75.3	68.3	64.0	61.3	72.7	63.7	68.0	61.7
22	65.7	67.3	79.3	82.0	80.7	71.3	70.3	64.3	59.0	76.0	68.0	69.0	61.7
23	59.3	66.0	84.4	82.0	84.7	67.3	69.3	72.0	57.0	68.0	73.7	62.5	60.8
24	58.7	61.7	85.0	79.5	79.0	66.3	69.0	73.0	58.7	75.2	62.0	65.0	64.3
25	67.7	64.3	79.7	76.6	70.5	63.3	71.0	70.3	62.7	68.3	64.5	66.0	59.3
26	66.7	63.0	70.3	79.7	74.3	71.3	74.0	69.7	65.3	69.7	63.0	65.0	64.7
27	72.0	71.7	67.7	78.7	77.7	71.3	75.3	76.0	61.3	56.3	65.0	64.5	61.2
28	75.3	71.3	70.0	74.3	71.3	75.0	69.7	69.7	67.0	58.3	69.7	65.7	64.0
29	71.0	70.7	69.7	64.5	75.3	72.0	68.3	67.3	63.0	56.7	66.3	67.0	66.0
30	63.7	64.7	68.3	61.3	76.0	67.3	62.0	71.7	66.0	62.0	71.7	69.3	73.0
31	65.0	68.7	66.5	61.3	75.0	61.0	66.3	69.0	68.7	62.3	70.9	69.8	72.7
Mean,	66.45	71.27	75.06	74.76	76.95	71.81	69.90	69.52	66.36	69.08	69.55	67.77	68.13

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	66.3	70.0	63.7	70.0	- -	74.0	74.0	74.3	62.7	70.0	63.3		69.1
2	67.0	69.7	67.3	67.0	- -	80.3	71.0	71.3	65.3	67.3	66.3		
3	68.5	72.7	70.3	67.0	- -	72.3	70.0	70.3	66.7	63.0	71.3		
4	67.7	72.7	62.7	67.7	- -	73.0	71.7	70.3	69.3	62.7	67.0		
5	70.7	73.3	65.0	58.2	- -	73.3	66.7	68.3	63.0	67.3	74.0		
6	67.0	75.2	69.5	62.8	- -	74.3	70.7	62.4	66.3	76.7	69.3		
7	71.7	76.0	68.3	66.0	- -	66.7	70.7	66.3	67.0	71.0	70.7		
8	70.3	67.0	73.3	69.0	- -	67.0	58.3	68.3	67.3	69.0	69.0		
9	67.8	69.0	68.0	69.2	- -	70.3	64.3	67.0	64.0	65.3	69.0		
10	66.0	67.0	67.3	66.8	- -	68.3	63.7	69.7	65.7	65.0	67.0		
11	61.5	64.0	66.7	66.0	- -	69.7	63.3	68.3	62.0	68.3	66.3		
12	60.3	65.0	71.0	66.0	- -	69.3	63.0	70.3	62.7	69.0	66.7		
13	64.5	69.5	67.7	68.7	- -	73.3	65.3	69.0	63.7	71.3	65.7		
14	67.3	64.3	67.0	70.5	- -	66.0	67.7	69.7	73.3	70.7	72.3		
15	67.7	62 7	64.3	69.8	- -	64.7	65.7	69.0	71.7	64.7	65.0		
16	67.7	60.3	62.3	63.7	- -	66.7	70.7	69.7	61.7	70.3	67.0		
17	70.3	59.3	66 0	66.7	- -	66.3	71.3	66.7	58.3	68.0	61.0		
18	68.7	56.0	60.7	68.3	- -	66.0	65.7	65.3	58.7	70.7	64.7		
19	70.8	61.7	62.3	71.0	- -	65.7	60.7	68.3	59.3	66.3	67.0		
20	69.3	62.0	62.0	68.3	- -	69.3	59.7	61.0	61.3	63.0	63.3		
21	68.7	67.3	63.0	64.5	- -	68.3	61.3	54.7	63.7	65.7	62.0		
22	72.7	68.0	62.0	64.3	- -	71.7	63.7	65.7	61.0	70.0	65.7		
23	62.0	71.5	72.7	67.2	- -	63.3	64.3	68.0	63.0	57.0	65.3		
24	65.3	72.0	72.0	67.8	- -	67.0	72.3	66.0	62.7	63.7	65.0		67.6
25	74.3	67.0	69.0	69.3	- -	68.7	67.3	64.0	61.3	65.3	63.0		67.2
26	75.3	69.7	60.3	65.2	- -	59.0	63.3	55.3	65.3	65.3	65.3		66.5
27	71.7	65.7	62.3	70.2	- -	60.7	56.3	59.3	64.3	61.3	63.0		66.5
28	72.3	58.7	59.0	71.7	- -	59.7	55.3	62.3	59.3	64.0	56.7		65.4
29	71.7	66.0	62.7	68.7	- -	59.0	54.7	60.3	63.3	67.7	55.3		66.1
30	72.3	67.0	64.7	58.8	- -	63.0	56.7	63.7	61.3	67.0	55.7		66.4
31	67.3	64.7	69.7	64.3	- -	70.7	54.3	65.0	64.0	68.3	61.7		66.3
Mean,	68.55	66.92	65.89	66.92	- -	67.99	64.63	66.13	63.84	66.93	65.32		

TABLE I.—*Continued.* Mean Temperature in September.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	18 0.	1821.
1	69°.9	63°.0	57°.7	71°.8	54°.2	64°.8	66°.3	58°.0	55°.7	61°.0	69°.3	66°.3	68°.2	67°.7
2	62.1	66.8	62.6	71.2	62.8	70.7	70.7	61.5	63.0	68.2	69.0	77.0	69.2	69.5
3	67.8	63.5	66.3	65.7	71.8	72.3	72.8	64.7	69.8	67.0	68.0	80.7	61.0	71.8
4	70.0	63.5	71.7	76.0	60.3	67.8	70.3	50.7	64.5	69.2	65.0	75.3	68.8	64.3
5	72.8	61.3	62.3	76.5	59.8	68.3	52.8	55.2	61.1	73.0	69.0	67.6	69.7	66.0
6	68.6	[65.1]	68.0	65.7	62.0	59.2	49.1	56.0	68.0	67.2	67.3	66.7	73.3	60.0
7	66.4	[64.0]	61.2	58.7	59.5	61.2	59.5	[64.0]	63.7	62.5	67.0	65.8	68.7	59.3
8	60.7	[62.7]	60.3	55.0	60.5	59.5	64.5	[62.7]	63.3	60.3	62.0	69.0	70.0	69.3
9	55.2	[64.0]	54.7	56.8	63.3	63.7	58.5	[64.0]	67.7	64.7	54.7	71.3	73 5	70.5
10	60.8	[63.1]	62.3	56.7	61.3	71.5	56.4	[63.1]	58.7	[63.1]	62.5	61.5	81.2	66.5
11	65.3	[63.0]	67.0	62.3	55.3	70.5	66.3	[63.0]	53.0	[63.0]	64.2	63.7	74.3	59.7
12	57.8	[62.1]	63.8	67.2	66.5	74.7	57.5	[62.1]	54.5	[62.1]	56.8	64.7	68.2	55.0
13	56.2	[61.3]	68.3	65.7	68.3	75.7	51.5	[61.3]	52.5	[61.3]	57.3	66.0	65.0	60.2
14	(57.9)	[59.4]	67.3	68.0	59.3	68.3	47.0	[59.4]	55.0	[59.4]	59.1	61.2	65.3	59.5
15	59.7	52.7	56.7	58.3	59.8	62.3	61.0	[59.9]	58.5	[59.9]	60.0	56.3	63.2	53.8
16	59.5	49.2	53.0	64.7	55.8	62.2	57.5	[58.9]	63.2	[58.9]	61.0	54.8	62.8	57.5
17	67.1	52.8	52.5	58.7	56.0	62.7	62.7	[58.9]	61.2	[58.9]	59.0	56.5	64.8	58.2
18	70.0	52.8	54.3	66.5	61.8	63.5	63.0	[61.0]	58.7	[61.0]	62.3	61.0	67.3	59.5
19	71.2	59.3	59.7	66.3	51.7	62.0	52.8	[60.6]	59.5	[60.6]	62.7	62.8	50.0	54.3
20	63.3	66.0	62.3	52.0	49.8	64.9	56.5	[60.1]	60.8	[60.1]	63.7	53.1	47.3	50.3
21	46.8	61.5	66.7	50.3	46.7	60.3	62.4	[58.1]	52.7	[58.1]	57.0	49.5	45.0	62.2
22	44.3	57.3	60.2	48.9	48.0	52.0	58.7	[55.4]	55.8	[55.4]	59.3	53.2	45.7	54.3
23	51.5	62.3	53.3	56.3	48.7	57.6	62.2	[56.3]	58.6	[56.3]	55.7	59.7	43.8	55.8
24	57.0	59.7	53.7	50.7	49.8	58.8	55.6	[56.5]	59.7	[56.5]	56.3	65.2	49.8	51.7
25	57.3	55.3	57.2	62.8	53.3	57.9	57.2	[56.7]	49.5	[56.7]	67.2	61.7	55.8	62.3
26	49.2	49.7	61.1	55.0	50.7	55.3	48.2	[55.3]	43.2	[55.3]	53.8	59.6	43.7	42.5
27	41.6	48.8	59.3	46.1	54.7	50.0	48.7	[55.1]	41.7	60.3	53.3	57.7	49.7	43.7
28	41.6	52.0	63.7	58.3	45.0	49.9	44.1	[56.0]	48.7	54.7	51.7	65.3	53.5	53.0
29	53.2	47.7	65.7	60.0	45.2	47.8	53.2	[54.9]	54.3	48.2	52.3	65.0	58.5	61.7
30	60.5	58.0	72.7	46.3	54.2	52.8	55.7	[55.5]	61.7	40.8	55.8	62.1	63.7	63.3
Mean,	59.17	58.93	61.69	60.63	56.54	62.26	58.08	58.83	57.93	60.12	60.74	63.33	61.34	59.45

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	66.4	(74.0)	- -	58.6	56.0	63.0	74.3	68.0	61.3	68.3	58.0	63.7	64.3	64.7
2	68.7	(70.9)	- -	59.3	57.0	65.7	76.0	70.0	59.3	67.3	65.3	60.3	66.7	60.0
3	70.6	68.3	- -	52.0	67.7	65.7	70.3	59.0	58.0	69.3	65.0	55.0	71 3	65.7
4	69.6	69.6	- -	52.3	74.0	66.3	68.0	60.0	61.7	64.3	59.0	56.7	76.0	67.7
5	64.6	67.2	- -	59.7	73.3	55.7	69.3	61.0	58.7	63.0	65.3	67.3	75.3	73.3
6	60.5	72.1	- -	52.7	68.3	59.3	64.7	58.3	61.2	70.8	59.3	67.0	75.7	64.0
7	63.8	64.8	- -	56.3	62.0	55.3	64.3	63.7	57.7	68.0	60.9	67.3	67.8	65.7
8	66.5	57.0	- -	56.3	63.7	53.0	61.0	58.7	60.3	68.7	63.0	63.3	61.7	56.7
9	68.9	59.1	- -	60.0	57.0	66.7	56.3	56.3	66.0	75.8	61.0	63.0	70.0	63.7
10	72.6	59.6	- -	57.3	60.5	65.3	56.2	57.3	67.7	70.3	57.3	63.7	66.0	62.3
11	74.5	60.2	- -	47.3	72.0	63.3	55.7	57.7	68.3	70.3	63.3	61.7	55.0	64.3
12	66.7	59.8	- -	50.0	69.7	53.3	58.7	59.7	60.0	69.7	64.7	50.3	50.0	58.7
13	70.5	60.7	- -	67.3	65.0	51.7	59.0	60.3	62.5	63.0	54.0	51.0	51.7	60.7
14	64.3	60.3	- -	56.3	68.0	53.0	57.0	60.3	55.3	64.7	54.2	52.7	56.3	56.7
15	66.2	60.9	- -	58.3	62.0	60.0	57.7	59.7	56.0	60.0	61.3	59.7	64.0	54.3
16	62.6	57.3	- -	61.7	52.7	59.0	56.2	51 0	54.3	59.7	71.7	52.7	64.7	53.0
17	52.4	61.3	- -	58.3	53.0	60.0	56.7	54.0	52.5	57.7	60.7	55.0	67.0	51.3
18	51.8	70.3	- -	60.3	60.1	59.5	59.3	54.7	50.7	62.7	64.7	60.0	71.3	56.3
19	55.7	64.6	- -	60.3	63.3	54.7	59.7	54.3	53.0	59.7	71.2	73.0	70.3	57.0
20	63.8	56.3	- -	51.3	58.2	55.0	63.3	57.0	56.7	64.7	66.5	65.7	71.3	59.7
21	64.7	50.3	- -	55.0	54.3	58.0	58.2	64.0	54.3	58.7	61.7	62.0	66.5	63.3
22	47.8	42.4	- -	56.7	60.7	59.7	59.0	50.7	60.0	55.7	62.7	57.7	68.3	59.7
23	45.7	44.1	- -	58.0	52.3	65.0	64.0	55.3	61.0	64.0	58.8	55.0	63.0	56.7
24	43.0	49.7	- -	60.0	48.1	62.8	65.0	51.3	63.0	68.0	53.0	58.3	61.3	54.3
25	45.0	53.6	- -	51.3	48.0	61.7	66.5	52.7	62.0	63.3	58.5	62.3	61.0	55.7
26	67.0	53.9	- -	40.3	53.3	62.0	60.7	54.7	62.0	63.7	57.7	64.0	60.5	53.0
27	68.1	55.1	- -	47.3	61.7	56.2	57.0	49.7	62.7	66.0	60.3	61.0	66.0	54.7
28	69.0	52.7	- -	43.0	66.7	54.3	57.3	58.7	65.5	64.3	60.8	56.3	56.3	56.3
29	67.1	40.3	- -	43.7	63.5	53.3	56.0	52.7	60.7	57.3	64.5	61.0	45.3	58.0
30	69.0	49 0	- -	44.7	54.3	60.7	55.7	54.7	56.3	56.3	68.3	64.2	47.7	49.0
Mean,	62.91	58.85	- -	54.52	60.88	59.31	61.43	57.67	59.63	64.50	61.76	60.36	63.75	59.21

Table I.—*Continued.* Mean Temperature in September (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	67°.7	65°.7	65°.5	64°.3	75°.5	63°.3	68°.7	58°.0	65°.7	59°.7	73°.0	67°.7	65°.3
2	65.0	63.7	65.3	74.7	70.3	68.0	76.0	67.0	64.3	64.7	71.3	66.8	66.3
3	61.3	70.3	60.5	75.7	72.0	71.3	74.0	74.0	67.3	70.2	66.7	67.3	66.0
4	69.7	67.3	64.0	74.5	71.7	70.3	63.3	76.0	62.2	66.7	71.0	76.3	68.0
5	60.0	71.3	75.5	72.8	70.0	63.7	62.7	67.7	57.0	64.0	75.3	70.8	67.7
6	49.0	69.3	67.7	73.0	68.0	65.7	59.7	65.7	63.3	62.7	80.0	70.2	66.7
7	47.0	70.0	78.3	71.7	71.0	71.3	60.3	63.0	66.8	61.3	72.7	60.3	60.5
8	55.7	69.3	68.0	71.2	72.5	63.3	59.7	60.3	65.7	55.3	74.3	60.8	61.0
9	57.0	74.0	67.0	70.9	73.7	65.0	59.3	55.7	64.3	54.0	58.0	68.5	61.7
10	51.2	73.3	73.3	76.9	76.7	65.3	57.3	52.0	70.3	55.7	55.0	58.0	62.0
11	45.0	75.3	69.3	65.2	67.2	64.3	56.7	52.3	61.3	55.7	61.3	56.0	63.2
12	62.3	67.0	65.8	66.0	65.2	68.3	64.0	49.0	63.3	57.7	73.5	62.0	56.5
13	60.7	62.0	63.8	65.3	63.2	64.7	59.7	51.7	64.0	55.0	73.0	61.3	51.0
14	69.7	65.0	65.2	67.0	64.3	66.7	55.0	52.0	62.3	53.0	68.0	62.3	53.8
15	72.0	66.7	72.2	63.3	68.3	63.3	57.7	57.7	68.7	61.2	60.5	59.3	60.7
16	58.7	66.7	65.4	72.1	70.0	60.0	58.0	66.7	69.7	53.3	56.0	55.7	51.0
17	60.7	67.0	63.8	76.7	69.7	61.7	58.7	63.7	62.0	52.0	57.0	52.8	48.7
18	65.3	67.3	66.7	71.0	72.3	65.3	57.7	71.3	64.3	63.3	60.7	56.3	48.3
19	70.7	68.3	67.3	73.0	71.3	59.7	61.0	67.3	66.7	61.7	60.5	56.0	52.3
20	81.0	65.7	67.1	68.7	65.7	62.3	56.7	57.0	68.0	57.5	63.3	54.3	57.3
21	62.3	55.3	65.0	70.2	64.8	66.7	55.7	73.7	67.3	55.0	59.5	55.3	58.7
22	61.3	63.3	71.3	70.3	55.7	61.3	48.3	54.3	53.0	49.0	53.2	56.8	45.3
23	64.3	62.3	72.2	71.0	60.7	68.7	49.0	56.0	50.3	48.0	53.0	58.8	45.7
24	64.3	61.3	59.5	62.0	64.0	69.0	48.0	66.0	50.3	48.5	62.3	54.8	52.8
25	55.7	63.3	55.7	68.0	60.3	69.3	56.0	52.0	56.7	51.5	52.7	54.8	49.0
26	54.0	69.3	60.0	61.3	61.0	64.7	56.7	56.0	50.3	50.5	57.7	48.2	45.3
27	59.3	67.0	60.0	63.3	68.5	62.7	57.3	44.7	48.7	56.0	50.7	53.7	42.2
28	49.0	72.3	69.0	54.7	67.0	61.0	62.7	47.7	40.3	56.0	51.3	56.7	45.5
29	44.7	61.7	69.0	55.2	63.3	63.3	55.3	53.7	42.7	59.0	53.3	59.5	52.2
30	38.3	62.3	71.9	49.3	64.7	49.0	52.7	55.0	52.0	59.7	59.7	48.7	62.3
Means,	59.43	66.78	66.85	67.99	67.62	64.65	58.92	59.57	60.30	57.25	62.72	59.68	56.22

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	65.7	69.7	64.7	67.0	- -	64.7	62.0	56.0	58.3	70.3	57.7		64.6
2	60.7	70.3	56.0	71.8	- -	63.7	65.3	57.7	64.3	68.3	59.3		
3	60.0	68.0	57.0	70.0	- -	67.0	62.0	60.0	71.0	66.7	55.3		
4	57.0	67.7	62.0	66.8	- -	65.7	56.3	60.7	70.3	70.3	56.7		
5	65.0	65.0	62.3	70.2	- -	69.3	60.3	67.7	68.0	70.3	57.7		
6	69.0	69.0	70.3	66.2	- -	75.0	63.3	68.0	59.7	66.3	55.0		65.1
7	67.3	70.2	71.3	68.0	- -	74.3	61.7	62.7	51.3	66.0	54.0		64.0
8	56.3	59.3	71.3	71.7	- -	60.3	72.7	60.0	51.7	72.0	55.0		62.7
9	58.5	63.5	71.0	73.5	- -	63.3	77.3	66.3	60.3	75.3	55.7		64.0
10	58.5	61.0	66.3	63.3	- -	53.3	65.3	66.7	62.7	69.3	56.3		63.1
11	59.3	63.5	77.0	60.7	- -	52.0	68.0	70.0	73.3	68.7	61.0		63.0
12	60.3	53.2	72.0	65.2	- -	58.8	73.7	64.0	62.7	65.3	66.3		62.1
13	65.3	53.8	69.7	62.7	- -	56.3	68.3	63.0	62.7	58.0	63.3		61.3
14	61.3	53.2	50.7	54.5	- -	55.7	52.3	61.7	66.7	59.0	47.3		59.4
15	64.0	55.8	49.0	56.3	- -	60.7	52.3	59.0	66.3	58.0	40.7		59.9
16	57.2	56.8	54.0	55.5	- -	52.0	63.7	61.3	53.7	65.0	46.7		58.9
17	69.0	54.2	53.3	55.7	- -	53.7	69.7	52.0	55.0	64.3	52.3		58.9
18	58.0	54.7	58.0	58.3	- -	57.7	57.7	66.3	51.7	55.7	55.7		61.0
19	50.0	60.8	63.3	58.5	- -	64.0	45.3	[63.2]	49.0	56.0	56.7		60.6
20	51.8	61.3	64.7	64.0	- -	54.3	46.7	[62.7]	52.7	62.0	61.7		60.1
21	52.3	56.7	62.3	57.7	- -	42.3	53.3	[60.7]	47.0	71.0	47.0		58.1
22	56.0	59.7	47.7	62.2	- -	47.0	57.0	[58.0]	49.0	54.7	46.7		55.4
23	58.7	62.5	46.3	56.7	- -	51.3	53.3	[58.9]	50.7	49.3	48.0		56.3
24	55.3	62.2	47.7	54.3	- -	58.3	51.3	[57.1]	54.7	49.0	52.7		56.5
25	57.3	54.8	41.0	50.7	- -	58.3	54.7	[59.3]	56.0	50.3	59.0		56.7
26	63.7	47.2	49.3	54.7	- -	61.7	55.0	[57.9]	56.7	48.7	60.0		55.3
27	52.5	47.0	55.7	47.0	- -	64.0	60.0	[57.7]	56.0	51.0	56.3		55.1
28	57.5	59.7	61.7	47.8	- -	64.7	50.7	[58.6]	61.0	50.7	60.3		56.0
29	59.2	47.7	63.7	48.7	- -	49.7	49.7	52.7	43.3	52.7	53.7		54.9
30	50.0	50.7	64.0	42.8	- -	44.3	48.7	57.3	42.0	64.3	51.7		55.5
Mean,	59.22	59.30	60.11	60.08	- -	58.77	59.25	60.95	57.58	61.61	54.98		

TABLE I.—*Continued.* Mean Temperature in October.

Day of month.	1808.	1809.	1810.	1811.	1812.	1813.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.
1	58°.5	64°.7	72°.2	41°.4	63°.7	52°.7	56°.8	[55°.5]	60°.0	42°.0	54°.2	61°.8	50°.3	(63°.0)
2	61.7	60.0	56.1	46.0	61.5	53.7	63.7	[55.5]	58.8	47.8	56.0	54.7	56.0	(62.8)
3	49.6	62.3	52.8	56.5	64.2	52.9	59.3	[55.9]	55.8	46.8	55.5	49.3	59.5	(62.5)
4	46.3	65.5	63.7	52.3	62.0	54.3	60.2	[54.9]	44.3	53.7	58.0	46.1	64.5	62.2
5	50.1	65.7	66.0	53.8	56.0	47.3	54.5	49.3	44.0	54.7	54.3	52.6	60.5	(63.1)
6	48.0	69.5	62.7	50.8	47.3	40.8	49.8	57.5	43.3	51.0	56.0	63.8	60.7	64.0
7	44.7	60.9	56.1	52.7	46.2	47.7	43.8	48.3	40.0	59.3	49.2	67.3	51.3	(62.0)
8	43.5	50.8	52.2	58.9	51.7	51.5	39.3	55.2	49.3	52.2	54.0	63.0	46.3	(60.0)
9	45.0	64.7	51.8	68.7	45.8	55.7	39.0	55.2	53.8	46.7	58.8	59.3	47.0	(58.0)
10	53.1	72.3	47.7	51.7	45.3	49.5	53.7	50.3	46.5	42.8	57.8	57.5	46.3	56.0
11	57.6	59.3	42.2	60.7	42.3	47.3	51.7	57.8	48.8	41.2	62.2	50.5	49.2	40.7
12	57.3	45.2	38.7	59.2	43.7	42.8	58.4	59.5	46.3	50.3	62.3	44.8	51.0	44.7
13	56.3	53.5	42.7	56.7	36.2	43.2	58.6	51.3	46.0	58.2	55.3	43.1	45.3	59.5
14	44.1	60.2	54.2	57.8	39.5	43.7	52.3	49.7	54.3	48.3	45.7	38.3	52.2	45.2
15	44.8	57.2	52.3	44.5	53.2	43.0	63.0	44.3	57.8	48.1	55.6	53.2	53.5	44.0
16	41.2	46.0	54.7	52.3	49.2	52.5	42.6	41.9	60.0	41.4	55.2	56.0	55.5	48.2
17	55.8	50.2	47.3	47.7	47.0	55.8	40.2	52.0	55.2	37.2	51.8	55.0	48.7	41.7
18	40.8	43.2	37.7	43.7	41.7	56.0	46.0	49.5	42.0	42.3	52.0	41.0	43.1	33.0
19	30.5	46.7	39.3	59.6	44.8	44.8	50.4	46.5	51.2	36.0	48.3	40.0	51.2	31.5
20	43.6	43.3	46.0	64.0	36.7	36.2	48.0	45.8	47.3	39.7	53.0	49.8	52.3	36.8
21	44.8	41.2	50.2	36.3	53.8	35.3	44.2	48.7	50.7	35.8	59.7	46.7	48.0	48.0
22	39.2	45.8	55.5	42.5	40.8	36.7	46.3	48.5	54.8	50.8	42.3	44.8	39.8	40.0
23	48.3	48.7	33.7	58.6	40.8	42.0	40.3	45.8	55.0	55.3	34.3	38.1	42.7	33.0
24	44.3	51.2	34.0	37.7	44.2	47.2	39.7	41.0	49.1	54.5	42.2	49.8	46.0	33.3
25	37.6	44.2	31.0	31.9	44.7	55.7	39.3	44.0	46.8	41.0	52.5	46.2	40.3	31.2
26	48.2	44.0	44.7	37.0	53.0	58.8	48.7	39.7	55.3	32.7	52.9	40.7	39.0	39.5
27	44.0	44.5	46.8	37.5	46.2	61.0	55.5	41.0	46.2	42.7	45.2	40.5	31.8	51.5
28	31.3	46.3	48.0	44.9	42.2	55.8	56.3	31.3	43.3	42.0	41.7	39.9	32.0	50.3
29	34.2	48.8	52.8	45.3	48.7	56.0	51.2	35.8	47.3	30.0	36.9	45.4	35.8	45.2
30	29.5	56.0	37.5	35.5	43.3	51.0	48.9	42.7	46.2	32.2	39.0	47.0	34.3	48.2
31	29.2	45.4	28.7	47.0	53.0	42.5	46.3	32.5	46.2	38.0	42.8	36.3	38.8	35.8
Mean,	45.16	53.46	48.35	49.46	48.22	48.88	49.94	47.97	49.97	44.99	51.12	49.10	47.51	48.22

Day of month.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.
1	46.5	45.0	65.3	60.7	56.4	63.0	56.0	47.7	59.3	50.7	69.3	52.7	59.0	52.3
2	50.0	(53.1)	67.0	64.0	54.1	60.0	39.3	50.3	59.0	64.0	59.3	61.2	66.3	57.0
3	47.3	61.2	69.0	66.0	60.0	60.3	58.7	55.3	56.0	70.0	59.0	59.0	61.0	54.3
4	45.7	58.3	69.7	73.0	48.7	59.3	56.3	59.0	46.0	58.3	59.0	51.0	58.8	51.3
5	38.7	62.8	63.7	71.7	53.7	61.0	58.0	47.0	53.7	55.0	55.5	48.3	53.0	55.7
6	55.8	47.7	69.0	71.0	61.7	53.3	54.7	50.3	54.3	55.5	56.5	54.7	49.7	63.0
7	54.7	41.5	63.0	75.5	59.7	45.0	51.7	51.0	42.0	53.0	54.7	61.3	51.3	57.3
8	57.7	47.3	59.7	49.7	48.3	48.0	59.0	51.7	42.3	53.7	58.0	61.7	60.3	53.0
9	59.8	57.0	59.3	48.0	43.0	52.3	60.3	51.7	47.0	62.0	54.7	58.7	59.0	49.0
10	52.8	48.7	[52.0]	55.8	41.0	62.0	54.0	49.7	42.7	56.7	58.8	56.7	46.7	46.0
11	59.5	39.7	[50.9]	63.2	38.7	48.3	57.0	54.0	54.5	45.3	63.3	42.7	42.5	49.0
12	56.8	34.3	[50.5]	43.2	51.0	49.7	48.7	48.0	56.0	44.3	55.7	43.7	55.7	42.3
13	58.1	42.5	[51.6]	50.8	53.3	54.7	46.7	49.7	55.0	46.0	56.0	59.7	61.3	48.7
14	55.7	39.2	[49.7]	52.7	49.7	48.0	43.7	54.0	60.3	51.3	52.7	48.0	41.3	54.3
15	39.6	37.3	[49.1]	56.3	42.8	52.7	36.3	57.3	61.0	50.7	43.0	49.7	38.7	54.3
16	44.3	47.7	[48.3]	51.0	51.0	43.3	34.0	52.0	57.7	50.7	49.2	50.7	39.2	54.7
17	48.2	57.8	[49.5]	38.7	55.3	36.0	37.3	54.3	50.2	66.0	60.0	50.0	53.3	54.0
18	43.6	39.7	[47.9]	39.3	46.0	45.3	45.2	54.0	47.7	58.3	64.3	55.7	58.2	57.3
19	55.2	38.2	[48.3]	37.7	50.3	46.7	35.0	54.0	51.3	59.3	52.3	44.3	63.3	63.7
20	65.2	33.7	[47.4]	(39.7)	48.7	52.3	33.7	49.7	52.5	52.7	58.3	42.7	48.0	60.7
21	53.1	49.3	[46.1]	41.7	48.3	48.3	43.3	35.7	53.7	47.7	56.7	44.3	43.0	57.7
22	46.7	46.7	[45.8]	39.0	48.0	46.7	51.0	36.7	51.7	58.3	45.3	49.7	42.0	59.7
23	47.3	40.3	[45.5]	31.3	43.3	58.3	48.7	39.7	50.7	62.7	55.0	47.8	45.8	51.7
24	34.7	44.7	[46.6]	31.3	36.3	53.3	47.3	55.3	48.0	65.4	47.3	51.3	39.7	54.0
25	37.1	36.7	[44.0]	30.3	27.8	43.7	47.7	57.0	41.7	56.3	50.0	54.0	34.7	40.0
26	38.3	37.0	[44.3]	39.7	42.7	35.0	46.3	64.3	38.3	51.0	38.5	49.5	35.4	45.3
27	33.3	42.0	[44.2]	40.0	30.0	35.7	41.0	49.7	49.2	57.3	44.7	48.7	36.7	46.0
28	32.7	44.5	[43.9]	57.0	41.0	36.7	51.3	40.3	51.0	46.0	44.3	45.0	40.5	55.7
29	35.6	43.7	[45.1]	47.7	58.0	46.7	44.3	38.7	46.7	45.3	46.7	41.8	40.0	56.3
30	41.4	39.5	[44.4]	35.7	46.0	53.3	36.7	47.3	54.3	(46.1)	47.2	37.0	36.0	56.7
31	41.7	35.0	[42.3]	39.7	36.0	33.0	46.7	42.7	57.0	46.9	47.5	34.7	37.0	46.7
Mean,	47.64	44.89	52.36	49.71	47.44	49.42	48.07	49.94	51.96	54.40	53.61	50.19	48.30	53.15

TABLE I.—*Continued.* Mean Temperature in October (continued).

Day of month.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
1	45°.7	66°.3	73°.2	55°.0	56°.7	49°.3	54°.0	50°.3	43°.3	63°.0	55°.2	48°.0	66°.0
2	60.3	68.0	66.8	56.1	60.3	49.3	59.0	56.0	41.3	57.3	44.8	50.8	41.7
3	53.0	54.7	64.7	62.1	69.0	49.0	52.3	52.7	52.5	57.0	48.0	51.9	44.0
4	48.7	46.7	55.8	58.5	58.5	43.7	51.0	47.3	56.3	57.7	47.5	52.3	48.3
5	41.5	52.3	66.3	48.9	61.0	50.7	47.3	47.0	54.0	60.3	49.7	57.0	55.7
6	49.0	57.7	65.5	48.4	66.3	51.7	48.7	49.7	50.3	51.0	57.7	59.5	52.3
7	50.3	53.3	57.3	57.0	62.3	52.0	50.0	52.3	43.3	49.0	53.3	55.0	49.7
8	45.0	55.7	49.7	64.7	57.8	51.3	55.0	49.7	46.7	55.7	63.7	53.7	48.3
9	44.7	60.0	51.3	64.5	61.0	50.3	63.0	55.7	56.3	54.7	59.5	53.0	42.5
10	39.3	62.0	57.3	65.3	51.0	51.3	51.3	53.7	53.3	56.7	45.0	45.7	52.5
11	37.7	67.7	64.0	57.7	57.3	50.7	51.7	50.7	46.8	57.3	42.3	43.0	40.3
12	42.0	62.7	57.3	55.5	61.3	56.0	54.0	47.7	42.3	62.0	47.7	41.3	46.5
13	45.7	49.7	54.3	63.7	52.7	48.7	49.3	52.3	42.0	55.7	57.3	52.7	42.0
14	52.3	48.7	52.7	58.3	63.0	46.0	48.3	46.3	50.3	49.0	58.0	42.3	39.8
15	60.7	54.7	50.6	59.8	56.0	46.3	54.3	41.7	49.0	49.0	49.3	42.0	47.7
16	38.3	54.0	52.3	59.3	49.3	46.0	52.0	49.7	51.2	37.2	51.7	39.2	47.8
17	49.3	52.7	50.3	59.7	47.2	44.7	55.3	46.7	45.0	40.0	53.0	51.7	59.3
18	38.7	64.3	47.3	64.7	48.3	45.8	51.0	43.3	55.0	43.3	38.1	51.2	51.7
19	44.0	64.3	46.3	62.0	58.7	45.7	44.3	44.0	55.0	51.7	38.3	48.0	51.3
20	55.3	56.7	57.3	45.9	66.5	44.0	42.7	52.4	42.3	40.7	37.7	42.5	49.7
21	39.0	51.3	55.7	40.3	59.0	46.0	40.0	52.7	39.0	34.5	44.3	43.0	43.3
22	40.7	52.3	53.3	46.0	59.8	43.3	49.7	37.0	45.3	29.0	36.7	42.0	41.5
23	41.3	57.3	50.0	50.2	56.5	41.2	46.3	36.7	43.7	34.3	32.0	42.7	43.0
24	51.3	65.3	52.0	60.0	50.3	48.0	46.3	42.7	44.7	41.0	36.0	57.7	42.0
25	32.3	58.7	51.0	57.2	47.3	38.3	59.0	42.3	51.7	37.3	39.0	36.7	45.2
26	35.3	64.3	50.7	55.3	43.0	37.3	54.7	38.7	57.0	40.3	33.3	33.7	42.0
27	34.0	63.0	51.7	61.0	40.3	39.0	42.7	35.3	50.0	44.7	52.7	25.3	42.3
28	32.7	51.3	46.0	62.3	49.0	44.7	43.7	42.7	31.0	50.7	42.3	29.7	42.0
29	42.3	45.0	46.2	58.3	58.5	52.3	46.7	37.3	39.0	53.0	37.3	40.3	51.1
30	35.0	42.3	41.5	45.7	66.3	58.0	38.7	40.7	43.3	52.5	31.3	40.0	54.3
31	29.3	44.3	37.3	48.2	59.0	55.3	40.7	34.3	40.3	42.0	34.0	44.0	50.3
Mean,	43.68	56.35	54.06	56.50	56.57	47.72	49.77	46.10	47.14	48.63	45.70	45.77	47.57

Day of month.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.		Means.
1	44.3	50.5	53.3	48.0	- -	49.7	57.0	57.0	43.0	62.7	58.0		55.5
2	45.0	51.7	51.7	56.3	- -	55.0	59.7	50.3	46.7	51.0	54.7		55.5
3	47.3	49.7	55.6	48.2	- -	55.3	58.7	53.0	48.7	54.0	48.7		55.9
4	48.0	53.2	52.7	55.3	- -	59.0	58.7	50.0	46.7	62.7	60.0		54.9
5	45.0	50.3	51.0	54.2	- -	52.0	59.7	46.7	46.0	58.7	55.7		
6	46.7	55.3	53.3	46.7	- -	47.3	58.7	62.0	53.0	52.3	52.7		
7	39.8	43.7	55.7	54.0	- -	53.7	56.0	56.0	52.7	51.0	46.3		
8	45.5	38.0	60.0	50.3	- -	57.7	47.7	51.0	45.7	46.7	38.7		
9	44.2	53.5	61.0	51.2	- -	57.3	45.3	59.0	49.0	46.7	38.7		
10	47.7	51.7	60.0	51.3	- -	56.7	47.3	67.0	45.7	47.3	36.3		52.0
11	47.8	53.2	60.0	54.8	- -	49.3	48.0	62.3	44.0	46.3	42.0		50.9
12	47.8	57.8	60.3	54.7	- -	54.3	52.3	48.0	47.7	47.7	45.0		50.5
13	48.3	47.3	63.7	52.0	- -	57.0	53.0	52.0	54.3	49.0	50.0		51.6
14	39.0	45.0	60.0	46.0	- -	53.3	49.7	37.7	56.3	55.0	49.7		49.7
15	43.5	50.5	53.0	35.3	- -	42.7	48.7	37.0	53.7	53.3	40.7		49.1
16	50.3	53.3	51.3	39.3	- -	43.7	49.3	40.7	55.7	46.0	36.0		48.3
17	56.7	53.7	46.0	37.0	- -	41.0	47.0	42.7	51.0	49.0	48.7		49.5
18	53.5	53.2	48.0	44.2	- -	43.7	45.3	[49.0]	47.0	51.0	52.0		47.9
19	44.3	61.0	49.0	49.5	- -	42.3	45.3	[49.5]	51.7	58.0	38.7		48.3
20	42.5	50.0	52.0	46.0	- -	37.0	51.7	[48.5]	41.3	56.0	30.3		47.4
21	42.7	45.7	52.3	44.0	- -	42.0	57.3	[47.3]	40.3	48.7	31.0		46.1
22	48.7	48.3	57.3	48.5	- -	43.3	56.7	[46.9]	30.0	49.0	38.0		45.8
23	54.3	52.7	45.7	45.7	- -	42.3	48.7	[46.7]	36.3	52.7	37.0		45.5
24	45.7	59.0	43.7	56.0	- -	42.7	47.3	[47.7]	44.0	50.7	33.7		46.6
25	42.8	60.0	47.7	53.3	- -	44.7	47.3	[45.2]	47.7	40.0	31.7		44.0
26	38.3	59.0	48.0	37.7	- -	49.7	39.0	[45.4]	51.0	41.3	28.0		44.3
27	49.7	54.7	39.7	38.3	- -	49.3	43.7	[45.4]	40.7	52.0	25.0		44.2
28	47.3	44.0	37.7	46.7	- -	50.7	42.3	[45.0]	32.0	50.3	38.7		43.9
29	55.2	38.5	44.0	52.0	- -	53.0	39.3	45.3	39.7	40.3	35.7		45.1
30	50.3	37.8	52.7	46.7	- -	59.3	43.7	46.7	40.7	51.3	32.7		44.4
31	38.9	41.3	49.7	44.0	- -	58.0	39.0	40.0	42.7	56.0	38.3		42.3
Mean,	46.49	50.44	52.13	47.97	- -	49.78	49.77	49.08	45.93	50.84	41.68		

April, 1867.

In addition to Table I we have the following observed maxima and minima for each day in January, February, and March, 1807, from which we can deduce the daily mean temperatures by adding to each mean in January —°.3, in February —°.2, and in March —°.2, corrections which follow from the Toronto and Montreal series.

TABLE II.—Observed Daily extreme Temperature, and deduced Daily Mean Values, for January, February, and March, 1807.

Day of month.	January.			February.			March.		
	Maximum.	Minimum.	Mean corr'd.	Maximum.	Minimum.	Mean corr'd.	Maximum.	Minimum.	Mean corr'd.
1	—8°.5	10°.3	0°.6	33°.5	46°.0	39°.5	18°.0	45°.0	31°.3
2	—2.2	22.0	9.6	14.5	33.5	23.8	16.0	33.0	24.3
3	9.7	18.7	13.9	19.0	24.0	21.3	6.0	33.0	19.3
4	0.2	14.5	7.0	6.0	22.0	13.8	15.5	33.5	24.3
5	15.7	34.5	24.8	—10.0	16.0	2.8	16.0	43.5	29.5
6	28.5	38.5	33.2	—6.0	20.5	7.0	11.0	39.0	24.8
7	30.8	36.2	33.2	3.0	16.0	9.3	16.0	38.0	26.8
8	22.5	28.0	24.9	—12.0	7.0	—2.7	20.0	45.0	32.3
9	—1.5	26.0	12.0	—18.5	21.5	1.3	33.0	36.0	34.3
10	20.0	30.0	24.7	2.0	30.0	15.8	33.0	49.0	40.8
11	25.7	34.5	29.8	1.0	33.0	16.8	30.0	45.0	37.3
12	16.5	22.3	19.1	22.0	42.0	31.8	22.5	45.0	33.5
13	—4.7	17.5	6.1	11.0	35.0	22.8	16.5	45.0	30.5
14	—7.3	10.5	1.3	34.0	43.0	38.3	24.0	47.0	35.3
15	—2.2	28.8	13.0	34.0	42.0	37.8	19.0	40.0	29.3
16	19.8	23.0	21.1	—5.0	19.0	6.8	4.5	47.0	25.5
17	—3.3	32.3	14.2	—11.0	16.0	2.3	21.0	45.0	32.8
18	20.5	32.3	26.1	11.5	33.0	22.0	20.0	47.0	33.5
19	5.5	16.5	10.7	33.0	44.0	38.3	17.0	45.0	30.8
20	—19.0	19.5	0.0	11.0	23.0	16.8	15.0	45.0	29.8
21	—5.5	23.5	8.7	9.0	15.5	12.0	20.0	46.0	32.8
22	—20.3	6.5	—7.2	11.0	34.0	22.3	23.0	44.0	33.3
23	—30.0	24.0	—3.3	13.8	39.0	26.2	17.0	33.0	24.8
24	11.0	26.5	18.5	15.8	40.0	27.7	7.5	40.0	23.5
25	7.8	23.5	15.4	27.5	38.0	32.5	15.0	34.0	24.3
26	—13.5	—4.5	—9.3	25.0	35.5	29.8	27.0	44.0	35.3
27	—29.7	9.5	—10.4	11.0	33.0	21.8	25.0	50.0	37.3
28	—1.5	35.0	16.5	5.0	34.0	19.3	26.0	50.0	37.8
29	33.5	42.0	37.5				20.0	46.0	32.8
30	16.2	35.8	25.7				24.0	50.0	36.8
31	3.5	35.0	19.0				20.0	30.0	24.8
Mean,			14.08			19.90			30.63

The above daily means have a somewhat smaller weight than the daily means of Table I.

Correction for Diurnal Inequality to the Values of Table I.

The correction to be applied to the observed mean temperature at 7 A. M., 1 and 6 P. M., in order to produce the mean temperature of the day as it would result from 24 or hourly observations, can be found with sufficient accuracy from the observed hourly variations at Toronto and Montreal as given by Prof. Guyot in the Smithsonian miscellaneous collection of tables. These two localities are subject very nearly to the same thermal influences as Brunswick; this is indicated by their geographical latitude and by the isotherms for summer and winter. Taking the mean correction, resulting from the two tables at Toronto (by Prof. Dove and Capt. Lefroy) and Montreal, we obtain the following values for each month, expressed in degrees of Fahr. scale.

TABLE OF CORRECTIONS FOR DIURNAL INEQUALITY.

	Correction.		Correction.		Correction.
January . .	—0°.67	May	—2°.79	September . .	—2°.19
February . .	—0.67	June . . .	—2.97	October . .	—1.50
March . . .	—1.35	July	—3.30	November . .	—0.75
April . . .	—1.90	August . . .	—2.99	December . .	—0.56
				Year	—1.79

Applying these corrections to the monthly mean values of Table I, and adding also the three values of Table II, we form the following Table III of resulting mean monthly temperatures.

TABLE III.—RESULTING MEAN MONTHLY TEMPERATURES OBSERVED AT BRUNSWICK, ME.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1807	14°.08	19°.90	30°.63	- - -	- - -	- - -	- - -	- - -	- - -	- - -	34°.71	27°.99
1808	19.15	26.41	32.76	43°.50	49°.86	61°.03	65°.05	61°.92	56°.98	43°.66	35.12	25.67
1809	16.75	15.46	27.69	41.08	52.00	60.48	59.63	63.76	56.74	51.96	30.37	29.73
1810	18.11	24.81	30.04	43.97	52.57	60.59	62.59	63.85	59.50	46.85	35.61	24.32
1811	20.24	23.27	35.77	43.76	51.90	60.60	65.42	64.98	58.44	47.96	37.68	26.55
1812	16.66	20.07	24.83	40.46	46.53	57.67	62.11	62.25	54.35	46.72	36.26	23.36
1813	17.17	22.83	26.10	42.00	48.37	59.56	64.27	65.86	60.07	47.38	38.15	26.44
1814	19.36	26.12	29.11	42.77	52.71	59.71	64.06	62.07	55.89	48.44	37.81	21.47
1815	18.17	19.47	31.44	40.25	49.57	61.29	68.14	62.73	56.64	46.47	37.98	22.24
1816	19.40	22.76	26.38	40.66	48.75	55.87	61.94	63.15	55.74	48.47	38.80	23.19
1817	15.51	15.53	29.15	40.26	49.71	57.03	64.70	63.65	57.93	43.49	36.59	26.15
1818	19.31	16.18	33.62	41.28	55.44	65.61	68.32	66.27	58.55	49.62	41.04	22.06
1819	25.22	28.89	26.41	40.47	51.38	64.54	68.62	67.56	61.14	47.60	37.37	26.28
1820	16.45	27.01	30.30	41.88	52.14	63.34	73.53	67.62	59.15	46.01	33.13	17.81
1821	15.11	27.18	29.63	39.86	53.94	65.83	65.19	68.06	57.26	46.72	36.31	21.86
1822	14.08	20.57	33.03	38.59	54.39	61.71	66.83	63.92	60.72	46.14	36.17	21.74
1823	17.91	14.72	27.30	38.72	47.78	59.25	67.99	66.71	56.66	43.39	27.69	24.19
1824	19.45	21.25	30.78	42.26	50.67	61.03	68.81	64.83	- - -	50.86	30.60	27.51
1825	18.36	22.02	36.07	49.45	56.57	66.82	73.12	64.54	52.33	48.21	34.93	26.35
1826	21.40	23.51	32.02	40.37	58.12	66.33	72.20	68.31	58.69	45.94	35.16	23.52
1827	17.45	22.43	32.74	46.62	52.02	62.37	69.61	65.61	57.12	47.92	29.97	22.61
1828	24.16	31.75	34.84	41.18	54.70	65.81	69.53	68.22	59.24	46.57	37.45	29.84
1829	18.94	19.20	32.24	44.99	59.80	64.79	68.32	68.53	55.48	48.44	38.52	35.02
1830	18.89	21.51	35.13	51.19	56.80	63.24	68.96	67.62	57.44	50.46	45 03	33.76
1831	21.61	25.58	39.57	46.56	56.91	69.08	70.76	70.09	62.31	52.90	41.05	15.52
1832	25.56	23.92	33.59	40.54	51.42	60.50	64.05	66.59	59.57	52.11	38.83	25.44
1833	25.37	21.60	31.13	46.24	56.72	59.78	68.56	64.44	58.17	48.69	37.26	29.36
1834	18.96	29.51	33.49	46.03	51.05	61.35	70.37	65.69	61.56	46.80	37.08	22.44
1835	24.27	21.25	30.35	42.07	53.12	62.39	68.80	65.78	57.02	51.65	36.69	19.62
1836	23.57	17.76	29.82	40.62	51.72	61.89	67.62	63.46	57.24	42.18	35.42	24.71
1837	18.25	31.35	38.23	49.63	56.78	68.21	71.27	68.28	64.59	54.83	41.21	32.59
1838	35.22	23.75	40.92	45.29	58.82	71.78	76.15	72.07	64.66	52.56	39.19	27.93
1839	29.06	32.06	38.05	50.06	57.47	65.22	73.39	71.77	65.80	55.00	42.50	36.98
1840	21.91	36.92	39.09	51.12	61.01	68.58	74.77	73.96	65.43	55.07	42.71	28.59
1841	28.97	25.18	34.23	41.33	52.13	65.53	67.56	68.82	62.46	46.22	37.23	29.28
1842	24.86	30.17	35.83	43.35	52.79	60.87	69.42	66.91	56.73	48.27	36.83	24.03
1843	30.17	18.97	29.15	44.04	53.86	61.20	63.89	66.53	57.38	44.60	31.72	24.89
1844	11.72	21.40	30.04	45.56	52.16	60.80	63.46	63.37	58.11	45.64	33.12	22.44
1845	21.40	21.92	30.04	39.20	50.88	62.17	65.33	66.09	55.06	47.13	40.14	19.86
1846	20.85	15.67	32.94	44.12	51.73	61.25	67.12	66.56	60.53	44.20	40.38	22.81
1847	19.71	21.26	25.73	36.32	51.58	60.21	68.70	64.78	57.49	44.27	38.23	28.69
1848	23.91	24.39	28.29	42.16	53.21	60.09	64.05	65.14	54.03	46.07	34.22	28.64
1849	16.01	14.79	32.42	38.52	50.30	63.30	67.00	65.56	57.03	44.99	42.56	23.50
1850	21.97	25.69	29.23	38.13	47.66	62.90	66.39	63.93	57.11	48.94	38.66	19.82
1851	17.81	24.50	31.39	41.28	50.60	58.03	65.32	62.90	57.92	50.63	32.84	17.98
1852	17.18	23.94	32.22	38.91	52.49	61.50	67.02	63.93	57.89	46.47	35.24	30.11
1853	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
1854	16.19	17.50	28.48	37.05	53.34	61.41	69.42	65.00	56.58	48.28	38.77	20.78
1855	- - -	18.40	28.98	40.12	50.26	60.75	68.18	61.64	57.06	48.27	35.65	25.97
1856	14.14	17.54	23.83	42.02	47.95	63.02	67.57	63.14	58.76	47.58	35.28	20.58
1857	13.08	32.66	33.26	44.30	53.83	60.68	65.22	60.85	55.39	44.43	34.98	24.72
1858	25.45	20.65	31.12	43.02	51.05	63.75	65.32	63.94	59.42	49.34	33.92	17.99
1859	16.33	21.27	30.81	37.35	50.63	55.80	63.64	62.33	52.79	40.18	34.85	17.77
Means,	20.10	22.93	31.54	42.56	52.69	62.29	67.44	65.60	58.28	47.78	36.71	24.86

TABLE IV CONTAINS THE MONTHLY AVERAGE VALUES OF THE OBSERVED TEMPERATURES AT THE HOURS 7 A. M., 1 P. M., AND 6 P. M.

Numbers within brackets do not comprise a full month.

Year.	January.			February.			March.			April.		
	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.
1807	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1808	13°.9	24°.8	20°.8	21°.6	31°.9	27°.5	28°.8	38°.1	35°.1	39°.3	50°.9	45°.8
1809	10.1	23.4	18.7	9.4	22.0	17.5	[19.4	29.7	18.5]	37.7	49.8	41.7
1810	11.5	24.3	20.4	18.0	31.6	26.8	26.5	37.2	30.5	40.2	53.7	43.7
1811	15.1	25.9	21.5	18.1	29.4	24.2	32.5	42.6	36.4	39.7	53.2	43.9
1812	11.3	22.3	18.4	13.9	25.8	22.5	17.3	33.2	28.3	35.5	49.3	42.2
1813	11.7	22.3	19.6	16.2	29.5	24.9	19.1	33.7	29.5	35.8	50.9	44.9
1814	12.6	26.5	21.1	20.0	32.5	27.5	24.3	36.4	30.7	38.8	51.5	43.6
1815	12.4	24.1	19.9	10.6	27.3	22.5	28.3	37.3	32.7	38.0	48.0	40.4
1816	11.8	26.5	21.9	17.1	29.1	24.0	21.5	33.3	28.4	37.6	49.2	40.9
1817	9.2	21.5	17.9	7.1	22.4	18.8	24.5	37.0	30.0	37.9	48.3	40.3
1818	14.2	25.1	20.6	7.7	26.8	16.1	26.9	43.0	35.1	39.3	49.2	41.0
1819	17.6	34.1	26.0	21.1	38.1	29.4	22.2	36.0	25.1	37.5	48.0	41.6
1820	6.8	25.8	18.5	20.2	35.3	27.4	27.5	36.9	30.6	39.7	50.5	41.2
1821	[7.5	18.0	15.0]	23.2	31.8	28.6	27.0	36.1	29.5	38.6	47.0	39.7
1822	7.9	19.6	16.7	12.4	27.3	24.0	27.4	40.5	35.3	37.0	44.8	39.6
1823	11.9	24.0	19.8	7.7	22.2	16.3	21.3	34.9	29.8	35.3	46.6	40.0
1824	14.3	25.3	20.7	17.4	25.9	22.4	26.3	38.4	31.6	40.2	49.6	42.6
1825	13.6	22.4	21.0	16.0	27.4	24.6	33.2	40.6	38.5	44.4	57.7	51.9
1826	16.6	26.7	22.9	16.3	29.8	26.5	28.1	37.9	34.1	38.0	47.0	41.8
1827	12.0	22.8	19.5	16.8	28.4	24.1	26.9	41.0	34.5	42.7	53.4	49.4
1828	18.7	30.3	25.4	27.4	36.6	33.3	30.0	42.9	35.7	37.8	48.0	43.4
1829	14.5	24.5	19.8	11.8	26.0	21.7	27.9	39.1	33.7	43.3	53.2	44.1
1830	14.6	24.7	19.4	16.7	27.9	22.0	30.5	42.5	36.5	47.7	59.3	52.2
1831	17.0	26.3	23.5	20.3	31.9	26.5	35.9	46.9	39.9	45.0	53.2	47.2
1832	19.4	31.3	27.7	19.1	29.1	25.6	29.4	39.0	36.4	38.9	47.7	40.9
1833	22.1	29.6	26.4	14.8	27.3	24.9	27.0	36.8	33.5	44.4	53.9	46.3
1834	12.5	24.6	21.7	23.1	36.7	30.7	29.3	40.0	35.3	43.6	54.5	45.8
1835	18.0	30.3	26.7	15.6	26.9	23.2	24.6	37.4	33.1	40.0	48.8	43.1
1836	18.8	28.3	25.6	9.8	24.7	20.8	22.3	38.9	32.4	37.3	48.4	41.9
1837	11.3	24.3	21.2	26.5	36.9	32.7	32.3	46.9	39.5	45.9	56 7	52.0
1838	31.6	39.7	36.4	17.4	29.9	25.9	36.3	48.3	42.2	41.6	53.0	47.0
1839	24.4	34.7	30.1	26.9	37.7	33.6	34.5	44.1	39.6	45.3	58.4	52.1
1840	15.9	27.7	24.1	32.4	42.5	37.7	35.0	45.9	40.4	48.4	58.7	52.0
1841	25.0	33.8	30.2	17.5	32.0	28.1	27.7	43.4	35.7	40.0	47.9	41.7
1842	19.0	30.5	27.1	26.1	34.9	31.5	32.1	41.8	37.6	40.6	51.0	44.2
1843	24.9	36.1	31.5	13.1	24.7	21.1	23.6	36.4	31.5	41.6	52.4	43.8
1844	5.2	16.6	15.4	12.2	28.7	25.3	25.6	36.2	32.4	40.2	54.8	47.3
1845	17.0	26.2	23.0	15.6	27.7	24.4	24.8	37.4	31.9	37.4	46.2	39.7
1846	15.1	26.4	23.0	9.4	21.4	18.3	28.2	39.3	35.4	39.2	53.0	45.8
1847	14.5	25.2	21.4	14.5	27.0	24.3	20.1	32.3	28.8	33.0	43.6	37.9
1848	19.7	28.3	25.7	17.9	30.1	27.3	22.4	35.5	31.0	37.7	50.2	44.3
1849	9.9	21.9	18.3	7.4	21.7	17.4	27.8	39.0	34.2	35.0	46.4	39.9
1850	16.5	27.6	23.8	19.3	31.9	27.9	23.8	36.8	31.1	34.4	45.8	39.9
1851	11.7	23.7	19.9	18.5	31.1	25.9	26.8	38.5	32.9	38.4	48.0	43.2
1852	11.8	22.9	18.9	16.9	30.9	26.0	26.6	40.2	33.8	35.9	45.3	41.3
1853	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1854	10.4	22.1	18.0	11.2	23.2	20.1	23.3	36.2	29.9	33.6	45.6	37.6
1855	- -	- -	- -	13.3	23.6	20.3	22.7	37.2	31.0	35.9	49.2	41.0
1856	6.1	21.2	17.2	10.2	24.6	19.9	15.1	33.2	27.3	37.7	51.2	42.9
1857	6.4	18.7	16.2	27.5	38.4	34.1	26.9	42.7	34.2	40.7	53.1	44.8
1858	19.5	31.4	27.4	12.6	28.2	23.1	25.5	38.4	33.5	39.2	51.9	43.7
1859	11.1	21.9	18.0	14.2	29.1	22.5	25.4	40.0	32.8	33.5	45.8	38.4
Means,	14.5	25.9		16.7	29.4		26.5	38.8		39.3	50.5	

Table IV.—*Continued.*

Year.	May.			June.			July.			August.		
	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.
1807	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1808	48°.5	58°.5	51°.0	58°.7	71°.4	61°.4	62°.6	76°.7	65°.7	57°.3	73°.4	63°.9
1809	49.2	62.3	52.9	56.6	70.2	63.6	54.0	72.4	62.0	58.3	74.9	67.1
1810	49.2	64.2	52.5	56.0	73.4	61.3	58.0	74.9	64.3	60.5	74.0	65.6
1811	49.2	62.0	52.6	56.7	72.6	61.3	63.6	76.3	66.6	62.0	75.8	66.2
1812	43.4	57.2	47.4	53.9	68.6	59.4	58.3	74.1	63.8	58.4	73.5	64.0
1813	44.0	60.2	49.2	54.9	72.2	60.3	60.7	76.7	65.2	58.6	80.4	67.4
1814	49.0	63.1	54.4	55.6	72.4	60.0	60.5	77.0	64.6	58.0	73.1	63.9
1815	48.2	59.3	49.6	61.1	72.1	59.6	67.9	79.0	67.5	62.0	72.4	62.4
1816	[46.3	57.5	48.0]	53.7	66.7	56.0	62.3	72.4	60.9	61.4	73.6	63.3
1817	47.7	61.0	49.0	55.5	66.6	57.6	65.6	75.2	63.3	62.4	73.2	64.4
1818	54.2	66.2	54.3	64.4	75.9	65.4	66.2	81.4	67.1	64.0	76.9	66.7
1819	49.3	59.4	53.8	63.8	75.2	63.5	70.0	77.6	68.2	67.6	76.4	67.6
1820	51.9	62.3	50.6	63.7	74.0	61.2	72.6	84.5	73.4	66.2	77.8	67.8
1821	52.1	62.4	55.7	64.5	73.8	68.1	65.6	74.3	65.7	66.5	77.0	69.5
1822	52.6	65.6	53.3	60.9	72.7	60.5	67.3	77.2	66.0	63.1	74.1	63.5
1823	45.5	57.2	49.1	57.5	69.6	59.6	68.6	76.3	69.0	65.5	77.0	66.6
1824	49.6	59.1	51.6	59.4	70.3	62.4	66.4	81.6	68.4	[63.2	75.2	66.0]
1825	53.6	63.5	60.9	65.9	73.4	70.1	71.3	82.1	76.0	62.6	72.8	67.2
1826	55.1	69.0	58.5	63.4	76.2	68.3	68.4	83.8	74.2	66.4	76.9	70.6
1827	48.9	62.0	53.6	59.8	70.4	65.9	68.8	78.9	71.0	63.0	74.7	68.1
1828	53.8	62.8	55.9	65.1	74.7	66.6	68.4	80.3	70.0	66.0	80.4	67.3
1829	57.3	71.6	58.8	65.3	73.2	64.8	67.6	79.6	67.9	67.5	79.0	68.0
1830	55.6	65.8	57.4	63.8	72.9	61.8	70.2	79.3	67.3	66.8	77.0	68.1
1831	55.9	66.2	57.0	68.6	79.4	68.2	71.4	81.1	69.6	68.0	80.5	70.6
1832	50.9	60.3	51.6	59.5	70.9	59.5	63.9	74.2	63.9	64.5	77.4	66.9
1833	55.3	66.5	56.7	60.3	68.2	59.8	68.1	79.2	68.4	62.6	74.4	65.3
1834	51.2	59.6	50.7	61.6	70.6	60.7	69.3	81.9	69.7	64.1	75.5	66.5
1835	50.8	63.2	53.8	62.3	71.0	62.9	68.0	79.2	69.3	63.6	76.3	66.5
1836	49.6	60.3	53.6	60.8	70.7	63.1	67.3	77.1	68.3	60.7	74.3	64.3
1837	53.9	66.1	58.7	66.3	78.3	69.0	70.3	81.5	72.0	66.1	78.4	69.3
1838	56.8	67.4	60.6	70.7	82.2	71.4	74.5	86.6	77.3	69.2	82.5	73.4
1839	55.9	67.2	57.5	64.3	74.6	65.7	72.5	83.4	74.2	69.7	82.5	72.2
1840	60.2	72.1	59.1	67.1	78.8	68.7	73.9	86.2	74.1	72.8	85.7	72.3
1841	51.0	61.4	52.4	64.6	75.5	65.4	67.1	78.3	67.2	66.0	80.9	68.5
1842	51.4	62.3	53.0	60.1	70.7	60.7	68.6	80.9	68.7	65.5	77.2	67.0
1843	52.4	63.5	54.1	59.9	70.6	62.0	63.1	74.1	64.3	63.6	77.6	67.3
1844	50.4	60.7	53.9	60.1	69.7	61.6	62.4	73.3	64.5	62.0	71.9	65.1
1845	48.8	60.5	51.7	60.4	71.7	63.3	64.1	74.9	66.9	63.5	75.9	67.8
1846	49.7	61.1	52.8	59.0	71.4	62.2	64.9	77.5	68.8	63.3	77.3	68.0
1847	48.1	61.2	53.9	58.7	69.5	61.4	66.4	79.7	69.8	62.0	74.3	67.1
1848	51.7	61.2	55.1	59.2	69.3	60.7	63.3	73.7	65.1	62.3	75.1	67.0
1849	47.1	60.9	51.2	61.1	74.0	63.7	65.2	78.0	67.6	63.7	74.7	67.2
1850	46.7	55.9	48.8	61.0	73.2	63.4	65.8	75.8	67.4	61.4	73.4	66.0
1851	46.9	60.9	52.4	56.5	66.9	59.5	64.8	74.4	66.6	59.5	73.8	64.4
1852	49.8	62.3	53.6	60.2	71.0	62.3	65.1	77.2	68.7	61.3	73.6	65.9
1853	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1854	50.6	64.3	53.5	59.7	72.0	61.4	68.0	80.0	70.2	60.6	76.3	67.1
1855	47.7	60.4	51.1	59.8	70.3	61.0	68.7	77.3	68.6	58.4	71.8	63.7
1856	46.4	57.2	48.7	61.5	73.9	62.6	66.4	78.2	68.1	61.4	72.8	64.1
1857	53.0	64.4	52.1	59.1	71.7	60.1	63.9	77.3	64.4	58.0	70.6	62.9
1858	48.3	63.0	50.2	62.7	75.2	62.3	64.1	76.0	65.7	61.6	74.5	64.7
1859	47.8	62.1	50.6	53.9	66.3	56.1	61.8	75.0	64.1	58.9	74.1	62.9
Means,	50.6	62.4		60.8	72.3		66.2	78.1		63.2	75.9	

TABLE IV.—*Continued.*

Year.	September.			October.			November.			December.		
	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.	7 A. M.	1 P. M.	6 P. M.
1807	- -	- -	- -	- -	- -	- -	31°.6	39° 7	35°.0	23°.6	33°.4	28°.6
1808	50°.4	68°.9	58°.2	38°.9	51°.0	45°.5	30.7	40.6	36.2	21.8	30.0	26.8
1809	[50.0	65.3	56.4]	46.0	61.8	52.6	26.5	35.7	31.1	27.1	33.2	30.5
1810	53.4	70.3	61.4	41.5	55.5	48.2	32.9	40.3	35.7	19.6	30.2	24.9
1811	52.9	69.6	59.4	43.0	55.6	49.6	34.2	43.1	37.9	22.8	31.3	27.2
1812	46.0	65.8	57.8	41.9	53.9	48.8	32.6	42.2	36.2	17.3	28.9	25.6
1813	53 9	71.0	61.9	43.5	54.1	48.9	33.6	43.3	39.8	22.6	31.4	27.2
1814	49.8	65.6	58.7	42.8	56.4	50.6	33.5	42.8	39.4	15.9	26.9	23.4
1815	- -	- -	- -	[41.4	52.6	46.4]	33.5	43.2	39.4	14.9	28.6	25.0
1816	50.6	66.3	56.8	43.0	56.6	50.3	34.4	44.4	40.0	16.0	29.6	25.6
1817	[56.4	69.6	59.0]	38.2	51.0	45.7	32.1	42.0	38.0	21.5	31.2	27.5
1818	54.8	68.3	59.1	43.3	58.5	51.5	37.6	46.4	41.5	15.2	29.6	23.1
1819	59.7	69.6	60.7	43.8	55.1	48.4	35.8	40.8	37.8	22.0	31.5	27.1
1820	56.9	68.5	58.6	41.6	54.3	46.7	29.2	38.9	33.6	12.4	23.5	19.2
1821	55.4	64.4	58.6	[37.4	49.9	45.6]	32.8	40.8	37.6	16.9	26.9	23.5
1822	58.3	68.7	61.7	40.7	53.5	48.9	31.6	40.8	38.3	16.8	27.5	22.7
1823	51.7	67.0	57.9	41.0	49.1	44.6	23.6	32.6	29.2	19.1	29.6	25.5
1824	- -	- -	- -	- -	- -	- -	26.7	35.0	32.4	23.3	31.4	29.4
1825	49.6	58.8	55.1	43.5	54.9	50.7	28.7	40.9	37.5	22.8	30.6	27.4
1826	56.2	66.5	60.0	42.4	53.0	46.9	29.0	41.2	37.5	19.1	28.2	25.0
1827	53.6	66.3	58.0	43.8	55.1	49.3	27.1	34.3	30.9	17.1	28.7	23.7
1828	57.4	68.7	58.2	42.3	55.8	46.1	33.3	43.0	38.2	24.4	36.3	30.5
1829	51.2	65.3	56.5	44.1	56.4	49.3	35.7	43.2	38.8	31.3	39.5	35.9
1830	53.6	67.8	57.5	46.0	59.0	50.9	41.7	49.7	46.1	30.5	37.9	34.4
1831	59.5	70.6	63.4	48.1	60.5	54.6	37.8	45.7	41.9	9.2	21.1	18.0
1832	56.0	69.0	60.2	47.6	59.5	53.8	34.6	44.9	39.3	21.7	29.5	26.7
1833	56.1	66.4	58.6	44.5	55.4	50.3	31.8	42.9	39.3	24.7	33.7	31.4
1834	57.9	70.9	62.6	43.3	53.3	48.4	31.6	43.3	38.6	18.7	27.3	23.1
1835	53.1	65.0	59.5	46.7	59.7	53.1	31.5	42.4	38 3	14.4	24.6	21.4
1836	53.4	66.9	58.0	37.7	50.7	42.8	31.5	41.5	35.5	20.3	29.8	25.8
1837	61.9	74.2	64.3	50.6	63.2	55.2	38.3	45.6	41.4	27.2	37.7	34.6
1838	60.0	74.0	66.5	48.9	60.1	53.2	34.5	44.7	40.6	22.3	33.6	29.6
1839	62.4	74.9	66.6	50.5	64.3	54.7	38.0	48.8	43.0	33.4	41.1	38.1
1840	61.9	74.6	66.4	50.2	62.8	56.7	38.8	47.4	44.2	23.9	33.6	29.9
1841	59.1	71.3	63.5	41.7	54.4	47.1	34.3	41.8	37.8	25.2	33.9	30.5
1842	53.9	64.4	58.5	42.6	56.5	50.2	32.9	42.1	37.7	19.4	29.1	25.2
1843	52.6	66.5	59.5	41.0	50.8	46.5	27.5	37.0	33.0	20.6	29.9	25.8
1844	52.6	68.0	60.3	40.6	52.9	47.9	29.1	38.3	34.2	17.0	27.1	24.9
1845	51.3	62.8	57.6	41.4	54.7	49.8	36.3	45.2	41.2	16.0	23.6	21.6
1846	56.0	71.1	61.1	40.3	51.5	45.3	35.7	46.3	41.5	18.8	26.8	24.4
1847	54.5	65.1	59.4	39.2	51.9	45.9	34.6	43.3	39.0	24.4	33.3	29.9
1848	50.7	62.4	55.6	40.7	53.3	48.7	29.2	40.2	35.5	25.3	32.7	29.6
1849	52.7	65.9	59.1	40.8	51.9	46.8	37.4	47.9	44.6	19.1	28.4	24.7
1850	53.6	65.1	59.3	44.2	56.1	51.0	33.7	44.3	40.2	13.9	25.2	22.1
1851	51.5	68.6	60.2	44.7	59.6	52.1	28.7	38.2	33.9	12.2	23.3	20.2
1852	54.4	65.5	60.4	43.0	53.4	47.6	31.0	40.5	36.0	26.0	35.3	30.8
1853	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1854	51.3	66.5	58.5	43.4	55.9	50.1	34.7	44.6	39.3	15.4	26.4	22.3
1855	51.6	66.7	59.5	44.7	55.8	48.9	30.8	41.4	37.0	20.8	31.1	27.7
1856	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1857	50.0	65.5	57.2	38.4	53.3	46.2	29.6	41.3	36.2	19.9	29.6	26.4
1858	55.1	69.0	60.8	43.5	59.2	50.0	28.4	40.5	35.1	12.1	23.3	20.3
1859	48.3	62.8	53.8	34.9	48.9	41.2	29.8	41.5	35.4	11.7	24.1	19.2
Means,	54.2	67.6		42.9	55.4		32.6	42.1		20.2	30.0	

Diurnal Range of Temperature.

The monthly mean value of the diurnal range may be obtained from the observed differences at 7 A. M. and at 1 P. M. by multiplication with a factor derived from the two Toronto series (reductions by Prof. Dove and Capt. Lefroy) and the Montreal series of hourly observations given in the meteorological and physical tables by Prof. Guyot, Smithsonian Miscellaneous Collection.

	Observed difference.	Factor.	Diurnal range.		Observed difference.	Factor.	Diurnal range.
January	11°.4	1.2	13°.7	July	11°.9	1.7	20°.2
February	12.7	1.2	15.2	August	12.7	1.5	19.1
March	12.3	1.3	16.0	September	13.4	1.3	17.4
April	11.2	1.4	15.7	October	12.5	1.2	15.0
May	11.8	1.5	17.7	November	9.5	1.2	11.4
June	11.5	1.6	18.4	December	9.8	1.2	11.8
Mean annual value of diurnal range . . . . . . 16°.0.							

The diurnal fluctuation reaches a maximum value in July, range 20°.2, and attains a minimum value in November, range 11°.4.[1]

Annual Fluctuation of the Temperature.

The monthly mean temperatures (from 51 years), given in Table III, furnish the following average values for the seasons and year; to these were added for comparison the corresponding values from a series extending over 22 years, observed at Fort Preble, near Portland (latitude 43° 39′, longitude 70° 13′), taken from the Army Meteorological Register, 1855. It will be seen that the agreement in the observed temperatures is quite close.

	Brunswick.	Fort Preble.
Mean temperature of spring	42°.26 Fahr.	42°.77 Fahr.
" " of summer	65.11	65.91
" " of autumn	47.59	48.16
" " of winter	22.63	24.70
" " of year	44.40	45.38

Principally on account of the generalization of results from various stations and the necessity of contracting the bulky material of meteorology into a more manageable form, the periodic fluctuations are now generally expressed in Bessel's circular function.[2] A strict application of these formulæ demands, for the annual fluctuation, months of equal length; the resulting mean temperatures of the calendar months require, therefore, a correction for inequality.

The length of the tropical year is 365.25 days, hence the length of an average month 30.44 days. For complete quadriennia, or for a long series of years, we have the following simple rule: Cast into February .56 of the last day of January, then include with February the first and .62 of the second of March, with March the first and .06 of the second of April, with April the first and .50 of the second of

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[1] These values for diurnal range perhaps are too large, and should be considered only as approximations; possibly the thermometer may have been influenced by radiation.

[2] See U. S. Coast Survey Report for 1862, Appendix No. 22.

May, with May .94 of the first of June, with June the first and .37 of the second of July, with July .81 of the first of August, with August .25 of the first of September, with September .69 of the first of October, with October .13 of the first of November, and with November .56 of the first of December.[1] It is generally easy to obtain a sufficiently approximated value for the mean temperature on the days for which it is required.

	Observed temperature.	Corr'n to average month.	Corrected temperature.		Observed temperature.	Corr'n to average month.	Corrected temperature.
January	20°.10	°.00	20°.10	July	67°.44	—°.04	67°.40
February . . .	22.93	+.22	23.15	August	65.60	—.10	65.50
March	31.54	+.45	31.99	September . . .	58.28	—.11	58.17
April	42.56	+.57	43.13	October	47.78	—.20	47.58
May	52.69	+.27	52.96	November . . .	36.71	—.15	36.56
June	62.29	+.37	62.66	December . . .	24.86	—.11	24.75

The corrections found for Brunswick appear to conform to average values, in quantity and sign, to what we might expect in our latitudes.

Using the monthly means in the last column we form the equation:—

$$T = +\,44^\circ.50 + 23^\circ.15\,\sin\,(\,\theta + 248^\circ\;45') + 0^\circ.88\,\sin\,(2\theta + 258^\circ\;00')$$
$$+\;0.79\;\;\sin\,(3\theta + 225\qquad) + \;0.11\;\sin\,(4\theta + 333\qquad)$$

with a probable error of a single monthly representation of $\pm\,0^\circ.17$. The angle θ counts from January first at the rate of 30° a month (or 59′.2 a day). The numerical quantities in (T) indicate a normal character of the annual fluctuation.

Comparison of Observed and Computed Temperatures.

	Observed.	Computed.	Difference		Observed.	Computed.	Difference
January	20°.10	19°.92	+°.18	July	67°.40	67°.52	—°.12
February . . .	23.15	23.19	—.04	August	65.50	65.55	—.05
March	31.99	32.15	—.16	September . . .	58.17	57.93	+.24
April	43.13	42.88	+.25	October	47.58	47.92	—.34
May	52.96	53.27	—.31	November . . .	36.56	36.19	+.37
June	62.66	62.40	+.26	December . . .	24.75	25.08	—.33

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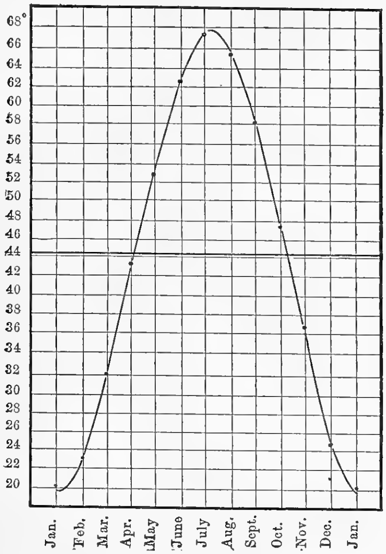
[1] The reader may be referred to an interesting paper on this subject, by De Forrest, in the May number of Silliman's Journal for 1866. See also his improved results in the September number of the same journal. If we have to deal with single years, either common or leap, the correction to refer the results to an average year and average month may be taken from the following table giving the number of days and fractions to be added or subtracted from each calendar month. The signification of the signs will be readily understood by examining that of January in connection with the rule given in the text.

	For common years.	For leap years.		For common years.	For leap years.
January . . .	— .56	— .56 days.	July . . .	+1.06	+ .06 days.
February . .	+1.87	+ .87	August . . .	+ .50	— .50
March . . .	+1.31	+ .31	September . .	+ .94	— .06
April . . .	+1.75	+ .75	October . . .	+ .38	— .62
May . . .	+1.18	+ .18	November . .	+ .81	— .19
June . . .	+1.62	+ .62	December . .	+ .25	— .75

It is, however, hardly worth while to apply corrections to results by a single year, the mean values from four years even are yet quite irregular. The numbers given in my reduction of Dr. I. I. Hayes' Arctic temperatures refer to the calendar year.

These results are laid down in the following diagram:—

Annual fluctuation of the temperature.



On the average, from 52 years of observations, the hottest day[1] falls on July 22d, or 31 days after the summer solstice, temperature + 67°.7; the coldest day falls on January 18th, or 28 days after the winter solstice, temperature + 19°.9 Fahr. The days when the average annual temperature is reached are April 20th and October 24th.

Table V contains the observed greatest and least monthly mean values from the whole series of observations, taken from Table I and corrected for diurnal fluctuation.

TABLE V.—OBSERVED EXTREMES MONTHLY MEANS.

	Least.	Greatest.	Range.		Least.	Greatest.	Range.
January	+11°.72	+35°.22	23°.50	July	+59°.63	+76°.15	16°.52
February	14.72	36.92	22.20	August	60.85	73.96	13.11
March	23.83	40.92	17.09	September . . .	52.33	65.80	13.47
April	36.32	51.19	14 87	October	40.18	55.07	14.89
May	46.53	61.01	14.48	November . . .	27.69	45.03	17.34
June	55.80	71.78	15.98	December . . .	15.52	36.98	21.46

The figures in the last column show quite plainly the general law of a greater variability in the temperature during the winter than during summer. In the cold-

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[1] Maxima and minima are most conveniently computed by the formula $0 = 23.15 \cos(\theta + 248° 45') + 1.76 \cos(2\theta + 258°) + 2.37 \cos(3\theta + 225°) + 0.44 \cos(4\theta + 333°)$ obtained by differentiating he formula in the text.

est month the monthly means have a range of 23½°, which is reduced in the third month of summer to 13°. In connection with this it appears also that the representation of the monthly means by a circular function is generally better for the summer than for the winter seasons.

Extreme Temperatures observed.

Between the limits already stated, comprising about ten years, we have a daily record of the extreme temperatures by means of a maximum and minimum thermometer; the following tables exhibit the observed extreme lowest temperature and the observed extreme highest temperature in each month.

TABLE VI.—LOWEST TEMPERATURE OBSERVED IN EACH MONTH.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1807	—30°	—18°	+ 4°	- -	- -	- -	- -	- -	- -	- -	+ 8°	— 4°
1808	—10	—15	+ 4	+19°	+28°	+36°	+46°	+37°	+23°	+ 9°	+12	— 6
1809	— 8	—17	—15	+20	- -	- -	- -	- -	- -	+23	+ 1	0
1810	—13	—18	— 6	+15	+25	+36	+44	+43	+32	+14	+ 6	— 9
1811	—12	—15	+ 5	+17	+24	+37	+46	+42	+33	+21	+10	— 1
1812	—28	—24	—19	+16	+23	+42	+43	+37	+28	+20	+10	—10
1813	—25	—17	—12	+19	+21	+39	+43	+44	+37	+16	+13	— 7
1814	—23	—21	—17	+18	+31	+37	+39	+39	+26	+17	+ 5	—19
1815	—26	—15	— 1	+10	+24	+40	+41	+39	- -	+20	+11	— 8
1816	—17	—16	— 9	+11	+25	+30	+33	+35	+25	+23	0	— 8
1817	—23	—23	— 7	+17	+22	+27	+42	+40	- -	+16	+10	— 1
Mean,	—20	—18	— 7	+16	+25	+36	+42	+40	+29	+18	+ 8	— 7

TABLE VII.—HIGHEST TEMPERATURE OBSERVED IN EACH MONTH.

1807	38°	46°	50°	- -	- -	- -	- -	- -	- -	- -	53°	50°
1808	47	51	62	78°	89°	97°	102°	96°	96°	67°	61	60
1809	42	41	51	72	- -	- -	- -	- -	- -	88	51	50
1810	42	51	52	75	88	90	89	86	83	84	61	46
1811	41	45	57	72	79	93	98	95	87	77	57	53
1812	46	47	52	70	78	83	87	85	85	76	55	51
1813	42	49	56	67	76	84	92	94	89	66	61	47
1814	42	49	63	82	94	85	90	86	85	74	56	42
1815	44	42	51	77	79	86	92	94	- -	69	63	46
1816	48	47	50	81	82	96	82	88	80	76	61	50
1817	44	48	53	65	78	84	92	90	- -	67	63	44
Mean,	43	47	54	74	82	89	92	90	86	74	58	49
Monthly range,	63	65	61	58	57	53	50	50	57	56	50	56

The monthly numbers in the two preceding tables appeared so regular that mean values could be set down; these will advantageously compare with similar quantities at other stations. Average monthly range 56°.

The total range of temperature experienced at Brunswick is very considerable[1]—not less than 132° Fahr. The lowest temperature recorded is —30°, and the highest 102°.

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[1] At the three Arctic stations, Port Foulke, Van Rensselaer Harbor, and Port Kennedy, the extreme range was respectively 108°, 117°, and 105° Fahr.

Relation between Temperature and the Direction of the Wind.

The method of reduction is briefly as follows: By means of the formula (*T*) the temperature for each day of the year was computed and referred to the mean of three daily observations, as recorded, by applying the correction for diurnal fluctuation with the sign reversed. The temperature thus computed was subtracted from the observed temperature of each day during which the wind has not changed its direction; a + sign indicates an elevating, a — sign a depressing effect. Separate entries were made for each season and for each of the eight principal directions of the wind. It was not possible to secure a sufficient number of observations for some of the cardinal points; for these we must content ourselves with annual mean results. 1128 observations (days) were employed in bringing out the following tabular results:[1]—

EFFECT OF THE DIRECTION OF THE WIND UPON THE TEMPERATURE IN DIFFERENT SEASONS, AND FOR THE YEAR.

Direction.	Winter.	Spring.	Summer.	Autumn.	Year.
N.	—1°.6	(—2°.5)	(—4°.2)	—7°.0	—3°.1
N. E.	—2.4	—6.5	(—7.8)	—2.3	—3.8
E.	+ - -	— - -	— - -	(+2.2)	- - - -
S. E.	+ - -	—2.9	—5.9	(+5.4)	- - - -
S.	+ - -	+ - -	(—0.6)	+ - -	+2.4
S. W.	+5.3	+2.2	—1.5	+4.5	+2.6
W.	—1.1	—0.7	+2.9	+1.8	+0.7
N. W.	—5.7	—6.2	—2.3	—4.2	—4.6

The most permanent and conspicuous effect upon the temperature, at all seasons, is that of the N. W. wind, its depressing influence is 4°.6 Fahr. on the average. N. and N. E. winds likewise lower the temperature throughout the year by 3°.1 and 3°.8, respectively. The S. W. wind, on the contrary, elevates the temperature above its normal value; its annual mean effect is 2°.6. During summer, however, this same wind slightly depresses the temperature. S. and W. winds, upon the yearly average, also elevate the temperature, though their effect may be different in different seasons.

Relation between Temperature and Summer Rains.

If we compare the mean daily temperature on rainy days (days with three entries of rain, or at least two entries of rain and one of fog or haze), with their respective normal temperature, we shall find a marked effect during the summer months (June, July, and August). On 87 days of comparison the temperature was almost invariably lower, the average amount of depression being 6°.5 Fahr.

Relation between Temperature and Precipitation in Winter.

During winter we find the effect reversed; on 283 days of either snow, sleet, or rain, during December, January, and February, the temperature was found higher than the normal value, on the average by 4°.3 Fahr. During rainy days in winter,

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[1] Figures within brackets depend upon a small number of observations.

this temperature difference was considerably greater than during days of snow, as it should be, from physical considerations.

Mean Annual Temperature and Secular Change.

The mean annual temperature of a place is one of the principal meteorological constants to be determined; by means of these values the annual isothermal lines may be drawn and the important question of a secular or periodical change may be investigated.

The annual means in Table VIII are made out directly from Table III; they are the average values of the monthly means. The few blanks in Table III were supplied by the substitution of the respective average monthly mean, as given at the bottom of the table; the annual mean was then taken as usual. The average for the year 1853 was obtained by interpolation from 8 months of observation at Fort Preble, and comparing the same with the monthly means from 22 years of observations as given in the Army Meteorological Register. The average for 1853 is but an approximate value.

TABLE VIII.—OBSERVED ANNUAL MEAN TEMPERATURE AT BRUNSWICK, ME.

Year.	0	1	2	3	4	5	6	7	8	9
1800	- - -	- - -	- - -	- - -	- - -	- - -	- - -	43°.66	43°.43	42°.14
1810	43°.57	44°.71	40°.94	43°.18	43°.29	42°.87	42°.09	41.64	44.78	45.46
1820	44.03	43.91	43.06	41.03	43.86	45.73	45.46	43.87	46.94	46.19
1830	47.50	47.66	45.17	45.61	45.36	44.42	43.00	49.60	50.69	51.45
1840	51.60	46.58	45.84	43.87	42.32	43.27	44.01	43.08	43.70	43.00
1850	43.37	42.60	43.91	44.53	42.73	42.95	41.78	43.62	43.75	40.31

The mean temperature from 52 years of observation is 44°.40 Fahr. according to the above table; reduced to the level of the sea it becomes 44°.60 nearly. The lowest observed annual mean, 40°.31, occurred in 1859, and the highest observed annual mean, 51°.60, occurred in 1840; range 11°.29, which is rather larger than the usual amount.

The numbers in Table IX are obtained by subtracting the average annual temperature from the mean of each year; a positive sign indicates a temperature above the normal value, a negative sign the reverse.

TABLE IX.—FLUCTUATION OF THE ANNUAL MEAN TEMPERATURE.

Year.	0	1	2	3	4	5	6	7	8	9
1800	- - -	- - -	- - -	- - -	- - -	- - -	- - -	— .74	— .97	—2.26
1810	— .83	+ .31	—3.46	—1.22	—1.11	—1.53	—2.31	—2.76	+ .38	+1.06
1820	— .37	— .49	—1.24	—3.37	— .54	+1.33	+1.06	— .53	+2.54	+1.79
1830	+3.10	+3.26	+ .77	+1.21	+ .96	+ .02	—1.40	+5.20	+6.29	+7.05
1840	+7.20	+2.18	+1.44	— .53	—2.08	—1.13	— .39	—1.32	— .70	—1.40
1850	—1.03	—1.80	— .49	+ .13	—1.67	—1.45	—2.62	— .78	— .65	—4.09

These numbers show the usual irregular fluctuations, though on a somewhat enlarged scale. A rough comparison with a number of other stations, treated in the same way and taken from the Army Meteorological Register, indicate a general conformity of the march of the annual mean temperatures, excepting, however, the hot years culminating with 1840, where our record may possibly be defective. The results for these years (1837, '38, '39, '40) should, therefore, be used with caution, as the thermometer may have been affected with radiation.

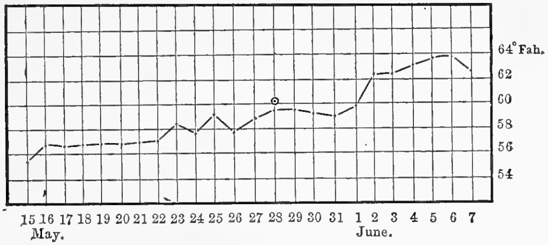
The numbers of Table IX are directly available for the study of the secular change of the temperature, and if made out for a great number of localities cannot fail to lead to valuable results.

That the temperature has remained sensibly the same for the period during which the observations were made, we can infer from the fact that between 1807 and 1832 inclusive, the mean annual temperature was 44°.1, and between 1833 and 1859 inclusive it was 44°.7, the difference 0°.6 $\pm$ 0°.5, with a probable error of the same magnitude, is too insignificant to point to any change in the climate.

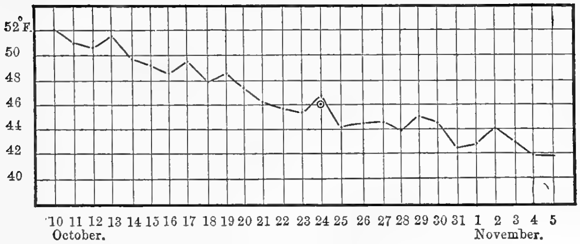
Supposed Anomalies in the Annual Fluctuation of the Temperature.

It has been supposed[1] that about the end of May there was a cold period and about the end of October a warm period, forming apparently anomalies in the regular march of the annual fluctuation. To test this supposition the daily means from 51 years of observations were made out (*vide* Table I), and laid down graphically on the two annexed diagrams, which cover, in time, the periods named above. These diagrams show the daily irregularity which even from so long a series amounts to ± 0°.8 in the daily mean.

Mean daily temperature from fifty one years of observation.



Mean daily temperature from fifty one years of observation.



The dots surrounded by a small circle indicate the temperature as computed by the formula for the annual fluctuation and corrected for diurnal inequality.

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[1] Dr. Wilson, of Geneva, N. Y., was led to suppose, from twelve years of observation at that place, that a cold period occurred about the end of May, and a warm one about the end of October.

From an inspection of the zigzag lines we can infer that no such exceptions to the regularity of the annual fluctuation occur (at Brunswick, Me.) as has been supposed. The temperature on May 30, 31, and June 1 is indeed somewhat depressed; but not sufficiently so, when compared with its probable error, to make sure of the existence of an exceptional cold period. The October curve is quite regular in its descent.

DIRECTION OF THE WIND.

The three observations taken each day, at morning, noon, and evening, though not at equal intervals, are yet sufficient to give, by their combination, a tolerably reliable daily mean. There are but a few omissions in the record between November, 1807, and December, 1859, in consequence of which the monthly number of observations does not come fully up to the true sum. Occasional blanks, in some cases, undoubtedly refer to calms, of which, however, there is no special mention. The direction of the wind is supposed to be given with reference to the true meridian;[1] and the horizon is supposed to be divided in eight principal directions, the nearest of which, to that of the wind, is recorded. The force of the wind is not stated; the resulting directions will therefore be given under the hypothesis of equal velocity.

The general formulæ for the reduction of observations of direction and force of the wind, are the following:—

Let $\theta_1 \quad \theta_2 \quad \theta_3 \ldots .$ be the angles which the direction of the wind makes with the meridian reckoned round the horizon, from the south westwards to 360°, a direction corresponding to that of the rotation of the winds in the northern hemisphere, and $v_1 \quad v_2 \quad v_3 \ldots$ the respective velocities which may be supposed expressed in (st.) miles per hour. The observations are supposed to be made at equal intervals. Adding up all velocity numbers referring to the same wind during a given period (say one month), and representing these quantities by $s_1 \quad s_2 \quad s_3 \ldots .$, the number of miles of air transferred bodily over the place of observation by winds *from* the southward is expressed by the formula

$$R_s = s_1 \cos \theta_1 + s_2 \cos \theta_2 + s_3 \cos \theta_8 + \ldots .$$

and for winds *from* the westward

$$R_w = s_1 \sin \theta_1 + s_2 \sin \theta_2 + s_3 \sin \theta_3 + \ldots .$$

The resulting quantity R and the angle ψ it forms with the meridian, are found by

$$R = \sqrt{R_s^2 + R_w^2} \qquad \tan \psi = \frac{R_w}{R_s}.$$

These general formulæ in the case of eight principal winds assume the following convenient form:—

$$R_s = (S - N) + (SW - NE) \sqrt{\tfrac{1}{2}} - (NW - SE) \sqrt{\tfrac{1}{2}}$$
$$R_w = (W - E) + (SW - NE) \sqrt{\tfrac{1}{2}} + (NW - SE) \sqrt{\tfrac{1}{2}}$$

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[1] The magnetic declination of the needle is nearly 11½° W. for the middle period of the series of observations.

Where the letters S, SW, W, etc., represent the *sum* of all velocity numbers, expressed in miles per hour, during the given period, or the quantity of air moved in the directions S, SW, W, etc., respectively. R_s represents the total quantity of air transported *to the northward*, and R_w the quantity transferred *to the eastward.* These formulæ for practical application may be used under the following form:—

$$\text{Let } S-N=a \qquad SW-NE=c$$
$$W-E=b \qquad NW-SE=d$$

Then

$$R_s = R \cos\psi = a + 0.707\,(c-d)$$
$$R_w = R \sin\psi = b + 0.707\,(c+d)$$

Since R_s, R_w, R, represent the quantity of air passed over during the given period in the direction 0° 90° ψ° respectively, we must, in order to find the average velocity for any resulting direction, divide by n, or by the number of observations during that period; we have consequently:—

$$V_s = \frac{R_s}{n} \qquad V_w = \frac{R_w}{n} \qquad \text{and } V = \frac{R.}{n}$$

A particle of air which has left the place of observation at the commencement of the period, of a day for instance, will be found at its close in a direction $180^\circ + \psi$, and at a distance of R miles, equal to a movement with an average velocity of $\frac{R}{n}$; this supposes an equal and parallel motion of all particles passing over; the length of the path described by each can be found by summation of all the v's during the period.

In the present case the above formulæ become simplified for want of recorded velocities which may all be put equal unity, consequently the summations will give at once the relative frequency with which each wind occurred during a given period.

Owing to the great variability in the observed directions of the wind, periods less than a month are not suitable for combination.

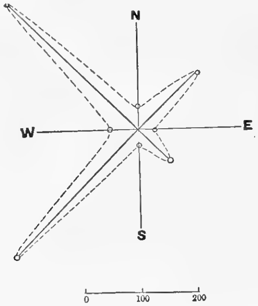
The following Table X contains 54,097 observations arranged for each month according to eight directions.

Table X.—Relative Frequency of each Wind recorded during $50\frac{1}{2}$ Years, three times a day.

	S.	N.	W.	E.	S. W.	N. E.	N. W.	S. E.	No. of years.
January	42	253	254	91	912	1071	1717	161	50
February	63	214	247	92	930	817	1646	178	51
March	109	194	221	153	1188	646	1768	372	51
April	160	183	185	171	1312	645	1409	447	51
May	206	149	116	268	1619	565	1064	620	51
June	194	141	163	149	1797	395	1118	533	51
July	236	136	251	111	2154	297	1127	378	51
August	166	136	246	110	2049	352	1139	437	51
September	138	136	193	116	1645	448	1260	297	48
October	147	177	275	106	1351	575	1484	337	49
November	67	229	297	113	931	813	1821	249	51
December	39	250	301	83	921	1107	1782	136	51
Year	1567	2198	2749	1563	16809	7731	17335	4145	
Proportional number in 1000 winds	29	40	51	29	311	143	320	77	

These proportional numbers are represented in the annexed diagram.

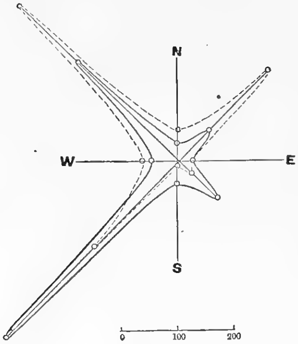
Relative Frequency of each Wind throughout the Year.



The following diagram shows the variation in the relative frequency of the winds during summer (June, July, August), and winter (December, January, February).

The proportional numbers for these seasons are the following:—

Relative numbers.	S.	N.	W.	E.	S. W.	N. E.	N. W.	S. E.
Summer . .	43	30	48	27	434	76	245	97
Winter . .	11	54	60	20	208	225	387	35



Full curve for summer, dotted curve for winter.

The proportional number for each wind indicates the predominance of the N. W. and the S. W. winds on the average during the year, of the S. W. wind in summer and of the N. W. in winter. The least frequent winds are from the S. and E.; from the E. in summer, and from the S. in winter. The numbers in the general table also indicate that the transition in the direction of the wind is gradual during the annual fluctuation.

The characteristic fluctuation for the two seasons is the *decrease* of the S. W. wind to less than one-half its amount from summer to winter, and the *increase* of the N. E. wind to three times its amount from summer to winter; the increase of the N. W. wind in winter is of less amount.

The following Table XI contains the resulting direction of the wind for each month, season, and during the year from over 50 years of observations

Table XI.—Resulting Direction of the Wind.

	ψ	$\frac{R}{n}$		ψ	$\frac{R}{n}$
January	S. 141° W.	0.406	July	S. 66° W.	0.462
February	131	0.403	August	68	0.426
March	116	0.344	September	84	0.381
April	101	0.263	October	101	0.349
May	62	0.222	November	131	0.404
June	66	0.346	December	140	0.421
Spring	S. 97° W.	0.257	Autumn	S. 106° W.	0.356
Summer	67	0.411	Winter	136	0.413
			Year	S. 102° W.	0.320

The average annual direction of the wind is 12° north of west, or W. by N. very nearly. The change from month to month appears quite regular; the extreme variation between the direction in January and July is 75°; in January the average direction is 51° N. of W. and in July 24° S. of W. The transition from 101° to 62° in April and May is rather sudden.

The numbers in the last column show the average length of the resultant; they indicate that in spring the neutralizing effect of opposing winds is at a maximum, and in winter at a minimum; in other words, the winds are more steady in winter than in spring.

If we bring out the resultant of the directions of the wind observed during each year we shall obtain the following Table XII. It contains the number of times each wind blew during the year, and in a few cases where the record was wanting during a month, an interpolated value is given, which is found by taking the mean of the number of winds in the same month in the years preceding and following. The tenth column exhibits the annual mean direction ψ.

April, 1867.

Year.	S.	N.	W.	E.	S. W.	N. E.	N. W.	S. E.	ψ	Alternate means.	Differences from mean.
1808	80	60	88	57	202	128	303	137	103°		
1809	87	59	43	38	259	152	308	83	103	104°	+ 3°
1810	87	67	78	41	218	149	289	106	105	106	+ 5
1811	88	91	57	32	240	139	303	72	110	107	+ 6
1812	57	71	70	55	277	118	304	82	102	101	+ 0
1813	92	69	65	26	306	109	314	79	91	95	— 6
1814	57	52	100	27	310	109	340	81	95	94	— 7
1815	72	41	57	32	301	142	324	86	95	95	— 6
1816	51	45	49	38	329	120	341	70	96	93	— 8
1817	70	45	51	24	367	174	266	76	85	93	— 8
1818	36	70	51	39	329	153	301	65	104	105	+ 4
1819	26	71	222	65	125	130	351	62	125	121	+20
1820	21	65	94	30	127	171	458	92	130	129	+28
1821	10	67	67	17	180	151	510	51	132	126	+25
1822	20	37	55	17	320	160	382	41	110	114	+13
1823	21	38	34	26	373	230	284	62	105	109	+ 8
1824	8	12	15	9	343	235	392	71	117	117	+16
1825	0	5	3	0	240	177	593	73	128	123	+22
1826	0	6	3	5	289	144	537	104	117	120	+19
1827	1	9	2	2	324	172	524	58	117	114	+13
1828	2	10	5	2	379	136	461	93	103	110	+ 9
1829	7	11	23	6	271	116	577	60	118	112	+11
1830	9	40	20	9	358	182	380	90	108	106	+ 5
1831	16	38	45	37	442	119	335	53	89	96	— 5
1832	8	68	28	52	398	120	338	72	98	99	— 2
1833	6	50	9	36	341	124	446	77	111	104	+ 3
1834	19	32	28	18	404	140	363	65	95	105	+ 4
1835	11	46	50	31	307	190	380	57	119	107	+ 6
1836	8	28	30	25	399	178	321	82	96	102	+ 1
1837	12	39	33	25	411	149	350	65	96	95	— 6
1838	14	41	38	28	427	139	307	86	93	92	— 9
1839	40	47	62	46	347	184	241	107	87	86	—15
1840	48	54	75	30	423	153	225	74	77	83	—18
1841	25	49	43	48	328	178	266	138	90	87	—14
1842	45	43	43	43	333	118	330	134	93	92	— 9
1843	33	61	29	45	327	130	340	116	92	89	—12
1844	38	28	51	31	378	177	260	120	79	89	—12
1845	46	31	20	19	352	154	348	116	92	89	—12
1846	33	40	29	27	366	160	321	98	94	91	—10
1847	19	44	47	36	400	143	281	103	84	90	—11
1848	23	47	66	39	377	151	311	57	97	94	— 7
1849	36	42	85	63	345	155	293	59	97	96	— 5
1850	30	44	98	59	346	147	290	67	95	94	— 7
1851	22	38	84	45	404	148	295	57	90	92	— 9
1852	26	51	91	44	359	137	272	71	92	90	—11
1853	—	—	—	—	—	—	—	—	—	86	—15
1854	27	40	65	18	429	169	243	82	81	86	—15
1855	20	48	99	25	374	188	270	64	97	91	—10
1856	25	29	95	44	344	132	307	106	89	90	—11
1857	10	28	69	66	401	152	270	99	83	88	—13
1858	23	13	80	33	335	165	350	93	98	91	—10
1859	10	3	31	3	456	196	298	84	84		

In the values of the annual mean direction we notice some kind of progression or periodicity to exhibit which columns eleven and twelve were added. The column headed "alternate means" is introduced to smooth down the irregularities in ψ; after the alternate means were written down the mean of the two numbers in the same horizontal line were taken. The mean value found from summation of the numbers in the columns for each wind is 101°, and subtracting this from each alternate mean the numbers in the last column result. They show a shifting of the wind from a more northerly direction (than the average) about 1820 or 1825 to a more southerly direction about 1840 or 1853, the resultant during the former years being 126°, and during the latter years 85° nearly, amount of variation 41°. This secular fluctuation is therefore less in amount than the annual fluctuation. The phenomenon deserves further study and confirmation from series of observations at other stations to enable us to recognize the reality and character of this movement.

ATMOSPHERIC PRECIPITATION.

Table XIII contains the number of days on which rain or snow fell on each month; days on which thunder-showers occurred were counted in. When rain and snow are registered on the same day such days were counted as rainy and snowy days alternately. Sleet was counted in with snow. Dashes indicate no observations.

TABLE XIII.—NUMBER OF DAYS OF RAIN AND SNOW.

Year.	Jan.		Feb.		March.		April.		May.		June.		July.		August.		Sept.		Oct.		Nov.		Dec.		Agr'g'te for year.	
	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.	r.	s.
1807	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	7	4	5	—	—
1808	3	7	2	8	2	5	10	1	9	0	8	0	13	0	6	0	7	2	8	1	5	2	6	7	69	33
1809	1	6	1	7	4	6	4	2	8	0	10	0	9	0	8	0	7	0	7	0	4	5	11	2	74	28
1810	1	13	1	2	3	9	6	3	10	0	8	0	8	0	12	0	7	0	7	1	7	3	2	8	72	39
1811	3	10	1	7	1	3	5	0	13	0	10	0	7	0	10	0	6	0	9	0	13	0	3	6	81	26
1812	2	8	4	11	0	7	5	2	10	0	15	0	12	0	13	0	5	0	9	0	5	5	2	9	82	42
1813	3	8	0	7	4	11	9	0	9	0	5	0	7	0	9	0	6	0	13	0	4	3	2	4	71	33
1814	1	8	2	9	0	8	7	0	16	0	7	0	10	0	11	0	7	0	3	0	7	3	0	8	71	36
1815	3	5	0	8	5	6	5	6	10	2	9	0	6	0	10	0	–	–	7	0	6	1	4	3	—	—
1816	1	5	4	8	2	7	5	1	10	0	7	1	5	0	8	0	4	0	7	1	7	4	2	1	62	28
1817	3	7	1	6	0	6	6	1	5	0	11	0	9	0	6	0	–	–	5	1	4	3	5	6	—	—
1818	4	4	0	5	3	4	7	6	9	0	7	0	9	0	3	0	10	0	0	0	5	2	0	8	57	29
1819	3	7	1	7	2	11	4	2	13	0	8	0	6	0	4	0	5	0	5	1	4	1	3	7	58	36
1820	0	11	4	6	2	7	1	2	14	0	3	0	4	0	5	0	5	0	10	0	4	3	0	10	52	39
1821	0	3	1	12	4	4	4	3	7	1	11	0	6	0	10	0	11	0	6	1	9	5	2	10	71	39
1822	0	8	1	10	2	6	7	6	6	0	11	0	10	0	7	0	6	0	4	1	8	1	3	5	65	37
1823	0	12	0	10	2	12	7	2	10	2	8	0	11	0	8	0	5	0	10	1	4	4	6	7	71	50
1824	4	9	4	8	2	8	10	0	5	0	10	0	5	0	8	0	–	–	–	–	4	4	4	5	—	—
1825	1	8	0	9	4	3	2	0	5	1	11	0	5	0	6	0	6	0	6	0	3	4	9	3	58	28
1826	5	8	3	6	11	4	6	2	8	0	10	0	6	0	13	0	6	0	8	0	12	3	6	6	94	29
1827	3	10	2	6	7	2	14	0	11	0	13	0	6	0	8	0	7	0	11	0	6	4	2	9	90	31
1828	3	8	8	3	2	6	7	3	15	0	9	0	13	0	7	0	10	0	7	0	12	7	2	6	95	33
1829	3	11	2	6	3	6	8	2	9	1	2	0	5	0	4	0	7	0	5	0	15	3	7	4	70	33
1830	2	11	0	6	8	4	2	0	7	0	9	0	8	0	8	0	9	0	4	0	10	1	6	4	73	26
1831	1	3	2	4	5	4	7	1	8	0	8	0	6	0	5	0	5	0	7	0	3	3	1	9	58	24
1832	4	8	2	9	4	3	3	4	10	0	6	0	4	0	8	0	5	0	7	0	5	1	4	4	62	29
1833	2	6	1	9	1	7	5	1	10	0	8	0	10	0	9	0	8	0	7	1	4	3	2	3	67	30
1834	1	6	2	2	4	4	5	0	9	0	7	0	3	0	3	0	4	0	4	2	5	2	2	7	49	23
1835	5	4	1	8	2	7	8	1	5	0	8	0	8	0	7	0	4	0	3	0	4	5	3	7	58	32
1836	2	8	1	7	1	5	6	1	5	1	3	0	4	0	6	0	4	0	6	0	4	4	3	3	45	29
1837	1	8	3	6	4	3	5	2	8	0	3	0	7	0	3	0	5	0	5	1	3	3	1	4	48	27
1838	7	4	0	5	0	5	6	0	10	0	5	0	6	0	4	0	4	0	9	1	4	0	1	4	56	19
1839	4	7	2	4	6	3	10	0	8	0	8	0	10	0	5	0	4	0	3	0	5	4	2	3	67	21
1840	1	6	2	1	3	6	5	1	3	1	5	0	3	0	6	0	5	0	6	1	4	4	1	8	44	28
1841	3	4	0	5	3	2	6	2	8	1	4	0	6	0	5	0	6	0	6	0	7	3	5	3	59	20
1842	3	4	6	5	2	9	5	3	9	0	8	0	11	0	4	0	9	0	5	0	6	2	2	8	70	31
1843	4	4	1	7	1	8	6	3	5	0	7	0	6	0	7	0	2	0	8	0	5	2	0	8	52	32
1844	1	7	0	7	9	4	3	0	9	0	4	0	6	0	6	0	4	0	11	0	5	1	5	5	63	24
1845	3	11	3	4	3	4	2	4	6	1	4	0	9	0	5	0	7	0	7	0	12	1	5	6	66	31
1846	1	10	0	5	5	3	4	1	11	0	4	0	8	0	5	0	2	0	6	1	5	2	3	4	54	26
1847	4	5	1	7	4	5	6	4	6	0	10	0	4	0	6	0	10	0	5	0	6	1	6	6	68	28
1848	4	3	0	8	3	6	5	0	15	0	8	0	8	0	7	0	11	0	7	0	2	2	4	7	74	26
1849	2	4	0	8	6	4	4	3	7	0	6	0	3	0	8	0	7	0	7	0	6	0	2	10	58	29
1850	3	8	2	3	1	7	2	3	13	0	7	0	7	0	5	0	7	0	6	1	4	1	2	9	59	32
1851	2	7	7	5	2	6	10	1	9	0	8	0	11	0	6	0	4	0	6	1	3	4	3	5	71	29
1852	1	13	2	4	5	6	5	4	6	0	8	0	5	0	5	0	6	0	6	1	3	3	5	4	57	35
1853	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	—	—
1854	1	10	1	7	1	5	5	2	7	0	4	0	3	0	2	0	3	0	3	0	6	2	3	5	39	31
1855	–	–	2	6	1	2	5	0	4	0	7	0	8	0	5	0	2	0	9	0	2	3	1	6	—	—
1856	0	8	0	6	0	5	6	0	9	0	4	0	5	0	7	0	7	0	2	0	4	1	2	5	46	25
1857	0	8	2	5	1	6	6	2	7	0	6	0	5	0	7	0	4	0	8	0	4	1	5	3	55	25
1858	2	4	0	4	2	6	4	4	7	0	6	0	11	0	7	0	3	0	8	0	1	5	1	3	52	26
1859	2	5	1	5	5	5	3	2	7	0	6	0	3	0	5	0	5	0	3	0	4	2	1	9	45	28
Yearly average,	2.3	7.2	1.7	6.3	3.1	5.6	5.6	1.8	8.6	0.2	7.3	0.0	7.1	0.0	6.7	0.0	5.9	0.0	6.4	0.4	5.6	2.8	3.2	5.8	64	30

From the above table we deduce the following results:—

Least number of days (1.7) on which rain fell in February, greatest number (8.6) in May; greatest number of days (7.2) on which snow fell in January; snow fell as late as June 8th (in 1816), and as early as September 26th (in 1808). On the average snow falls on a day in May once in five years, and on a day in October once every other year.

The average number of rainy days in a year is 64, varying between 39 and 95; the average number of snowy days in a year is 30, varying between 19 and 50. In a longer series these extremes may reach one-half and double their normal value.

Table XIV contains the amount of rain and snow collected during each month; the latter was reduced to its equivalent in water by taking one-tenth of the observed depth in inches.

TABLE XIV.—AMOUNT OF RAIN AND SNOW FALLEN (in inches).

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Aggregate for year.
1808	- - -	- - -	- - -	3.03	6.85	4.51	4.69	5.69	3.43	4.12	3.58	7.34	- - -
1809	3.20	2-15	2.90	0.05	2.93	3.60	5.45	2.48	5.31	2.15	7.18	4.91	42.31
1810	0.20	0.30	5.40	2.20	2.09	2.78	2.99	3.58	1.38	1.40	4.57	1.20	28.09
1811	0.50	4.50	- - -	- - -	4.30	2.00	4.00	3.61	0.51	2.61	7.72	1.30	- - -
1812	1.95	3.00	0.90	4.91	4.50	6.72	5.02	3.69	1.00	4.58	2.84	1.60	40.71
1813	2.90	2.15	5.08	2.80	2.74	2.98	3.28	2.14	0.67	6.08	6.07	0.55	37.44
1814	0.60	1.50	2.50	4.93	11.40	3.60	3.45	7.31	5.07	0.54	3.95	3.35	48.20
1815	2.37	1.85	1.16	2.76	1.80	4.75	1.49	3.02	- - -	1.22	1.62	2.35	- - -
1816	3.24	2.41	0.63	1.20	4.15	1.41	1.60	2.13	0.30	5.99	5.49	- - -	- - -
1817	5.75	4.10	1.95	1.94	0.52	5.09	2.16	3.35	- - -	2.55	4.70	4.15	- - -
1818	4.40	1.40	3.60	1.20	5.80	1.37	2.98	0.16	5.07	0.00	0.20	0.20	26.38
1819	- - -	1.80	5.00	2.20	- - -	- - -	- - -	- - -	- - -	- - -	0.30	- - -	- - -
1820	- - -	- - -	0.30	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.90	1.05	- - -
1821	0.50	2.10	1.60	0.60	- - -	- - -	- - -	- - -	- - -	- - -	- - -	3.10	- - -
1822	0.40	1.70	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.60	- - -
1823	1.90	3.70	3.80	0.60	- - -	- - -	- - -	- - -	- - -	- - -	- - -	2.80	- - -
1838	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.90	- - -
1839	2.45	4.90	6.08	6.19	4.06	4.32	8.43	7.04	2.18	1.02	4.10	3.42	54.19
1840	0.91	2.25	1.81	6.00	2.10	2.83	1.70	5.82	2.34	1.71	4.45	4.20	36.12
1841	4.20	1.40	4.40	9.15	3.27	1.85	1.80	0.52	7.60	2.00	3.99	8.00	48.18
1842	3.82	5.69	5.48	3.75	2.64	3.00	5.21	5.73	4.88	0.71	6.04	8.03	54.98
1843	4.15	7.28	7.75	9.02	3.83	3.92	3.26	12.21	0.88	7.30	5.23	2.10	66.93
1844	3.85	0.80	7.98	0.28	5.13	2.83	2.06	4.24	2.93	7.58	4.76	7.88	50.32
1845	8.06	3.57	3.13	2.66	6.53	2.26	8.67	4.41	3.85	4.86	17.75	9.89	75.64
1846	5.54	1.80	11.28	2.09	1.88	2.67	4.58	2.05	1.40	1.95	3.85	4.37	43.46
1847	5.95	5.60	2.40	5.07	3.14	6.64	2.75	6.63	5.49	4.77	5.78	6.95	61.17
1848	5.93	2.24	6.12	1.53	10.03	3.75	4.20	3.33	6.34	7.67	3.48	4.75	59.37
1849	1.85	1.40	4.15	3.50	2.70	3.62	1.72	7.82	2.40	3.40	3.65	3.10	39.31
1850	3.43	1.73	3.38	5.00	17.57	4.99	2.72	4.37	2.93	4.74	2.62	3.96	57.44
1851	3.89	2.74	0.80	6.01	2.37	4.80	4.78	0.97	2.11	9.34	5.89	3.67	47.37
1852	3.06	6.90	3.69	7.83	1.20	3.15	2.97	6.03	2.90	3.23	7.23	7.08	55.27
1853	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
1854	2.75	4.87	2.70	0.65	8.86	5.66	3.45	0.28	2.53	1.30	10.19	2.90	46.14
1855	5.68	0.50	0.50	2.75	2.78	4.57	4.37	4.80	1.40	9.73	3.40	4.10	44.58
1856	2.50	0.50	1.30	1.72	3.40	2.05	3.07	6.32	2.55	3.59	2.05	3.73	32.78
1857	3.10	2.60	4.90	5.29	3.43	3.45	2.40	5.78	0.70	5.05	2.08	4.10	42.88
1858	4.30	2.08	1.80	3.67	5.52	1.95	6.41	7.76	3.79	3.09	3.32	1.85	45.54
1859	3.60	2.10	8.15	2.70	3.59	7.35	1.35	2.12	5.89	1.75	4.45	5.39	48.44
Monthly average,	3.24	2.75	3.72	3.44	4.55	3.69	3.65	4.37	3.03	3.74	4.65	3.85	44.68
Years,	33	34	33	33	31	31	31	31	29	31	33	35	32

Average total precipitation during year, 44.68 inches; least quantity observed for any one year, 26 inches; and greatest quantity observed, 76 inches.

From the annual amounts set out in the above table a probable uncertainty of $\sqrt{\frac{.455\ \Sigma\Delta^2}{n\ (n-1)}} = \pm 1.5$ inches in the average annual amount may be deduced.

The maximum amount of rain in any one day was 8.25 inches on November 4, 1845; the next heaviest fall of rain occurred on August 11th, 1843, of 7.70 inches; on the 27th of May, 1850, 7.10 inches fell.

On the 10th of March, 1819, 30 inches of snow fell; on December 28th, 1848, 20 inches; in 1809, January 30th, 1811, February 4th, and 1823, September 17th, 18 inches of snow are recorded during a day.

The probable uncertainty of the annual average value from a series extending over 32 years is yet sufficiently large to mask the annual fluctuation to an extent which renders it difficult to recognize the maxima and minima with certainty. We may here use with advantage the results of two stations in the same hyetal region, given in the Army Meteorological Register (Washington, 1855). At Fort Preble, near Portland, the mean annual precipitation from a series of eight and a half years is 45.25 inches, and at Fort Constitution, near Portsmouth, from a series of thirteen years, 35.57 inches. We find that the annual fluctuation attains two maxima and two minima, the former in May and November, the latter in February or March and in September. The November maximum of precipitation and the February or March minimum are the most prominent features.

On the average there are 64 rainy days and 30 snowy days each year, or 94 days of precipitation, being 1 in 4 nearly. The average amount of water for a day is $\frac{44.68}{94} = 0.48$ inches. The corresponding monthly means are contained in the following table:—

	From Table XIII.	From Table XIV.	Average in one day.		From Table XIII.	From Table XIV.	Average in one day.
January . . .	$9^{d}.5$	$3^{in}.2$	$0^{in}.33$	July	$7^{d}.1$	$3^{in}.6$	$0^{in}.51$
February . . .	8.0	2.7	0.34	August	6.7	4.4	0.65
March	8.7	3.7	0.42	September . . .	5.9	3.0	0.51
April	7.4	3.4	0.46	October	6.8	3.7	0.54
May	8.8	4.5	0.51	November . . .	8.4	4.6	0.55
June	7.3	3.7	0.51	December . . .	9.0	3.8	0.42

The heaviest rains therefore fall in August, the lightest in January and February, epochs at which the air's capacity for vapor is greatest and least.

Relation of Rain (or Snow) to the Direction of the Wind.

To ascertain the dependence of rain (or snow) on the direction of the wind, the latter was tabulated for each rainy day and classified according to seasons. Such days only were used on which rain[1] (or snow) is recorded morning, noon, and evening, except for summer, when days with two consecutive entries of rain were included in order to obtain the requisite number of cases. The total number of directions thus classified on such rainy days during 51 years is 2756, of which occurred in spring 662, in summer 545, in autumn 596, and in winter 953.

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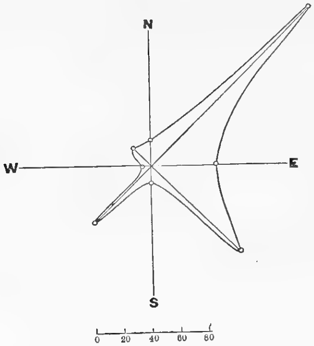
[1] Days with two entries of rain (or snow) and the third entry of sleet, hail, mist, or fog were also included.

Expressed in percentage for each season, the relative numbers of occurrence of rainy days for each of the eight principal directions was found as follows:—

TABLE XV.—SHOWING THE DEPENDENCE OF RAIN ON THE DIRECTION OF THE WIND IN EACH SEASON AND FOR THE YEAR.

Season.	S.	S. W.	W.	N. W.	N.	N. E.	E.	S. E.
Spring . . .	3	10	1	4	3	37	15	27
Summer . . .	5	22	2	3	3	21	12	32
Autumn . . .	3	13	1	4	5	41	12	21
Winter . . .	2	11	2	6	7	58	6	8
Year (sum) .	13	56	6	17	18	157	45	88

This table shows that it may rain (or snow) in each season with any one of the eight winds; that the greatest number of rainy days (or snowy days) on the average during the year, and also for three seasons, occur with N. E. wind, and the least number of rainy days, for each season and for the year occur with W. wind. The wet and dry winds, therefore, blow from N. E. and W. respectively. The wet and dry quarters of the compass are well exhibited by the annexed diagram for the annual mean values.



The N. E. wind in winter is most constantly accompanied by rain (or snow); in summer the S. E. wind surpasses the N. E. and S. W. in precipitation; in winter, however, the S. E. wind becomes indifferent.

The position of the place of observation with respect to the ocean sufficiently accounts for the characteristic shape of the graphical illustration.

Thunderstorms.

Number and Distribution during the Year.

The number of storms accompanied by lightning and thunder, recorded during 51 years, is 472, or nearly 9 a year.

They are distributed over the several months as follows:—

January . . .	1	April	13	July	130	October . . .	23
February . .	0	May	48	August . . .	107	November . .	8
March . . .	6	June	90	September . .	44	December . .	2

The maximum number occurs in the warmest month; in February none occurred. The aggregate number in summer is 327, and the aggregate number in winter 3.

Fog.

The total number of fogs recorded during 51 years is 1135, or 22 in a year on the average. Their distribution, expressed in number of days, over the several months, is as follows:—

	Aggregate.	Average for a year.		Aggregate.	Average for a year.
January . .	47	0.9	July . . .	164	3.2
February . .	31	0.6	August . . .	168	3.3
March . . .	54	1.1	September . .	139	2.7
April . . .	73	1.4	October . .	105	2.1
May . . .	97	1.9	November . .	63	1.2
June . . .	160	3.1	December . .	34	0.7

The maximum number occurs in summer, the minimum in winter.

Frost.

July is the only month in which no frost is recorded. Frost occurred as late as June 19th, and as early as August 3d. On the average the spring frosts cease after the first week in June, and the fall frosts may be expected after the first week in September.

Hail.

There are 34 hail storms recorded in 51 years. None occurred in July, August, and September. They were most frequent in March and December, as seen in the following table:—

January	4	July	0
February	2	August	0
March	8	September	0
April	3	October	2
May	3	November	3
June	1	December	8

STATE OF THE WEATHER.

The weather was recorded three times a day, the entries being fair, cloudy, or variable. If we sum up and take the mean, by months, of all fair, all cloudy, and all variable days, we find the results from a series of 51 years as follows:—

	Average number of				Average number of		
	Fair days.	Cloudy days.	Variable days.		Fair days.	Cloudy days.	Variable days.
January . .	12.8	9.0	9.2	August . .	15.6	5.5	9.9
February . .	11.7	7.1	9.5	September .	14.8	5.7	9.5
March . .	13.6	7.1	10.3	October . .	14.1	7.2	9.7
April . .	13.5	7.0	9.5	November . .	11.4	9.3	9.3
May . . .	12.7	7.7	10.6	December . .	12.3	9.0	9.7
June . . .	13.6	6.1	10.3				
July . . .	15.7	5.0	10.3	Year . .	161.8	85.7	117.8

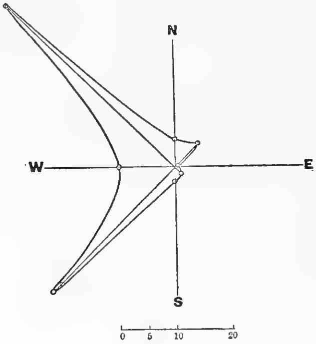
The greatest number of fair days (every second one), and the least number of cloudy days (every sixth one), occur in July; the least number of fair days (every third one nearly), and the greatest number of cloudy days (every third one nearly) occur in November; the variable days in each month differ but little from their average value (every third day nearly) throughout the year.

The dependence of rainy (or cloudy weather on the direction of the wind has already been stated; the relation of fair weather to the wind has been made out in the same manner from 4085 fair days between 1807 and 1814, and between 1850 and 1855.

TABLE XVI.—Showing the Dependence of Fair Weather on the Direction of the Wind for the half year April to September inclusive, for the half year October to March inclusive, and for the whole year.

Season.	S.	S. W.	W.	N. W.	N.	N. E.	E.	S. E.
April—September . . .	5	42	8	32	4	5	1	3
October—March . . .	2	20	11	52	5	7	1	2
Year	3	31	10	42	5	6	1	2

Thus in every hundred fair days, during the half year including winter, there are 42 with S. W. wind; and in every hundred fair days, during the half year including summer, there are 52 with N. W. wind. There is but one day in a hundred when fair weather is accompanied with E. wind.



In the above diagram the tabular numbers for the year have been thrown into a curve. Comparing it with the diagram given for the relation of rainy or cloudy weather to the wind, it will be seen to be nearly the converse of it.

MISCELLANEOUS PHENOMENA.

Earthquakes.

Seven earthquakes were found recorded during 51 years, between 1807 and 1859. There is no record of the year 1853. The dates are as follows:—

1808.	June	26th	$2^h\ 51^m$ A. M.	
1814.	November	28th	$7^h\ 15^m$ P. M.	
1817.	May	22d	$3^h\ 10^m$	(not stated whether A. M. or P. M.)
1823.	March	7th	1 (about)	(" " ")
1828.	July	25th	$6^h\ 30^m$ A. M.	
1828.	August	14th	10^h (about)	(not stated whether A. M. or P. M.)
1829.	August	26th	$9^h\ 15^m$ P. M.	

Aurora Borealis.

During the same period (51 years) as above, there were observed 86 auroras. That this is the total number which occurred may well be doubted, and they include probably only the brighter exhibitions. In their monthly occurrence they group themselves about the equinoxial months, especially about the autumnal equinox.

Distribution of Auroras during the Year.

January	4	July	0
February	10	August	6
March	10	September	18
April	6	October	17
May	1	November	8
June	1	December	5

That there exists also a periodic or secular variation appears with sufficient distinctness from the following figures:—

Table XVII.—Number of Auroras observed each Year.

1807	2	1820	1	1833	3	1846	—
1808	12	1821	—	1834	—	1847	—
1809	—	1822	—	1835	1	1848	6
1810	—	1823	—	1836	2	1849	1
1811	—	1824	—	1837	2	1850	—
1812	—	1825	—	1838	8	1851	—
1813	—	1826	—	1839	6	1852	—
1814	3	1827	6	1840	3	1853	—
1815	2	1828	1	1841	—	1854	—
1816	—	1829	6	1842	—	1855	—
1817	1	1830	8	1843	—	1856	—
1818	6	1831	2	1844	—	1857	1
1819	3	1832	—	1845	—	1858	—
						1859	—

We have therefore the following years of maxima of auroral displays: 1808, 1818, 1830, 1838, 1848, 1857, leaving differences of 10, 12, 8, 10, and 9 years. This indicates a period of about 10 ± 2 years.

The greater frequency of auroral lights about the time of the equinoxes, and the maximum frequency about the autumnal equinox has long been known, the discovery of one or two distinct periods in the secular change is of more recent date; the shorter of these periods is expressed in the above numbers.[1]

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[1] After writing the above paper Dr. R. Wolf's "Mitheilungen über die Sonnenflecken," No. XIX was received; according to the investigations of Herr Fritz and of Dr. Wolf the two periods of the aurora borealis, from observations in the middle latitudes, are 55.6 years for the great period, and 11.11 years for the subordinate cycle. For comparison with the results given in the text, the years of auroral maxima and minima since 1788, according to Fritz and Wolf, are appended:—

Maxima.	Minima.
1788 principal	
	1796
1804	
	1811 principal
1816	
	1825
1830	
	1834
1839	
	1842
1848 principal	
	1856
1859	

It will be observed that the years of maxima observed at Brunswick accord, as well as can be expected from a single locality, with these general results. The reader is also referred to Prof. Loomis' account of the aurora borealis in the annual report of the Smithsonian Institution for 1865, p. 208, and especially to the table p. 228.

APPENDIX.

MONTHLY EXTREMES OF THE ATMOSPHERIC PRESSURE.

THE only use which it is proposed to make of the barometric record is to exhibit the monthly extreme values, together with their annual variation. Supposing the temperature of the room in which the instrument was suspended to have remained above the freezing point, a reduction to it was applied to the readings of the barometer by means of the indications of the external thermometer.

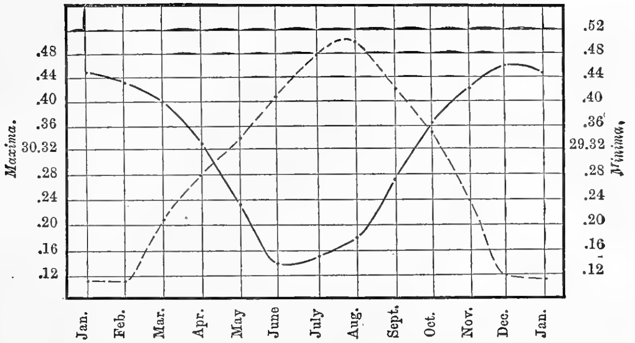
TABLE XVIII CONTAINS THE MONTHLY EXTREME READINGS OF THE BAROMETER (REFERRED TO 32° FAHR.) EXPRESSED IN INCHES.

Year.	January.		February.		March.		April.		May.		June.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1807	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1808	30.4	29.3	30.5	29.0	30.5	29.3	30.4	29.4	30.2	29.4	30.2	29.6
1809	.2	28.9	.4	28.6	.4	.5	.3	.5	.2	.4	.3	.7
1810	.5	29.2	.3	29.5	.3	.2	.4	.4	.2	.4	.2	.6
1811	.6	.5	.3	.1	.7	.3	.3	.5	.4	.3	.3	.5
1812	.5	.2	.4	.2	.4	.6	.4	.5	.2	.3	.0	.5
1813	.5	.2	.5	.2	.5	.4	.5	.4	.3	.6	.2	.6
1814	.2	28.9	.5	28.7	.2	.0	.3	.1	.2	.2	.2	.4
1815	.3	29.0	.5	29.3	.4	.1	.3	.3	.0	.4	.0	.4
1816	.5	.2	.4	28.8	.5	.1	.2	.2	.2	.3	.2	.1
1817	.3	28.9	.2	.6	.4	.4	.3	.3	.3	.5	.2	.1
1818	.4	29.2	.4	29.2	.6	.4	.0	.0	.1	28.9	.1	.4
1819	.8	.2	.4	28.9	.3	28.7	.2	.3	.2	29.1	.1	.4
1820	.2	.3	.5	29.0	.3	29.0	.3	.2	.1	.2	.0	.5
1821	- -	- -	.4	28.6	.1	28.7	.4	.1	.0	.3	29.9	.3
1822	.3	28.8	.4	29.0	.4	29.2	.2	.1	.1	.2	30.2	.3
1823	.6	29.0	.4	28.9	.5	.1	.8	- -	.5	.2	.2	.2
1824	.4	.0	.6	29.2	.7	.5	.1	.3	.2	28.9	.2	.2
1825	.5	.3	.5	.3	.2	.3	.4	.3	.2	29.5	29.9	.4
1826	.3	.1	.5	.0	.6	.4	.5	.4	.2	.4	30.1	.4
1827	.3	28.8	.6	.0	.5	.0	.4	.0	.2	.3	.2	.5
1828	.5	29.3	.5	.2	.5	.2	- -	.5	.4	.3	.3	.5
1829	.5	.3	.2	28.8	.2	.2	.3	.3	.4	.5	.3	28.9
1830	.5	.4	.6	29.3	.6	.0	.4	- -	.3	6	.1	29.3
1831	.3	.2	.6	.0	.3	.0	.1	28.9	.3	.2	.2	.6
1832	.6	.0	.6	.6	.4	.3	.2	29.4	.5	.2	.1	.5
1833	.5	.1	.2	.2	.5	.4	.4	.4	.3	.5	.1	.3
1834	.5	.1	.5	.5	.4	.6	.7	.3	.3	.5	.1	.3
1835	.4	.1	.6	.4	.6	.1	.2	.3	.3	.4	.3	.3
1836	.4	.3	.4	.0	.3	.3	.4	.3	.7	.4	.2	.6
1837	.0	.0	.2	28.7	.9	.3	.1	.0	.2	.4	.1	.4
1838	.4	.1	.1	29.3	.4	.3	.1	.3	.0	.5	.2	.4
1839	.8	.1	.3	.4	.5	.2	.3	.2	.2	.3	.0	.4
1840	.3	.0	.5	.4	.2	.2	.5	.3	.3	.3	.1	.4
1841	.7	.2	.1	.2	.4	.0	.4	28.9	.1	.0	.1	.5
1842	.4	.1	.5	28.7	.2	.4	.2	29.3	.2	.4	.4	.6
1843	.6	.0	.4	29.2	.2	.0	.2	.2	.3	.5	.2	.4
1844	.3	28.9	.2	.4	.4	.2	.7	.7	.2	.3	.2	.6
1845	.4	29.3	.5	.0	.3	.2	.3	.3	.4	.5	.0	.5
1846	.4	.3	.3	.2	.3	.3	.5	.4	.1	.2	.3	.5
1847	.4	28.6	.4	.0	.4	28.7	.3	.4	.1	.5	.1	.2
1848	.5	29.0	.3	28.9	.2	29.4	.5	.3	.1	.1	29.9	.4
1849	.5	.3	.7	29.3	.9	.4	.4	.3	.4	.4	30.2	.5
1850	.5	.2	.5	.0	.2	.1	.1	.1	.2	.3	.2	.6
1851	.5	28.8	.8	.3	.4	.3	.4	.4	.2	.3	.2	.5
1852	.4	29.1	.5	.2	.5	.1	.0	.0	.2	.5	.2	.3
1853	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1854	.5	.3	.7	.2	.3	.0	.5	.5	.2	.4	.0	.5
1855	- -	- -	.3	.4	.1	.3	.7	.4	.1	.5	.0	.2
1856	.5	.4	.2	28.8	.1	.1	.3	.5	.2	.3	.3	.5
1857	.5	.2	.8	29.4	.3	.3	.3	.1	.3	.5	29.9	.3
1858	.7	.4	.3	.3	.4	.1	.2	.4	.3	.3	30.0	.6
1859	.6	.4	.7	- -	.4	.4	.1	.3	.2	.5	.3	.3
Means,	30.45	29.11	30.43	29.11	30.40	29.21	30.33	29.28	30.23	29.34	30.14	29.41

Table XVIII.—*Continued.*

Year.	July.		August.		September.		October.		November.		December.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1807	- -	- -	- -	- -	- -	- -	- -	- -	30.2	29.3	30.4	29.1
1808	30.1	29.5	30.3	29.6	30.3	29.5	30.5	29.7	.4	.2	.4	28.7
1809	.2	.6	.2	.6	.1	.6	.4	.6	.5	.5	.6	29.2
1810	.1	.6	.1	.5	.3	.6	.4	.4	.4	.4	.5	.3
1811	.3	.7	.3	.8	.3	.5	.6	.5	.6	.4	.4	.0
1812	.2	.7	.2	.5	.3	.5	.4	.2	.5	.1	.4	28.9
1813	.1	.3	.2	.4	.3	.4	.3	.2	.4	.4	.3	29.0
1814	.0	.3	.2	.5	.1	.3	.2	.2	.5	.4	.3	.3
1815	.0	.4	.1	.4	- -	- -	.1	.0	.4	.2	.3	.1
1816	.0	.4	.2	.3	.4	.4	.1	.1	.3	.4	.5	.3
1817	.2	.4	.1	.5	- -	- -	.5	.0	.2	.2	.5	.2
1818	.0	.4	.1	.5	.1	.4	.2	.2	.3	.3	.2	.0
1819	.2	.5	.2	.6	.2	.2	.2	.2	.5	.1	.3	.2
1820	.1	.2	.1	.2	- -	- -	.4	.1	.3	.0	.3	.1
1821	.2	.4	.2	- -	- -	- -	- -	- -	- -	.1	.4	- -
1822	.4	.5	.2	.5	.3	.4	.3	.3	.5	.4	.5	.3
1823	.3	.3	.3	.4	.5	.5	.1	.0	.3	.3	.9	.3
1824	.7	.4	.2	.3	- -	- -	- -	- -	.4	.3	.5	.0
1825	.1	.6	.3	.3	.2	.3	.5	.4	.6	.3	.5	.3
1826	.1	.5	.2	.6	.2	.5	.4	.3	.4	.3	.2	.1
1827	.1	.5	.3	.7	.4	.6	.3	.3	.5	28.7	.5	.1
1828	.0	.5	.1	.5	.2	.5	.4	.6	.5	29.0	.3	.4
1829	.2	.5	.2	.5	.3	.5	.7	.7	.4	.3	.7	.2
1830	.3	.5	.1	.6	.3	.5	.3	.6	.4	.5	.5	.1
1831	.3	- -	.3	.7	.2	.3	.4	.6	.3	.0	31.0	.0
1832	.0	.4	.1	.6	.2	.6	.4	.5	.4	.4	30.4	28.8
1833	.1	.5	.1	.5	.1	.5	.4	.0	.5	.2	.5	29.4
1834	.1	.6	.2	.4	.5	.5	.4	.5	.6	.4	.5	.0
1835	.2	.4	.1	.5	.4	.4	.8	.4	.4	.3	.4	.2
1836	.1	.5	.2	.5	.4	.5	.4	.3	.4	.2	.5	.0
1837	.0	.4	.4	.4	.3	.4	.4	.6	.4	.4	.4	.0
1838	.1	.6	.2	.4	.2	.5	.2	.5	.8	.5	.6	.1
1839	.2	.6	.2	.4	.2	.4	.6	.7	.5	.3	.2	.2
1840	.2	.5	.2	.6	.2	.4	.4	.3	.4	.4	.6	.4
1841	.2	.6	.2	.9	.3	.4	.3	.1	.4	.1	.6	.0
1842	.1	.6	.3	.6	.1	.3	.4	.4	.3	28.9	.5	.1
1843	.3	.6	.3	.6	.3	.6	.1	.3	.4	29.4	.4	.2
1844	.1	.5	.1	.5	.3	.2	.5	.4	.2	.2	.5	28.9
1845	.0	.4	.2	.5	.2	.3	.4	.6	.5	28.6	.5	29.1
1846	.4	.5	.1	.5	.4	.4	.7	.3	.7	.7	.3	.2
1847	.1	.6	.2	.4	.2	.5	.6	.1	.5	29.4	.4	.0
1848	.1	.4	.2	.5	.1	.2	.5	.4	.4	.3	.4	.4
1849	.2	.5	.0	.5	.3	.3	.2	.3	.3	.5	.4	.0
1850	.1	.4	.1	.3	.1	.4	.1	.2	.3	.2	.3	.2
1851	.1	.3	.2	.6	.3	.7	.7	.5	.5	.1	.5	.3
1852	.2	.3	.2	.7	.5	.4	.2	.5	.4	.3	.5	.3
1853	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1854	.1	.6	.2	.6	.4	.3	.4	.2	.3	.3	.6	28.8
1855	.1	.6	.1	.3	.2	.4	.2	.5	.4	.3	.4	29.1
1856	.1	.5	.0	.4	.1	.5	.3	.5	.4	- -	- -	- -
1857	.1	.6	.1	.4	.3	.6	.4	.3	.5	.3	.4	.1
1858	.0	.5	.2	.5	.4	.1	.5	.3	.3	.4	.5	.0
1859	.1	.5	.1	.6	.3	.0	.2	.4	.5	.2	.6	.3
Means,	30.15	29.48	30.18	29.50	30.27	29.42	30.37	29.35	30.42	29.24	30.46	29.12

The monthly average values at the bottom of the table, derived from nearly 50 years of observation, show a very regular annual progression, which is exhibited in the following diagram.


Barometric monthly extremes.

The barometric maxima reach their greatest value (30.46 inches) in December, and their least value (30.14) in June; the barometric minima reach their highest value (29.50) in August, and their lowest value (29.11) in January and February. These epochs, it will be noticed, correspond to the times of the extreme values of the temperature in its annual variation.

The regularity in the annual progression of the barometric monthly extremes is further exhibited by the following values of the average monthly means (mean of highest and lowest readings), and of the monthly range.

	Average.	Range.		Average.	Range.
January	$29^{in}.78$	$1^{in}.34$	July	$29^{in}.81$	$0^{in}.67$
February . . .	.77	1.32	August . . .	.84	0.68
March	.80	1.19	September . . .	.84	0.85
April	.80	1.05	October . . .	.86	1.02
May	.79	0.89	November . . .	.83	1.18
June	.78	0.73	December . . .	.79	1.34

The average pressure for the year is 29.81 inches, which is probably very near the mean value of the atmospheric pressure at Brunswick; reduced to the sea level it becomes 29.90 inches.

The monthly range of the greatest and lowest value is a maximum (1.34 inches) at the period of the greatest cold, and a minimum (0.67 inches) at the period of the greatest heat of the year. It appears that the range in January is just double that of July.

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SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.
120

RESULTS

OF

METEOROLOGICAL OBSERVATIONS

MADE AT MARIETTA, OHIO, BETWEEN 1826 AND 1859, INCLUSIVE.

BY
S. P. HILDRETH, M.D.

TO WHICH ARE ADDED RESULTS OF OBSERVATIONS TAKEN AT MARIETTA,
BY MR. JOSEPH WOOD, BETWEEN 1817 AND 1823.

REDUCED AND DISCUSSED,
AT THE EXPENSE OF THE SMITHSONIAN INSTITUTION.

BY
CHARLES A. SCHOTT,
ASSISTANT U. S. COAST SURVEY; MEMBER AM. PHIL. SOC. PHILADELPHIA.

[ACCEPTED FOR PUBLICATION, JUNE, 1867.]

INTRODUCTION.

THE meteorological observations reduced and discussed in the following pages were made between the years 1817 and 1859, inclusive, at Marietta, the oldest town in the State of Ohio. It is situated at the junction of the Muskingum and Ohio rivers, in latitude 39° 25′ and longitude 81° 29′ W. of Greenwich; and is elevated about 580 feet above the ocean.

The Hon. Josiah Meigs, Surveyor-General of the United States, directed that a journal of the weather should be kept at the Land Office in Marietta, including a record of the temperature, fall of rain, and the state of the sky. The records of the earlier observations of this series are not now to be found, but those made by Mr. Wood, between 1817 and 1823, inclusive, and the continuation of them until 1859, by the late Dr. S. P. Hildreth, were presented to this Institution for analysis and publication. A small portion of the manuscript was lost in the fire which destroyed a part of the Smithsonian building in 1865. Fortunately the deficiency thus caused was supplied by the publication of the monthly means in Silliman's Journal of Science and Arts, Vols. XVI to XXVII.

The records were given in charge to Mr. Schott, and have been discussed on the general plan adopted for other observations previously published by the Institution.

The Institution is indebted to Dr. Geo. O. Hildreth for information as to the instruments used by his father, and other facts relative to this valuable series of observations.

JOSEPH HENRY,
Secretary, S. I.

SMITHSONIAN INSTITUTION,
May 20, 1868.

CONTENTS.

(Illustrated with 13 small diagrams.)

RESULTS OF OBSERVATIONS

FOR

TEMPERATURE OF THE ATMOSPHERE.

THE observations for temperature made by Mr. Wood commence in June, 1818, and extend without interruption to March, 1823. The reading of the thermometer was recorded daily at sunrise, 2 P. M., and at sunset, excepting the last five months when the evening observations were omitted.

Dr. Hildreth's series commenced in 1824, but the record of the first two years is lost; it extended without interruption to December, 1859; of the years 1851, 1855, 1856, and 1857 only the monthly means are preserved. His thermometer has a tube 10½ inches in length, and bears the mark "Carpenter, London." It was suspended in the shade, had a northern exposure, and was read three times a day, generally at 6, 2, 9 in summer, and at 7, 2, 9 in the winter months (November, December, January, and February), with such exceptions respecting the time of the morning observations as are noted at the head of columns in Table II. In a few instances only was the 2 P. M. observations shifted to 3 P. M., as stated in the table.

Tables I and II contain the (uncorrected) daily means,[1] from 3 observations (excepting the 5 months mentioned above), also the monthly (uncorrected) means, expressed in degrees and decimals of Fahrenheit's scale.

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[1] These means, together with the monthly means, were inserted in the manuscript record by Prof. W. Rogers Hopkins.

TABLE I.—RESULTING MEAN DAILY TEMPERATURE (UNCORRECTED) OBSERVED AT MARIETTA. At ⊙ rise, 2 o'clock P. M., and ⊙ set, by JOSEPH WOOD.

	June. 1818.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1819.	Feb.	March.	April.	May.	June.	July.	Aug.
1	63°.0	75°.3	79° 7	72°.0	55°.7	49°.0	36°.3	35°.3	39°.7	37°.7	45°.7	68°.3	63°.3	69°.7	80°.3
2	64.3	76.3	79.7	71.3	61.0	50.3	30.0	32.0	38.3	26.3	49.0	63.7	62.7	69.3	82.0
3	68.3	77.3	79.3	70.0	61.0	57.7	31.7	32.7	45.0	30.3	54.3	57.0	69.0	70.3	84.3
4	74.3	78.0	74.7	74.3	56.0	64.7	31.7	32.0	51.0	42.3	52.7	66.7	71.7	70.0	83.0
5	70.6	79.0	75.0	76.3	48.3	61.7	42.7	34.0	49.7	49.0	36.0	67.3	73.7	72.3	83.7
6	78.3	79.3	75.0	77.7	54.7	46.3	33.0	37.3	48.0	59.0	39.3	70.7	75.0	75.3	84.0
7	78.3	77.0	71.3	72.0	55.7	40.0	27.7	28 3	50.7	53.0	54.3	70.3	77.0	76.0	81.7
8	70.0	78.0	74.0	63.3	58.3	35.3	33.0	36.7	54.7	46.3	55.7	68.0	78.0	74.7	79.7
9	70.3	70.0	75.0	61.0	57.3	41.7	41.7	40.7	57.0	36.0	46.0	66.7	76.3	79.3	78.0
10	73.3	71.3	73.7	59.3	59.7	47.0	41.0	47.7	48.3	40.7	53.3	64.3	71.7	79.7	80.0
11	78.0	80.0	76.7	63.7	60.0	51.3	35.0	53.0	42.7	41.7	50.7	60.3	73.7	78.3	80.7
12	74.7	84.3	77.3	67.7	58.7	45.0	28.7	39.0	34.0	47.3	55.0	62.0	70.0	77.3	81.7
13	75.7	86.7	79.7	71.3	60.7	49.7	31.0	34.3	32.0	37.3	62.0	59.7	67.7	76.3	83.7
14	72.7	82.7	74.7	72.0	60.0	56.3	32.0	37.7	39.7	31.0	67.3	68.7	71.0	80.3	82.7
15	70.7	80.3	74.3	76.7	60.7	58.0	32.3	48.0	37.0	33.7	58.3	64.0	75.3	77.3	80.7
16	67.7	77.7	74.0	68.7	56.7	48.7	30.3	35.0	35.7	32.3	66.7	54.0	78.7	74.0	81.3
17	69.3	78.0	70.3	61.0	62.3	42.0	27.3	38.3	31.0	27.0	52.7	45.7	81.0	69.0	77.0
18	70.0	78.7	71.7	59.7	56.3	45.0	29.7	55.0	24.0	36.0	52.3	52.7	82.0	68.0	74.0
19	67.3	79.3	76.3	60.0	57.3	38.7	30.0	49.7	26.0	36.3	49.3	59.0	75.3	71.0	77.7
20	68.3	79.0	78.0	58.7	63.7	41.3	31.0	50.0	35.7	26.0	47.3	58.0	67.0	72.7	79.7
21	71.0	75.7	77.3	58.0	50.7	48.7	30.7	57.3	32.0	26.3	49.7	60.7	70.7	74.3	78.3
22	74.3	74.0	75.3	63.3	36.7	51.3	37.7	55.0	39.0	36.0	49.0	66.3	71.7	74.7	74.3
23	70.7	74.7	73.7	61.7	37.7	57.3	38.3	56.3	36.7	45.0	56.0	71.3	77.0	81.7	66.7
24	75.0	77.0	74.0	64.0	38.7	48.3	34.7	51.0	34.7	46.0	64.0	71.3	73.3	77.0	64.3
25	76.0	74.7	76.3	66.7	47.3	48.7	38.0	31.7	38.0	57.7	60.7	70.0	71.0	77.3	68.0
26	78.0	74.3	77.3	67.3	48.7	55.7	35.3	42.3	36.0	44.0	59.7	68.0	69.3	75.3	65.7
27	79.7	76.3	76.7	64.0	47.7	49.7	32.7	41.3	36.7	33.0	54.7	58.7	74.7	75.0	67.7
28	80.0	77.0	75.0	56.3	40.3	48.0	25.7	46.0	37.0	42.0	54.3	64.3	77.0	76.0	69.7
29	82.3	77.7	75.7	56.0	41.0	41.7	39.3	33.0		56.3	64.3	70.7	76.0	77.3	72.7
30	81.3	79.0	75.3	55.7	44.0	34.3	40.7	41.7		48.3	66.3	68.0	70.7	76.0	69.3
31		80.0	75.7		58.0		42.7	37.3		35.3		64.0		79.7	73.3
Mean,	75.15	77.70	75.56	65.65	53.44	48.01	33.92	41.61	39.64	39.98	54.22	63.90	73.06	75.01	76.95

	Sept. 1819.	Oct.	Nov.	Dec.	Jan. 1820.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	78.3	62.0	46.0	44.7	17.3	16.7	46.0	52.3	64.0	58.0	82.3	73.3	71.0	67.0	52.0
2	77.3	57.7	48.7	38.7	21.0	35.7	24.3	33.7	63.0	59.3	80.7	74.3	69.0	67.7	52.7
3	80.0	59.3	42.3	40.7	21.3	32.7	30.7	27.0	65.0	62.3	82.0	77.0	68.3	69.3	47.3
4	79.7	61.7	42.0	38.7	24.3	29.0	41.7	36.7	68.7	70.0	81.3	78.0	70.7	69.3	44.3
5	79.3	70.7	36.7	36.3	26.3	42.0	48.7	51.7	67.0	68.0	81.0	74.0	76.0	68.7	40.7
6	79.3	72.0	53.7	42.7	17.7	48.3	34.3	48.7	65.0	61.3	81.0	70.0	78.0	60.0	35.3
7	77.7	71.0	44.0	44.3	28.0	43.3	35.0	55.7	63.3	65.0	78.7	73.0	79.3	54.0	41.7
8	78.7	74.3	40.7	47.0	39.3	36.7	30.3	46.0	63.7	68.0	81.3	75.7	80.0	57.0	46.0
9	75.3	58.0	50.3	40.7	37.3	43.7	30.0	41.0	61.7	73.7	79.3	79.0	80.7	60.0	42.3
10	72.3	51.3	49.7	29.0	37.3	36.0	36.3	49.3	66.0	77.7	77.7	80.7	81.7	60.0	33.0
11	70.7	50.7	58.3	32.3	27.7	36.3	28.0	62.7	67.3	78.0	80.7	83.3	79.0	44.7	34.0
12	69.7	54.3	56.3	27.7	17.7	45.7	35.7	66.0	61.3	72.0	82.3	80.7	65.3	50.7	33.7
13	70.3	52.7	44.7	34.0	27.3	44.0	41.3	56.7	60.7	73.7	77.0	80.0	61.3	54.0	31.3
14	65.7	49.7	37.3	40.7	33.3	53.0	40.0	68.0	62.0	73.7	70.7	79.0	62.3	49.0	31.0
15	59.3	56.0	50.7	35.0	33.3	58.0	38.7	66.3	56.0	74.0	67.0	77.7	60.7	42.0	33.7
16	60.0	48.3	64.3	33.7	29.3	59.7	43.0	60.7	55.3	76.0	67.3	76.0	62.7	40.3	43.3
17	63.0	40.7	53.3	31.3	26.7	48.3	47.3	57.0	55.3	76.7	71.7	73.7	68.3	41.0	44.7
18	66.3	42.0	43.7	35.7	26.3	43.0	41.0	63.7	57.0	77.0	74.7	71.0	71.7	43.3	46.0
19	70.7	42.3	37.7	40.7	20.3	46.3	43.7	67.3	56.3	77.3	75.7	66.0	65.7	48.0	50.3
20	69.0	45.3	48.3	34.7	21.0	44.3	48.3	70.7	59.0	79.3	78.0	64.3	59.3	44.0	42.7
21	63.7	40.0	56.3	30.3	32.3	37.3	36.7	73.3	66.3	79.3	77.3	69.7	57.3	39.0	44.3
22	62.7	40.3	56.7	39.3	35.7	46.0	40.0	68.7	69.3	75.7	77.7	71.0	60.3	41.3	37.3
23	62.7	51.0	53.7	48.3	26.7	48.7	52.0	74.0	71.7	76.0	78.0	73.0	63.7	49.3	42.3
24	62.3	42.3	52.3	33.7	24.7	51.3	53.3	77.7	70.7	76.3	77.7	74.0	65.0	47.7	43.0
25	62.3	36.0	56.0	25.0	29.3	62.3	53.7	78.0	64.3	74.7	79.3	77.0	63.3	40.0	57.7
26	57.0	41.0	60.0	31.3	28.3	63.3	62.7	75.3	55.7	70.7	75.7	72.0	62.7	37.0	32.3
27	58.0	48.0	48.3	31.3	38.3	44.0	57.7	67.0	56.3	74.0	75.7	64.7	65.7	35.7	25.0
28	57.0	53.0	38.7	23.7	39.0	34.0	48.3	65.7	58.3	74.7	76.3	67.3	68.7	36.3	33.3
29	61.3	57.0	35.3	25.0	33.7	36.7	44.0	59.7	64.0	78.3	75.7	70.0	69.0	36.0	31.3
30	61.3	44.3	33.7	23.0	34.0		37.0	60.7	63.7	80.7	75.7	73.0	68.3	47.3	30.7
31		39.3		15.3	26.3		47.3		58.7		75.0	71.3		57.7	
Mean,	65.03	52.00	47.98	34.66	28.43	43.67	41.84	59.36	62.46	72.71	77.23	73.86	68.50	50.23	40.11

TABLE I.—*Continued.*

	Dec. 1820.	Jan. 1821.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1822.
1	24°.3	23°.3	35°.0	56°.0	49°.3	66°.7	64°.7	75°.3	78°.7	74°.3	62°.0	45°.7	47°.0	33°.3
2	25.0	28.0	36.7	45.0	36.0	58.7	65.0	75.3	79.0	68.7	64.3	44.3	47.0	30.3
3	34.3	17.3	40.3	52.0	34.0	55.7	65.7	73.7	78.7	65.3	63.3	54.3	39.3	32.9
4	45.7	17.0	45.7	53.0	38.3	52.3	70.7	63.7	76.0	68.0	55.7	45.7	40.0	11.7
5	36.7	20.0	35.7	30.0	55.3	55.7	70.7	65.3	76.0	64.3	61.3	52.3	34.7	10.7
6	33.0	24.7	36.3	22.7	55.0	59.0	75.0	68.7	77.0	67.7	65.7	51.3	30.0	28.7
7	45.7	26.3	35.3	27.7	57.0	57.3	77.3	72.7	74.0	70.3	66.3	41.7	32.7	27.3
8	35.3	27.3	29.7	28.0	40.7	57.3	78.3	77.0	72.7	76.7	56.7	45.0	38.3	35.0
9	35.0	35.3	41.3	33.0	42.7	61.0	77.7	78.0	72.7	80.0	50.0	48.3	36.3	24.3
10	24.7	28.7	38.3	34.3	47.3	68.3	79.3	77.7	74.7	79.0	52.3	35.7	35.7	19.3
11	40.0	30.7	48.3	46.0	45.3	68.7	78.7	72 0	75.7	79.0	57.0	40.3	32.0	24.7
12	35.0	25.0	53.3	45.7	48.0	67.0	81.3	70.0	77.3	73.3	62.0	33.3	27.7	33.3
13	36.0	32.3	43.0	50.7	40.0	66.7	81.7	67.3	76.3	67.7	67.3	35.0	32.0	20.7
14	36.0	35.7	45.0	46.3	40.0	63.7	79.0	70.3	79.3	67.0	54.0	34.7	21.0	20.3
15	29.7	26.7	40.3	59.0	46.7	64.7	75.0	72.7	81.7	71.7	53.0	33.3	15.0	30.0
16	24.0	23.3	40.0	33.3	58.7	72.0	73.0	74.7	82.0	74.3	49.3	41.3	13.7	26.3
17	30.3	23.0	31.3	28.3	40.7	72.3	71.7	73.7	82.0	72.7	45.3	39.3	28.0	33.0
18	34.7	19.7	32.0	20.0	33.0	67.7	70.7	66.7	79.0	72.7	43.0	37.0	34.0	48.3
19	41.7	17.0	46.0	23.0	39.3	56.0	71.3	67.0	79.3	71.0	41.7	34.0	20.0	40.7
20	40.7	21.3	45.3	42.3	51.7	59.7	69.7	67.0	80.3	70.7	45.0	36.3	32.7	41.7
21	44.3	25.7	32.0	34.7	58.0	63.3	69.7	71.3	74.7	71.7	49.7	47.7	35.0	42.7
22	34.7	32.3	35.0	43.3	48.0	62.7	74.0	66.7	70.3	65.7	53.7	51.0	31.3	43.0
23	38.3	27.3	30.3	49.0	56.0	66.3	76.7	73 7	64.3	67.3	51.0	36.3	22.3	23.7
24	38.0	9.7	26.0	50.7	62.3	70.7	78.0	76.3	66.7	73.7	51.3	34.0	16.3	11.7
25	29.0	—5.3	28.3	39.3	58.0	70.0	78.3	74.3	69.7	65.7	44.7	31.3	20.7	11.0
26	27.7	13.3	36.7	22.7	63.0	69.0	78.7	74.7	73.3	53.0	49.0	31.3	15.0	26.7
27	27.7	37.7	40.0	23.3	66.7	66.0	78.0	74.3	74.0	53.7	57.7	34.3	25.3	37.3
28	36.3	36.7	51.7	24.3	64.7	69.0	75.3	77.7	74.7	58.7	48.0	34.3	32.3	40.0
29	35.7	38.3		32.7	66.7	74.0	77.3	78.3	73.0	64.0	52.0	41.3	27.3	44.7
30	22.7	42.0		41.0	65.0	76.7	75.3	78.0	73.3	66.3	57.7	40.3	26.7	44.0
31	22.0	50.7		48.3		76.3		79.3	74.3		59.0		31.0	33.7
Mean,	33.67	26.16	38.53	38.24	50.24	64.98	74.58	72.68	75.50	69.13	54.48	40.30	29.69	30.02

	Feb. 1822.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.*	Dec.*	Jan.* 1823.	Feb.*	March.*
1	26.6	53.0	42.0	75.0	77.7	80.0	80.7	74.3	60.0	41.0	39.5	34.0	21.0	28.5
2	23.7	52.0	45.7	74.7	76.3	79.7	81.7	72.3	52.3	40.5	31.0	35.5	33.0	41.0
3	31.0	36.3	53.3	74.3	72.7	77.7	81.3	65.0	57.7	42.5	14.0	38.5	36.5	31.0
4	25.7	38.6	53.7	70.3	74.7	73.7	80.0	58.7	55.0	44.5	18.0	42.0	18.5	42.5
5	30.0	41.3	59.0	61.7	75.0	75.3	72.0	61.7	59.0	46.0	24.5	29.5	11.0	51.0
6	24.0	47.6	45.3	62.0	75.3	79.0	68.7	62.7	63.3	49.5	30.5	22.0	12.5	41.0
7	18.7	48.7	49.3	61.7	78.3	80.0	73.0	67.0	63.0	57.5	29.0	22.0	7.0	39.0
8	27.3	48.0	50.3	64.7	79.0	79.0	76.0	67.7	58.3	49.0	27.0	27.0	4.5	37.5
9	33.3	44.3	53.7	61.7	76.7	76.3	76.3	72.3	63.7	49.0	28.5	33.5	9.5	45.5
10	23.7	44.0	64.3	60.0	75.7	79.0	76.7	73.0	64.0	58.0	38.0	36.5	28.5	50.5
11	25.0	46.0	55.0	64.3	79.7	75.7	76.7	74.0	58.3	57.0	46.5	34.0	35.0	49.5
12	37.7	52.6	55.0	66.7	74.3	76.0	76.0	76.7	58.7	55.5	39.5	29.0	35.5	47.5
13	37.3	37.3	64.7	68.7	74.0	75.3	78.7	74.7	50.3	50.0	50.5	22.0	31.5	44.5
14	36.3	30.7	54.0	69.0	75.3	74.7	79.7	75.0	47.7	43.5	54.5	20.5	35.0	44.0
15	31.0	35.3	47.7	70.3	77.7	74.0	77.0	74.0	43.7	44.5	30.5	32.0	10.5	42.5
16	45.3	40.3	48.7	72.3	74.7	70.3	74.0	69.0	56.0	44.5	28.0	26.0	11.0	44.0
17	38.7	45.7	50 3	73.3	73.3	71.0	73.3	59.7	59.0	44.0	36.0	41.5	17.5	50.5
18	28.7	51.3	46.7	75.0	69.0	75.7	78.3	62.7	68.7	56.0	42.0	46.0	29.0	48.0
19	30.0	54.7	44.0	74.7	64.3	78.7	73.7	61.7	67.3	52.0	58.5	44.5	19.5	39.5
20	39.3	55.3	47.7	70.0	71.3	78.0	76.3	64.0	70.3	51.0	37.5	44.0	41.0	39.5
21	54.7	48.7	51.0	73.7	72.3	76.0	73.7	63.7	58.7	54.0	38.0	41.5	41.5	40.5
22	41.3	58.3	50.0	71.7	71.0	73.3	70.7	61.0	43.7	49.0	34.5	35.5	42.5	47.0
23	38.0	47.3	55.0	65.3	74.0	75.0	71.3	63.7	42.3	47.0	22.0	38.5	39.0	53.5
24	35.3	47.7	70.0	61.0	80.0	74.0	69.7	67.3	40.7	45.0	16.5	39.0	33.5	47.5
25	25.3	54.0	73.7	66.7	78.3	72.0	72.7	69.7	40.3	45.0	28.0	38.5	29.5	44.0
26	35.3	59.0	73.0	70.3	76.7	70.3	72.7	71.7	42.7	48.0	26.5	37.0	41.0	40.0
27	44.3	58.7	67.7	73.7	72.0	74.0	71.3	72.7	50.0	34.0	23.0	32.5	25.5	35.5
28	52.0	54.3	56.0	76.3	71.0	78.3	75.7	64.0	46.3	46.0	25.5	27.0	22.0	40.5
29		39.7	61.0	79.7	74.7	75.7	72.7	58.3	41.3	44.0	23.0	24.0		40.0
30		47.3	68.3	80.0	76.7	75.7	73.3	61.7	42.7	45.5	18.0	24.5		36.5
31		47.7		77.7		78.7	75.0		48.7		28.0	26.5		43.5
Mean,	33.55	47.29	55.10	69.88	74.75	75.87	75.12	67.32	53.98	47.76	31.82	33.04	25.78	42.75

The daily and monthly means in columns headed with an asterisk are derived from two readings a day, at sunrise and at 2 o'clock P. M.

Table II.—Mean Daily Temperature (uncorrected) in January.

	1829. (7)	1830. (7)	1831. (7)	1832. (⊙)	1833. (7)	1834. (7)	1835. (⊙)	1836.	1837. (7)	1838.	1839.	1840. (⊙ 7)	1841.	1842.
1	58°.0	41°.0	29°.7	15°.0	51°.3	33°.3	39°.7	35°.3	30°.7	37°.7	19°.0	9°.3	22°.0	35°.0
2	27.0	42.3	32.3	31.7	50.3	38.0	34.7	37.3	7.0	44.7	35.3	7.7	13.0	40.3
3	18.3	50.0	45.3	25.3	52.7	11.0	19.7	43.3	12.0	53.0	35.7	9.7	7.3	25.3
4	27.3	38.3	52.0	27.3	53.7	10.7	15.7	53.3	20.0	51.0	35.7	24.0	14.0	34.3
5	33.3	30.7	27.0	36.7	50.7	15.7	12 7	43.7	20.3	49.0	33.7	25.3	20.7	24.7
6	48.3	30.7	25.0	37.3	55.0	17.0	20.7	44.0	26.3	39.7	38.3	30.0	39.7	39.3
7	48.7	45.3	28.0	35.0	38.3	27.3	21.0	43.0	26.7	60.3	52.3	29.0	50.0	36.7
8	41.7	37.3	41.0	42.0	35.0	27.7	20.7	42.0	24.7	30.7	38.0	28.0	38.3	36.7
9	22.0	36.3	31.0	34.0	34.0	27.3	20.7	37.0	28.0	30.7	35.3	30.0	37.0	44.0
10	15.7	33.3	31.0	31.3	15.0	35.3	21.3	31.0	35.7	19.7	53.7	37.3	40.7	36.3
11	17.3	21.7	32.0	25.3	12.7	40.0	28.7	27.7	32.7	16.7	57.3	36.3	44.3	39.7
12	24.0	27.7	25.3	25.3	17.7	43.3	32.0	35.0	27.0	23.3	50.3	32.3	38.3	35.7
13	34.7	32.7	17.3	31.0	24.3	23.3	41.0	37.0	24.0	30.7	49.7	35.3	34.7	31.3
14	40.3	38.3	24.7	35.7	34.0	23.7	39.7	30.0	24.7	41.0	47.0	34.7	36.7	47.3
15	37.7	37.7	23.0	35.7	36.0	27.3	40.7	29.3	16.3	35.7	38.3	17.0	38.7	30.7
16	38.7	37.7	20.7	34.3	27.0	36.7	32.7	29.3	27.3	40.3	33.7	4.7	43.3	36.3
17	30.0	32.7	11.7	42.3	15.7	53.3	30.0	38.0	29.3	55.7	38.0	14.7	29.3	38.0
18	28.3	26.0	22.3	56.3	27.7	53.3	30.7	33.3	36.0	44.0	44.7	8.3	9.3	42.0
19	33.3	36.3	26.0	42.0	34.7	46.0	34.7	28.0	38.0	26.7	28.0	17.3	16.7	43.3
20	34.3	36.7	30.7	32.0	41.7	33.3	45.7	29.3	36.7	20.0	26.3	29.7	32.3	45.0
21	33.7	27.3	35.7	23.3	38.7	16.0	45.3	41.3	27.3	18.0	25.0	36.7	32.0	32.3
22	31.3	38.0	21.7	28.0	37.3	9.3	38.0	28.3	25.3	19.3	31.7	35.7	28.3	27.3
23	35.3	21.7	13.0	31.3	41.3	17.0	37.7	18.0	27.7	30.7	12.3	18.0	31.3	21.3
24	34.3	18.0	15.7	37.7	42.0	21.0	39.7	23.3	32.0	32.3	24.3	14.0	38.3	24.0
25	42.0	32.7	6.7	9.3	32.7	26.0	54.7	29.0	23.0	40.0	36.3	11.7	35.0	31.3
26	45.7	19.7	20.7	—2.7	29.7	18.7	47.3	17.7	31.7	41.0	35.0	20.3	37.3	36.7
27	28.7	26.0	11.7	3.3	29.3	13.0	51.7	8.0	34.7	37.3	24.0	29.0	43.3	30.3
28	22.3	22.3	17.0	22.0	36.7	15.3	46.7	3.7	34.0	31.3	24.0	36.3	35.7	42.7
29	29.3	24.0	27.0	25.7	37.7	18.3	42.7	20.3	36.0	28.3	31.3	39.0	42.0	52.3
30	30.7	11.3	27.3	25.0	50.7	28.0	45.7	32.7	34.0	27.0	34.3	36.3	34.0	41.7
31	36.0	20.7	34.3	32.0	32.7	37.3	26.7	19.0	38.7	25.0	26.3	24.3	36.7	45.7
Mean,	33.17	31.43	26.02	29.37	35.98	27.21	34.14	31.23	28.01	34.87	35.32	24.58	32.26	36.37

	1843. (7)	1844. (7)	1845. (⊙)	1846.	1847.	1848. (7)	1849.	1850. (7)	1852.	1853.	1854.	1858. (7)	1859. (7)	
1	24.3	33.3	41.3	42.7	61.0	56.7	35.0	13.0	35.3	- -	20.0	44.3	35.7	
2	34.7	38.7	39.3	38.3	42.0	34.3	22.3	24.7	32.0	- -	17.3	32.0	33.0	
3	14.7	31.0	43.7	35.7	37.0	33.3	19.3	31.0	28.0	- -	43.0	36.7	36.3	
4	23.0	27.3	35.7	34.0	47.3	34.7	21.0	22.7	27.3	- -	45.7	42.7	30.7	
5	43.3	28.0	40.7	34.0	40.0	42.0	26.3	18.3	29.7	- -	34.0	36.3	37.0	
6	50.3	29.3	34.7	37.0	37.0	28.0	22.3	26.7	28.0	- -	29.7	43.0	39.3	
7	53.7	36.0	34.7	38.7	21.7	29.0	29.0	36.0	21.3	- -	18.3	31.7	39.0	
8	30.0	21.7	31.7	35.3	7.7	35.3	32.7	36.0	27.7	- -	22.0	30.3	10.7	
9	32.3	32.0	41.3	28.7	23.3	20.3	26.3	36.0	31.0	- -	23.0	40.7	17.7	
10	36.7	32.0	29.3	30.7	21.0	7.0	17.0	40.0	28.7	- -	40.0	48.3	16.3	
11	37.0	30.0	26.0	32.0	16.7	22 7	13.3	49.3	24.0	- -	38.0	58.3	37.3	
12	35.7	40.3	28.7	31.0	9.0	31.7	25.0	38.3	10.3	- -	42.3	43.3	42.7	
13	26.3	36.0	39.0	26.0	33.7	38.3	39.0	30.3	10.0	- -	29.0	43.3	39.3	
14	22.7	34.0	31.3	31.3	44.3	44.7	37.7	29.3	25.0	- -	16.7	43.0	48.0	
15	31.3	40.0	39.0	36.7	58.7	51.0	39.7	29.7	28.7	- -	31.7	48.7	38.7	
16	36.3	46.7	52.0	36.7	37.0	39.7	32.0	37.0	32.0	- -	46.3	40.3	37.7	
17	39.7	29.3	54.3	28.3	24.7	36.0	38.7	37.3	26.3	23.3	32.3	35.3	35.3	
18	38.0	30.0	28.0	14.7	39.3	32.0	18.7	37.3	16.7	25.0	30.7	35.0	29.7	
19	42.0	28.0	31.0	18.3	19.0	26.3	18.3	34.0	—1.3	26.7	33.3	32.3	34.3	
20	48.0	30.3	37.3	26.3	18.7	34.3	33.7	35.3	—3.0	30.0	56.7	33.3	49.7	
21	56.3	36.7	35.3	34.0	16.3	40.7	33.3	48.0	16.0	34.7	19.3	35.7	35.0	
22	45.3	42.3	34.7	23.3	14.7	34.3	30.7	36.7	9.3	36.7	18.0	38.7	16.3	
23	44.3	52.0	41.0	20.3	31.0	37.3	28.0	38.0	17.3	33.7	9.3	39.3	11.0	
24	40.7	35.0	42.7	26.3	36.7	38.3	38.3	39.3	20.7	33.0	20.0	48.0	23.0	
25	40.0	19.3	35.3	42.0	36.7	44.0	53.0	52.7	32.0	27.7	30.3	56.3	31.0	
26	32.7	13.0	34.0	47.7	44.7	49.0	39.3	49.3	36.0	10.7	46.0	52.0	37.3	
27	48.3	12.0	41.3	37.0	26.7	45.3	31.0	50.7	26.0	11.7	32.3	42.0	42.0	
28	32.7	20.0	42.0	37.0	29.0	39.0	33.3	41.3	34.0	28.0	20.3	42.0	49.3	
29	33.0	12.7	35.0	43.0	40.0	34.7	48.0	32.7	40.7	30.3	31.0	34.7	37.7	
30	35.0	19.3	32.0	48.7	31.3	36.7	33.3	32.0	42.3	38.7	40.0	29.7	27.7	
31	31.0	14.0	25.7	36.0	31.0	39.0	31.7	40.7	45.3	34.7	42.7	33.0	27.0	
Mean,	36.75	30.01	36.71	33.27	31.51	35.99	30.55	35.59	25.06	32.77	30.94	40.33	33.08	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN FEBRUARY.

	1829. (7)	1830. (7)	1831. (7)	1832. (⊙)	1833. (7)	1834. (7)	1835. (⊙)	1836.	1837. (6)	1838. (7)	1839.	1840.	1841.	1842. (7)
1	37°.7	30°.0	33°.0	35°.7	26°.7	34°.0	26°.3	6°.3	37°.7	27°.0	28°.7	17°.3	36°.3	31°.7
2	31.0	12.0	34.3	46.7	30.3	35.3	22.0	5.7	29.3	19.0	20.7	17.7	40.0	42.0
3	17.3	24.0	33.7	56.0	30.0	37.3	18.7	8.0	26.0	15.0	33.7	20.7	32.0	56.7
4	28.0	32.7	14.7	40.3	29.0	41.3	15.3	5.3	39.3	21.0	35.7	16.7	27.3	59.0
5	28.0	16.7	13.7	30.7	35.0	42.0	24.7	1.0	48.0	23.3	18.7	29.3	36.0	39.7
6	31.7	16.7	12.0	37.0	36.0	42.7	19.3	21.7	42.0	25.3	14.3	47.3	40.7	45.7
7	38.3	20.3	15.3	41.0	24.3	39.0	—4.0	34.7	49.0	37.3	26.0	41.3	36.3	33.3
8	40.0	16.3	15.7	51.7	26.7	42.0	—0.3	32.0	34.7	38.3	39.0	46.0	43.3	16.3
9	24.7	27.0	16.0	55.3	45.7	42.0	3.7	31.3	28.0	26.7	30.3	50.0	35.7	22.3
10	27.8	35.7	22.3	34.0	46.7	46.3	10.7	31.3	28.7	29.7	29.3	40.0	21.7	37.7
11	26.0	24.7	25.0	(47.3)	38.7	44.0	22.3	33.3	29.0	16.7	34.0	32.0	9.7	46.0
12	12.7	36.0	11.7	(32.3)	41.7	33.0	21.3	43.3	32.0	36.0	33.0	40.7	12.3	51.0
13	17.7	30.7	13.3	(37.7)	34.3	36.0	36.0	36.3	19.0	31.7	32.7	43.3	17.0	50.3
14	15.3	35.7	22.3	(39.0)	33.0	53.0	24.0	24.3	34.7	21.0	41.3	40.3	18.7	31.3
15	20.0	41.3	35.3	(39.3)	34.7	57.7	33.3	31.0	47.0	18.0	38.0	31.3	23.7	22.3
16	21.3	42.3	41.3	(26.3)	37.7	39.0	30.7	27.3	36.0	16.3	38.7	35.7	33.7	27.0
17	19.7	43.0	25.3	(32.7)	46.7	37.7	35.3	24.7	17.0	14.0	35.7	43.3	38.3	15.7
18	23.7	40.0	29.3	(56.7)	46.7	47.7	36.0	20.3	19.3	17.0	30.7	51.0	31.3	40.3
19	30.3	42.3	43.0	(56.0)	40.7	50.3	27.7	31.0	32.7	20.0	28.3	58.0	34.7	30.0
20	17.0	51.7	34.0	(29.7)	38.0	53.0	30.7	37.0	41.7	11.3	39.0	55.0	28.7	25.7
21	17.0	46.3	36.7	(24.7)	29.3	54.7	39.7	38.7	36.0	5.0	47.0	47.3	38.0	27.7
22	24.3	40.0	42.7	26.7	41.0	60.3	47.7	42.3	34.7	8.3	49.3	58.0	39.7	29.3
23	18.7	42.7	36.7	26.3	44.0	56.0	33.3	43.3	48.0	22.0	53.3	52.7	35.3	34.3
24	34.3	47.0	32.7	20.7	27.3	45.7	37.3	39.3	38.0	15.7	50.7	40.0	30.3	45.3
25	39.3	41.3	34.7	32.7	22.0	34.0	39.3	26.7	37.0	12.7	54.0	36.0	33.3	54.3
26	37.0	37.3	42.7	31.3	34.0	30.7	27.0	21.7	39.3	12.7	45.3	51.3	40.3	47.0
27	30.3	38.7	50.0	31.3	38.7	34.7	14.7	21.0	30.7	21.3	41.0	50.7	39.7	40.3
28	26.3	44.8	53.3	38.7	29.0	40.3	13.7	26.0	25.0	20.7	33.3	47.3	41.0	40.0
29				37.7				39.3				48.0		
Mean,	26.26	34.19	29.31	37.78	35.27	43.20	24.52	27.04	34.34	20.82	35.77	40.97	31.96	37.22

	1843.	1844.	1845.	1846.	1847.	1848. (7)	1849. (6)	1850.	1852.	1853. (6)	1854.	1858.	1859. (6)
1	10.7	29.0	18.7	32.0	38.0	33.3	43.7	40.0	36.0	36.3	47.7	32.0	34.7
2	17.7	35.3	18.3	39.0	43.0	38.7	37.7	42.0	32.7	47.3	41.3	35.3	39.0
3	31.3	33.3	30.0	45.7	26.7	39.3	29.0	21.0	34.0	43.3	21.0	36.0	33.3
4	38.3	38.0	23.7	36.3	16.3	38.7	33.0	8.0	39.3	50.0	25.7	30.7	24.0
5	32.0	39.3	21.0	43.3	24.0	21.7	30.7	15.0	42.0	38.0	33.7	25.7	26.7
6	13.3	36.7	19.3	38.3	29.7	20.7	24.0	29.0	49.3	28.0	28.7	31.0	28.0
7	9.7	30.3	26.3	40.3	37.0	25.7	17.3	24.7	40.7	24.0	38.7	35.3	24.0
8	21.3	19.0	23.3	28.7	41.0	26.7	26.7	43.3	36.0	26.0	43.0	32.3	34.0
9	26.7	20.3	33.3	26.3	40.0	28.3	24.0	41.3	34.3	18.7	37.7	35.0	33.3
10	44.0	20.0	38.3	31.7	34.7	29.7	24.7	31.3	43.3	30.7	35.0	22.0	23.7
11	31.7	31.0	48.3	40.0	28.3	27.3	33.3	28.0	32.7	42.0	34.3	16.0	28.0
12	29.7	35.3	46.0	32.0	25.3	27.3	28.0	30.0	22.7	38.7	50.3	28.0	31.3
13	27.0	40.3	32.7	29.3	23.7	27.0	27.7	36.3	35.3	36.0	53.3	30.3	25.0
14	29.7	33.3	51.7	36.0	29.0	36.7	23.0	34.3	26.0	22.7	57.3	34.3	32.0
15	18.0	41.7	51.7	35.0	45.3	37.7	13.0	24.7	33.3	32.7	37.3	26.3	43.0
16	11.3	37.3	34.7	34.7	48.0	40.0	13.3	24.7	31.0	38.7	32.0	25.7	43.0
17	15.0	33.7	38.3	32.3	42.0	44.3	20.3	32.7	24.0	34.0	26.3	20.3	42.3
18	34.0	31.3	41.0	25.7	40.3	43.0	19.0	33.7	21.3	40.0	37.3	24.0	49.0
19	36.3	35.3	49.0	32.3	44.0	48.3	16.0	30.7	24.7	30.0	45.0	29.0	55.7
20	29.0	37.7	53.7	31.0	44.3	57.7	29.3	42.7	28.7	27.3	36.7	20.7	45.7
21	30.7	44.0	57.7	29.0	54.3	49.3	39.0	43.3	36.7	38.0	39.7	24.7	35.3
22	27.3	40.7	52.3	19.3	34.7	42.7	39.7	33.0	43.3	44.0	39.0	14.0	42.0
23	22.7	44.7	51.0	29.3	29.0	42.0	36.7	34.0	41.0	25.3	24.3	11.3	52.3
24	31.3	34.0	46.0	29.3	33.7	33.3	40.3	42.0	51.3	22.3	31.3	21.3	42.0
25	28.7	36.3	46.7	22.7	37.7	32.3	35.0	45.3	43.3	29.3	42.7	30.7	40.0
26	37.3	44.3	39.3	12.0	38.0	32.7	35.3	48.7	32.0	38.7	48.7	32.0	41.0
27	33.3	39.0	41.7	21.0	38.3	34.0	44.7	46.7	32.7	44.7	35.3	41.0	49.0
28	24.7	35.0	39.0	25.7	30.3	41.7	51.7	50.7	42.7	52.0	38.7	35.7	40.0
29		51.0				34.3			28.3				
Mean,	26.52	35.42	38.32	31.36	35.59	35.66	29.85	34.53	35.12	34.95	37.93	27.88	37.05

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN MARCH.

	1829. (7)	1830. $\left(\frac{7}{6}\right)$	1831. (7)	1832. (⊙)	1833.	1834. (6)	1835. (⊙)	1836. $\left(\frac{7}{6}\right)$	1837.	1838. (6)	1839.	1840. (6)	1841.	1842. (7)
1	27°.3	49°.7	52°.7	38°.0	22°.7	36°.7	17°.0	33°.3	29°.3	25°.7	35°.7	61°.3	45°.3	52°.7
2	32.0	35.3	50.7	44.0	10.0	31.0	21.3	21.7	27.7	31.3	39.0	54.7	41.3	59.3
3	41.3	32.7	51.0	52.7	19.3	27.0	24.3	36.0	24.7	27.0	14.3	57.0	38.7	58.0
4	49.7	37.3	52.7	50.3	22.0	35.0	20.7	41.7	31.0	33.7	11.7	57.0	37.7	65.7
5	38.7	43.3	44.3	41.0	26.7	44.7	24.3	38.0	36.0	39.0	26.3	44.3	33.3	47.7
6	31.7	51.0	46.7	39.0	25.3	51.3	32.3	30.7	41.3	38.0	34.7	43.3	33.0	54.3
7	34.7	59.3	40.3	36.7	35.3	52.7	42.7	29.0	54.0	42.3	44.0	48.7	36.0	36.3
8	42.0	30.0	36.0	41.3	36.7	50.3	37.3	29.7	55.3	39.0	40.7	41.7	34.3	42.3
9	41.7	31.7	37.7	51.7	35.0	35.3	42.3	40.0	40.3	37.7	42.7	54.0	31.3	57.7
10	45.3	46.7	40.7	54.3	42.3	39.0	38.7	40.3	37.3	35.0	33.7	35.3	33.7	54.3
11	52.0	42.7	48.0	57.0	49.3	45.3	39.3	20.3	42.7	43.3	38.7	26.7	38.0	40.3
12	37.3	53.3	45.0	58.3	44.0	47.7	39.0	17.0	51.7	41.3	42.3	32.3	38.3	41.3
13	31.3	52.7	33.0	32.7	31.3	41.0	48.0	41.0	53.3	47.7	51.3	36.3	35.0	43.7
14	28.7	45.3	40.3	26.7	42.3	45.0	44.7	39.3	34.7	49.0	43.0	40.0	36.0	46.0
15	35.7	40.3	45.3	33.3	44.7	42.3	55.3	35.7	33.7	46.7	38.7	52.7	31.7	40.3
16	48.3	50.3	37.3	40.3	46.7	47.7	59.7	35.0	31.3	41.0	45.3	52.7	26.3	51.0
17	29.7	52.3	26.7	15.7	53.7	50.7	43.0	51.3	44.0	32.0	49.0	52.7	27.0	61.3
18	29.0	43.7	36.7	20.0	52.3	58.7	42.0	37.0	43.7	38.3	65.0	53.3	31.0	60.7
19	30.3	48.3	30.0	32.7	53.7	61.0	44.0	33.3	34.3	37.0	42.0	52.0	45.7	67.0
20	30.3	51.7	28.7	49.0	59.7	60.3	49.3	33.0	49.0	48.7	53.3	48.0	46.0	68.7
21	30.7	60.0	35.3	40.0	60.3	35.3	53.3	31.0	50.7	51.3	56.7	38.0	47.7	58.0
22	27.0	62.7	46.0	36.7	49.7	33.0	34.3	28.7	33.3	56.0	43.7	41.3	61.7	43.0
23	33.0	44.3	55.7	52.3	47.3	44.7	30.0	30.3	34.7	63.3	46.0	51.3	47.3	47.7
24	33.3	43.7	60.0	56.7	50.0	43.3	40.7	38.7	42.7	62.3	42.3	46.3	46.7	55.7
25	31.0	43.3	55.7	61.3	42.0	40.7	52.0	31.0	47.3	46.7	37.3	35.0	54.0	59.7
26	32.7	39.0	54.7	40.0	40.3	41.0	52.0	37.3	48.3	51.0	45.7	40.3	62.0	43.7
27	38.0	50.0	56.7	40.0	38.3	42.7	50.7	49.3	56.7	65.3	63.3	53.3	64.3	47.7
28	50.0	50.0	49.3	44.3	33.3	48.3	44.3	51.7	47.3	63.0	57.3	58.0	58.3	47.0
29	51.3	61.3	58.7	47.3	34.7	46.7	39.0	45.0	35.7	57.7	57.0	55.3	56.0	52.7
30	50.7	56.7	51.0	53.3	38.3	35.3	44.7	45.3	37.7	54.3	33.3	40.3	42.7	62.3
31	50.7	50.0	61.7	60.7	43.7	41.7	50.0	47.3	55.0	59.3	39.0	37.0	46.0	46.7
Mean,	37.59	47.06	45.43	43.46	39.71	43.71	40.52	36.09	41.44	45.39	42.35	46.46	42.14	52.02

	1843.	1844.	1845. (⊙)	1846.	1847.	1848. (6)	1849. (6)	1850.	1852.	1853.	1854.	1858.	1859. (6)	
1	23.0	56.7	46.3	29.7	31.3	27.0	46.0	41.3	46.3	41.7	43.7	26.3	35.3	
2	15.7	45.3	53.0	32.3	32.3	27.7	36.0	37.3	34.7	38.7	52.3	15.3	41.3	
3	22.7	38.3	44.3	31.3	37.3	25.3	32.3	27.3	29.0	29.7	51.0	16.7	53.0	
4	27.7	30.7	44.0	36.0	35.7	22.7	42.7	21.7	36.7	25.0	49.0	14.3	47.3	
5	27.0	29.3	45.3	41.7	36.3	23.0	42.0	34.0	46.7	28.3	40.7	14.3	51.7	
6	21.7	36.7	46.7	48.3	41.3	30.0	50.7	45.7	36.7	27.3	38.3	9.7	47.3	
7	30.0	44.7	51.3	43.7	52.3	39.7	46.3	40.0	36.7	44.0	48.3	19.0	58.0	
8	31.7	55.3	54.0	49.3	49.0	46.3	37.3	41.0	52.0	44.7	58.7	26.3	44.7	
9	39.7	42.3	41.7	47.7	46.7	34.0	39.3	47.0	56.0	42.0	54.0	28.3	45.7	
10	42.3	39.3	42.3	49.3	43.0	30.3	42.3	42.0	41.3	40.7	46.0	35.7	51.3	
11	33.3	47.3	35.7	52.7	32.3	34.0	42.0	37.7	50.3	43.3	41.0	43.0	56.3	
12	34.3	53.3	37.3	52.3	28.7	43.3	56.0	39.7	52.7	47.0	43.7	35.7	50.3	
13	24.3	51.7	43.3	53.0	29.0	30.7	55.7	47.3	65.3	42.7	51.3	39.7	49.3	
14	23.3	45.3	43.3	44.0	30.7	21.3	59.3	56.0	57.3	30.0	60.3	57.0	56.0	
15	30.0	52.3	33.3	45.7	24.3	18.3	55.3	43.3	50.0	24.0	57.7	49.0	44.0	
16	25.3	47.3	36.7	38.7	23.0	26.7	50.7	40.7	46.0	31.3	61.0	57.3	42.7	
17	22.7	39.3	41.3	37.3	27.7	39.7	44.3	54.3	49.3	38.0	50.7	60.0	51.3	
18	22.7	27.0	30.3	50.0	47.0	39.7	41.0	46.0	28.7	39.7	33.0	53.7	47.7	
19	19.7	27.3	26.0	51.3	44.7	50.3	40.7	37.3	24.0	42.7	32.3	51.3	33.3	
20	24.0	36.0	27.7	46.0	58.0	54.0	51.3	35.7	21.3	46.0	41.7	52.7	39.7	
21	25.0	32.0	32.3	38.7	45.7	48.7	40.7	46.0	32.7	47.3	46.7	55.3	52.0	
22	19.0	36.0	34.7	44.0	37.3	41.7	38.7	42.7	39.3	46.3	50.3	42.7	54.3	
23	12.0	30.7	48.0	47.3	43.0	38.7	46.3	33.7	40.0	41.3	47.7	43.0	52.3	
24	17.0	38.3	35.0	54.0	45.0	46.3	52.7	31.3	38.3	38.3	38.0	43.0	61.7	
25	28.3	50.0	36.7	44.0	50.7	51.0	43.0	30.3	49.3	48.0	29.0	48.7	43.0	
26	26.3	58.0	43.7	43.0	35.3	58.0	32.0	32.0	56.7	51.3	31.7	49.7	39.7	
27	39.3	56.7	49.7	42.0	32.7	44.0	34.3	28.7	39.7	40.7	39.3	53.3	58.0	
28	41.3	61.7	53.3	40.3	45.7	46.0	42.0	32.7	46.0	37.0	29.3	46.7	65.3	
29	35.7	47.0	56.0	38.3	52.7	53.3	49.3	38.0	56.0	44.0	38.3	42.3	50.7	
30	44.3	34.3	59.3	35.0	53.0	57.0	46.7	38.7	58.7	59.0	41.7	47.3	42.3	
31	42.7	35.7	65.3	38.0	34.7	74.0	46.7	43.7	55.3	59.7	59.0	55.0	41.3	
Mean,	28.13	42.77	43.16	43.38	39.55	39.44	44.63	39.13	44.29	40.67	45.34	39.75	48.61	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) in APRIL.

	1829. (6)	1830. (6)	1831. (6)	1832. (⊙)	1833.	1834. (6)	1835. (⊙)	1836.	1837.	1838.	1839.	1840.	1841.	1842. (7)
1	54°.0	46°.0	50°.0	51°.0	47°.0	65°.0	54°.3	54°.7	39°.3	45°.0	47°.3	40°.0	54°.0	44°.7
2	45.0	42.0	60.0	49.0	57.7	52.0	55.0	57.3	43.3	36.7	54.7	40.3	44.0	55.7
3	41.7	46.7	57.3	47.3	63.7	52.3	52.0	61.0	47.0	39.7	60.7	52.7	43.7	66.3
4	50.0	53.7	58.3	42.7	52.3	47.7	42.3	53.0	33.0	41.7	60.7	59.3	48.0	65.7
5	51.3	58.3	49.3	48.0	45.7	43.0	37.7	47.0	36.7	48.3	62.0	53.3	43.3	59.0
6	43.7	64.3	53.0	52.0	50.7	48.3	41.3	38.3	45.0	48.3	62.0	45.7	46.0	59.0
7	47.0	66.0	56.7	50.0	56.3	50.7	40.0	46.7	56.7	53.3	64.0	43.3	55.7	68.3
8	50.3	68.3	52.7	49.7	50.3	49.0	49.3	61.0	36.7	56.7	54.7	50.3	53.0	53.7
9	61.0	62.7	37.0	45.7	56.7	47.3	56.0	60.0	37.7	48.0	54.3	57.3	58.7	49.7
10	43.7	49.0	46.0	57.0	60.7	51.7	59.3	36.3	41.3	46.0	65.3	65.3	40.0	57.3
11	41.7	48.7	38.7	57.3	68.0	54.7	59.3	38.7	48.3	43.7	62.7	62.0	45.7	60.7
12	47.0	58.0	39.0	60.7	49.3	61.3	58.0	48.7	51.0	40.0	49.0	55.3	41.3	60.3
13	46.0	59.3	48.3	62.0	41.0	59.3	51.3	56.7	58.0	42.3	47.0	46.7	46.7	63.0
14	48.0	58.0	59.3	63.7	44.3	64.3	36.0	53.3	50.0	43.3	46.3	50.3	40.7	50.0
15	48.7	62.0	61.7	61.7	50.7	65.3	39.7	43.0	50.0	38.3	48.0	50.7	41.7	52.7
16	54.0	56.3	66.3	47.3	53.7	64.7	37.3	46.0	51.3	35.7	50.3	62.0	49.7	55.7
17	56.7	65.0	65.7	45.3	51.0	67.7	36.7	57.3	40.0	59.7	50.3	72.7	56.7	49.3
18	61.0	59.7	68.0	49.3	51.3	68.0	46.0	51.3	46.0	48.7	43.7	60.0	51.0	52.3
19	58.0	60.7	57.7	46.0	54.0	67.0	63.0	53.3	54.3	37.3	50.3	53.3	49.7	48.7
20	54.0	65.7	66.0	47.3	60.0	65.3	56.0	62.3	51.7	33.7	58.7	51.7	49.0	54.0
21	43.7	65.3	65.7	60.3	61.3	69.3	56.0	58.0	48.3	43.3	53.7	61.0	39.0	58.0
22	60.3	63.7	64.7	56.0	64.0	67.7	51.3	47.7	46.3	57.7	61.3	63.0	45.7	67.3
23	63.7	65.3	53.0	53.7	69.3	61.0	44.7	62.0	40.7	47.0	70.0	70.0	53.3	65.7
24	45.3	64.0	49.0	62.3	55.7	56.0	43.3	49.0	39.3	54.0	72.0	69.3	60.3	69.3
25	34.7	68.3	50.3	66.7	59.3	43.3	52.7	63.0	39.3	65.7	60.7	74.0	61.3	69.3
26	34.7	47.7	53.7	61.3	54.7	38.0	48.0	73.0	40.0	64.7	58.3	60.7	61.3	58.0
27	48.3	49.0	56.0	58.7	58.7	43.0	50.3	64.3	44.7	61.0	61.7	52.7	49.0	49.3
28	59.7	55.3	51 7	58.3	66.0	54.7	52.7	70.0	50.3	70.0	65.7	52.0	57.7	47.0
29	63.0	62.0	49.0	62.7	70.7	51.7	63.0	70.7	59.7	58.7	65.0	57.3	50.7	40.3
30	61.3	64.7	54.7	65.3	71.7	48.0	60.7	73.7	69.3	47.7	65.3	63.3	50.7	52.0
Mean,	50.58	58.52	54.62	54.61	56.52	55.91	49.77	55.24	46.50	48.53	57.52	56.52	49.60	56.74

	1843.	1844.	1845.	1846.	1847.	1848. (6)	1849.	1850.	1852.	1853.	1854. (6)	1858.	1859. (6)	
1	33.0	44.0	47.7	48.3	43.3	43.7	39.7	46.7	49.3	58.0	40.0	50.7	47.3	
2	34.7	50.7	46.3	47.3	52.7	46.0	40.7	59.3	40.0	52.7	30.3	56.7	53.3	
3	37.0	53.0	53.3	48.0	51.7	58.3	48.7	57.3	36.0	46.0	35.7	57.3	53.0	
4	39.7	58.7	63.0	53.0	59.7	59.3	58.0	48.7	41.0	42.3	51.7	60.7	43.3	
5	43.3	62.7	48.7	55.0	57.0	51.3	48.0	48.7	50.0	42.7	56.3	50.0	32.7	
6	38.7	62.7	39.7	61.7	63.3	49.3	51.7	41.3	34.7	46.3	64.7	42.7	40.3	
7	43.0	64.0	41.0	63.0	59.0	50.0	67.0	44.3	43.3	45.0	64.3	43.7	51.0	
8	56.0	62.7	29.3	42.3	53.7	56.7	61.3	44.3	40.0	51.7	65.0	61.3	37.7	
9	40.0	63.3	35.7	48.3	53.3	57.3	60.7	37.7	40.7	53.3	62.3	64.0	43.3	
10	39.3	62.7	61.7	60.7	53.7	60.0	59.3	45.3	45.3	43.3	46.7	62.7	55.3	
11	45.0	66.0	47.0	61.0	46.7	67.0	51.0	40.7	49.3	46.7	45.0	61.3	72.0	
12	48.7	67.3	47.7	42.3	54.0	56.3	55.0	44.3	46.7	66.0	50.0	60.3	61.0	
13	51.3	67.0	62.0	40.0	49.0	51.0	52.0	33.7	51.3	68.0	58.0	47.3	67.3	
14	56.3	69.7	58.0	45.0	48.3	44.0	35.3	37.3	54.7	52.0	54.3	47.7	57.7	
15	61.7	65.3	62.3	45.7	42.7	43.7	32.0	39.3	48.7	50.0	43.0	52.3	47.3	
16	59.7	67.7	61.7	50.3	41.0	47.3	33.0	44.3	52.7	49.7	34.0	52.3	42.0	
17	57.3	56.7	69.7	60.7	51.0	53.0	43.3	41.7	53.7	44.7	33.0	51.0	38.7	
18	51.3	57.0	66.0	62.7	34.7	42.7	33.0	46.0	47.3	44.3	42.0	46.7	42.3	
19	49.7	56.3	67.3	55.7	47.3	41.0	41.3	46.7	44.0	47.3	48.0	63.0	52.3	
20	56.3	58.7	54.7	57.7	63.3	41.0	41.3	47.0	46.3	55.7	60.7	62.0	52.0	
21	59.3	60.0	54.7	65.0	67.3	53.7	46.0	55.0	46.0	59.3	66.7	53.7	50.3	
22	60.0	66.7	58.0	67.0	65.3	57.7	50.7	64.0	49.7	73.3	64.3	60.7	47.0	
23	60.3	72.0	66.3	69.7	47.0	62.0	56.0	52.0	49.3	57.3	55.0	46.0	42.7	
24	59.3	70.3	68.7	69.3	48.3	54.0	50.7	48.0	50.3	56.7	62.7	42.7	48.7	
25	65.7	64.7	62.3	64.7	50.7	52.3	49.3	44.7	62.0	47.3	65.0	41.0	56.3	
26	64.0	67.0	65.7	62.7	59.3	48.3	58.0	57.0	62.7	50.7	66.3	41.7	57.0	
27	52.0	53.3	64.2	64.7	66.7	49.0	66.0	65.0	48.7	56.7	51.7	42.3	52.7	
28	54.0	52.7	70.3	64.3	66.3	60.3	64.0	61.0	54.0	61.3	34.7	50.7	56.7	
29	60.0	54.0	70.3	62.7	65.3	55.7	56.7	55.3	57.3	62.7	36.3	62.7	58.7	
30	55.7	61.0	70.0	62.3	53.7	57.0	67.7	63.0	66.7	58.7	38.7	72.0	63.7	
Mean,	51.08	61.25	57.12	56.69	53.84	52.30	50.58	48.65	48.72	52.99	50.88	53.56	50.79	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN MAY.

	1829. (6)	1830. (6)	1831. (6)	1832. (⊙)	1333. (6)	1834. (6)	1835.	1836.	1837.	1838.	1839.	1840. (6)	1841.	1842.
1	65°.0	64°.3	55°.3	62°.3	71°.0	51°.7	63°.3	74°.7	41°.7	52°.0	67°.3	56°.7	53°.0	65°.0
2	61.7	65.7	52.7	62.0	71.3	52.7	58.7	73.0	58.0	60.7	64.7	59.3	48.3	52.3
3	59.3	67.3	59.3	68.0	69.3	53.7	64.0	66.3	68.3	56.7	49.7	63.7	44.0	46.3
4	50.3	69.7	56.3	63 7	72.7	53.3	69.7	65.7	68.7	50.0	47.6	64.0	44.7	49.0
5	56.3	65.7	55.7	48.7	72.7	64.0	67.0	68.7	82.3	47.0	60.3	54.3	45.7	50.7
6	63.0	54.0	46.3	57.3	69.7	61.3	59.0	61.0	53.0	46.3	56.0	50.3	53.0	56.7
7	65.3	51.7	62.0	66.3	70.3	55.3	59.3	62.3	56.0	43.7	65.0	54.7	47.3	58.0
8	61 7	57.3	52.7	55.7	71.0	54.0	56.7	55.7	62.3	43.0	70.3	57.3	53.7	53.0
9	53.3	60.0	42.3	60.0	71.3	52.7	47.3	54.7	70.7	44.0	75.7	51.3	53.7	50.0
10	50.3	58.3	50.3	66.0	67.7	53.3	52.0	57.3	63.0	45.7	70.7	44.7	60.7	63.0
11	49.0	69.3	65.0	68.7	69.7	65.0	54.7	63.7	69.3	49.3	66.3	51.3	52.7	68.0
12	51.3	70.0	65.7	67.7	69.7	56.7	56.0	69.3	57.7	55.7	66.0	56.7	55.0	58.0
13	52.3	67.7	63.3	67.7	61.7	38.7	53.3	59.7	64.7	59.3	59.0	59.7	52.7	56.3
14	62.7	66.7	65.3	68.7	64.0	48.3	60.7	57.7	63.3	67.3	62.0	59.7	50.7	54.7
15	66.3	62.3	67.3	60.0	64.7	43.7	55.7	69.0	47.0	64.3	71.7	66.7	52.0	56.7
16	66.7	63.0	69.3	64.3	68.3	46.0	56.3	73.0	52.0	70.0	62.7	72.7	56.7	63.3
17	61.3	53.0	72.0	67.0	71.3	54.3	60.7	72.0	47.0	69.3	59.7	71.0	66.0	65.0
18	71.0	56.0	70.7	65.3	72.0	58.3	64.0	70.0	46.3	57.0	60.3	71.7	65.7	68.0
19	71.0	57.3	62.0	60.0	72.0	64.3	70.3	65.7	50.7	58.7	64.7	75.0	63.0	63.3
20	69.0	61.0	56.3	55.7	68.3	68.7	71.3	73.0	52.0	63.0	67.0	66.7	62.0	54.0
21	68.7	55.7	60.0	57.3	65.0	72.0	69.0	73.0	58.7	65.3	67.3	60.7	70.3	59.3
22	72.0	57.7	57.0	61.3	66.3	69.0	72.3	68.3	60.3	58.0	74.0	61.0	71.3	67.0
23	76.0	55.0	52.7	61.3	67.3	75.3	69.7	69.7	60.3	50.7	77.3	65.3	71.7	58.7
24	74.7	53.3	49.3	48.0	66.0	72.3	66.3	61.7	61.3	47.7	79.3	63.3	72.0	62.0
25	69.3	53.7	51.3	52.7	69.3	71.3	67.3	61.3	59.3	46.0	69.7	65.3	71.7	56.7
26	74.7	56.0	55.0	54.3	71.0	69.7	70.0	61.7	60.3	56.0	70.0	66.0	64.7	58.3
27	74.0	60.0	65.0	57.7	69.3	74.3	70.0	68.7	64.0	59.7	67.0	67.7	71.7	64.3
28	76.0	62.7	72.7	54.7	64.3	70.3	75.0	66.0	69.0	53.7	53.3	61.7	70.7	63.0
29	80.3	68.3	71.3	62.3	61.3	68.0	72.0	68.3	69.0	52.0	51.7	67.3	73.0	68.3
30	78.0	62.7	72.0	58.0	55.7	69.0	67.3	61.7	69.0	56.3	58.7	70.0	69.0	60.7
31	77.7	63.3	75.0	58.3	60.0	74.0	66.7	59.3	70.7	65.7	61.3	71.7	71.0	58.0
Mean,	65.43	60.93	60.63	60.67	67.88	60.68	63.40	65.55	60.50	55.29	64.39	62.20	59.91	58.96

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854. (6)	1858. $\left(\frac{7}{6}\right)$	1859. (6)	
1	48.7	70.3	65.3	58.0	56.3	60.3	54.3	49.3	65.3	66.0	53.3	57 3	64.0	
2	49.7	64.7	65.3	56.3	52.3	57.0	56.7	48.0	58.7	69.3	52.0	57.3	66.3	
3	53.3	67.7	59.0	60.0	50.0	58.7	70.0	61.0	58.7	69.7	45.7	64.3	63.3	
4	59.0	56.3	64.3	61.3	52.0	64.3	72.7	59.0	59.0	67.0	57.7	57 3	64.3	
5	67.0	61.0	54.3	65.3	52.7	65.7	70.7	53.0	61.0	64.0	58.0	62.3	66.7	
6	70.0	57.0	55.7	63.3	55.3	69.3	68.0	51.3	61.3	60.7	55.7	55.7	67.7	
7	68.7	59.0	47.7	66.0	62.7	66.7	68.7	52.0	65.3	60.0	50.3	59.3	69.0	
8	60.3	63.3	47.3	66.7	63.0	57.7	65.7	55.7	64.3	56.0	55.7	62.3	68.3	
9	54.3	62.0	59.7	64.0	58.7	60.0	61.3	54.0	69.7	57.3	62.0	69.7	69.3	
10	55.7	66.0	66.0	60.0	64.7	50.3	60.0	44.3	68.0	53.3	61.0	52.0	61.0	
11	53.0	77.3	67.0	49.3	67.3	47.3	59.3	45.3	66.7	54.0	61.7	55.7	65.3	
12	61.7	61.7	68.3	55.7	66.7	46.7	52.7	53.7	62.7	57.3	65.0	56.0	66.7	
13	63.0	59.0	70.0	63.7	66.3	54.3	60.3	62.7	61.3	54.7	70.0	62.7	71.7	
14	74.0	62.0	68.0	66.0	63.0	52.3	57.3	56.7	66.7	57.3	67.3	70.0	61.3	
15	77.0	65.7	51.0	61.7	63.0	58.0	57.0	56.7	62.3	68.3	64.0	66.0	62.7	
16	65.3	72.3	49.0	57.0	61.3	61.7	59.3	61.3	66.0	73.7	71.7	50.7	62.7	
17	59.3	59.0	54.3	66.0	63.3	62.3	61.3	63.3	59.7	74.7	71.3	66.3	68.0	
18	56.7	61.3	58.3	64.7	59.3	68.7	57.7	48.7	53.0	72.7	56.3	61.0	71.3	
19	53.0	59.7	68.0	51.3	60.0	72.3	58.7	57.0	51.3	50.7	55.7	56.0	66.3	
20	54.0	66.3	63.0	56.7	62.3	72.0	62.3	55.9	47.0	51·3	58.3	54.7	62.0	
21	58.0	48.7	61.0	59.7	64.0	69.7	66.0	49.0	54.0	56.7	63.7	49.0	69.0	
22	59.0	50.3	68.3	68.3	61.0	71.0	66.7	54.3	64.0	65.0	63.3	53.7	61.0	
23	58.7	60.0	55.0	74.0	59.7	74.7	64.7	56.7	64.7	60.3	67.7	68.7	60.3	
24	65.7	68.7	51.0	71.7	60.7	72.0	54.3	59.3	66.0	56.7	66.0	64.7	65.0	
25	69.7	72.3	46.7	74.0	68.0	69.7	48.7	55.7	66.7	46.0	73.3	65.7	71.3	
26	72.0	66.7	58.3	76.0	58.3	69.7	55.7	54.7	67.3	56.7	71.7	66.0	70.7	
27	67.0	68.0	55.7	75.7	60.0	67.0	64.3	60.0	68.0	58.3	67.0	60.3	64.3	
28	58.7	68.3	68.7	73.7	65.3	71.3	62.0	68.7	68.3	67.3	73.0	62.3	61.7	
29	50.3	71.0	53.3	74.0	68.7	75.0	62.0	67.7	70.0	68.3	73.3	60.3	66.0	
30	56.3	71.7	48.3	74.0	71.3	70.0	61.3	62.0	64.0	66.7	71.0	69.0	70.0	
31	51.3	62.3	51.7	72.3	71.3	56.7	63.7	52.3	60.3	62.7	59.0	70.7	68.7	
Mean,	60.33	63.86	58.69	64.71	61.56	63.62	61.42	55.78	62.62	61.39	62.63	60.86	66.00	

Table II. *Continued.*—Mean Daily Temperature (uncorrected) in June.

	1829. (6)	1830. (6)	1831. (6)	1832. (⊙)	1833. (6)	1834. (6)	1835.	1836.	1837. (6)	1838.	1839.	1840. (6)	1841.	1842.
1	79°.3	67°.7	76°.0	61°.3	65°.3	75°.3	66°.3	59°.7	69°.3	63°.7	58°.7	74°.7	73°.3	56°.3
2	77.2	66.3	74.7	69.3	69.3	69.6	72.3	63.0	73.0	65.0	59.7	72.3	75.0	66.0
3	75.7	65.0	73.0	67.0	61.3	61.3	72.7	64.7	77.0	66.0	60.7	67.3	68.7	65.0
4	74.3	69.7	63.3	60.7	60.0	60.0	69.0	67.7	73.0	70.7	58.0	64.3	68.0	66.3
5	75.7	71.7	61.3	59.0	64.7	59.7	69.3	68.3	70.3	67.0	55.0	72.0	74.7	72.7
6	77.0	68.3	65.7	58.0	69.7	64.3	71.0	69.7	72.3	51.3	60.0	66.7	80.0	62.3
7	75.7	59.3	69.0	61.0	73.3	70.7	70.0	70.0	63.7	63.0	65.0	55.7	79.3	61.7
8	64.7	59.7	71.7	58.0	63.0	74.7	72.3	72.7	56.3	69.0	70.3	56.3	77.0	63.0
9	61.7	62.0	76.3	64.0	64.0	78.0	72.3	73.3	62.7	70.0	71.0	61.0	76.3	68.7
10	69.0	67.0	78.7	70.7	65.3	77.3	75.3	74.0	64.3	73.7	72.0	63.7	72.7	58.0
11	72.3	68.3	76.3	73.0	64.3	64.7	74.7	69.3	70.0	73.0	74.3	70.0	76.3	51.0
12	73.0	73.7	73.3	73.0	68.3	60.7	74.0	65.7	67.3	71.7	78.3	75.7	76.0	63.7
13	74.3	74.7	69.0	74.7	66.0	62.3	74.7	63.3	66.7	73.3	79.0	72.0	71.0	62.7
14	79.3	77.3	72.0	75.0	66.7	65.0	71.7	66.3	65.3	76.7	66.0	67.0	67.7	65.7
15	80.0	76.3	72.0	76.3	69.7	67.3	65.3	68.0	65.0	72.0	63.7	62.0	63.0	70.0
16	78.3	73.3	74.0	77.7	66.7	71.3	70.0	71.0	62.0	70.3	58.7	61.3	63.0	68.3
17	73.7	73.3	74.7	77.3	68.7	75.3	64.7	74.7	57.0	72.0	63.7	68.3	72.3	71.0
18	63.7	69.7	74.0	74.7	69.0	64.3	67.7	78.0	61.0	75.7	67.0	64.0	73.3	69.0
19	64.0	72.3	75.3	60.3	74.3	70.0	70.0	75.3	61.3	74.7	59.7	63.3	72.3	69.7
20	68.0	70.0	71.7	59.7	72.7	70.0	58.3	71.0	60.7	73.3	66.3	66.3	77.0	66.0
21	65.0	58.3	73.3	64.3	68.3	74.7	54.0	62.7	55.7	74.7	64.3	70.3	75.3	67.3
22	70.3	60.0	73.3	67.7	66.7	74.0	59.3	67.3	63.0	75.0	60.3	70.3	76.7	72.7
23	73.7	62.0	59.0	67.7	70.0	73.3	64.3	66.7	64.7	74.7	63.7	73.3	73.0	69.7
24	69.7	64.0	63.0	69.3	63.0	73.0	65.7	66.7	70.7	73.7	65.3	70.7	73.3	67.3
25	67.7	66.0	65.0	70.3	60.0	70.7	74.3	68.3	70.3	74.0	67.3	75.0	73.7	73.0
26	70.7	71.3	66.7	72.3	62.7	73.3	72.7	68.7	70.7	70.3	71.3	76.7	72.0	75.3
27	73.3	74.7	70.7	67.7	63.0	69.3	72.0	66.7	71.0	71.3	75.3	75.7	66.3	70.3
28	68.3	68.7	71.7	69.3	59.0	72.7	68.0	64.7	73.3	72.3	67.3	77.7	73.7	67.7
29	62.0	68.0	67.7	69.7	64.3	73.7	65.0	68.0	76.3	74.7	68.7	78.7	76.7	71.0
30	58.7	70.7	60.7	72.3	69.3	69.3	61.3	69.7	75.0	75.3	71.0	68.7	77.0	73.3
Mean,	71.21	68.31	70.43	68.04	66.29	69.53	68.60	68.50	66.97	70.93	66.05	68.70	73.15	66.83

	1843.	1844.	1845. (⊙)	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854.	1858. (6)	1859. (5)	
1	48.3	65.3	62.3	73.3	66.3	58.7	65.7	54.3	66.0	69.0	57.0	63.3	73.3	
2	55.3	66.7	68.7	67.3	62.7	66.0	70.0	58.0	71.3	73.3	60.3	66.0	66.7	
3	69.3	62.7	69.0	67.0	65.7	67.7	72.0	60.3	72.7	77.7	63.3	69.0	67.0	
4	70.7	63.7	70.3	68.7	65.7	71.7	75.0	64.7	56.7	74.0	69.0	77.0	45.3	
5	70.0	67.3	71.3	62.3	61.0	68.0	66.3	69.0	54.0	74.7	72.3	70.3	51.7	
6	60.0	73.3	69.3	57.7	59.0	56.7	68.7	71.7	62.0	75.7	70.0	69.0	59.0	
7	62.7	71.3	73.3	60.7	62.0	54.7	74.7	73.3	64.7	74.0	71.7	70.0	68.0	
8	73.0	65.0	77.7	64.7	70.0	57.0	74.3	73.3	62.0	67.3	63.0	73.7	71.0	
9	74.3	70.0	76.3	67.0	73.0	63.0	65.7	66.7	57.0	68.0	58.7	75.7	65.0	
10	67.3	66.0	73.3	66.0	69.7	65.3	62.3	61.3	53.0	70.7	65.7	77.0	52.3	
11	52.7	56.7	79.3	71.0	68.3	66.0	65.3	56.7	57.7	68.7	67.7	65.0	53.0	
12	60.7	63.7	70.7	67.0	62.7	61.0	63.3	63.3	63.3	73.0	67.3	65.3	66.3	
13	68.0	64.7	71.0	66.3	63.3	54.0	68.3	67.3	71.3	74.7	66.3	56.7	72.0	
14	68.7	67.3	67.0	70.0	58.3	64.3	72.0	70.7	72.0	78.3	66.3	59.0	75.0	
15	69.7	63.0	67.3	69.0	55.7	71.0	70.7	72.7	76.0	78.7	68.7	61.3	73.7	
16	71.3	67.7	67.3	69.7	61.7	74.7	66.0	73.3	76.3	76.0	73.7	64.7	69.7	
17	66.0	72.0	59.0	73.0	64.0	74.3	65.3	73.7	74.3	75.3	74.7	68 7	62.7	
18	62.0	74.7	64.3	74.3	70.7	74.0	71.3	74.0	70.0	71.0	73.3	74.0	64.3	
19	66.3	73.3	61.3	71.0	71.0	70.3	73.3	75.0	71.7	76.7	76.7	72.3	63.3	
20	65.3	70.7	68.7	66.0	67.7	75.0	74.0	76.0	72.7	80.3	76.0	69.7	71.0	
21	69.3	65.3	72.3	58.3	66.3	72.0	77.7	74.0	72.0	80.3	74.3	74.7	70.3	
22	69.3	62.3	72.3	56.7	66.3	71.7	77.3	75.0	70.7	76.7	71.0	79.3	65.7	
23	70.3	65.7	75.7	58.3	67.3	71.7	77.0	74.3	58.3	77.0	74.0	80.7	63.0	
24	72.0	67.7	76.0	63.3	68.7	67.0	73.0	71.7	64.7	68.0	71.7	79.3	66.3	
25	70.3	72.3	72.3	67.3	73.7	69.7	74.7	68.0	58.0	64.0	66.0	79.3	68.3	
26	71.7	77.0	69.7	71.3	74.3	71.0	74.0	66.3	62.3	66.3	75.0	82.3	74.7	
27	71.0	75.3	73.0	74.0	75.0	76.7	76.7	70.0	65.7	71.7	80.0	83.0	77.7	
28	72.7	69.7	69.3	70.7	75.3	76.0	75.3	72.3	69.3	76.7	80.3	79.7	80.7	
29	76.3	70.3	64.7	69.0	62.7	70.3	74.0	73.7	72.7	80.7	78.7	82.0	78.0	
30	79.0	78.3	56.7	69.3	62.3	73.0	76.7	74.0	71.3	88.7	78.7	81.7	69.3	
Mean,	67.45	68.30	69.65	67.01	66.34	67.74	71.34	69.15	66.32	74.04	70.38	72.32	66.81	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN JULY.

	1829. (6)	1830. (6)	1831. (6)	1832. (⊙)	1833. (6)	1834.	1835.	1836.	1837.	1838. (5)	1839.	1840.	1841. (7)	1842.
1	59°.0	73°.3	64°.0	76°.0	74°.3	75°.0	55°.3	71°.0	75°.3	75°.0	73°.7	61°.7	76°.3	72°.0
2	61.0	75.3	71.0	76.3	72.7	77.3	63.3	72.3	72.0	75.7	70.3	62.3	68.7	70.7
3	64.3	72.0	72.7	77.0	64.7	74.7	68.7	70.7	71.3	76.3	71.3	62.0	67.0	68.7
4	68.7	75.3	71.0	77.0	62.0	74.3	68.3	73.3	69.3	77.7	64.3	61.3	65.3	70.7
5	70.7	73.7	68.3	78.3	62.3	76.3	66.3	71.7	73.7	75.0	60.7	67.3	72.0	70.3
6	68.7	73.3	71.7	77.3	69.3	76.0	70.7	73.7	75.3	70.7	63.3	66.7	74.7	63.7
7	69.0	74.0	76.0	80.7	74.7	79.3	72.3	75.3	71.7	74.7	68.0	70.7	67.0	65.0
8	72.3	71.7	74.0	82.3	75.7	80.0	67.3	77.3	68.7	78.3	71.0	70.3	64.7	65.0
9	70.0	63.7	70.0	70.7	70.0	80.0	61.0	74.3	64.3	80.7	73.3	72.3	70.3	64.3
10	70.1	65.0	59.7	64.0	66.3	67.7	65.0	71.0	69.7	80.3	76.3	70.7	70.3	65.0
11	74.3	63.7	60.7	60.3	71.0	67.0	64.0	68.3	71.3	79.7	73.0	74.0	66.3	65.7
12	66.3	64.0	63.7	63.7	74.0	67.7	75.0	76.3	65.3	67.3	67.3	77.3	73.0	69.3
13	63.0	66.3	67.7	63.3	79.7	73.3	75.3	76.3	68.0	65.7	71.3	78.7	80.0	71.7
14	70.0	69.3	70.7	64.3	74.0	74.3	72.3	71.7	73.3	71.0	71.0	76.0	80.7	70.7
15	77.0	72.7	65.0	63.3	65.3	75.7	65.0	70.0	75.3	74.7	68.3	78.0	72.3	64.0
16	78.3	75.7	64.0	66.7	65.0	77.7	62.7	71.0	69.7	74.0	66.3	79.0	68.3	66.7
17	77.7	77.7	71.0	70.0	69.3	73.7	66.3	71.3	71.0	76.7	70.3	80.3	68.7	70.7
18	82.0	79.7	76.0	74.3	64.3	68.3	68.7	68.7	76.3	79.7	71.3	77.3	72.7	73.7
19	73.7	81.3	77.7	74.7	69.3	71.7	71.0	69.0	75.3	82.3	73.3	77.3	74.0	74.3
20	70.7	81.3	75.7	75.7	77.3	75.0	70.0	68.0	68.7	81.7	73.0	64.7	76.7	68.0
21	73.3	81.0	75.3	74.7	80.3	79.3	65.0	73.0	69.7	72.7	76.3	66.3	78.3	65.3
22	78.7	79.3	73.7	67.0	81.3	81.7	65.7	73.3	72.7	65.7	75.3	70.0	77.0	72.0
23	77.7	79.7	74.7	69.3	80.7	83.3	70.7	70.0	72.0	69.0	79.3	71.3	78.7	76.3
24	72.0	81.3	73.3	72.3	81.7	80.3	72.7	74.0	67.7	75.3	76.3	70.3	81.3	71.7
25	73.0	82.3	72.3	68.7	75.7	81.3	76.3	70.3	66.3	79.0	70.0	65.0	78.7	74.7
26	70.3	83.7	73.0	64.0	77.3	82.3	77.3	67.7	71.7	81.7	75.0	67.0	73.0	76.0
27	71.0	78.7	75.7	68.0	78.0	81.3	76.3	64.7	71.0	83.7	77.7	72.3	69.7	77.0
28	75.0	75.7	77.0	63.7	77.0	80.7	77.7	68.7	70.3	83.3	76.7	78.3	72.7	76.3
29	73.3	75.0	73.0	71.7	76.0	77.3	77.3	74.0	74.0	83.3	78.0	74.3	68.7	78.0
30	74.3	77.0	74.7	67.7	72.0	71.3	76.3	72.0	78.3	83.3	78.0	73.3	73.0	76.3
31	71.7	78.0	75.0	67.3	64.3	73.7	75.7	74.3	73.7	78.3	74.3	72.3	67.7	63.7
Mean,	71.52	74.86	71.23	70.65	72.43	76.05	69.67	71.72	71.39	76.52	72.08	71.24	72.51	70.23

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854. (6)	1858. (7) (3) (6) (3)	1859. (5) (3)	
1	80.7	78.7	63.0	71.7	63.3	75.0	72.7	77.3	72.7	82.3	73.7	74.0	73.7	
2	76.3	75.3	68.0	73.7	66.0	74.0	61.7	74.0	60.7	80.0	75.0	79.0	79.7	
3	61.3	70.0	64.0	74.3	68.7	68.7	62.0	74.7	62.7	76.3	78.7	75.7	65.7	
4	64.0	66.3	58.7	76.0	70.3	63.0	62.3	76.7	66.0	77.7	82.7	74.3	60.7	
5	70.3	72.3	62.3	76.7	71.0	69.3	64.7	81.7	71.0	73.0	79.0	76.3	62.7	
6	69.0	75.0	71.0	76.7	71.7	69.0	66.0	77.7	79.3	73.0	76.3	79.7	58.0	
7	76.7	69.7	77.0	75.7	70.3	71.0	68.7	70.7	80.3	71.3	78.0	75.0	67.3	
8	69.7	67.0	77.0	71.0	71.0	68.0	72.7	72.0	80.3	75.3	80.0	77.0	70.3	
9	69.7	73.0	74.0	78.7	73.0	69.0	73.7	75.7	81.0	79.0	77.0	79.0	73.7	
10	73.0	78.7	78.0	81.3	71.7	69.7	76.3	77.7	79.3	74.0	69.3	80.3	78.0	
11	66.3	70.3	77.7	82.0	71.7	71.0	74.3	78.7	76.3	74.7	68.3	78.3	79.0	
12	66.7	71.7	78.3	76.7	73.7	72.3	78.0	77.0	78.3	70.0	68.3	67.7	81.7	
13	71.7	75.3	79.3	72.0	78.0	73.0	79.7	76.0	75.3	68.7	67.7	70.0	83.7	
14	74.7	76.7	74.0	67.7	71.0	74.7	72.7	72.7	71.0	69.7	70.7	73.3	84.3	
15	78.7	78.3	77.3	61.3	68.3	73.0	66.0	76.7	67.3	74.3	72.0	72.7	82.0	
16	80.3	78.3	76.7	61.7	72.0	62.0	64.7	79.3	71.0	68.7	77.0	76.0	80.0	
17	77.0	71.0	79.0	61.0	75.0	62.0	67.0	78.0	68.0	66.3	78.3	77.0	83.0	
18	76.7	74.3	74.3	62.7	78.3	66.0	71.0	72.7	68.3	68.3	75.7	76.3	81.0	
19	77.3	78.3	70.0	60.7	77.3	70.0	74.3	71.3	71.3	72.3	79.3	76.0	81.0	
20	68.7	74.3	74.0	64.7	72.0	74.0	76.0	70.7	74.0	67.0	81.7	77.3	79.0	
21	66.0	73.0	84.3	64.3	72.0	72.7	72.0	73.7	76.7	72.7	81.7	78.7	73.3	
22	70.0	74.0	80.7	68.0	71.7	69.3	66.0	73.7	79.0	71.0	81.0	73.3	76.7	
23	72.7	75.0	71.3	72.7	74.7	67.3	69.0	73.0	78.7	72.0	80.0	71.3	71.3	
24	73.0	77.3	63.3	74.7	76.3	69.3	75.3	74.7	75.0	75.0	76.7	70.3	64.3	
25	77.3	77.0	66.3	72.7	74.7	71.3	75.7	79.7	77.3	66.7	73.7	70.7	76.3	
26	76.0	72.7	66.7	74.7	70.3	75.7	76.7	80.0	72.0	67.3	75.0	74.7	76.0	
27	80.0	70.7	69.3	76.7	58.7	74.0	74.7	80.7	65.7	66.0	70.3	77.3	64.7	
28	79.7	71.7	66.7	73.7	61.0	74.7	72.7	79.0	70.3	68.0	71.7	78.7	64.0	
29	79.0	71.0	67.0	77.3	68.7	70.7	75.3	79.7	77.3	69.3	79.7	78.3	66.3	
30	66.3	77.3	67.0	78.7	67.0	71.0	74.7	77.3	74.3	75.7	81.3	75.3	70.7	
31	64.0	78.3	60.7	71.3	64.3	70.0	69.3	78.0	64.7	73.3	83.0	75.0	72.7	
Mean,	72.66	73.95	71.51	71.95	70.75	70.34	71.14	76.15	73.07	72.22	76.22	75.44	73.57	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN AUGUST.

	1829. (6)	1830. (6)	1831. (6)	1832. (⊙)	1833. (6)	1834.	1835. (⊙)	1836.	1837.	1838.	1839.	1840. (6)	1841.	1842.
1	68°.0	79°.7	75°.7	65°.7	67°.3	71°.3	68°.3	69°.7	71°.0	75°.7	69°.7	69°.0	67°.0	54°.0
2	70.7	74.7	75.3	69.7	68.7	72.3	66.0	67.3	76.0	70.0	68.7	71.0	68.7	56.0
3	74.7	72.7	67.7	73.0	73.0	72.0	67.3	71.3	75.7	71.3	69.3	74.0	69.7	62.0
4	75.0	70.7	63.0	74.7	74.3	75.7	69.3	69.3	64.7	78.7	70.7	72.0	72.0	63.3
5	74.7	75.0	64.7	73.7	76.0	76.0	72.3	65.0	63.0	82.0	70.3	72.7	67.7	60.7
6	77.7	76.7	65.7	74.0	78.7	76.3	69.3	68.7	66.7	84.0	69.3	75.3	71.3	65.0
7	76.0	82.3	65.3	71.0	73.3	76.3	66.0	74.0	76.3	80.7	75.0	70.0	68.0	64.3
8	76.0	80.0	63.0	71.3	70.7	77.0	66.0	75.0	75.0	80.3	76.7	64.7	67.0	66.7
9	76.0	70.0	66.0	68.7	68.3	77.0	69.0	73.3	75.0	81.3	67.3	64.3	73.0	64.7
10	73.7	73.7	69.0	65.7	66.0	77.3	72.3	71.3	70.7	83.0	65.0	68.0	71.7	67.3
11	68.7	78.3	69.7	64.0	74.0	82.0	72.3	70.3	70.7	80.7	67.0	74.3	67.7	66.7
12	71.0	71.3	72.0	70.3	77.7	83.3	74.3	62.7	68.7	73.7	74.0	70.0	66.0	68.0
13	76.7	72.0	73.3	73.7	70.0	80.3	77.0	71.7	66.7	71.3	68.0	66.3	67.3	70.7
14	74.7	76.0	73.7	77.0	72.0	78.0	74.0	75.3	66.3	71.7	66.3	67.0	70.0	72.7
15	71.3	81.0	74.7	76.3	74.0	68.3	74.7	73.3	67.7	74.3	66.0	67.3	72.0	71.7
16	73.0	75.7	74.3	74.0	68.0	66.0	75.7	71.3	68.7	69.7	63.7	70.7	72.0	74.3
17	68.7	69.3	74.3	66.7	64.3	75.0	76.3	69.3	74.0	71.0	62.7	74.0	71.7	75.0
18	69.0	66.0	77.7	66.0	66.3	78.7	76.7	71.7	70.7	71.3	66.3	74.7	74.0	72.3
19	62.0	68.3	76.3	67.3	64.7	76.3	64.7	73.7	74.0	71.3	66.0	74.3	75.0	68.0
20	64.0	69.7	77.0	70.3	68.0	70.0	63.7	62.7	76.0	73.7	64.3	75.0	77.7	64.3
21	70.0	71.3	74.0	70.0	72.3	66.3	59.3	66.7	76.0	75.3	67.7	76.3	77.3	63.7
22	72.3	78.3	70.7	70.3	70.7	66.0	55.7	62.7	57.3	79.3	66.7	75.0	73.3	69.0
23	73.7	76.3	66.7	66.3	72.7	71.0	57.3	64.0	58.7	81.3	68.7	77.0	67.3	70.0
24	74.0	75.0	63.7	66.7	67.0	68.7	67.0	64.0	61.3	79.3	73.3	70.3	70.0	68.0
25	73.0	66.3	69.3	56.3	66.3	63.7	67.7	70.3	66.0	78.0	77.7	65.0	67.0	66.3
26	64.7	64.0	68.3	60.7	69.3	67.3	67.0	68.7	73.3	71.0	76.7	65.0	64.0	66.0
27	65.0	71.3	68.7	62.7	70.3	63.3	67.3	67.7	73.7	74.0	73.0	71.3	68.7	70.0
28	69.0	73.7	65.3	68.0	62.0	61.0	68.0	71.0	69.3	70.7	61.7	75.7	71.7	67.3
29	71.7	78.3	63.0	71.7	58.0	64.7	66.0	69.0	74.0	68.0	57.3	78.0	73.7	70.7
30	70.0	72.0	64.7	76.0	62.7	70.0	63.0	57.3	76.7	70.7	57.3	77.3	70.7	69.3
31	72.3	71.0	66.7	68.0	72.3	71.0	56.0	64.0	62.7	74.7	58.0	67.7	70.3	73.3
Mean,	71.52	73.57	69.65	69.34	69.64	72.33	68.05	68.78	69.88	75.42	67.88	71.39	70.43	67.14

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854. (5)	1858. (6) (3)	1859. (6)	
1	68.7	77.3	64.0	69.3	65.0	66.3	64.0	75.3	61.7	73.0	83.7	73.7	76.3	
2	65.0	73.3	64.7	69.7	65.7	66.7	64.0	74.7	61.7	74.0	83.3	77.0	74.0	
3	68.3	73.3	65.0	69.3	68.7	69.7	70.7	77.7	65.0	71.3	77.3	77.7	76.3	
4	72.7	69.7	66.7	72.7	71.7	71.7	69.7	70.7	70.0	69.7	74.3	77.7	76.7	
5	73.3	64.7	70.3	76.3	69.7	69.0	74.0	73.7	66.0	73.3	70.0	77.3	73.0	
6	76.7	68.7	70.7	79.3	65.7	66.0	71.3	72.7	64.0	75.0	74.3	75.3	71.7	
7	75.7	66.3	73.7	79.7	65.3	64.0	72.7	75.0	67.3	73.7	63.0	79.7	71.0	
8	70.3	72.3	72.3	80.0	67.7	67.0	72.3	76.0	71.3	72.3	61.7	79.0	74.0	
9	71.3	73.0	75.3	78.0	71.3	71.0	68.7	74.3	67.7	75.3	66.7	72.7	74.7	
10	67.3	73.7	73.0	74.7	70.7	73.7	64.7	72.3	70.0	75.7	73.0	76.7	79.3	
11	70.0	64.0	72.3	71.3	71.0	73.7	64.3	69.3	65.0	78.0	75.3	81.7	75.3	
12	73.3	64.7	69.3	74.7	69.3	74.7	65.3	70.0	65.3	79.3	74.3	77.3	73.0	
13	71.7	68.7	67.0	77.3	72.7	73.3	69.3	77.7	68.7	79.0	75.7	77.7	74.7	
14	77.3	74.3	71.7	75.3	74.7	76.7	68.7	75.3	72.3	78.7	74.0	73.3	73.7	
15	70.0	73.0	72.7	77.3	69.7	77.0	61.3	70.0	72.0	77.3	71.7	72.7	75.7	
16	72.0	76.3	72.0	78.0	74.7	78.0	66.7	66.0	65.7	77.0	68.3	75.3	75.3	
17	71.3	77.3	74.7	72.7	73.0	74.7	69.3	68.3	71.0	76.0	67.0	76.7	73.0	
18	68.7	78.3	75.7	68.0	67.3	69.7	71.3	73.3	70.0	71.3	66.3	74.3	70.0	
19	66.7	80.0	71.3	71.3	60.7	65.0	70.0	75.0	74.3	66.0	68.7	66.3	66.7	
20	62.7	78.3	74.3	77.7	60.0	60.3	74.0	72.3	73.3	62.7	72.3	71.0	63.3	
21	65.3	72.3	74.0	76.0	63.0	63.0	74.0	71.3	71.7	63.3	73.7	74.7	65.3	
22	65.3	77.0	74.0	73.7	67.3	67.7	74.0	74.7	76.3	68.0	76.0	67.3	69.0	
23	64.0	71.3	76.7	70.7	65.3	69.0	72.3	74.7	75.7	74.0	77.0	60.7	68.7	
24	66.7	64.7	77.3	71.3	66.3	69.7	69.3	71.3	74.0	72.3	78.3	62.3	69.7	
25	69.3	62.7	77.0	72.0	67.0	71.3	70.7	71.3	74.0	68.3	78.7	64.7	70.3	
26	72.7	60.3	76.3	76.0	68.7	71.3	69.3	68.0	76.3	70.0	76.0	71.3	67.0	
27	73.7	57.0	73.7	75.3	68.0	73.3	70.0	62.7	68.7	65.0	75.0	69.7	70.3	
28	73.3	58.7	75.7	74.3	67.3	74.7	74.3	61.0	65.3	59.3	76.7	65.7	63.0	
29	75.3	61.0	74.7	73.0	63.3	70.3	73.7	68.7	63.7	61.7	76.0	62.3	53.7	
30	76.3	64.3	72.3	73.0	66.7	69.7	75.0	70.3	63.7	66.0	75.0	60.7	61.3	
31	75.0	66.0	72.3	74.0	71.3	71.7	65.7	72.0	64.7	69.7	75.0	65.0	67.0	
Mean,	70.64	69.76	72.28	74.25	68.02	70.31	69.69	71.77	68.91	71.49	73.49	72.16	70.74	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN SEPTEMBER.

	1829. (6)	1830. (6)	1831. (6)	1832. (⊙)	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840. (6)	1841.	1842.
1	75°.7	70°.7	72°.0	62°.0	75°.3	73°.3	54°.0	65°.3	55°.7	67°.7	59°.0	64°.0	69°.7	73°.3
2	77.3	68.0	70.3	66.0	69.3	73.0	57.0	63.3	59.3	54.7	59.0	63.3	75.7	75.3
3	61.3	75.0	66.0	68.7	74.3	77.7	62.7	66.7	63.0	54.7	62.0	61.0	76.0	74.0
4	60.3	65.3	64.3	71.7	79.0	80.0	65.3	69.3	63.7	56.3	61.7	61.7	72.0	73.7
5	66.3	75.0	67.3	61.3	75.3	76.3	70.3	64.0	68.3	62.3	66.7	64.3	70.0	71.7
6	69.7	77.3	69.0	57.7	68.3	74.3	70.0	62.0	65.0	64.3	69.0	62.0	71.3	70.0
7	59.3	70.0	71.0	62.7	68.3	71.3	60.7	64.7	68.7	68.0	68.3	63.0	74.7	76.0
8	53.3	68.3	73.3	61.3	68.3	77.3	56.0	69.0	71.7	69.0	72.3	69.0	74.0	76.7
9	58.0	67.0	72.7	63.7	69.7	68.7	63.3	71.3	72.3	69.0	72.0	70.0	74.0	66.7
10	57.3	68.7	74.3	64.7	69.3	58.3	66.0	68.7	75.0	70.0	58.0	63.0	77.3	76.3
11	54.0	70.3	67.0	67.7	60.7	50.0	66.0	66.3	69.0	69.7	56.0	52.0	68.0	79.3
12	60.7	72.0	61.7	56.0	58.3	51.7	66.3	73.7	55.3	67.7	53.0	51.0	66.3	64.7
13	60.3	72.7	58.7	58.0	54.0	58.3	62.7	74.7	53.0	65.7	52.7	57.0	59.0	63.7
14	64.0	72.3	61.3	59.7	56.0	62.0	54.7	73.7	58.7	66.0	55.0	58.3	60.0	69.3
15	59.0	61.7	63.0	66.3	60.0	62.3	53.3	75.3	59.7	67.3	68.0	60.7	63.7	60.7
16	54.3	57.3	55.0	73.3	63.3	63.0	58.0	77.3	62.7	65.3	65.7	63.3	65.7	53.7
17	52.3	51.0	53.3	72.0	67.3	64.0	62.3	76.3	69.3	63.3	62.7	60.7	58.7	59.7
18	54.3	49.7	55.3	71.3	70.3	65.0	67.3	76.0	60.7	63.3	57.3	53.7	63.0	55.0
19	57.3	53.0	59.7	69.0	75.3	63.0	58.7	75.3	56.0	63.3	61.0	57.0	67.3	52.0
20	65.0	58.0	61.7	67.7	73.0	60.7	53.3	75.0	53.3	65.0	64.7	60.0	68.7	55.0
21	74.0	61.0	64.3	62.0	63.3	58.7	49.7	73.3	57.0	67.3	68.0	49.0	69.0	48.0
22	69.0	66.7	67.0	59.0	54.0	59.3	50.7	77.7	60.0	66.7	68.7	48.7	67.7	48.7
23	72.0	68.3	63.7	57.0	52.7	61.0	46.7	75.3	51.0	49.7	60.3	51.3	63.3	55.3
24	73.3	68.0	58.0	58.3	55.3	56.0	49.0	75.0	57.0	52.3	60.7	56.3	60.3	62.7
25	72.3	62.7	60.0	53.7	60.3	58.3	49.3	57.7	60.3	56.0	56.7	60.0	57.7	60.7
26	59.3	58.7	53.7	56.3	63.7	62.3	49.0	56.7	63.3	60.7	51.0	67.3	61.7	59.3
27	56.0	61.0	50.0	64.7	69.7	62.3	54.0	60.0	65.3	65.3	46.3	62.0	61.7	63.0
28	57.7	50.7	52.0	65.7	70.0	46.3	47.3	59.3	67.7	68.7	42.7	52.0	66.7	64.3
29	69.7	49.0	55.0	64.0	66.3	44.7	44.0	49.0	65.0	72.7	50.3	60.7	57.3	55.3
30	55.3	53.3	53.3	53.3	61.7	53.3	42.0	50.7	71.0	65.3	43.3	66.3	48.7	55.0
Mean,	62.61	64.10	62.47	63.15	65.75	63.10	56.98	68.09	62.60	63.91	59.73	59.62	66.30	63.96

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854.	1858. (6) (3)	1859. (6)	
1	72.7	68.0	74.0	75.0	72.3	67.3	59.0	60.3	69.0	73.0	76.7	65.0	65.7	
2	77.0	72.0	72.7	77.0	67.0	66.0	56.0	60.3	75.3	72.3	77.7	69.7	62.3	
3	75.0	68.0	74.0	77.7	72.3	66.3	63.0	62.0	66.7	69.3	79.3	69.7	62.7	
4	74.0	64.3	72.7	76.0	73.0	68.0	66.0	68.0	64.7	73.7	80.7	67.3	65.0	
5	74.0	67.3	64.7	79.0	72.7	68.7	71.3	66.7	66.0	75.3	79.7	65.0	59.0	
6	72.7	65.7	66.7	78.0	66.3	59.3	66.7	64.7	66.0	76.0	78.7	68.0	58.0	
7	72.7	64.7	70.0	78.3	71.0	57.0	58.0	65.0	69.3	69.7	76.7	71.7	63.3	
8	73.3	66.3	66.0	78.7	74.0	61.7	58.7	60.7	70.0	63.3	80.0	73.0	60.3	
9	63.3	67.3	67.7	74.7	59.3	64.0	56.0	59.7	74.3	63.0	77.7	76.3	67.3	
10	60.3	68.0	58.7	75.3	55.7	64.3	57.7	66.0	74.0	64.0	72.7	77.0	70.7	
11	56.0	68.7	61.0	76.3	58.3	69.3	59.0	62.3	67.7	58.3	69.3	63.7	73.7	
12	58.0	68.3	60.3	79.7	63.0	59.3	62.0	58.3	60.7	57.3	74.7	59.7	63.7	
13	65.0	69.0	70.0	78.7	56.3	58.0	61.0	55.3	53.7	65.7	77.0	60.0	64.3	
14	67.3	67.0	65.3	78.7	51.0	68.3	63.3	56.7	62.7	66.0	76.0	67.7	57.0	
15	64.7	65.0	63.3	72.0	51.7	64.0	66.7	60.7	60.7	65.3	70.3	67.3	61.7	
16	66.7	68.0	61.7	59.0	57.0	55.3	71.3	62.7	57.0	67.0	61.3	62.3	64.7	
17	70.3	68.3	67.7	65.7	66.0	55.0	70.3	62.7	58.0	71.7	63.0	55.7	60.3	
18	74.0	70.3	70.0	64.3	61.3	57.3	63.0	64.0	63.3	73.7	69.7	54.0	63.3	
19	76.7	73.3	67.0	61.3	57.7	62.7	60.7	65.3	65.3	65.0	72.0	65.7	66.3	
20	78.3	73.3	67.0	66.7	62.0	59.0	63.7	61.3	68.3	63.7	60.3	70.7	69.7	
21	77.0	60.0	54.7	65.3	57.3	48.3	68.0	64.0	66.7	58.3	55.7	69.7	69.3	
22	76.3	52.7	45.0	60.3	56.7	46.3	69.3	67.0	59.3	55.3	54.0	56.3	63.7	
23	76.3	52.7	55.7	66.3	58.7	47.0	55.7	70.0	59.3	54.0	57.7	52.7	61.3	
24	76.0	56.7	50.3	69.3	59.7	52.3	55.0	70.0	67.7	58.7	62.7	62.0	59.7	
25	74.0	58.3	48.0	71.0	59.7	58.7	61.0	74.3	71.0	60.3	65.0	57.3	61.7	
26	60.7	54.7	51.7	61.3	68.3	53.7	63.3	75.7	55.0	62.3	70.7	55.7	63.3	
27	52.7	51.0	61.3	58.0	68.0	52.7	54.7	70.3	57.3	64.7	67.7	55.3	61.7	
28	52.3	45.3	65.3	53.0	55.3	56.3	58.0	62.7	59.7	60.0	68.7	56.7	64.0	
29	57.7	45.7	70.0	57.0	54.7	60.3	65.3	52.7	60.7	49.3	62.3	65.0	65.0	
30	62.3	52.0	68.0	60.7	58.0	57.7	68.0	51.3	55.3	52.3	61.7	71.3	70.0	
Mean,	68.57	63.07	63.68	69.81	62.14	59.48	62.39	63.36	64.16	64.28	69.99	64.37	63.95	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN OCTOBER.

	1829. $(\frac{6}{7})$	1830. $(\frac{6}{7})$	1831. $(\frac{6}{7})$	1832. (⊙)	1833. (6)	1834.	1835.	1836.	1837.	1838.	1839. (6)	1840. (7)	1841.	1842.
1	49°.7	57°.7	64°.0	48°.7	69°.0	70°.0	50°.7	62°.7	64°.0	63°.0	44°.7	69°.7	48°.7	55°.0
2	51.7	61.3	67.3	46.3	58.3	64.0	51.0	55.3	65.0	67.7	51.3	66.3	52.3	54.3
3	56.3	54.3	68.0	52.0	49.3	61.3	51.3	49.3	60.0	63.7	60.0	47.7	47.0	55.7
4	50.3	51.3	63.0	57.3	44.7	61.0	50.0	39.3	57.0	56.0	63.0	50.7	46.0	52.0
5	48.3	57.0	47.0	57.0	49.3	45.3	45.0	44.7	59.7	58.3	67.7	56.0	47.3	51.0
6	52.0	60.7	44.7	59.0	53.0	47.7	43.7	42.0	56.3	62.0	67.7	60.0	53.0	55.0
7	60.3	60.7	52.3	55.7	58.3	55.0	42.7	48.0	52.3	48.7	65.7	59.3	57.7	53.7
8	63.7	56.7	58.7	62.7	53.3	64.0	44.0	44.0	50.3	48.7	64.0	60.7	58.0	58.0
9	63.7	62.3	48.3	70.3	58.0	60.7	44.7	47.0	51.7	53.0	66.7	65.3	52.7	55.0
10	66.0	62.0	47.3	67.3	49.3	45.7	50.7	46.7	59.3	46.7	69.0	62.7	51.3	50.0
11	59.0	65.0	46.3	56.0	46.0	48.3	55.0	47.0	64.3	51.0	70.0	68.3	62.7	55.0
12	51.7	64.3	51.0	56.0	52.3	54.0	56.7	46.0	62.3	47.3	66.3	54.0	59.0	50.0
13	49.3	62.3	53.3	55.3	54.7	50.3	56.0	50.3	44.3	45.3	56.3	51.7	46.0	50.3
14	51.3	54.0	62.3	52.0	51.3	36.0	59.0	49.0	41.0	55.0	58.7	53.7	44.3	51.3
15	58.3	51.3	64.0	42.7	59.7	45.3	62.7	48.3	53.0	47.3	53.7	53.3	50.7	46.0
16	62.3	53.7	63.0	50.7	63.7	50.7	67.0	44.7	62.3	40.7	53.7	49.7	48.0	52.7
17	65.0	53.3	64.7	58.3	63.0	62.0	65.0	44.3	62.3	41.0	56.7	56.0	38.0	56.3
18	66.3	54.7	58.0	63.0	43.3	62.0	65.7	39.3	64.7	49.0	57.7	66.3	40.0	54.0
19	61.3	52.7	49.0	67.7	43.0	36.0	62.0	57.0	65.7	52.7	52.0	66.0	45.7	40.0
20	43.0	46.0	50.7	67.7	45.3	32.7	61.0	36.3	65.3	43.3	45.7	57.3	47.7	41.7
21	42.0	49.7	55.0	68.3	45.3	39.7	63.3	34.7	55.0	43.3	46.7	58.3	45.7	43.7
22	45.3	56.3	62.0	64.3	40.7	52.3	61.7	38.7	65.0	42.0	54.7	49.0	42.7	50.0
23	56.7	51.3	66.0	51.3	44.7	47.3	60.3	48.3	65.7	45.0	60.0	50.0	44.7	54.3
24	64.3	55.7	48.0	43.7	53.7	41.7	53.0	55.0	50.3	46.3	61.3	29.0	34.3	52.3
25	68.0	60.0	50.7	43.7	52.3	47.3	48.0	43.7	46.0	45.7	62.0	38.3	32.3	45.0
26	53.3	61.3	61.3	42.0	49.3	52.7	52.7	38.7	38.7	43.3	62.7	30.0	41.3	42.0
27	42.7	63.3	42.7	47.0	53.0	46.7	59.3	44.3	32.7	43.3	62.3	36.7	43.7	42.7
28	51.3	62.7	38.7	39.0	36.0	40.7	56.3	48.7	37.7	36.3	58.7	43.7	49.0	44.0
29	53.0	58.7	43.0	39.3	31.0	32.0	57.0	41.3	35.3	34.0	49.7	48.0	55.0	47.3
30	53.0	59.7	44.3	44.3	28.7	46.3	58.3	39.3	32.7	39.3	43.7	46.0	55.3	50.0
31	46.0	62.0	43.0	45.7	33.7	48.0	46.7	35.0	34.7	32.7	50.0	43.7	62.0	50.0
Mean,	55.00	57.49	54.11	54.01	49.46	49.89	54.85	45.45	53.38	48.12	58.13	53.14	48.45	50.26

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854. (6)	1858.	1859. (6)	
1	67.7	53.7	54.3	62.0	63.3	55.7	63.3	59.3	62.7	59.0	68.7	60.7	58.0	
2	61.0	58.0	55.0	60.7	57.0	61.7	64.0	58.3	68.0	53.3	63.0	60.7	58.0	
3	54.7	58.3	57.7	58.0	55.0	57.7	62.7	50.7	62.7	45.3	62.0	69.3	61.0	
4	53.3	50.3	60.7	57.7	59.7	63.0	55.3	56.0	63.0	50.0	51.3	71.0	61.3	
5	53.0	51.7	51.3	58.0	59.3	58.7	50.3	55.0	60.7	55.7	47.0	60.3	64.3	
6	58.0	51.7	44.0	59.0	55.0	53.7	55.7	46.0	61.3	45.0	52.7	58.0	51.3	
7	60.7	47.0	55.7	64.7	55.7	57.3	48.7	43.7	72.7	44.7	55.7	59.3	52.3	
8	44.7	50.7	62.7	65.3	56.3	53.3	50.7	47.7	75.3	51.0	57.7	49.0	55.3	
9	43.7	56.0	65.3	65.0	57.7	51.0	53.0	53.7	70.0	58.0	59.0	47.7	48.0	
10	49.0	59.3	65.0	58.7	59.3	53.3	45.3	60.3	60.0	45.3	60.7	51.7	47.0	
11	58.7	47.3	54.7	58.3	49.3	47.0	48.0	62.7	56.7	41.0	62.7	52.7	52.3	
12	53.7	42.0	43.0	57.3	49.0	46.3	48.0	52.0	56.0	41.3	66.0	58.3	55.0	
13	44.0	49.0	47.0	52.7	43.0	49.7	44.7	48.7	49.3	46.7	67.0	59.0	56.3	
14	36.0	53.0	52.7	46.3	38.7	54.7	48.0	52.0	46.7	45.3	62.7	49.7	59.7	
15	45.3	48.7	37.3	47.7	40.3	58.3	54.0	53.0	47.7	45.0	44.7	49.3	46.3	
16	43.7	47.7	36.0	61.7	49.0	59.7	67.3	65.0	49.3	50.7	49.0	56.3	53.0	
17	42.0	50.0	42.7	47.7	58.0	46.0	50.3	64.3	51.3	52.3	47.0	57.0	62.7	
18	44.3	55.3	49.0	42.0	58.0	40.7	44.7	60.0	63.7	52.7	45.0	58.7	46.3	
19	44.0	43.7	56.3	42.3	50.3	41.0	49.0	48.0	53.3	53.3	40.3	62.0	41.0	
20	55.3	36.0	51.0	42.3	47.0	42.3	46.7	44.0	48.0	58.0	44.3	61.3	35.3	
21	59.3	44.0	39.7	40.3	50.3	42.0	53.3	43.3	55.3	66.0	51.0	54.0	35.3	
22	44.7	48.0	36.3	39.0	55.0	43.0	51.7	56.3	53.0	60.3	55.7	57.3	37.3	
23	40.0	51.3	41.7	39.0	52.3	48.0	56.3	57.3	52.7	46.3	57.3	56.3	41.3	
24	46.3	54.7	47.0	46.7	60.7	55.3	46.7	49.0	50.0	37.3	57.3	46.0	46.0	
25	50.0	59.7	51.0	45.3	52.3	53.0	47.3	41.0	52.7	39.3	54.7	52.3	53.7	
26	42.3	58.3	49.7	51.3	37.7	48.7	54.0	40.7	56.3	47.3	55.3	51.7	50.7	
27	35.0	45.3	51.0	55.0	35.3	48.7	52.7	42.3	58.7	53.3	55.3	58.3	40.0	
28	38.7	37.0	52.7	40.3	35.0	55.3	58.7	44.7	63.3	48.3	59.7	54.7	35.7	
29	43.3	32.7	50.7	42.3	40.0	57.7	49.3	43.3	61.3	46.0	61.3	60.0	39.7	
30	35.0	34.0	51.0	42.7	43.7	57.3	47.3	45.0	58.7	46.0	62.3	54.7	38.7	
31	31.7	37.7	57.0	49.3	55.0	43.7	40.7	52.7	54.3	44.0	59.0	52.7	38.3	
Mean,	47.70	48.77	50.61	51.56	50.91	51.73	51.85	51.48	57.88	49.28	55.98	56.45	49.07	

TABLE II. *Continued.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN NOVEMBER.

	1829. (7)	1830. (7)	1831. (7)	1832. (⊙)	1833. (7)	1834.	1835. (⊙)	1836.	1837.	1838.	1839.	1840.	1841.	1842.
1	40°.7	58°.3	41°.3	55°.3	42°.7	48°.7	47°.3	41°.7	38°.7	39°.3	44°.3	42°.7	61°.3	50°.3
2	44.7	60.0	41.7	54.7	53.0	55.0	50.0	44.7	40.0	44.0	41.3	45.3	52.7	50.7
3	43.7	54.7	40.3	59.7	52.0	56.0	58.3	38.7	38.3	52.0	38.3	47.0	49.7	52.0
4	41.3	54.0	44.0	61.0	44.7	61.0	58.7	32.3	51.7	54.0	45.3	46.0	38.7	49.3
5	41.3	52.3	41.7	56.7	44.3	48.7	59.0	31.3	55.0	46.0	52.3	47.3	41.7	48.0
6	45.7	48.0	44.7	59.3	47.7	40.0	60.7	38.0	50.3	39.7	42.0	43.3	38.7	50.3
7	45.0	50.0	48.3	42.7	52.7	44.0	49.7	46.0	46.7	54.7	41.7	48.0	43.3	53.0
8	44.3	49.7	51.0	40.0	51.7	44.7	51.3	45.0	37.0	35.0	39.3	53.3	55.0	54.0
9	53.0	51.0	52.3	39.3	57.0	43.3	52.7	43.0	50.7	26.3	35.3	45.0	49.3	41.0
10	37.7	43.0	60.3	42.7	44.7	51.3	47.3	48.3	54.3	26.3	32.3	40.0	52.7	37.7
11	23.3	43.7	47.7	48.0	52.7	48.0	44.3	60.3	58.7	39.7	39.0	38.3	53.7	36.7
12	26.7	48.7	47.3	44.0	44.7	45.3	41.3	46.7	57.7	49.7	42.7	46.7	52.7	41.7
13	28.3	47.3	44.7	46.0	43.7	53.3	40.3	38.7	46.3	56.7	44.7	41.0	41.0	38.3
14	41.3	47.0	42.7	33.3	39.3	63.0	47.7	36.0	38.7	52.0	48.3	43.3	39.7	40.3
15	37.3	57.0	42.3	26.3	33.3	33.3	52.3	38.0	38.7	60.3	42.3	33.3	36.7	31.0
16	49.3	58.3	35.0	32.3	28.0	32.0	54.0	34.7	39.7	35.3	37.7	34.0	35.3	36.0
17	49.7	55.3	54.7	40.0	38.0	46.0	42.3	27.3	53.3	26.7	36.0	33.3	34.3	48.7
18	44.0	47.3	49.7	49.3	33.0	44.7	47.0	28.7	51.3	27.7	44.7	30.7	39.0	24.7
19	29.7	47.0	36.7	44.7	28.3	42.0	64.0	36.0	53.7	24.7	40.3	30.7	42.7	22.0
20	31.3	49.3	34.7	31.0	31.3	41.7	66.0	45.3	56.0	35.3	30.0	30.0	37.3	27.0
21	44.7	52.0	34.3	33.3	34.0	41.3	40.7	43.7	56.0	42.0	21.3	40.7	54.3	20.0
22	53.7	56.3	32.0	40.7	36.3	43.0	32.0	34.3	45.3	43.7	27.7	52.7	52.7	26.3
23	30.3	49.3	32.3	36.3	35.7	35.0	34.7	34.0	27.7	47.3	30.3	38.3	35.3	37.7
24	24.7	48.3	29.0	31.0	33.3	30.3	32.0	32.3	28.0	38.3	41.7	39.0	33.7	24.7
25	36.3	43.3	35.3	30.7	33.7	31.7	29.0	25.3	29.7	21.3	18.0	34.3	48.3	25.7
26	34.0	44.3	39.0	49.7	32.0	30.0	29.7	23.7	32.0	24.7	18.3	30.3	40.7	30.0
27	30.0	45.0	35.3	43.3	36.7	32.0	32.0	24.0	36.0	34.3	30.3	27.3	30.0	18.3
28	39.3	47.3	31.0	40.7	34.3	36.7	31.7	26.7	48.3	29.3	41.7	36.0	32.0	17.7
29	48.0	44.7	19.3	40.3	42.0	48.7	16.7	29.0	54.7	21.3	42.7	50.3	30.3	26.7
30	47.3	42.3	20.7	58.3	44.7	38.0	32.3	36.7	52.7	27.7	43.3	46.7	30.0	32.0
Mean,	39.55	49.82	40.31	43.69	40.84	43.62	44.83	37.01	45.57	38.51	37.78	40.50	42.75	36.39

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852. (7)	1853.	1854. (6)	1858.	1859. (7)	
1	39.0	45.0	54.3	59.7	57.3	36.7	45.3	54.7	50.7	46.7	56.0	52.0	36.7	
2	44.7	50.3	45.7	55.0	56.3	35.3	52.7	56.0	49.0	49.7	46.7	55.7	37.3	
3	30.7	47.0	37.0	53.0	54.0	42.7	60.0	58.3	51.7	41.7	50.3	53.7	41.0	
4	31.3	45.3	37.3	51.0	53.0	51.7	57.7	55.3	55.7	36.0	40.7	50.3	51.7	
5	31.3	39.7	41.0	46.0	42.0	37.3	59.7	56.3	56.0	38.7	34.3	46.0	51.3	
6	31.0	40.7	46.0	53.0	42.3	39.7	58.7	52.0	61.3	34.3	44.3	44.0	51.3	
7	34.3	53.0	46.3	58.3	56.0	32.3	58.7	36.7	46.7	37.7	49.3	45.7	49.3	
8	37.7	46.7	40.0	59.0	67.0	32.7	46.7	38.0	44.0	59.3	39.3	43.0	50.7	
9	38.7	49.7	33.0	58.7	62.0	31.7	42.0	39.3	40.7	43.0	39.7	40.0	49.7	
10	51.3	55.0	37.3	59.3	40.3	29.7	44.7	43.3	34.0	38.3	52.7	42.7	51.3	
11	44.0	59.7	40.7	55.7	37.3	38.0	44.3	45.3	51.0	48.0	47.7	38.7	46.3	
12	29.3	54.7	37.7	53.0	36.7	47.3	45.3	46.3	40.7	58.7	53.0	40.0	64.3	
13	34.3	39.3	41.3	52.0	44.0	43.0	39.3	42.0	34.7	49.7	34.0	37.7	22.3	
14	31.0	32.7	48.7	51.3	43.3	44.7	43.3	39.7	32.7	42.0	35.3	33.7	30.3	
15	44.7	36.0	39.0	41.7	42.7	40.0	46.0	42.7	29.3	45.3	43.7	31.3	35.7	
16	53.3	42.0	46.3	42.3	42.7	41.0	48.0	35.3	30.0	46.3	40.0	26.7	39.3	
17	56.7	45.3	53.3	48.3	49.7	35.3	52.0	30.0	36.0	53.7	43.7	29.0	45.3	
18	45.7	34.3	59.0	53.7	54.0	33.7	48.7	33.7	34.7	53.7	35.0	35.3	51.0	
19	35.0	33.7	48.7	45.0	37.3	34.3	45.3	34.7	36.7	53.3	36.0	29.7	48.3	
20	41.3	43.7	56.0	42.0	36.0	30.0	42.7	34.0	37.3	58.0	38.3	30.7	40.0	
21	47.3	43.3	46.3	44.7	41.0	30.7	44.0	31.7	34.0	58.7	37.3	35.7	44.3	
22	40.0	46.3	39.3	39.0	50.0	33.7	44.7	28.3	37.0	59.7	45.0	36.3	51.0	
23	53.7	46.0	31.3	38.0	57.3	44.7	52.7	32.0	42.3	54.0	51.3	34.7	43.0	
24	52.0	26.3	26.3	43.7	48.3	48.7	58.0	34.7	41.7	38.3	54.7	34.7	38.3	
25	39.3	22.7	35.3	29.3	34.7	35.0	57.0	38.7	49.3	30.0	37.7	35.7	52.3	
26	36.0	30.7	41.3	17.0	30.7	32.7	42.7	47.3	47.7	34.7	32.0	36.0	46.7	
27	32.3	34.7	29.0	26.3	30.0	32.0	39.0	56.0	30.7	37.7	31.3	32.7	38.0	
28	35.3	44.3	19.0	44.7	32.3	39.7	32.0	52.7	38.0	48.3	27.7	41.0	36.3	
29	40.0	41.7	22.7	41.7	24.7	50.3	32.0	62.0	42.7	54.3	34.3	37.0	35.7	
30	35.7	44.7	24.7	32.7	29.0	34.3	38.0	45.7	41.7	35.3	29.0	32.3	55.3	
Mean,	39.90	42.48	40.14	46.50	44.40	37.95	47.36	44.69	41.93	46.17	41.34	38.72	44.48	

TABLE II. *Concluded.*—MEAN DAILY TEMPERATURE (UNCORRECTED) IN DECEMBER.

	1829. (7)	1830. (7)	1831. (7)	1832. (⊙)	1833. (7)	1834.	1835. (⊙)	1836.	1837.	1838.	1839.	1840.	1841.	1842. (7)
1	44° 7	41°.3	24°.0	42°.0	37°.3	42°.7	23°.7	25°.7	56°.3	41°.3	47°.7	23°.7	31°.3	29°.7
2	44.3	45.7	34.7	38.7	42.7	44.0	22.0	22.0	57.3	39.0	45.3	28.0	34.3	35.0
3	34.0	53.0	27.3	40.3	41.3	31.3	32.0	26.7	40.7	28.3	41.7	38.0	49.3	45.3
4	37.7	39.3	10.3	34.7	39.3	28.0	38.0	36.0	35.7	38.3	38.7	32.3	40.3	49.3
5	49.7	36.7	16.0	35.0	37.3	32.0	23.3	38.7	33.7	38.3	32.7	28.0	30.7	51.0
6	56.0	38.7	14.0	34.7	39.3	46.0	25.0	24.0	39.0	30.0	35.0	29.3	32.0	36.7
7	61.0	34.7	19.0	39.0	38.0	46.0	27.7	21.3	35.3	33.3	43.3	33.3	31.3	36.0
8	42.7	41.3	25.0	51.0	41.3	32.3	26.0	29.7	37.3	27.0	42.0	38.3	40.7	49.7
9	36.0	37.7	21.3	39.0	39.3	26.7	36.7	43.7	41.0	16.0	33.7	43.7	56.3	36.3
10	32.0	35.3	20.3	35.7	36.0	25.3	26.0	39.3	39.7	24.7	34.3	41.0	52.3	32.3
11	46.0	42.7	24.7	34.7	33.7	30.7	27.0	38.0	33.7	42.0	34.7	35.3	42.3	32.0
12	39.7	36.0	12.0	39.3	32.0	30.0	33.7	35.7	31.3	36.3	33.0	43.3	40.3	34.0
13	37.0	43.7	12.3	41.3	32.0	38.0	23.7	47.0	27.3	28.0	31.3	41.0	45.0	32.0
14	39.3	53.7	17.6	40.0	38.7	29.3	37.3	32.7	24.0	30.0	38.7	39.3	43.7	31.3
15	41.3	33.7	8.0	41.7	34.0	35.3	28.7	34.7	30.0	33.0	31.7	49.3	45.7	25.0
16	26.7	29.3	18.0	40.0	32.3	41.3	12.3	32.3	32.0	29.3	27.3	40.7	37.0	32.0
17	35.0	26.7	8.7	36.7	40.7	35.0	17.0	27.0	46.3	34.7	27.3	28.3	27.3	30.3
18	37.7	35.3	7.3	31.3	35.0	40.7	33.7	20.0	33.7	38.7	27.3	18.7	21.7	33.3
19	39.0	37.7	24.3	26.7	36.0	39.3	45.0	25.0	31.0	28.3	26.7	17.3	28.3	33.7
20	40.7	31.0	17.3	22.0	32.0	41.3	44.7	46.7	24.7	24.3	23.7	16.3	35.7	37.0
21	48.7	4.7	33.7	18.0	31.7	40.7	35.3	14.3	25.3	36.3	28.7	26.7	30.3	38.0
22	33.7	3.7	11.7	19.3	37.7	41.0	24.0	14.0	23.0	40.7	32.7	35.3	32.7	23.3
23	48.0	22.3	16.7	23.0	36.3	40.0	20.3	34.0	21.3	12.3	33.7	26.3	44.3	12.0
24	57.7	40.3	35.7	32.7	42.3	43.3	35.3	39.0	26.3	16.7	32.3	32.3	27.3	16.7
25	53.3	47.0	26.0	40.3	36.0	35.3	46.3	45.3	36.0	25.7	29.3	30.7	25.3	32.0
26	55.0	41.3	28.3	47.7	33.7	28.7	45.3	20.7	40.3	15.7	27.3	38.0	25.3	29.7
27	52.3	32.3	27.7	40.7	30.7	25.3	30.3	17.7	30.7	16.7	31.7	25.7	30.7	32.0
28	47.0	34.3	32.0	33.7	30.3	30.7	33.7	22.3	40.3	18.7	29.3	26.3	35.3	36.3
29	49.3	30.3	21.3	32.3	34.0	34.7	40.3	30.7	33.0	25.3	22.3	35.0	31.0	40.7
30	55.0	42.0	21.0	36.0	45.3	35.0	39.3	30.7	37.3	14.0	12.3	36.0	35.3	31.0
31	42.7	36.3	28.0	50.3	44.7	34.0	32.0	33.0	39.3	11.0	19.0	29.0	34.3	22.7
Mean,	44.01	35.74	20.78	36.05	36.80	35.61	31.14	30.57	34.93	28.19	32.08	32.47	36.05	33.42

	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1852.	1853.	1854. (7)	1858.	1859. (7)	
1	34.0	40.0	24.0	39.0	35.7	41.3	44.7	41.7	32.7	37.3	33.7	33.3	64.7	
2	31.7	36.3	9.3	55.0	43.0	40.3	33.7	52.7	36.7	35.0	33.7	42.3	40.3	
3	33.3	38.7	24.0	40.0	35.3	40.7	36.0	52.3	45.7	31.7	34.7	47.7	28.0	
4	38.0	41.0	28.3	32.0	34.3	49.7	39.3	41.3	48.0	31.3	24.0	50.7	35.3	
5	25.7	50.7	15.3	33.7	33.0	58.0	42.7	38.3	43.0	31.7	20.7	57.3	43.7	
6	25.3	54.7	12.7	41.7	27.3	58.3	36.7	36.0	43.3	51.0	28.7	40.3	52.3	
7	33.7	42.0	19.0	51.3	34.7	62.7	27.7	34.3	46.7	36.7	24.0	47.7	16.7	
8	35.3	30.7	34.3	46.0	46.3	60.3	32.7	24.3	39.3	30.0	18.0	31.3	13.0	
9	28.3	24.7	36.0	35.7	53.3	42.3	43.3	32.0	40.7	31.7	26.7	18.7	22.0	
10	26.0	23.7	21.7	36.7	56.0	54.3	32.3	28.3	36.3	32.7	37.0	27.3	27.0	
11	36.3	24.3	17.7	37.3	41.7	33.7	20.0	39.0	33.7	35.0	28.7	33.7	32.0	
12	23.3	31.0	27.3	27.3	48.3	28.7	19.0	40.0	32.0	33.3	25.3	44.7	34.3	
13	20.0	36.7	32.7	31.7	45.3	33.3	24.7	26.0	33.3	37.7	33.0	50.3	29.0	
14	29.7	29.3	38.3	29.7	39.7	45.0	31.0	28.3	26.0	37.3	38.7	55.3	28.0	
15	44.7	26.7	33.3	27.0	28.0	47.3	34.0	37.0	32.0	31.3	36.3	46.3	25.3	
16	50.7	23.3	31.0	32.3	29.0	53.0	46.0	41.0	41.3	37.3	37.3	35.0	32.3	
17	44.3	19.3	31.0	34.0	29.7	42.0	32.7		40.0	41.3		34.3	38.7	
18	38.3	23.7	29.3	28.7	28.3	49.0	31.3		34.0	28.0		37.0	36.0	
19	34.0	31.0	9.0	30.0	35.7	59.3	43.3		39.7	27.3		40.7	34.3	
20	33.0	29.3	5.0	27.0	29.7	46.3	48.7		52.0	13.7		45.7	37.3	
21	36.7	36.7	14.0	34.7	21.7	40.3	38.7		34.0	21.3		47.3	21.3	
22	49.0	41.0	26.0	32.7	24.3	36.0	30.0		32.7	35.0		35.0	16.7	
23	39.3	27.0	26.7	24.7	26.3	30.7	26.3		47.0	24.3		43.3	19.3	
24	38.3	28.0	31.0	35.7	30.0	47.7	28.7		55.0	18.7		30.0	13.3	
25	41.0	47.0	28.0	43.3	20.3	38.7	11.3		42.7	28.0		29.3	31.7	
26	43.3	49.3	23.7	40.3	12.0	29.3	22.7		37.3	33.7		34.3	44.0	
27	41.7	31.0	21.3	55.0	17.7	34.3	28.0		42.3	31.0		40.7	29.7	
28	35.0	29.7	32.0	51.7	38.0	31.7	30.3		36.7	32.0		40.3	28.7	
29	32.0	31.7	36.3	36.7	41.7	33.3	33.7		30.0	23.7		42.3	32.7	
30	29.3	52.3	27.3	49.3	46.0	30.7	16.7		39.3	29.7		51.3	30.0	
31	31.7	41.3	29.3	56.7	51.0	30.0	10.3		47.0	15.3		44.0	9.3	
Mean,	34.93	34.58	25.00	37.95	34.94	42.85	31.49		39.37	31.09		40.57	30.35	

The resulting daily temperatures observed by Mr. Wood between 1818 and 1823, at sunrise, 2 o'clock, and sunset, require a correction to refer them to the mean daily value resulting from hourly observations. For this purpose we require to know the time of sunrise and sunset, which may conveniently be found by the following formulæ:—

1. By the fundamental equation

$$\cos t = \frac{\cos\zeta - \sin\phi \sin\delta}{\cos\phi \cos\delta} \quad \text{where } \zeta = 90^\circ + r - \pi + s + d$$

2. By a differential equation

$$\cos t = -\tan\phi \tan\delta \qquad \text{and} \qquad dt = \sec\delta \sec\phi \operatorname{cosec} t \, d\zeta$$

where ϕ = geographical latitude
δ = sun's declination
ζ = sun's zenith distance
t = apparent time when the sun's upper limb is in the horizon, for first method, and when the sun's centre is in the horizon, for second method.
r, π, s, d = refraction, parallax, semi-diameter, and dip, respectively.

For ordinary cases we may put r = refraction in horizon = 34′ for a temperature of 50° Fahr., and for an atmospheric pressure of 30 inches, π = solar parallax may be neglected, s = semi-diameter = 16′. Exclusive of parallax and dip we have for sunrise and sunset, $d\zeta = +50'$. If we wish to take into account the elevation of the eye above the horizon, we have $d = 0.98\sqrt{x}$ where x = elevation in feet and d = dip in minutes, which is to be added to the numerical value of $d\zeta$.

The apparent time t is to be changed to mean time by application of the equation of time.

The mean time of sunrise and sunset[1] was made out for every tenth day and for the middle of each month; the corrections were taken from the Philadelphia table (Smithsonian Collection of Meteorological and Physical Tables); they are as follows:—

	⊙ rise. 2 P. M. ⊙ set.	⊙ rise. 2 P. M.	7 A. M. 2 P. M. 9 P. M.	6 A. M. 2 P. M. 9 P. M.	⊙ rise. 2 P. M. 9 P. M.	5 A. M. 2 P. M. 9 P. M.	7 A. M. 3 P. M. 9 P. M.	6 A. M. 3 P. M. 9 P. M.	5 A. M. 3 P M. 9 P. M.
January	−1°.33	−0°.54	−0°.22	−0°.33	−0°.30				
February . . .	−1.53	−0.40	−0.17	−0.19	−0.17				
March	−1.40	−0.38	−0.15	+0.02	−0.01				
April	−1.40	−0.17	−0.53	+0.06	+0.17				
May	−0.71	+0.24	−0.57	+0.14	+0.33				
June	−0.53	+0.03	−0.77	+0.04	+0.59	+0°.60			
July	−0.51	+0.18	−0.61	+0.17	+0.32	+0.58	−0°.73	+0°.03	+0°.44
August . . .	−1.00	−0.23	−0.44	+0.16	+0.30	+0.35		+0.10	
September . . .	−1.63	−0.60	−0.35	+0.20	+0.21			+0.16	
October . . .	−2.02	−0.63	−0.33	+0.08	+0.06				
November . . .	−1.75	−0.73	−0.28	−0.27	−0.28				
December . . .	−1.38	−0.60	−0.29	−0.23	−0.33				
Year	−1.27	−0.32	−0.39	−0.02	+0.07				

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[1] A table of mean time of sunrise and sunset is given in the Annuaire Météorologique de la France pour 1850; but it is limited by the latitudes of 42° and 51°.

By means of these numbers the monthly means of the preceding table were all referred to the mean resulting from hourly observations; these corrected values are contained in Table III. The manuscript table of monthly means (prepared at the Smithsonian Institution) was used in preference to the printed means in Silliman's Journal, for years for which the original record was lost; these values were likewise corrected to refer to 24 observations a day.

TABLE III.—RESULTING MEAN MONTHLY TEMPERATURES OBSERVED AT MARIETTA BETWEEN 1818 AND 1859 INCLUSIVE.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1818	- -	- -	- -	- -	- -	72°.62	77°.19	74°.56	64°.02	51°.42	46°.26	32°.54
1819	40°.28	38°.11	38°.58	52°.82	63°.19	72.53	74.50	75.95	63.40	49.98	46.23	33.28
1820	27.10	42.14	40.44	57.96	61.75	72.18	76.72	72.86	66.87	48.21	38.36	32.29
1821	24.83	37.00	36.84	48.84	64.27	74.05	72.17	74.50	67.50	52.46	38.55	28.31
1822	28.69	32.02	45.89	53.70	69.17	74.22	75.36	74.12	65.69	51.96	47.03	31.22
1823	32.50	25.38	42.37	- -	- -	- -	- -	- -	- -	- -	- -	- -
1826	30.51	36.93	48.53	51.00	67.32	72.85	72.31	71.21	66.52	55.88	42.75	33.06
1827	26.54	41.68	46.29	56.09	60.28	65.23	74.95	74.49	66.90	54.38	42.59	41.58
1828	41.68	43.88	48.69	50.43	63.09	73.69	71.07	73.22	62.32	52.17	45.32	39.03
1829	32.95	26.09	37.44	50.64	65.57	71.25	71.69	71.68	62.81	54.88	39.27	43.72
1830	31.21	34.37	47.00	58.58	61.07	68.35	75.03	73.73	64.30	57.37	49.54	35.45
1831	25.80	29.14	45.28	54.68	60.50	70.47	71.40	69.81	62.67	53.99	40.03	20.49
1832	29.07	37.77	43.45	54.78	61.00	68.63	70.97	69.64	63.36	54.07	43.41	35.72
1833	35.76	35.10	39.73	56.58	68.02	66.33	72.60	69.80	65.95	49.54	40.56	36.51
1834	26.99	43.03	43.73	55.97	60.82	69.57	76.22	72.49	63.30	49.97	43.34	35.32
1835	33.84	24.37	40.51	49.94	63.54	68.64	69.84	68.35	57.18	54.93	44.55	30.81
1836	31.01	26.87	36.03	55.30	65.69	68.54	71.89	68.94	68.29	45.53	36.73	30.28
1837	27.79	34.15	41.46	46.56	60.64	67.01	71.56	70.04	62.80	53.46	45.29	34.64
1838	34.65	20.65	45.41	48.59	55.43	70.97	77.10	75.58	64.11	48.20	38.23	27.90
1839	35.10	35.60	42.37	57.58	64.53	66.09	72.25	68.04	59.93	58.21	37.50	31.79
1840	24.32	40.80	46.48	56.58	62.34	68.74	71.41	71.55	59.82	52.81	40.22	32.18
1841	32.04	31.79	42.16	49.66	60.05	73.19	71.90	70.59	66.50	48.53	42.47	35.76
1842	36.15	37.05	51.87	56.21	59.10	66.87	70.40	67.30	64.16	50.34	36.11	33.13
1843	36.53	26.35	28.15	51.14	60.47	67.49	72.83	70.80	68.77	47.78	39.62	34.64
1844	29.79	35.25	42.79	61.31	64.00	68.34	74.12	69.92	63.27	48.85	42.20	34.29
1845	36.41	38.15	43.15	57.18	58.83	68.89	71.68	72.44	63.88	50.69	39.86	24.71
1846	33.05	31.19	43.40	56.75	64.85	67.05	72.12	74.41	70.01	51.64	46.22	37.66
1847	31.29	35.42	39.57	53.90	61.70	66.38	70.92	68.18	62.34	50.99	44.12	34.65
1848	35.77	35.49	39.46	52.36	63.76	67.78	70.51	70.47	59.68	51.81	37.67	42.56
1849	30.33	29.66	44.65	50.64	61.56	71.38	71.31	69.85	62.59	51.93	47.08	31.20
1850	35.37	34.36	39.15	48.71	55.92	69.19	76.32	71.93	63.56	51.56	44.41	34.38
1851	34.14	40.52	45.06	51.30	61.67	66.81	72.66	70.34	66.47	52.27	39.03	27.70
1852	24.84	34.95	44.31	48.78	62.76	66.36	73.24	69.07	64.36	57.96	41.65	39.08
1853	32.55	34.76	40.69	53.05	61.53	74.08	72.39	71.65	64.48	49.36	45.89	30.80
1854	30.72	37.76	45.36	50.94	62.77	70.42	76.39	73.84	70.19	56.06	41.17	31.95
1855	34.96	25.67	38.42	55.44	62.81	66.85	75.35	73.51	70.28	50.33	47.25	33.24
1856	18.61	25.32	32.28	54.35	61.31	72.51	76.67	69.79	63.95	53.89	40.92	28.90
1857	18.75	42.53	37.86	42.56	57.63	68.21	72.70	72.40	66.75	52.03	40.05	38.64
1858	40.11	27.71	39.77	53.62	60.64	72.36	75.09	72.26	64.53	56.53	38.44	40.28
1859	32.86	36.86	48.63	50.85	66.14	67.41	74.01	70.90	64.15	49.15	44.20	30.06
Mean,	31.41	34.00	42.14	53.04	62.25	69.58	73.25	71.54	64.56	52.08	42.16	33.58

Mean Annual Temperature.

Taking the annual means of the monthly values given in Table III, after substituting the respective monthly means of the whole series for those months in 1818 and 1823 where our series is defective, we find the annual mean temperature for 40 years as follows:—

	0	1	2	3	4	5	6	7	8	9
1810	- -	- -	- -	- -	- -	- -	- -	- -	53°.45	54°.07
1820	53°.07	51°.61	54°.09	51°.86	- -	- -	54°.07	54°.25	55.38	52.33
1830	54.67	50.36	52.66	53.04	53°.39	50°.54	50.43	51.28	50.57	52.42
1840	52.27	52.05	52.39	50.38	52.84	52.16	54.03	51.62	52.28	51.85
1850	52.07	52.33	52.20	52.61	53.96	52.84	49.71	50.84	53.44	52.93

Mean annual temperature from 40 years of observation 52°.46 Fahr. Warmest year 1828, coldest year 1856, difference in the mean temperature for these years 5°.67, which is comparatively a small range of variation.

If we subtract the mean value 52°.46 from each annual mean, we obtain the following table of annual excesses (+) and annual defects (—).

	0	1	2	3	4	5	6	7	8	9
1810	- -	- -	- -	- -	- -	- -	- -	- -	+0°.99	+1°.61
1820	+0°.61	—0°.85	+1°.63	—0°.60	- -	- -	+1°.61	+1°.76	+2.92	—0.13
1830	+2.21	—2.10	+0.20	+0.58	+0°.93	—1°.92	—2.03	—1.18	—1.89	—0.04
1840	—0.19	—0.41	—0.07	—2.08	+0.38	—0.30	+1.57	—0.84	—0.18	—0.61
1850	—0.39	—0.13	—0.26	+0.15	+1.50	+0.38	—2.75	+0.38	+0.98	+0.47

To obtain a measure of the variability of the annual mean temperature we may, with sufficient precision, employ the formula[1] $\varepsilon = 1.2533 \frac{[\Delta]}{n}$ where $\Delta =$ difference of each mean from the mean of the whole series; [ ] indicates summation irrespective of sign; $n =$ number of years, and $\varepsilon =$ mean error or mean deviation; in a short series $n - 1$ might be substituted for n. The formula supposes the positive and negative differences to balance.

Accordingly the mean deviation of any annual mean = ± 1°.25. Dividing this by $\sqrt{n}$ we find the mean uncertainty of the final annual temperature 52.°46 to be ± 0°.20.

If we add the differences of the first 20 years we find the annual temperature 0°.2 higher, and if we add those of the last 20 years the annual temperature 0°.1 nearly, lower than the mean, indicating no change in the climate as measured by the annual temperature between 1818 and 1859. To ascertain whether the summer and winter temperatures also have remained unchanged the following comparison is added:—

Mean Monthly Temperature.

	1818 to 1840.	1840 to 1859.		1818 to 1840.	1840 to 1859.
December	33°.38	33°.79	June	70°.14	69°.02
January	31.38	31.43	July	73.40	73.10
February	33.91	34.08	August	72.03	71.06
Mean	32.96	33.10	Mean	71.86	71.06

The differences 0°.14 in winter and 0°.80 in summer are too small, and fully covered by their probable uncertainty to draw any other inference than that of an unchanged temperature of the seasons.

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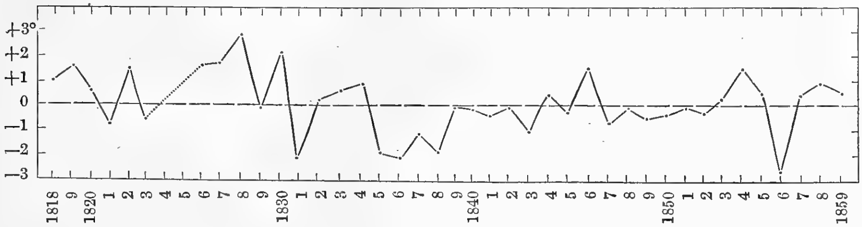
[1] See Chauvenet's Manual of Spherical and Practical Astronomy, Vol. II, p. 496. Philadelphia, 1863.

The variation in the annual mean temperature is further exhibited in the annexed diagram (A).

DIAGRAM A.—*Fluctuations of the Mean Annual Temperature during* 40 *Years.*



Irregular Fluctuations of the Temperature as Exhibited in the Monthly Means.

The irregular variations of the temperature may be shown by comparison of the mean temperature on each day with its normal temperature found from the 31 years of record, or it may be determined, for each month, by comparison of each monthly mean with the corresponding mean from the whole series, and using the formula $\varepsilon = 1.2533 \frac{[\Delta]}{n}$ we secure the advantage of an expression of the mean deviation of any monthly mean value. The mean deviation of a monthly value is as follows:—

January	± 5°.04	July	± 2°.32
February	6.02	August	2.32
March	4.49	September	2.76
April	3.87	October	2.95
May	2.87	November	3.66
June	2.90	December	4.48

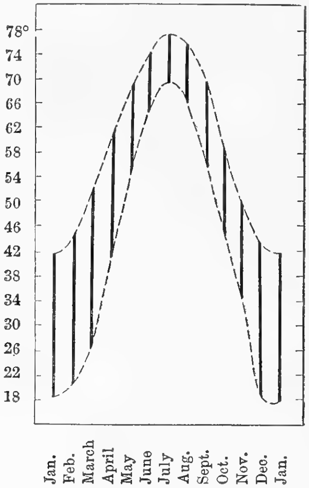
The irregular fluctuations of the temperature are therefore greatest in February and least in July and August, the ratio is nearly 2.6 to 1.

The irregular fluctuations may also be exhibited by the extreme values in the monthly means, for each month, during a series of years; for Marietta the lowest and highest means are as follows:—

	Lowest.	Highest.		Lowest.	Highest.
January	18°.61	41°.68	July	69°.84	77°.19
February	20.65	43.88	August	67.30	75.95
March	28.15	51.87	September	57.18	70.28
April	42.56	61.31	October	45.53	58.21
May	55.43	69.17	November	36.11	49.54
June	65.23	74.22	December	20.49	43.72

These extreme means are shown in diagram (B).

Diagram B.



The irregularity in the daily mean temperature is further illustrated by the following table of observed extremes for each month during 31 years.

	Lowest.	Highest.		Lowest.	Highest.
January	— 6°.6	60°.8	July	+55°.5	86°.2
February	— 4.3	61.8	August	+53.9	84.0
March	+ 9.5	74.0	September	+42.2	80.9
April	+25.6	76.6	October	+28.8	75.4
May	+42.4	82.3	November	+16.4	66.7
June	+45.9	88.7	December	+ 3.4	64.4

The above numbers are corrected for diurnal fluctuation.

The extreme lowest temperature observed was —23°.0 at 7 A. M. January 20th, 1852, and the extreme highest 102°.0 at 3 P. M. July 14th, 1859. Extreme range observed 125° of Fahrenheit's scale.

Annual Fluctuation of the Temperature.

The monthly means at the bottom of Table III require a small correction to refer them from calendar to average months; this correction has been effected in the same manner as in my discussion of the Brunswick observations.[1] The corrections and corrected monthly means are as follows:—

---

[1] The rule given for complete quadriennia is as follows: Cast into February .56 of the last of January; include with February the first and .62 of the second of March; with March the first of April and .06 of the second; with April the first and half of the second of May; with May .94 of the first of June; with June the first and .37 of the second of July; with July .81 of the first of

	Mean temp. of calendar months.	Correction.	Temperature of average months.
January . . .	31°.41	—0°.02	31°.39
February . . .	34.00	+0.16	34.16
March . . .	42.14	+0.42	42.56
April	53.04	+0.56	53.60
May	62.25	+0.25	62.50
June	69.58	+0.28	69.86
July	73.25	—0.06	73.19
August . . .	71.54	—0.06	71.48
September . . .	64.56	—0.12	64.44
October . . .	52.08	—0.23	51.85
November . . .	42.16	—0.10	42.06
December . . .	33.58	—0.10	33.48
			52.55

The numbers in the last column are represented by the formula—

$$T = + 52^\circ.55 + 21^\circ.13 \; sin \; (\theta + 255^\circ \; 01') + 0^\circ.74 \; sin \; (2\theta + 302^\circ \; 20') + 0^\circ.46 \; sin \; (3\theta + 124^\circ)$$

the angle θ counting from January 1st at the rate of 30° a month. According to this expression the lowest temperature occurs January 15th (31°.1 Fahr.), and the highest temperature July 23d (73°.4 Fahr.); the annual range is 42°.3. The annual mean temperature is reached April 14 and October 15.

The formula[1] gives the monthly means as follows:—

August; with August .25 of the first of September; with September .69 of the first of October; with October .13 of the first of November; and with November .56 of the first of December.

In strictness a second correction is required for curvature on account of which the mean temperature, in any one month, does not correspond to the mean of the times. This correction is small, and might, practically, be altogether avoided by subdividing the period in a greater number of parts, thus taking, for instance, half monthly instead of monthly means. Independently of these corrections, the number of terms retained in Bessel's function must bear a certain relation to the number of subdivisions of the period.

It has been thought unnecessary to apply the second correction in our series of observations, such a refinement not being demanded by them.

[1] To show the variation of the quantities A B_1 C_1 B_2 C_2 etc., in the expression $T = A + B_1 \; sin \; (\theta + C_1) + B_2 \; sin \; (2\theta + C_2) +$ etc., with the geographical position, a few tabular results are herewith appended.

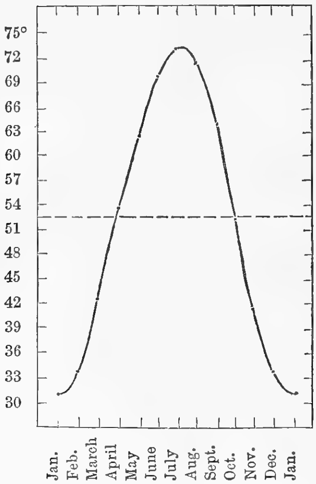
Locality.	Latitude.	Longitude.	A.	B_1.	C_1.	B_2.	C_2.	B_3.	C_3.
Marietta, O. . . .	39° 25′	81° 29′	52°.55	21°.13	255° 01′	0°.74	302° 20′	0°.46	124°
Geneva, N. Y. . . .	42 53	77 02	47.06	23.03	246 35	0.50	80 51	0.18	121
Brunswick, Me. . .	43 54	69 57	44.50	23.15	248 45	0.88	258 00	0.79	225
Port Kennedy, North Som.	72 01	94 14	+2.02	39.20	249 05	0.80	256 56	1.06	275
Port Foulke, Smith St. .	78 18	73 00	+6.06	33.11	242 14	6.32	119 03	0.74	318
Van Rensselaer H'br, N. G.	78 37	70 53	—2.20	35.39	251 43	6.72	69 47	3.20	17

Locality.	Years of ob's.	Coldest day.	Warmest day.	Range of temp.	Epoch of Mean Temperature.	
Marietta, O. . . .	39	Jan. 15	July 23	42°.3	April 14	Oct. 15
Geneva, N. Y. . . .	15	" 26	" 24	46.6	" 23	" 22
Brunswick, Me. . .	51	" 18	" 22	47.8	" 20	" 24
Port Kennedy, North Som.	1	" 19	" 20	79.4	" 23	" 22
Port Foulke, Smith St. .	1	Feb. 16	" 15	69.6	" 22	Nov. 14
Van Rensselaer H'br, N. G.	2	March 1	" 8	67.9	" 29	Oct. 12

	Observed.	Computed.	O—C.		Observed.	Computed.	O—C.
January	31°.39	31°.17	+0°.22	July	73°.19	73°.25	—0°.06
February	34.16	34.19	—0.03	August	71.48	71.69	—0.21
March	42.56	42.64	—0.08	September	64.44	63.94	+0.50
April	53.60	53.34	+0.26	October	51.85	52.44	—0.59
May	62.50	62.81	—0.31	November	42.06	41.51	+0.55
June	69.86	69.66	+0.20	December	33.48	33.96	—0.48

The probable error of the representation of any one monthly mean is ± 0°.27, and that of the annual mean ± 0°.08.

Diagram C.



The temperature for the meteorological seasons is as follows:—

Spring	52°.88
Summer	71.51
Autumn	52.78
Winter	33.01

Adding 1°.54 we find the annual mean temperature reduced to the level of the sea = 54°.09 Fahr.

Supposed Epochs of Irregularities in the Annual Variation.

Various periods of apparent irregularities, so called hesitations, in the curve of the mean annual temperature have been pointed out by meteorologists.[1] Of these, perhaps, those about the beginning of December, and about the middle of May are the most conspicuous. The cause of such breaks in the march of the temperature may either be local or cosmical; if the latter, it must be felt in all parts of the globe.

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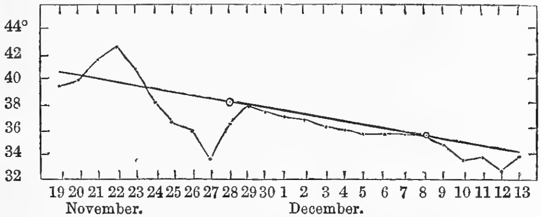
[1] See Report of British Association for Advancement of Science; Birmingham Meeting, 1865; also Herschel's Meteorology, p. 191.

For the examination of the march of the temperature about the beginning of December, the following daily means (corrected for diurnal fluctuation) were taken from a series of 32 years.

November 19	39°.4	November 27	33°.8		December 5	35°.6	
" 20	40.0	" 28	36.6	38.1 by formula	" 6	35.7	
" 21	41.7	" 29	37.9		" 7	35.7	
" 22	42.5	" 30	37.6		" 8	35.4	35.7 by formula
" 23	40.9	December 1	37.2		" 9	34.7	
" 24	38.1	" 2	36.9		" 10	33.4	
" 25	36.4	" 3	36.3		" 11	33.8	
" 26	35.9	" 4	36.0		" 12	32.4	
					" 13	33.8	

The annexed diagram (D) exhibits the daily means by a broken line, and the mean temperature, computed by the formula *T*, by a smooth line passing through ⊙.

Diagram D.—Marietta, O.

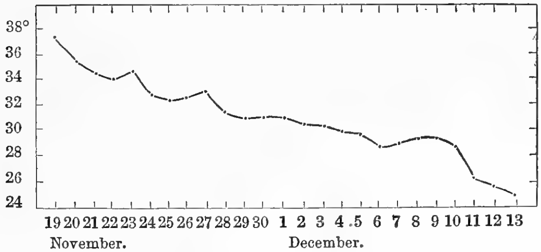


The Marietta observations, though indicating a normal temperature about December 3d, show a remarkable depression between November 25th and 28th, reaching 4° on the 27th; this depression is preceded by an elevation reaching $2\frac{3}{4}$° on the 22d.

To verify the above, the observations taken at Brunswick, Me., during 51 years were also examined with the following results:—

November 19	37°.4	November 27	33°.0	December 5	29°.6
" 20	35.6	" 28	31.3	" 6	28.6
" 21	34.3	" 29	30.8	" 7	28.8
" 22	34.0	" 30	31.0	" 8	29.3
" 23	34.7	December 1	31.0	" 9	29.3
" 24	32.8	" 2	30.4	" 10	28.6
" 25	32.3	" 3	30.2	" 11	26.1
" 26	32.5	" 4	29.8	" 12	25.5
				" 13	24.5

Diagram E.—Brunswick, Me.



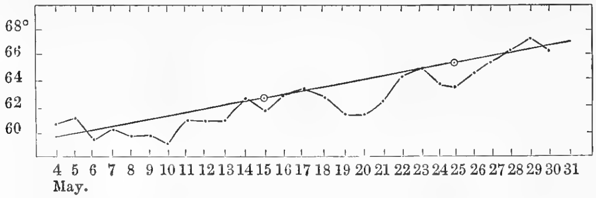
These numbers when projected indicate no trace of an anomalous character, from which it may be inferred with considerable probability that the Marietta inflexion is of accidental origin.

The mean daily temperatures from May 4th to May 30th, from 31 years of observations at Marietta, and from 51 years of observation at Brunswick, are as follows:—

	Marietta.	Brunswick.		Marietta.	Brunswick.
May 4	60°.6	51°.7	May 17	63°.4	56°.3
" 5	61.1	51.2	" 18	62.6	56.5
" 6	59.2	52.1	" 19	61.5	56.6
" 7	60.2	53.0	" 20	61.4	56.6
" 8	59.5	53.4	" 21	62.4	56.7
" 9	59.4	53.4	" 22	64.3	56.9
" 10	58.9	52.6	" 23	64.9	58.3
" 11	61.1	53.3	" 24	63.7	57.7
" 12	60.9	54.3	" 25	63.4[2]	59.2
" 13	61.1	54.7	" 26	64.4	57.8
" 14	62.5	54.3	" 27	65.3	58.9
" 15	61.8[1]	55.4	" 28	66.2	59.5
" 16	62.9	56.6	" 29	67.2	59.5
			" 30	66.2	59.3

The above Marietta numbers, plotted on diagram (F), do not indicate any deviation from the normal temperature about May 14th, nor any depression of the temperature about the end of the month; the Brunswick numbers progress so regularly that it was unnecessary to project them.

Diagram F.—Marietta, Ohio.



Other suspected periods of temperature irregularities are about February 12th, and between the first and second week in March.

The mean daily temperatures from February 7th to 21st from 32 years of observation at Marietta, and from 51 years of observation at Brunswick, are as follows:—

	Marietta.	Brunswick.		Marietta.	Brunswick.
February 7	30°.0	22°.6	February 14	33°.6	21°.8
" 8	30.7	22.5	" 15	33.7	23.1
" 9	31.6	21.8	" 16	32.7	23.4
" 10	31.7	23.1	" 17	30.9	23.5
" 11	32.0	22.8	" 18	33.6	24.9
" 12	33.0	20.9	" 19	36.2	22.4
" 13	32.4	21.1	" 20	36.6	25.5
			" 21	37.3	28.9

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[1] Computed temperature, 62°.8.

[2] Computed temperature, 65°.4.

Diagram G.—Marietta, Ohio.

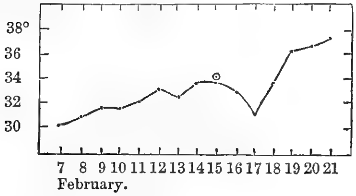
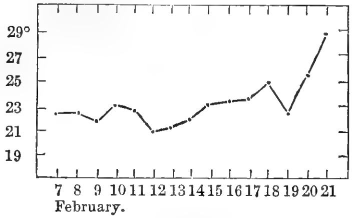


Diagram H.—Brunswick, Me.

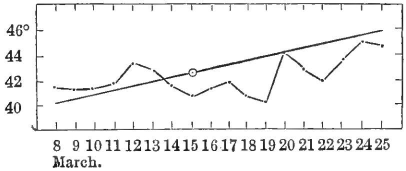


The Marietta curve exhibits a remarkable depression of temperature about February 17th, amounting to about 4°. This may possibly be part of the phenomenon noticed in Europe about February 12th. It is, however, not supported by the Brunswick observations, which indicate but a slight depression about the 12th and 19th.

The mean daily temperatures from March 8th to March 25th, from 32 years of observation at Marietta, and from 51 years of observation at Brunswick are as follows:—

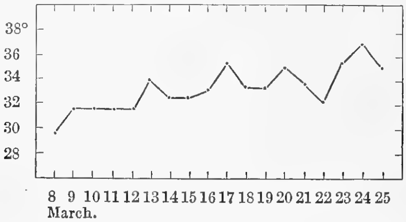
	Marietta.	Brunswick.
March 8	41°.6	29°.7
" 9	41.4	31.8
" 10	41.3	31.8
" 11	41.8	31.8
" 12	43.3	31.8
" 13	42.7	34.0
" 14	41.5	32.3
" 15	40.8	32.3
" 16	41.4	33.1
March 17	41°.8	35°.6
" 18	40.8	33.5
" 19	40.1	33.5
" 20	44.2	35.1
" 21	42.8	33.7
" 22	41.9	32.2
" 23	43.5	35.7
" 24	45.0	37.0
" 25	44.7	35.2

Diagram I.—Marietta, Ohio.



July, 1867.

Diagram K.—Brunswick, Me.



The irregularities in the Marietta curve are quite considerable, but as they are not supported by corresponding irregularities in the Brunswick observations[1] they must be regarded as accidental. There is a slight corresponding depression in the two curves on the 22d.

For the proper estimation of the irregularities in the Marietta curve of the daily means derived from 32 years of observations we require to know the probable error of each mean value; this value $\left(r = 0.845 \frac{[\Delta]}{n}\right)$ in February when it is near its maximum, is ± 1°.3, and in August, when near its minimum, is ± 0°.8 very nearly. Within the limits $\pm 1.3 \sqrt{2}$ and $\pm 0.8 \sqrt{2}$, therefore, the means vary from day to day without indicating the presence of any unusual cause of deviation.

Table IV contains the monthly means for the observing hours 6 or 7, 2, 9; the morning observations being made at various times a column has been added to each month indicating the hour as noted in the journal or as inferred. In Mr. Wood's observations the evening record refers to sunset.

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[1] The daily means given for Brunswick are simply the means of the three observations on each day, uncorrected for diurnal irregularity, and consequently correspond to other means given in Table I of my results of meteorological observations at that station. (Smithsonian Contributions to Knowledge—204—Dec. 1866.)

Table IV.

Year.	January.				February.				March.			
			2	9			2	9			2	9
1819	⊙	35°.32	47°.19	42°.32	⊙	34°.00	45°.92	39°.00	⊙	35°.25	45°.96	38°.74
1820	“	23.64	34.26	27.39	“	36.55	51.83	42.65	“	32.45	51.39	41.67
1	“	20.42	33.58	24.48	“	34.07	44.64	36.89	“	31.35	45.90	37.48
2	“	25.08	36.39	28.61	“	26.53	42.32	31.82	“	38.94	55.19	47.74
3	“	29.35	36.74	- -	“	19.46	32.10	- -	“	36.77	48.74	- -
1829	7	27.74	40.00	31.58	7	20.64	33.50	24.64	7	29.23	47.45	36.16
1830	“	25.59	39.00	29.52	“	24.00	46.43	32.14	7–6	39.68	55.97	45.55
1	“	20.74	32.03	25.29	“	20.57	39.50	27.87	7	37.16	55.84	43.29
2	⊙	23.77	36.71	27.64	⊙	33.65	42.93	36.72	⊙	33.06	55.29	42.03
3	7	31.06	43.09	33.80	7	30.43	42.32	33.07	6	29.87	51.78	37.48
4	“	20.97	35.64	25.03	“	36.10	52.50	41.00	“	34.93	54.83	41.38
5	⊙	26.45	43.09	32.87	⊙	19.82	30.43	23.28	⊙	31.16	51.00	39.41
6	7	26.16	37.42	30.13	7	21.00	34.89	25.24	7–6	29.83	44.22	34.22
7	“	23.77	33.61	26.67	6	28.60	42.32	32.10	6	33.48	51.77	39.06
8	“	27.84	44.32	32.42	7	13.85	28.82	19.78	“	35.03	57.77	43.38
9	“	30.76	41.09	34.13	“	29.46	44.03	33.82	“	33.87	52.35	40.84
1840	⊙–7	20.25	29.84	23.64	“	32.75	51.31	38.86	“	38.93	56.16	44.29
1	7	28.93	37.35	30.51	“	26.71	39.35	29.82	“	33.96	51.90	40.55
2	“	31.06	44.58	33.48	“	31.00	44.68	36.00	7	43.93	62.55	49.58
3	“	30.35	45.48	34.42	“	20.92	33.07	25.57	6	21.25	35.80	27.35
4	“	25.52	35.74	28.77	“	27.03	44.93	34.31	“	37.06	50.77	40.48
5	⊙	31.42	43.58	35.13	“	30.11	47.89	37.25	⊙	34.87	53.22	41.39
6	7	28.67	39.00	32.16	“	26.39	37.96	29.75	6	33.61	54.96	41.58
7	“	27.38	37.51	29.64	“	30.85	41.64	34.28	“	33.61	47.61	37.45
8	“	29.84	44.32	33.81	“	30.13	43.38	33.48	“	31.35	48.67	38.29
9	“	26.67	35.16	29.83	6	23.71	36.96	28.89	“	36.32	54.20	43.38
1850	“	30.45	41.46	34.87	7	28.25	41.39	33.96	“	31.58	47.52	38.29
1852	“	19.35	31.29	24.58	“	28.74	42.21	34.34	“	36.39	53.39	43.09
3	- -	- -	- -	- -	6	28.78	42.11	33.96	6	32.95	50.19	38.87
4	- -	- -	- -	- -	7	31.47	45.64	36.68	- -	- -	- -	- -
1858	7	34.90	47.45	38.64	“	22.07	35.25	26.32	6	30.22	51.32	37.71
1859	“	27.19	39.74	32.32	6	32.07	43.14	35.93	“	40.80	58.29	46.74
Mean,		27.02	38.92			27.50	41.42	32.56		34.16	51.61	

TABLE IV.—*Continued.*

Year.	April.				May.				June.			
			2	9			2	9			2	9
1818	- -	- -	- -	- -	- -	- -	- -	- -	○	67°.43	76°.57	75°.47
19	⊙	44°.90	63°.73	54°.03	⊙	57°.29	69°.40	65°.00	“	66.36	79.24	73.60
1820	“	50.00	67.63	60.46	“	55.51	67.19	64.68	“	67.43	76.16	74.54
1	“	41.40	59.40	49.93	“	57.16	72.22	65.55	“	70.03	78.70	75.03
2	“	49.66	59.24	56.40	“	63.52	74.19	71.93	“	70.53	78.66	75.06
1829	6	41.63	61.63	48.33	6	53.06	79.84	63.42	6	63.03	80.67	70.10
1830	“	46.67	73.17	55.73	“	51.45	72.42	58.94	“	61.13	77.27	66.53
1	“	43.87	67.66	52.33	“	50.83	71.84	58.45	“	63.20	79.67	68.63
2	⊙	45.13	66.63	52.07	⊙	51.03	72.03	58.96	⊙	58.97	79.00	66.16
3	6	42.73	72.33	54.50	6	60.71	77.29	65.64	6	59.40	74.30	65.16
4	“	46.93	67.16	53.63	“	48.50	74.48	59.06	“	60.60	79.96	68.03
5	⊙	40.00	61.10	48.23	“	55.55	74.16	60.51	“	62.70	76.90	66.17
6	6	44.46	67.43	53.84	“	57.06	76.49	63.09	“	61.13	77.70	66.67
7	“	36.13	58.63	44.77	“	51.03	71.97	58.51	“	60.77	74.66	65.50
8	“	39.73	58.77	47.10	“	47.35	64.10	54.42	“	62.83	80.17	69.84
9	“	43.27	72.53	56.76	“	54.84	76.29	62.03	“	58.60	75.26	64.30
1840	“	47.70	66.33	55.53	“	52.09	74.16	60.45	“	60.63	78.67	66.80
1	“	40.33	60.87	47.73	“	49.13	72.29	58.32	“	64.50	84.16	70.80
2	7	47.26	68.10	54.86	“	50.13	69.29	57.46	“	59.60	75.96	64.93
3	6	43.60	59.60	50.03	“	51.38	71.32	58.29	“	59.20	77.63	65.53
4	“	47.90	76.63	59.23	“	56.03	73.35	62.19	6	60.90	77.36	66.64
5	“	45.16	71.60	54.60	“	47.48	72.19	56.42	⊙	62.90	78.03	68.03
6	“	44.43	70.50	55.16	“	56.20	75.12	62.83	6	60.03	75.37	65.63
7	“	43.00	65.86	52.66	“	50.45	75.00	59.25	“	58.63	75.53	64.86
8	“	40.13	65.83	50.94	“	54.90	74.48	61.48	“	58.93	77.60	66.70
9	“	40.20	62.13	49.40	“	52.22	72.29	59.67	“	63.93	79.50	70.60
1850	“	38.93	58.63	48.40	“	45.32	67.42	54.61	“	58.47	81.47	67.50
1852	“	40.44	57.00	48.72	“	53.34	73.94	60.58	“	58.00	75.63	65.33
3	“	44.33	62.57	52.07	“	50.82	73.58	59.77	“	63.09	87.03	72.00
4	“	42.44	62.20	48.00	“	51.31	77.45	59.13	“	60.47	84.40	66.27
1858	“	44.60	63.76	52.33	7–6	53.80	70.06	58.74	“	63.46	84.26	69.23
1859	“	44.00	58.56	49.80	6	54.55	80.29	63.16	5	58.76	77.74	63.93
Mean,		43.58	64.75			53.03	73.11			62.05	78.60	

TABLE IV.—*Continued.*

Year.	July.				August.				September.			
			2	9			2	9			2	9
1818	⊙	72°.87	80°.87	79°.35	⊙	70°.35	79°.00	77°.32	⊙	59°.67	69°.37	67°.93
9	“	69.80	79.81	75.42	“	71.58	81.97	77.32	“	62.50	73.63	68.96
1820	“	72.61	81.64	77.45	“	69.03	78.45	74.10	“	61.66	74.77	69.07
1	“	68.26	76.48	73.32	“	70.77	80 77	74.97	“	64.76	73.87	68.77
2	“	72.35	79.45	75.80	“	70.29	80.03	75.03	“	62.80	71.26	67.90
1829	6	63.55	81.23	69.90	6	63.23	80.81	70.52	6	55.73	71.20	60.93
1830	“	66.68	85.39	72.58	“	63.61	86.36	70.74	“	56.23	74.27	61.90
1	“	65.16	79.32	69.19	“	63.93	77.09	67.93	“	56.57	70.46	60.37
2	⊙	62.19	81.54	68.82	⊙	62.54	78.35	67.13	⊙	54.80	74.00	60.66
3	6	64.64	82.12	70.55	6	59.16	82.96	66.80	6	56.66	76.80	63.80
4	“	68.09	85.68	74.39	“	61.96	84.84	70.19	“	51.93	76.40	60.97
5	“	61.19	79.81	68.00	⊙	60.84	77.55	65.77	“	48.06	67.93	54.96
6	6	64.71	80.42	70.03	6	61.29	77.74	67.32	6	61.03	77.10	66.13
7	“	64.03	80.51	69.64	“	63.22	78.22	68.19	“	54.73	72.70	60.37
8	5	69.58	85.35	74.64	“	65.96	87.29	73.00	“	51.13	79.67	60.93
9	6	64.06	82.45	69.74	“	60.35	78.06	65.22	“	52.47	69.46	57.27
1840	“	62.61	82.32	68.80	“	63.87	81.58	68.74	“	50.10	71.26	57.50
1	7	65.58	81.61	70.32	“	62.29	81.48	67.51	“	59.10	76.43	63.37
2	6	62.00	80.22	68.48	“	59.71	75.87	65.84	“	55.76	74.33	61.80
3	“	63.25	83.51	71.22	“	62.16	80.67	69.06	“	61.56	76.63	67.53
4	“	67.42	82.35	72.09	“	62.25	78.90	68.13	“	54.30	74.53	60.37
5	“	64.51	79.96	70.06	“	63.64	82.32	70.88	“	56.23	72.87	61.93
6	“	64.54	79.90	71.42	“	67.22	83.12	72.41	“	62.03	79.73	67.67
7	“	63.25	79.93	69.09	“	61.35	76.58	66.12	“	54.26	71.30	60.86
8	“	63.90	78.42	68.71	“	63.32	78.68	68.93	“	51.77	69.26	57.40
9	“	63.19	80.64	69.58	“	62.16	78.77	68.16	“	51.76	75.40	60.00
1850	“	68.97	84.71	74.74	“	64.65	79.68	71.00	“	54.47	74.03	61.57
1852	“	64.57	83.19	71.45	“	61.32	77.35	68.06	“	55.00	75.30	62.20
3	“	63.78	82.20	70.68	“	63.76	81.13	69.58	“	58.47	72.00	62.37
4	“	66.16	88.74	73.74	“	65.13	84.55	70.81	“	60.37	81.13	68.47
1858	7,3–6,3	66.55	87.61	72.16	6, 3	63.74	83.80	68.96	6, 3	53.66	78.90	60.56
1859	5, 3	62.29	87.39	71.03	6	62.22	82.39	67.61	6	55.93	74.53	61.40
Mean,		65.70	82.02			63.97	80.51			56.42	74.08	

TABLE IV.—*Continued.*

Year.	October.				November.				December.			
			2	9			2	9			2	9
1818	⊙	56°.06	60°.42	43°.84	⊙	40°.83	53°.97	50°.43	⊙	28°.84	37°.55	35°.38
9	"	45.22	60.09	50.68	"	42.00	55.83	46.13	"	29.06	41.36	33.57
1820	"	43.90	56.68	50.13	"	33.80	47.70	38.84	"	29.68	38.26	33.09
1	"	46.03	64.19	53.23	"	34.46	47.56	38.86	"	24.06	36.55	28.45
2	"	48.06	60.93	52.96	"	38.93	56.60	- -	"	26.22	37.42	- -
1829	6–7	46.77	65.29	52.97	7	33.27	46.30	39.10	7	40.08	51.00	41.13
1830	"	48.29	68.74	55.42	"	42.67	59.67	47.17	"	31.36	40.58	35.23
1	"	45.93	64.32	52.09	"	34.60	48.53	37.80	"	15.61	26.48	20.16
2	⊙	44.25	66.03	51.74	⊙	36.86	52.10	42.10	⊙	31.19	42.64	34.32
3	6	43.32	57.31	47.54	7	33.27	50.33	38.93	7	31.51	43.70	35.19
4	"	41.90	60.13	47.64	"	35.90	53.10	41.86	"	31.00	41.93	33.90
5	"	45.29	66.80	52.45	⊙	39.36	52.47	42.67	⊙	26.25	37.68	29.49
6	"	37.42	55.71	43.22	7	30.36	45.87	34.80	7	23.87	39.00	28.84
7	"	45.97	62.90	51.29	"	37.80	55.55	43.36	"	29.32	42.19	33.29
8	"	40.71	57.00	46.64	"	31.73	45.43	38.37	"	23.16	34.93	26.48
9	"	47.51	71.16	55.71	"	32.17	45.06	36.10	"	28.87	36.71	30.67
1840	7	45.80	63.22	50.38	"	32.40	51.06	38.03	"	28.38	37.74	31.29
1	6	40.19	59.13	46.03	"	37.70	50.06	40.50	"	33.26	39.93	34.96
2	"	39.96	63.48	47.35	"	29.00	45.17	35.00	"	29.16	39.77	31.35
3	"	41.80	55.96	45.35	"	34.23	46.93	38.53	"	29.90	41.06	33.84
4	"	41.25	58.48	46.58	"	34.83	52.27	40.33	"	29.58	41.48	32.68
5	"	39.87	63.84	48.13	"	35.27	47.40	37.76	"	19.58	32.19	23.23
6	"	44.64	61.19	48.87	"	41.03	54.30	44.17	"	32.96	43.96	36.93
7	"	42.90	61.09	48.74	"	38.80	52.83	41.57	"	30.58	39.93	34.32
8	"	43.67	62.61	48.90	"	33.20	44.53	36.13	"	38.58	49.00	40.97
9	"	45.90	60.70	48.97	"	39.36	58.50	44.23	"	28.12	36.48	29.87
1850	"	42.90	62.54	49.00	"	36.73	54.83	42.50	"	- -	- -	- -
1852	"	50.02	68.39	55.23	"	36.96	48.50	40.33	"	33.75	45.94	38.42
3	"	40.93	61.61	45.33	"	37.91	56.80	43.80	"	23.32	38.87	31.08
4	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1858	6	49.22	66.32	53.80	7	35.76	43.13	37.26	7	36.16	46.45	39.09
1859	"	40.61	60.35	46.26	"	35.33	55.50	42.60	"	26.45	35.39	29.22
Mean,		44.40	62.15			36.02	50.90			29.00	39.87	

Mean Range of the Diurnal Fluctuation for each Month.

The observing hours noted in Table IV are sufficiently near the times of the morning and afternoon extreme temperatures to deduce from this record the diurnal range. For this purpose we multiply each observed range with a factor deduced from the Philadelphia series of hourly observations.[1] To the table of monthly mean diurnal ranges at Marietta I have added for comparsion values similarly deduced from 51 years of observations at Brunswick, Me., latitude 43° 54.′5.

	Observed difference.	Factor.	Marietta diurnal range.	Brunswick diurnal range.
January	11°.90	1.01	12°.0	13°.7
February	13.92	1.03	14.3	15.2
March	17.45	1.07	18.7	16.0
April	21.17	1.08	22.8	15.7
May	20.08	1.12	22.5	17.7
June	16.55	1.16	19.2	18.4
July	16.32	1.13	18.4	20.2
August	16.54	1.07	17.7	19.1
September	17.66	1.06	18.7	17.4
October	17.75	1.05	18.6	15.0
November	14.88	1.04	15.5	11.4
December	10.87	1.03	11.2	11.8
Year			17.5	16.0

At Marietta the diurnal range attains its greatest value in April, and its least value in December; there is also an indication of a secondary minimum in August, and of a secondary maximum in September or October. In April the range is more than double the amount observed in December. The range, in general, appears rather large, which may possibly be due to a position of the thermometer not sufficiently sheltered from radiation.

Direction of the Wind.

The materials for the discussion of the wind are taken from Dr. Hildreth's record; it extends with tolerable completeness over the years 1829 to 1850 inclusive; the record for 1852–53–54 and 1858–59 is, in some months, less complete. During these 27 years for which the original record is preserved, the direction of the wind was, in general, observed once a day; but it appears, whenever an important change in the direction took place during the day, two and even three entries a day were made. The precise hour when the direction of the wind was recorded is not given, but this is of little consequence since the average direction during the day is set down. There is no entry for calms, and the directions stated may be taken to refer to the true meridian (the magnetic meridian differs but 1° or 2° from the true one).

The method and formulæ for the reduction and force of the wind are the following:—

Let θ_1 θ_2 θ_3 . . . . : be the angles which the direction of the wind makes with the (true) meridian, reckoned round the horizon, from the south westward to 360°,

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[1] Tables, meteorological and physical, prepared for the Smithsonian Institution by Prof. A. Guyot.

a direction corresponding to that of the rotation of the winds in the northern hemisphere, and v_1 v_2 v_3 . . . . . the respective velocities which may be supposed expressed in (st.) miles per hour. The observations are supposed to be made at equal intervals. Adding up all velocity numbers referring to the same wind during a given period (say one month) and representing these quantities by s_1 s_2 s_3 . . . . ., the number of miles of air transferred bodily over the place of observation by winds *from* the southward is expressed by the formula

$$R_s = s_1 \cos\theta_1 + s_2 \cos\theta_2 + s_3 \cos\theta_3 + \ldots$$

and for winds *from* the westward

$$R_w = s_1 \sin\theta_1 + s_2 \sin\theta_2 + s_3 \sin\theta_3 + \ldots$$

the resulting quantity R and the angle ψ it forms with the meridian, are found by

$$R = \sqrt{R_s^2 + R_w^2} \qquad \tan\psi = \frac{R_w}{R_s}$$

These general formulæ, in the case of eight principal directions, assume the following convenient form:—

$$R_s = (S-N) + (SW-NE)\sqrt{\tfrac{1}{2}} - (NW-SE)\sqrt{\tfrac{1}{2}}$$
$$R_w = (W-E) + (SW-NE)\sqrt{\tfrac{1}{2}} + (NW-SE)\sqrt{\tfrac{1}{2}}$$

where the letters S, SW, W, etc., represent the *sum* of all the velocity numbers, expressed in miles per hour, during the given period, or the quantity of air moved in the directions S, SW, W, etc. respectively. R_s represents the total quantity of air transported to *the northward*, and R_w the quantity transported to *the eastward*. These formulæ for practical application may be used under the following form:—

Put $S-N = a \qquad SW-NE = c$

$W-E = b \qquad NW-SE = d$

Then

$$R_s = R\cos\psi = a + 0.707\,(c-d)$$
$$R_w = R\sin\psi = b + 0.707\,(c+d)$$

Since R_s R_w R represent the quantity of air passed over during the given period in the direction 0°, 90°, ψ°, respectively, we must, in order to find the average velocity for any resulting direction divide by n, or by the number of observations during that period; we have consequently:—

$$V_s = \frac{R_s}{n} \qquad V_w = \frac{R_w}{n} \qquad \text{and } V = \frac{R}{n}$$

A particle of air which has left the place of observation at the commencement of the period, of a day, for instance, will be found at its close in a direction 180° + ψ, and at a distance of R miles, equal to a movement with an average velocity of $\frac{R}{n}$; this supposes an equal and parallel motion of all particles passing over. The length of path described by each can be found by summation of all the v's during the period.

In the present case the above formulæ become simplified since we have no record of velocities; they may, therefore, all be put equal unity, and in consequence the summations give at once the relative frequency with which each wind occurred during the given period.

Owing to the great variability in the observed directions of the wind, periods less than a month are not suitable for combination. The number of times each wind is recorded during each month is tabulated for the whole series, and in those cases where the record gives two entries in a day the weight $\frac{1}{2}$ is given to each, when three are recorded, two are first combined to their average direction, and weights are given as before.

Table V contains results of 9467 observations, and shows the relative frequency of each of the eight directions of the wind, as recorded for each year.

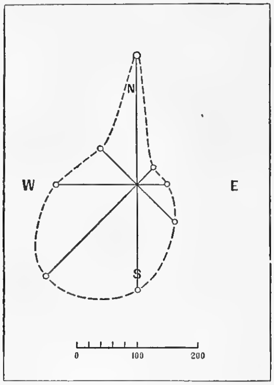
TABLE V.

Year.	S.	N.	W.	E.	S. W.	N. E.	N. W.	S. E.
1829	51	79	51	20	70.5	16.5	49	26
1830	39	83	52.5	12.5	95	15.5	39	26.5
1831	38.5	58.5	67	6.5	117	12	43	18.5
1832	32	68.5	63.5	12.5	106	14.5	32	36
1833	13	70.5	45	16.5	113	26.5	42	35.5
1834	14	84	62.5	11	87	19.5	30	54
1835	31	54	64.5	8	111	19.5	39.5	34.5
1836	58	84	51	22.5	60	18.5	33	36
1837	62	86.5	57	17.5	74	13	29.5	15.5
1838	49.5	87	41.5	17.5	68	30	35	32.5
1839	71.5	53	61.5	26	54.5	22	35	32.5
1840	45.5	55.5	68	13.5	91	17.5	30.5	41.5
1841	56.5	103.5	45	11.5	79	14	25.5	25
1842	64.5	72	36	20	89.5	7	39	32
1843	81	74.5	46	7.5	79	25.5	25.5	25
1844	83.5	82.5	28	15.5	91	13	27	24.5
1845	50	59.5	45	5	130.5	10	42	22
1846	50	78	36.5	27	99	12	19.5	42
1847	91.5	93	29.5	22	66.5	8.5	11	37
1848	113.5	110.5	30	14.5	45	9.5	10	29
1849	91	97.5	45.5	12.5	42	10	19	46.5
1850	85.5	92	35.5	13.5	58.5	7.5	17.5	32
1852	81	66	38.5	18	57	8	15	35.5
1853	64	91.5	19.5	17	32.5	4	20	26.5
1854	63.5	29.5	42.5	23	17.5	5.5	51	14
1858	64	60.5	69.5	51.5	56.5	6	35	11
1859	94	74	55	48.5	28.5	2.5	23.5	6.5
Sum . . .	1638.5	2048	1287	491	2019	368	818	797.5
Prop. in 1000	173	217	135	52	213	39	87	84

These proportional numbers exhibit the relative frequency of each wind, on the average, throughout the year. Their graphical representation is shown in the annexed diagram.

August, 1867.

Diagram L.



The north and the southwest winds are the prevailing winds during the year, and the northeast and the east winds are the least frequent.

Annual Variation in the Relative Frequency of the Wind.

In the following Table VI the results of the observations are arranged according to months and seasons.

Table VI.

Month and Season.	S.	N.	W.	E.	S. W.	N. E.	N. W.	S. E.
January	121.5	157.5	137	36.5	181.5	26.5	74	54
February	88	153.5	120	31	171	27.5	107.5	56
March	107	184	121	36	168.5	32	104	58.5
April	110	200	98	43	160.5	37	69	71
May	169	181	85	32	157	28	74	76
June	176	150	95.5	31	205	26	47	49
July	145	187	75.5	48.5	206	27	47	68
August	175	210.5	59.5	39	141	40	33.5	108.5
September	173	178	80.5	52	125	43	46	75
October	155	199	96.5	47	151	30	58	68.5
November	100	114	155.5	41	201	30	72	59.5
December	119	133.5	163	54	151.5	21	86	53.5
Spring	386	565	304	111	486	97	247	205.5
Summer	496	547.5	230.5	118.5	552	93	127.5	225.5
Autumn	428	491	332.5	140	477	103	176	203
Winter	328.5	444.5	420	121.5	504	75	267.5	163.5
Year	1638.5	2048.0	1287.0	491.0	2019.0	368.0	818.0	797.5

The above results show comparatively small changes in the seasons; the W. and N. W. wind blow more frequently in winter, and the S. wind more frequently in summer.

The proportional numbers for each season are as follows:—

Season.	S.	N.	W.	E	S. W.	N. E.	N W.	S E.
Spring	161	235	127	46	202	40	103	86
Summer	208	230	96	49	231	39	53	94
Autumn	182	209	142	59	204	43	75	86
Winter	141	192	181	52	217	32	115	70

The prevailing winds in each season are as follows: In spring, N.; in summer, N. or S. W.; in autumn, N. or S. W.; in winter, S. W. winds.

The N. E. wind is least frequent in all seasons.

Annual Fluctuation in the Resulting Direction of the Wind.

From Table VI we derive the following results for direction and value of $\frac{R}{n}$ for each month, season, and for the year. For comparison the corresponding values as found for Brunswick, Me., are added.

TABLE VI.—MEAN MONTHLY DIRECTION AND VALUE OF $\frac{R}{n}$ OF THE WIND AT MARIETTA AND BRUNSWICK.

Month and Season.	Marietta, Ohio.			Brunswick, Maine.		
	⤈	$\frac{R}{n}$	⤈—69°	⤈'	$\frac{R'}{n}$	⤈'—102°
January	75°	0.294	+ 6°	141°	0.406	+39°
February	90	0.301	+21	131	0.403	+29
March	93	0.264	+24	116	0.344	+14
April	91	0.181	+22	101	0.263	— 1
May	61	0.203	— 8	62	0.222	—40
June	51	0.313	—18	66	0.346	—36
July	54	0.213	—15	66	0.462	—36
August	24	0.119	—45	68	0.426	—34
September . . .	42	0.128	—27	84	0.381	—18
October	69	0.170	— 0	101	0.349	— 1
November	68	0.341	— 1	131	0.404	+29
December	76	0.295	+ 7	140	0.421	+38
Spring	82	0.244	+13	97	0.257	— 5
Summer	47	0.210	—22	67	0.411	—35
Autumn	63	0.208	— 6	106	0.356	+ 4
Winter	80	0.288	+11	138	0.413	+36
Year	69	0.225		102	0.320	

Annual range at Marietta 69°, at Brunswick 75°. The extremes are reached in February and August, or near the epochs of greatest cold and heat.

Table VII contains the resulting direction of the wind for each year of observation; also the value $\frac{R}{n}$ or the average length of the resultant.

TABLE VII.

Year.	⤈	$\frac{R}{n}$	Year.	⤈	$\frac{R}{n}$	Year.	⤈	$\frac{R}{n}$
1829	94°	0.236	1838	103°	0.152	1847	27°	0.185
30	88	0.289	39	57	0.201	48	33	0.138
31	76	0.434	40	63	0.305	49	45	0.141
32	75	0.320	41	91	0.221	50	50	0.182
33	91	0.260	42	60	0.254	52	32	0.240
34	94	0.228	43	60	0.243	53	81	0.067
35	73	0.361	44	52	0.241	54	73	0.229
36	84	0.154	45	65	0.422	58	73	0.209
1837	85	0.262	1846	44	0.218	1859	54	0.137

The resulting direction of the wind from 27 years of observation is 68° (W. of S.) or nearly W. S. W., with an average value of $\frac{R}{n} = 0.234$, since we were obliged to assume all winds as of equal velocity.

Apparent Secular Change in the Direction of the Wind.

The most notable feature in the above table is a tolerably regular fluctuation in mean annual direction of the wind similar to that found from the observations at Brunswick, Me. From about 1834, or perhaps an earlier period, the values of ψ decrease until about 1847; after this date they begin to increase again. To bring out this variation, somewhat freed from accidental irregularities, alternate means were taken and the two results for each year were combined to a mean value, which are given together with their differences from the mean direction (68°) in the following table:—

Year.	ψ_1	ψ_1—mean.	Year.	ψ_1	ψ_1—mean.	Year.	ψ_1	ψ_1—mean.
1829	- - -	- - -	1838	87°	+19	1847	33°	—35°
30	86°	+18°	39	70	+ 2	48	34	—34
31	79	+11	40	68	+ 0	49	43	—25
32	79	+11	41	76	+ 8	50	46	—22
33	88	+20	42	68	0	52	48	—20
34	88	+20	43	58	—10	53	67	— 1
35	81	+13	44	57	—11	54	75	+ 7
36	82	+14	45	56	—12	58	- - -	- - -
37	89	+21	46	45	—23	59	- - -	- - -

The range of the variability in the mean direction of the wind as observed at Marietta is 56°, which is but little inferior to the annual variability of the wind.

The above variation of the mean direction of the wind, from year to year, deserves special attention, and should be further investigated from other observations, since the resulting epochs at Brunswick and Marietta are quite discordant. It must also produce a small effect upon the mean annual temperatures, and thus connects itself with the supposed secular change of the temperature. The column headed "ψ_1—mean" will serve for ready comparison of results at other stations.

The numerical values of $\frac{R}{n}$, also appear to be subject to a variation; during the above period these values are decreasing.

Relation of the Direction of the Wind to Temperature.

To find the deviation of the temperature of each wind from the normal temperature, a table of mean temperatures for every day of the year was computed by means of the formula (T) given above; to these means was applied, with its sign reversed, the correction to the mean of 3 observations to the mean of 24 observations in a day, in order to make the tabular numbers directly comparable with the observed daily means (uncorrected). As the deviation from the normal temperature is different in the summer and winter seasons, the year was divided into two equal parts (with regard to temperature), taking the epochs of the mean annual temperature or April 15th and October 15th as the limiting epochs. The observations also indicate that unless a certain wind has been *blowing for some time* it will not indicate its peculiar temperature; an interval of half a day or a day, however, after a change of wind is sufficient, and the temperature difference (from the tabulated values) of each of the 8 winds has been set down whenever the record of the direction shows no change during two days or more. The record of the years 1829–30–31–32–33–34 and 1847–48–49–50 was exhausted, and that of 1840–41–42–43–44–45–46 partially, to obtain the requisite number of comparisons. For the Directions E. and N. E., single days on which these winds blow, had to be included in the comparison. The total number of days of comparison of temperature and direction of wind is 2340, with the following results:—

EFFECT OF THE DIRECTION OF THE WIND ON THE TEMPERATURE.

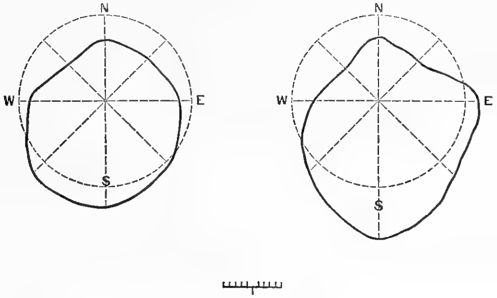
+ elevation above normal. — depression below normal value.

Direction.	Half year including		Year.
	Summer.	Winter.	
N.	—4°.5	—4°.0	—4°.3
N. E.	—4.4	—5.1	—4.7
E.	—2.5	+2.3	—0.2
S. E.	+0.3	+3.3	+1.8
S.	+2.7	+8.8	+4.9
S. W.	+2.2	+2.3	+2.2
W.	—1.9	—3.5	—3.0
N. W.	—5.8	—6.5	—6.2

These results show that on the average during the year the elevating effect of the south wind nearly equals the depressing effect of the northwest wind. The southeast, south, and southwest winds are the warm winds, all others being cold. The temperature effect in winter is far more marked than in summer, as shown by the extreme range of effect, which is 15°.3 in winter, and 8°.5 in summer.

In the annexed diagram the dotted circles indicate the normal line of temperature, and the curves, when *inside* the circle, show the amount of depression, and when *outside*, the amount of elevation of the temperature by the respective wind indicated. Besides an increased effect in winter, the whole curve appears slightly tilted when compared with the summer curve.

DIAGRAM M.


Half year, including summer. *Half year, including winter.*

The mean effect is expressed by the formula

$$T = -1.^{\circ}2 + 5.0 \; sin \; (\theta + 281^{\circ}) + 1^{\circ}.1 \; sin \; (2\theta + 64^{\circ}$$

where θ counts from the north in the direction north, east, etc. The observed and computed values compare as follows:—

Direction.	Observed.	Computed.	O—C.
N.	—4°.3	—5°.1	+0°.8
N. E.	—4.7	—3.5	—1.2
E.	—0.2	—1.2	+1.0
S. E.	+1.8	+2.5	—0.7
S.	+4.9	+4.7	+0.2
S. W.	+2.2	+2.1	+0.1
W.	—3.0	—3.1	+0.1
N. W.	—6.2	—5.8	—0.4

Relation of Direction of Wind to Rain.

To ascertain the relative amount of rain observed or to be expected for each direction of the wind, the latter was tabulated for all the rainy days during 22 years (1829 to 1850). Dividing the year in two equal parts, one including summer (April 15 to Oct. 15), the other winter (Oct. 15 to April 15), we have in the first 1018 days, and in the second 803 days on which rain fell, and the corresponding relative frequency of each direction of the wind for the two seasons is given in column 2 of Table VIII. As each wind does not occur the same number of times in any given period, the above numbers, to reduce them to a common measure, must be divided by the relative frequency of each wind (made out from Table VI). These numbers are given in column 3, and the ratio in column 4. The relative frequency of rain and wind is expressed in percentage.

TABLE VIII.

Direction of wind.	Summer.			Winter.		
	Relative frequency of rain.	Relative frequency of wind.	Ratio.	Relative frequency of rain.	Relative frequency of wind.	Ratio.
S.	22	20	1.1	14	14	1.0
S. W.	31	21	1.5	19	22	0.8
W.	13	10	1.3	18	17	1.0
N. W.	6	7	0.9	11	11	1.0
N.	12	24	0.5	17	20	0.8
N. E.	3	4	0.8	3	4	0.7
E.	4	5	0.8	7	5	1.4
S. E.	9	9	1.0	11	7	1.5

During the summer, therefore, the directions from which most rain comes are S., S. W., and W., the S. W. wind bringing relatively the maximum amount; in winter these directions are E., S. E., and S., the S. E. wind bringing relatively the maximum amount. Rain rarely comes from the northward in summer or winter.

Relation of the Direction of the Wind to Fair Weather.

The same process of investigation being pursued as above, the result of a tabulation of the winds on days of fair weather during summer and winter for the years

1829 to 1833, and 1846 to 1850 (ten years, comprising a total of 1931 entries) is given in Table IX expressed in percentage.

TABLE IX.

Direction of wind.	Summer—April 15 to October 15.			Winter—October 15 to April 15.		
	Relative frequency of fair weather.	Relative frequency of wind.	Ratio.	Relative frequency of fair weather.	Relative frequency of wind.	Ratio.
S.	21	20	1.0	12	14	0.9
S. W.	19	21	0.9	24	22	1.1
W.	9	10	0.9	17	17	1.0
N. W.	5	7	0.7	11	11	1.0
N.	29	24	1.2	24	20	1.2
N. E.	4	4	1.0	3	4	0.8
E.	5	5	1.0	3	5	0.6
S. E.	8	9	0.9	6	7	0.9

Fair weather is accompanied most frequently by N. wind, both in summer and winter; in the half year including summer, easterly winds (except S. E.), and in the half year including winter, westerly winds favor fair weather.

ATMOSPHERIC PRECIPITATION.

The amount of rain and melted snow collected is taken from the annual communications to Silliman's Journal of Science and Arts, by Dr. Hildreth; the frequency of precipitation is taken from the record as well as the results of the earlier series of observations by Mr. Wood.

TABLE X.—AMOUNT AND FREQUENCY OF RAIN (OR SNOW) OBSERVED AT MARIETTA, BY JOSEPH WOOD.

	AMOUNT IN INCHES.							FREQUENCY, NUMBER OF DAYS.						
	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1817.	1818.	1819.	1820.	1821.	1822.	1823.
January,	- -	2.50	3.20	1.46	1.35	1.31	4.42	- -	- -	7	4	2	2	3
February,	- -	3.00	3.30	5.79	4.94	1.65	1.28	- -	- -	8	7	5	1	1
March,	- -	3.70	5.57	2.95	3.70	2.18	6.21	- -	- -	7	4	4	2	6
April,	- -	2.30	1.48	3.93	4.24	5.11	2.86	- -	- -	4	6	6	5	- -
May,	- -	5.90	4.54	3.50	3.01	2.35	5.08	- -	- -	9	6	4	5	- -
June,	- -	2.45	2.20	3.80	3.68	4.09	8.07	- -	6	5	4	3	7	- -
July,	- -	8.87	3.26	4.73	4.52	4.80	6.91	- -	13	10	7	5	7	- -
August,	- -	5.30	6.31	1.53	6.50	2.15	3.20	- -	9	5	6	5	4	- -
Septemb'r,	- -	7.10	1.10	0.20	6.05	4.45	2.03	- -	5	5	1	5	6	- -
October,	- -	3.70	2.25	4.73	1.41	4.31	- -	- -	7	5	8	2	7	- -
Novemb'r,	4.45	2.10	0.70	2.66	2.60	8.59	- -	- -	3	2	4	2	6	- -
December,	1.00	4.00	2.39	3.83	1.32	2.39	- -	- -	3	4	4	1	4	- -
Yearly sum,	- -	50.92	36.30	39.11	43.32	43.38		- -	- -	71	61	44	56	

TABLE XI.—AMOUNT, IN INCHES, OF RAIN (OR MELTED SNOW) OBSERVED AT MARIETTA, BY DR. S. P. HILDRETH.

	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.
January,	4.04	2.75	1.58	4.04	4.50	3.13	5.37	2.42	2.55	0.42	2.12	2.30	2.33	3.87	2.42	1.84	2.42
February,	6.75	2.33	1.63	2.50	10.25	3.42	2.42	1.50	1.80	1.80	1.79	2.00	3.08	1.31	3.12	2.17	1.08
March,	2.13	2.04	5.00	2.92	1.33	1.92	1.58	2.00	2.80	3.00	2.25	2.25	3.21	3.42	2.66	3.70	2.83
April,	6.50	4.00	1.00	2.85	2.00	0.83	1.83	3.87	3.87	1.17	4.45	1.44	4.25	5.80	3.04	4.75	0.70
May,	6.58	1.08	3.80	4.25	3.16	5.75	1.75	3.13	6.63	4.08	5.71	4.46	5.21	3.37	4.21	2.96	5.75
June,	4.92	4.00	5.84	7.00	2.85	4.80	5.50	5.50	2.04	7.84	6.92	4.33	4.25	4.30	7.30	4.21	4.12
July,	5.08	2.12	3.50	12.12	3.08	6.84	5.08	2.58	3.92	5.13	0.96	6.04	2.17	3.50	2.37	1.33	7.75
August,	3.00	5.54	0.75	7.58	7.92	0.25	1.33	6.54	3.16	4.84	3.50	2.04	5.25	3.17	6.08	1.91	2.17
September,	3.42	4.00	4.25	3.58	2.08	3.30	0.67	2.75	3.16	4.23	1.33	3.25	2.00	3.37	3.21	9.25	2.87
October,	2.50	3.16	1.91	3.70	2.75	3.17	3.75	4.80	2.08	4.25	1.95	0.25	3.92	1.83	1.58	4.43	3.54
November,	3.42	4.00	3.67	1.25	3.75	3.88	3.25	5.50	2.50	3.30	3.42	2.50	1.92	3.50	3.04	2.63	2.54
December,	1.16	4.50	4.33	1.75	4.66	3.08	2.13	1.87	2.25	3.80	1.08	2.46	1.50	5.38	3.04	2.58	0.87
Sum,	49.50	39.52	37.26	53.54	48.33	40.37	34.66	42.46	36.75	43.86	35.48	33.32	39.09	42.82	42.07	41.76	36.64
In 1827,	41.48																

	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Monthly mean from 38 years.	Difference from annual mean
January,	2.58	3.25	3.66	2.04	4.09	5.25	0.50	2.08	2.20	3.25	2.50	2.75	1.55	1.66	3.10	2.70	—0.84
February,	1.50	2.33	2.88	1.33	2.58	3.41	4.88	3.66	4.92	2.33	1.50	1.66	1.50	3.41	7.20	3.00	—0.55
March,	2.67	2.37	4.30	3.00	4.37	4.50	1.44	4.30	0.88	4.25	2.67	1.34	1.30	1.00	5.08	2.97	—0.58
April,	2.50	2.04	2.54	1.38	2.50	3.17	3.04	7.58	5.92	5.42	2.08	2.25	3.08	5.00	6.46	3.35	—0.20
May,	1.33	1.37	1.75	5.66	5.92	3.25	6.00	4.21	3.21	2.12	5.17	4.16	5.16	12.42	1.56	4.20	+0.65
June,	6.55	7.04	2.77	3.25	4.42	4.84	2.60	5.70	0.88	3.66	5.68	5.25	4.08	3.09	4.62	4.59	+1.04
July,	3.22	6.20	6.80	8.05	1.21	4.41	2.40	3.84	4.12	2.04	6.00	2.50	4.87	5.33	1.08	4.44	+0.90
August,	2.00	6.00	2.80	4.86	3.50	6.91	3.60	3.50	2.83	3.66	3.09	2.75	5.21	7.42	4.46	4.02	+0.48
September,	4.38	1.68	4.84	1.08	2.63	4.66	2.38	1.08	2.80	2.16	8.00	1.17	1.63	1.37	4.95	3.23	—0.32
October,	2.80	4.00	6.42	3.09	3.92	2.54	1.68	2.30	4.29	4.62	1.85	2.42	2.58	7.66	2.79	3.22	—0.32
November,	3.04	3.55	2.70	2.86	2.58	2.42	4.00	4.50	2.83	2.29	3.55	4.00	4.84	4.82	2.08	3.30	—0.25
December,	1.33	6.44	10.84	6.58	5.17	7.00	2.42	3.75	2.16	3.00	3.66	2.21	4.84	8.66	5.17	3.54	—0.00
Sum,	33.90	46.27	52.30	43.18	42.89	52.36	34.94	46.50	37.04	38.80	45.75	32.46	40.64	61.84	48.55	42.56	

(*b*). NUMBER OF DAYS OF RAIN (OR SNOW).

	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.
January,	- -	7	8	9	11	10	8	6	8	4	6	8	3	8	4	5	7
February,	- -	5	10	4	11	6	7	3	5	5	4	7	10	4	5	8	5
March,	- -	8	13	8	5	6	5	8	8	8	6	7	8	9	9	5	7
April,	- -	10	4	6	7	5	6	9	7	5	9	7	10	14	9	10	4
May,	- -	6	9	12	11	12	5	8	9	10	14	10	9	7	9	5	11
June,	- -	10	11	11	6	13	8	11	8	13	10	10	11	9	11	9	10
July,	- -	11	5	18	8	8	9	7	8	10	4	8	6	9	6	5	8
August,	- -	7	3	11	11	2	3	9	8	10	6	7	10	6	11	8	6
September,	- -	12	7	10	6	8	4	4	11	7	2	8	7	8	6	9	5
October,	- -	11	8	11	7	5	8	6	8	6	6	3	10	7	3	11	8
November,	- -	15	10	5	11	7	7	10	5	4	8	6	5	8	7	9	6
December,	- -	10	11	8	10	5	5	6	5	5	2	7	5	9	5	5	2
Sum,	- -	112	99	113	104	87	75	87	90	87	77	88	94	98	85	89	79

	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Monthly mean.	Dif. from annual mean.
January,	5	8	4	5	6	9	- -	3	- -	8	- -	- -	- -	5	6	6.1	—1.0
February,	5	7	5	4	4	8	- -	4	9	5	- -	- -	- -	8	7	5.9	—1.2
March,	5	6	5	10	6	5	- -	8	4	8	- -	- -	- -	4	10	6.7	—0.4
April,	7	9	4	4	6	9	- -	11	11	7	- -	- -	- -	9	12	7.5	+0.4
May,	4	6	7	14	8	7	- -	7	9	5	- -	- -	- -	17	6	8.4	+1.3
June,	10	11	8	10	11	10	- -	7	7	11	- -	- -	- -	10	12	9.2	+2.1
July,	7	9	13	16	7	9	- -	8	8	3	- -	- -	- -	8	4	8.3	+1.2
August,	5	9	11	8	8	8	- -	9	10	8	- -	- -	- -	9	10	7.6	+0.5
September,	6	5	7	5	4	6	- -	5	5	6	- -	- -	- -	4	9	6.2	—0.9
October,	5	4	8	8	7	6	- -	5	6	6	- -	- -	- -	12	5	6.8	—0.3
November,	6	5	7	4	4	5	- -	8	7	6	- -	- -	- -	9	4	6.4	—0.7
December,	4	9	10	12	9	- -	- -	10	5	- -	- -	- -	- -	14	7	6.5	—0.6
Sum,	69	88	89	100	80	- -	- -	85	- -	- -	- -	- -	- -	109	92	85.6	- -

The average annual amount of rain (and melted snow) from 38 years of observation is 42.56 inches; the least quantity observed in any one year 32.46 inches (in 1856); and the greatest quantity 61.84 (in 1858). These extreme variations are much less than those recorded at Brunswick, Me., although the latter series of observations extends over 32 years only.

The probable uncertainty of the above annual mean is $\sqrt{\frac{0.455\ \Sigma\Delta^2}{n\ (n-1)}} = \pm\ 0.7$ inches.

The last two columns of Table XI contain the annual variation in the amount of precipitation; the monthly means are derived from 38 years (that of October from 37 years), and the difference from the average amount, 3.55 inches, is shown in the last column; the + sign in the months of May, June, July, and August indicating more than the average amount, and the — sign in the remaining months less than the average. In the annual fluctuation there is but one well-marked maximum of rain in June (corresponding to that of May at Brunswick, Me.), and one well-marked minimum of rain (and snow) in January (corresponding to that of February at Brunswick, Me.).

Table XI (*b*) contains the number of days of precipitation, or the frequency of rain (or snow); the column of monthly means is derived from 32 years (on the average), and plainly indicates an annual fluctuation which is better shown in the last column headed "difference from annual mean" (7.1 days). In February rain or snow falls on one day *less*, and in June rain falls on two days *more* than on the average in any one month. The average number of rainy days in the year is 86 nearly, varying between 44 and 113.

If we divide the monthly mean amount by the average monthly frequency, we obtain the average quantity of rain in any one day.

AVERAGE QUANTITY IN ANY ONE DAY OF RAIN (OR SNOW).

January	0in.44	July	0in.53
February	0.51	August	0.53
March	0.44	September	0.52
April	0.44	October	0.48
May	0.50	November	0.52
June	0.51	December	0.55

The copiousness of precipitation is nearly the same throughout the year; in summer the rains are slightly heavier than in winter. The Brunswick series of observations in this respect was far more decided in its results.

On the average a fall of rain, on any day, amounts to 0.50 inches; while at Brunswick the quantity was 0.48 inches. The three heaviest falls of rain recorded on any one day were October 22, 1858, 3.1 inches; December 10, 1847, 3.5 inches; and July 3, 1844, 4.25 inches. Very heavy (comparatively) falls of rain may therefore take place in midwinter as well as in midsummer.

Snow.

Snow is recorded to have fallen as late as May 13 (in 1829), and as early as October 4 (in 1836). The heaviest fall of snow occurred February 1, 1830, when 7 inches fell; April 18, 1854, 8 inches; January 14, 1831, and again December 14, 1833, 15 inches; even as late as April 29 (in 1854), as much as 4 inches fell.

August, 1867.

Frost.

Frost is recorded in every month of the warmer half of the year, and quite frequently in the first half of June. In 1848 there were four mornings of frost between June 1 and 13; in 1843, June 2, ice formed one-eighth of an inch thick; frost occurred June 22 and 23, in 1846; July 1, 1835; August 1 and 2, 1842; August 23, 1835; August 25, 1832, August 29, 1859.

State of the Weather.

The number of fair and of cloudy days in each month were published by Dr. Hildreth, in Silliman's Journal, for a number of years; to these were added the fair days recorded by Mr. Wood, making in all, between 1818 and 1859, 37 results for each month, excepting April, May, and December, for which the number of years is but 36.

TABLE XII.—AVERAGE NUMBER OF FAIR DAYS IN EACH MONTH DURING THE PERIOD 1818 TO 1859.

January	13.8	July	21.9
February	13.9	August	21.7
March	16.7	September	20.3
April	17.7	October	18.9
May	19.4	November	14.5
June	20.3	December	12.7

The numbers show a regular progression during the year. In December the number of fair days is least; they increase each month and reach their maximum in July, after which month they again gradually diminish.

The greatest number of fair days recorded in any one month is 30 (in July and August), and the least number, 3 (in November); the average aggregate number of fair days in any one year is 211¾ (and of cloudy days consequently 153½), varying between 170 (in 1858), and 262 (in 1830). It is, therefore, comparatively seldom that in any year the number of fair and of cloudy days are equal.

Summing up the number of fair days in each year, we have the following results:—

TABLE XIII.

	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
1810	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	193
1820	181	174	180	- - -	- - -	- - -	- - -	- - -	242	208
1830	262	205	216	222	255	221	219	224	248	228
1840	204	205	215	193	209	236	201	198	211	226
1850	233	229	203	221	231	- - -	228	200	170	190

Atmospheric Pressure.

The barometer was not exposed to the natural temperature of the air, but was suspended in a room heated during the winter. Between 1829 and 1832, November, an ordinary instrument was used; from the first of November, 1832, however, a more reliable instrument was substituted; it was made by Dr. Peters, of Pittsburg. This barometer is suspended twelve feet above the banks of the Ohio River. The instrument was read off three times a day, without, however, recording the temperature of the mercury. We can, therefore, make but a very limited use of these observations. Supposing the temperature of the room was not allowed to fall below 62° Fah., and to show the same temperature as that of the external air in the shade when above 62°, a corresponding reduction of the barometric readings to the freezing point of water was applied. The observations were taken quite irregularly, generally three times a day, often but once or twice a day, with occasional omissions for a number of days.

Table XIV contains the monthly extreme readings[1] of the barometer (referred to 32° Fah.) expressed in inches. The hours of observation are 6, 2, 9 in summer, and 7, 2, 9 in winter, with such exceptions as have been stated in the record of temperatures.

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[1] The monthly extremes (and all other readings and means) published by Dr. Hildreth, in Silliman's Journal, are *not* reduced to the freezing point of water.

TABLE XIV.

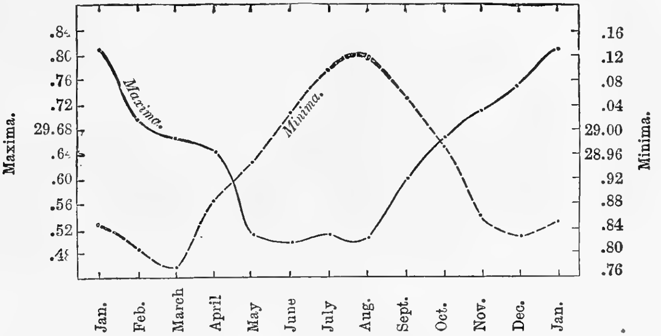
	January.		February.		March.		April.		May.		June.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1829	29.9	28.8	29.7	28.7	29.7	28.7	29.7	28.7	29.4	28.5	29.2	28.4
1830	.5	.5	.6	.4	.5	.3	.4	.4	.0	.3	28.9	.1
1	.6	.3	.6	.2	.3	.1	.2	27.8	.0	.3	29.1	.4
2	.5	.4	.6	.6	.4	.4	.2	28.3	.0	.4	- - -	- - -
3	.7	29.1	.7	29.1	.7	29.0	.6	29.0	.5	29.0	29.6	29.0
4	.9	28.8	.8	28.8	.9	28.9	.9	.0	.8	28.9	.5	28.8
5	.7	.8	.7	29.0	.8	.6	.6	28.9	.6	29.0	.5	29.0
6	.6	.9	.7	28.9	.7	.6	.6	.9	.5	.0	.5	.0
7	.6	.7	.8	.6	.7	.8	.5	.6	.5	.0	.5	28.9
8	.8	29.1	.6	.6	.7	.9	.5	.9	.5	28.8	.5	.9
9	.9	28.9	.8	.6	.8	.9	.6	.9	.5	.9	.4	29.0
1840	.7	.9	.7	.8	.6	.8	.7	29.1	.5	.8	.6	.1
1	30.0	.9	.6	.8	.7	.8	.7	28.7	.5	.9	.4	.1
2	29.8	.9	.7	.7	.7	.8	.7	29.0	.6	.8	.5	.1
3	.7	.7	.5	.7	.5	.4	.5	28.9	.5	29.0	.6	.1
4	.7	29.0	.6	29.0	.8	29.0	.8	29.2	.6	.1	.7	.2
5	.8	.0	.7	.0	.7	.0	.6	.2	.6	.3	.6	.2
6	.9	.0	.8	28.9	.6	28.9	.8	.1	.5	.0	.5	.1
7	.8	28.9	.6	.9	.8	29.0	.8	.1	.6	.1	.5	.1
8	.8	.9	.6	29.0	.7	.0	.7	.2	.5	.1	.5	.2
9	30.0	29.2	.8	.1	.5	28.7	.5	28.9	.6	.0	.6	.1
1850	29.7	28.8	.8	28.4	.6	.6	.6	.6	.5	28.9	.6	.1
1	30.0	.7	.9	.9	.5	.9	.7	.6	.7	29.0	.6	28.9
2	29.7	.6	.7	.5	.8	.4	.3	.5	.6	.0	.6	.9
3	.8	.4	.5	.8	.6	.8	.5	.7	.5	.0	.6	29.1
4	.9	.7	.7	.7	.6	.7	.8	.9	.5	28.8	.5	.0
5	30.0	.4	.7	.8	.7	.7	.8	29.0	.5	.9	.5	28.8
6	29.8	.8	.6	.5	.6	.7	.6	28.9	.5	.9	.5	29.1
7	.8	29.0	30.0	29.1	.6	.8	.6	.9	.5	.7	.5	28.9
8	.9	28.9	29.7	28.8	.6	.9	.6	.6	.6	.7	.5	.9
1859	.8	.8	.5	.8	.6	.5	.5	.8	.5	29.0	.6	29.1
Mean	29.81	28.85	29.70	28.81	29.67	28.78	29.63	28.89	29.51	28.95	29.50	29.03

	July.		August.		September.		October.		November.		December.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1829	29.2	28.2	28.9	28.3	29.3	28.4	29.4	28.5	29.4	28.4	29.6	28.5
1830	28.9	.3	.9	.3	.3	.2	.2	.3	.2	.4	.5	.3
1	29.1	27.9	29.0	.4	.5	.4	.2	.4	.3	.4	.4	.3
2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	.6	29.0	.8	29.0
3	29.6	29.2	29.5	29.1	29.6	29.2	29.8	28.9	.8	.0	.7	28.8
4	.5	.3	.4	.2	.7	.2	.7	.9	.7	28.9	.8	.8
5	.6	.2	.5	.2	.7	28.8	.7	.9	.7	.7	.7	.9
6	.6	.0	.5	.0	.6	29.0	.6	.9	.7	.9	.9	.7
7	.5	.0	.5	.1	.6	.2	.7	.9	.8	.7	.9	.8
8	.6	.2	.6	.2	.6	.1	.8	.9	.9	.8	.9	.7
9	.6	.0	.6	.1	.6	.0	.7	29.1	.9	.8	.5	.7
1840	.6	.1	.6	.1	.7	.0	.5	.0	.6	.8	.7	.8
1	.6	.1	.6	.2	.6	.0	.7	.0	.7	.9	.8	.7
2	.6	.1	.6	.2	.5	.1	.6	.0	.6	.7	.7	.8
3	.6	.2	.6	.3	.7	.2	.8	.0	.7	29.1	.9	29.1
4	.5	.1	.5	.2	.7	.1	.7	.1	.6	.1	.7	.1
5	.5	.1	.6	.1	.5	.1	.9	.0	.7	.0	.8	.1
6	.6	.1	.5	.2	.5	.1	.7	.0	.8	.0	.9	.0
7	.5	.2	.5	.0	.6	.1	.9	.0	.8	.1	.6	28.9
8	.5	.0	.5	.1	.6	.0	.6	.0	.6	.0	.9	29.0
9	.6	.2	.4	.0	.7	28.9	.6	28.9	.5	.0	.9	28.9
1850	.4	.1	.5	.1	.6	29.0	.5	29.0	.6	.1	.7	.4
1	.5	.0	.6	.1	.7	.0	.5	28.9	.7	28.8	.7	.9
2	.6	.0	.6	.1	.6	.0	.5	29.1	.7	.6	.6	.8
3	.5	.2	.6	.1	.6	28.9	.6	28.9	.8	29.1	.6	.5
4	.5	.2	.5	.2	.8	29.0	.7	.8	.8	28.5	.6	.8
5	.6	.1	.7	.0	.6	.1	.5	29.0	.6	.8	- - -	- - -
6	.6	.0	.5	28.9	.5	.0	.7	.1	.6	.6	29.7	28.9
7	.5	.0	.6	29.0	.6	.2	.6	.0	.9	.3	.7	.8
8	.5	.1	.5	.1	.7	.1	.7	.0	.6	.8	.8	.7
1859	.7	28.9	.5	.2	.6	.0	.6	28.8	.8	.9	.7	.7
Mean	29.51	29.10	29.50	29.12	29.60	29.05	29.67	28.97	29.71	28.86	29.75	28.83

The observations made with the old barometer between 1829 and 1832 show, when compared with the succeeding record, a defect in the instrument most probably due to the presence of air above the mercury; they were therefore omitted in taking the monthly means which are given at the bottom of the table. The means are derived from 27 years of observations (28 in November). They indicate a regular progression, the maxima attaining their greatest value in January and their least value between June and August (29.81 and 29.50 inches respectively), and the minima attaining their least value in March and their greatest value in August (28.78 and 29.12 inches respectively).

Comparing the annexed diagram with the corresponding one of the annual inequality of the barometric extremes at Brunswick, Me., a close correspondence will be noticed in the epochs and range of variation, though the curves are not so regular owing to the shorter series of observations (27 years at Marietta and 50 at Brunswick).

Diagram N.—*Annual Inequality in the Barometric Extremes.*



In Table XV the monthly averages (of the extremes) and the ranges are given.

Table XV.—Monthly Average and Range of Extreme Barometric Readings (at 32° Fah.).

	Average.	Range.		Average.	Range.
January	29in.33	0.in96	July	29in.30	0in.41
February . . .	.25	0.89	August	.31	0.38
March	.23	0.89	September . . .	.32	0.55
April	.26	0.74	October	.32	0.70
May	.23	0.56	November . . .	.29	0.85
June	.26	0.47	December . . .	.29	0.92

On the average the monthly means of extremes are 0in.04 higher between July and December than between January and June; the amount is the same also at Brunswick.

The annual fluctuation in the range (difference of monthly extremes) is very regular, but of smaller amount than the equally systematic results at Brunswick. The monthly range is greatest (0.96 inches) in January, and least (0.38 inches) in

August; the August range is nearly one-third the value reached in midwinter. Average value $0^{in}.69$.

The average atmospheric pressure for the year (from 27 years of observation of extremes) is 29.28 inches;[1] the barometer never rose above 30.00 inches (at 32° Fah.), which was attained four times in January; and never fell below 28.30 inches, which was attained in November. Absolute range 1.70 inches. At Brunswick we had extreme highest value 31.00 inches (at 32°), extreme lowest 28.60 inches, and absolute range 2.40 inches.

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[1] Supposing the average pressure at the sea level in latitude 39° equal $30^{in}.03$ (at 32 Fah.) and a difference of level of 91.6 feet (at a temperature of 53° Fah.) for every tenth of an inch of barometric pressure, the above average value for Marietta would assign to it a height above the sea of 687 feet, which is considerably too high; the index error of the barometer is not known.

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THE

GLIDDON MUMMY-CASE

IN THE

MUSEUM OF THE SMITHSONIAN INSTITUTION.

BY

CHARLES PICKERING, M.D.

[ACCEPTED FOR PUBLICATION, JUNE, 1867.]

INTRODUCTION.

The following article has been prepared at the request of the Institution by Dr. Pickering, in illustration of an interesting specimen of ancient Egyptian Archæology, which was presented by Mr. Gliddon in 1842 to the National Institute of Washington, and at the dissolution of this society in 1857, came by its charter under the charge of the Smithsonian Institution.

The cover of the Mummy-Case, obtained by Mr. Gliddon, was sawed by him into three parts, one of which was presented to the National Institute, another to the Naval Lyceum of Brooklyn, and the third to Mrs. Ward, of New York. Diligent inquiry for the two last-mentioned portions has been made, in order to have them also examined and figured, but without success, and attention is now called to the fact in hope that if the other portions are still in existence, the fact may be communicated to the Smithsonian Institution.

The accompanying plate represents the cover of the Mummy-Case as if perfectly flat. It is, however, curved at each side, although the upper surface is nearly plane except at the edges.

JOSEPH HENRY,
Secretary, S. I.

Smithsonian Institution,
July, 1st, 1867.

ON THE

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BY

CHARLES PICKERING, M. D.

In conversation, some fourteen years ago, the late Mr. Gliddon informed me that he procured this mummy-case at Sacara, from an Arab who having dug it up was committing it to the flames; that the portion saved contained no king's name to fix the date, and was sawed by him on arriving in America into three pieces, one of which he deposited in Washington.

This Washington fragment (the only one I have seen) is represented in the annexed colored engraving; and on examination before and after visiting Egypt, appeared to me to belong to an early period; conviction gradually strengthening, that it is one of the oldest, if not the oldest specimen of hieroglyphic writing known.

The earliest writing of ascertained date, is under Snophru of the Third dynasty, builder of the great stone pyramid at Dashur, and supposed to be Sephouris, who reigned from B. C. 3110 to 3080: the style of writing under Snophru is the same as under the Fourth dynasty during the building of the pyramids at Gizeh.

On the Gliddon mummy-case, and the Abusir tomb (now in Berlin), the writing is in a different and clearly anterior style. Towards the beginning of the Third dynasty, Tosorthos or Sesorthos, reigning from B. C. 3240 to 3211, in the words of Manetho γραφης επεμεληθη, improved the writing: as all improvements in writing have tended in one direction to increased facility, the mummy-case at least seems to have preceded such an interference.

Sesorthos also inaugurated building with hewn or squared stone: Manetho's statement referring perhaps to larger constructions as pyramids, and not precluding knowledge of the art; the Abusir tomb is in fact of squared stone.

Metallic implements are required for squaring stone, and the *crucible* on the mummy-case indicates smelted copper: but the *stone adze* is also figured, as appears from the mode of fastening, though the material of the blade may remain uncertain; the character is changed in form throughout subsequent hieroglyphic writing, and clearly represents a metallic adze.

This stone adze of the Gliddon mummy-case, and the hieroglyphic character possibly of the stone celt or hatchet continuing as late as the Fifth dynasty (Leps.

June, 1867.

Denk. ii, pl. 64), are all the traces I have been able to detect of a Stone age in Egypt. The implements belong to the period when writing was invented, and instead of being used in Egypt, may have been traditional forms derived from the parent country eastward.

The *throne* on the mummy-case, narrow and straight-backed, seems also to belong to the commencement of the art of writing; and may indicate nothing beyond the rule of a chief, or the Bedouin form of government.[1]

The twice-curved *throwing-club* of the mummy-case is figured also on the Abusir tomb, and occasionally in the hand of Egyptians as late as the Seventeenth dynasty (Leps. Denk. ii, pl. 3, and iii, pl. 5 and 9). The pattern is clearly Mesopotamian: a similar throwing-club is in the hand of the Asiatic strangers at Benihassan, in the sixth year of Sesostris, B. C. 2121; and is the only kind figured on the Assyrian monuments.

By an exception among the birds, the plumage of the falcon remains uncolored, the real object represented (as suggested to me by Mr. Birch in London) being a *banner* or standard: a sense of nationality is implied, with military organization, and foreign wars.

The two appendages of the perch are distinctly feathers, and imply the art of *falconry:* an art to the present day found by Layard among the Bedouins along the Euphrates.

A more Southern country is indicated by the *kneading-trough;* the checkered workmanship being the same as in the shallow baskets to the present day brought down the Nile, and ascertained by myself to be manufactured at the southern extreme of Arabia.

The *flag-shaped fan* has a narrower flap than at the present day; in those observed by myself at the first cataract of the Nile, and made around Mocha in Southern Arabia, of strips of leaves of the doum-palm, Hyphæne crinita.[2]

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[1] Even Arab writers speak of a period when Greece was uninhabited; and notwithstanding recent discoveries, there is yet room for doubt, whether in the days of the Egyptian king Snophru there was a human being in Europe.

Seti Mienptah ruled Egypt from B. C. 1396 to 1366, and his tomb at Thebes contains the hieroglyphic sign of a northern animal, the *beaver;* also the earliest figures of northern people, possibly Europeans, having egret-plumes on the head, and wearing an ox-hide bordered and banded with swan's down; there are no traces of woven cloth.

The Stone-age relics of Switzerland and Northern Europe have not disclosed a state of society anterior to cultivating flax and weaving cloth: these countries were certainly inhabited when *amber* first reached the Mediterranean. Under Crotopus, who reigned in Greece from B. C. 1290 to 1269, Phaethon's sisters were transformed into poplars, whose tears along the Rhine became amber; the public being thus far enlightened respecting the amber trade.

The extension of population and of civilization are two different things: the mummy-case contrasting with the condition of France during more than eight hundred years, rejecting civilization from the Greek settlement of Rhodon on the Rhone under Rhodian rule of the sea (B. C. 918 to 895) to the intense barbarism witnessed in B. C. 87, by Posidonius.

[2] A point yet farther south is indicated by the crested bird of hieroglyphic writing; occurring throughout, either entire or the head and neck only, but shown by the outline figure on the Abusir tomb (Leps. Denk. ii, pl. 5) to be the *Ibis cristata* of Madagascar. In the present state of our knowledge, the fact seems inexplicable.

The *oblique-handled staff* figured, continues in use to the present day; and one picked up by myself on the pilgrim trail in passing Suez, was recognized at Mocha as of the pattern belonging exclusively to Western Arabia.

The small bird, from the form and plumage, is distinctly the *house-sparrow*, Fringilla domestica: its thick bill continues on the Abusir tomb, but subsequent representations are no longer recognizable. In conformity also, the Coptic vocabulary gives "jaj" sparrow, "jajĕ" enemy; a meaning implied by the sparrow seeking the owl's protection and finding oppression (Horap. ii, 48), also by the depredations of the sparrow on grain-crops.

The owl, from the form and plumage, is distinctly the *barn owl*, Strix flammea: the outline on the Abusir tomb corresponds, but representations throughout subsequent hieroglyphic writing are no longer recognizable.

From the color of the bill and feet, the *chick* is clearly the young of the red-legged partridge, Perdix Græca: a fact that in the absence of the Gliddon mummy-case, might not have been ascertained.[1]

The asp or *cobra* is shown by the coloring to be the indigenous Egyptian species, C. haje; and the fillet around the body seems to imply the art of *serpent-charming*. According to Horapollo, i, 59, the bee signifies a people obedient to their king; but the Coptic vocabulary gives "ga" people or nation, "ga" under, "ĕgrēi" beneath, "agori" asp or basilisk. The connection in Hindustan of the cobra with mythology, seems therefore a later idea, borrowed from the West.

In the absence from the mummy-case of all emblems of idolatry, the solitary eye is not human, but the *all-seeing eye:* the Coptic vocabulary gives "ai" to be, to exist.

The pitcher or *spondist*, for pouring out libations, is also figured; and the *ointment-vase*.

The *house* clearly belongs to the origin of writing: and the seat of this invention is shown by the flat roof to be in a rainless climate not north of Egypt: the addition of an arched window implies building material either of mud hardening in the sun, or regularly-formed mud-bricks. An arch at this early date conflicts with much that has been said in print; and the dwelling is in every way superior to those of Modern Egypt, observed by myself to be mere conical mud huts without any window.

The *arched window* occurs besides detached in the hieroglyphic writing, and is a frequent character subsequently, known to signify the feminine: in the mind of soldiers away from home, a cottage-window might bring up the image of some one behind; and the Coptic vocabulary gives "thimĕ" village, "thimĕ" woman, wife. Beyond Egypt and hieroglyphic writing, the arched window turned on end became an early, if not the earliest form of the Greek thelta or th soft; westward denotes in Latin a cognate sound; and to the present day is retained in most European languages as the capital letter **D**.

The Egyptians themselves, as figured on the mummy-case, though the yellow

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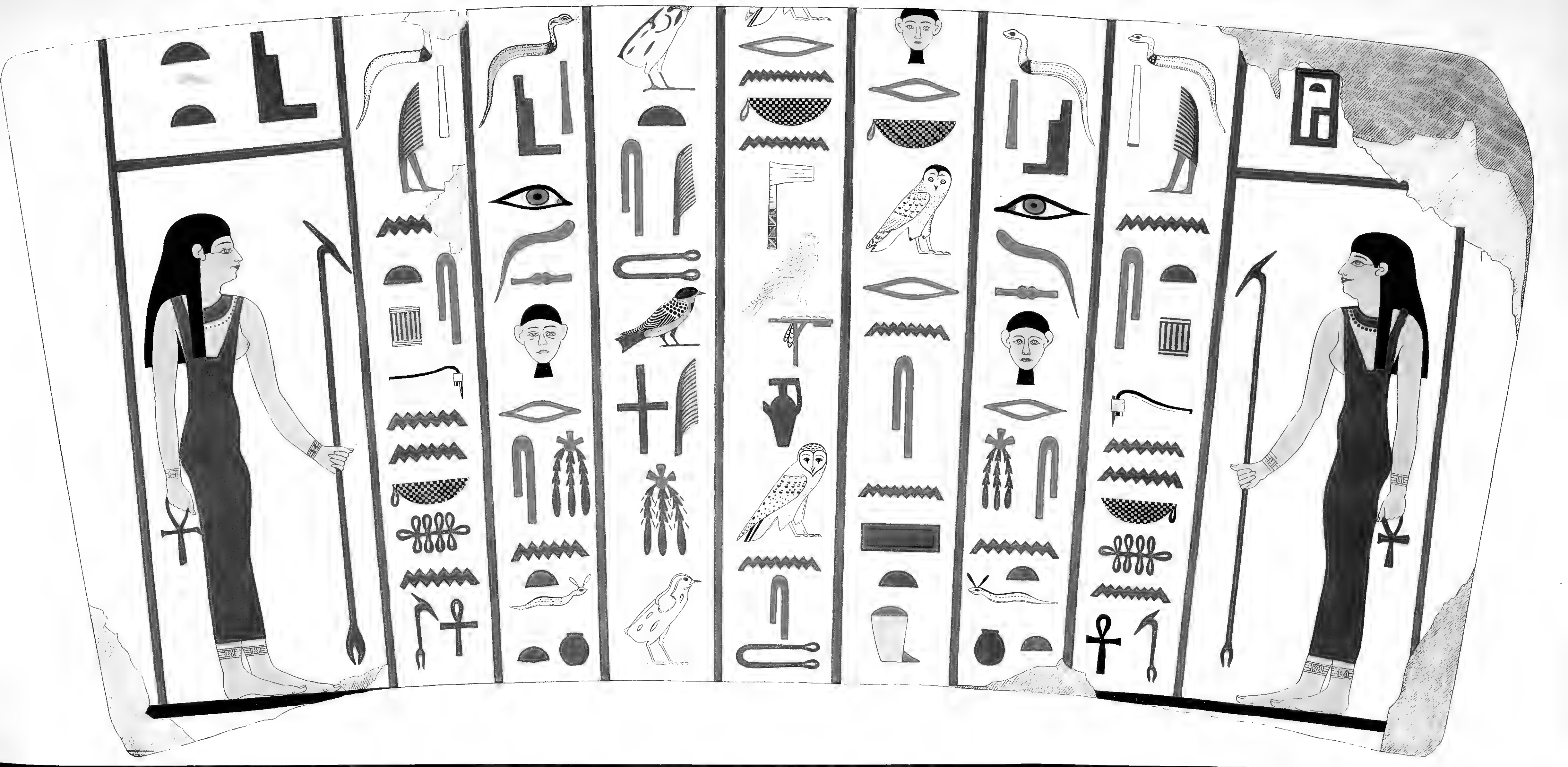
[1] As late as king Snophru, hieroglyphic writing presents a distinct figure of the *eagle* (Leps. Denk. ii, pl. 2): subsequent representations are no longer recognizable.

complexion may prove conventional, are clearly from the hair and features of the Arabian or White Race.

In regard to the material, the mummy-case is formed of layers of *linen ;* over which is a thin coating of *chunam* to receive the paintings. This firm, smooth plaster or stucco continues in use both in Egypt and Hindustan throughout monumental history; and to the present day is applied around the Indian Ocean to a great variety of purposes, including sheathing ships. I found sea-water employed in the manufacture of chunam by the Arabs at Zanzibar.



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THE ORBIT AND PHENOMENA OF A METEORIC FIRE-BALL,

SEEN JULY 20, 1860.

BY

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[ACCEPTED FOR PUBLICATION, JULY 1868.]

COMMISSION

TO WHICH THIS PAPER HAS BEEN REFERRED.

Prof. H. A. Newton.
Chas. A. Schott.

Joseph Henry,
Secretary S. I.

COLLINS, PRINTER,
PHILADELPHIA.

REFERENCES TO THE MAP.

N. B.—To avoid crowding, the following places are indicated on the map by numbers alone.

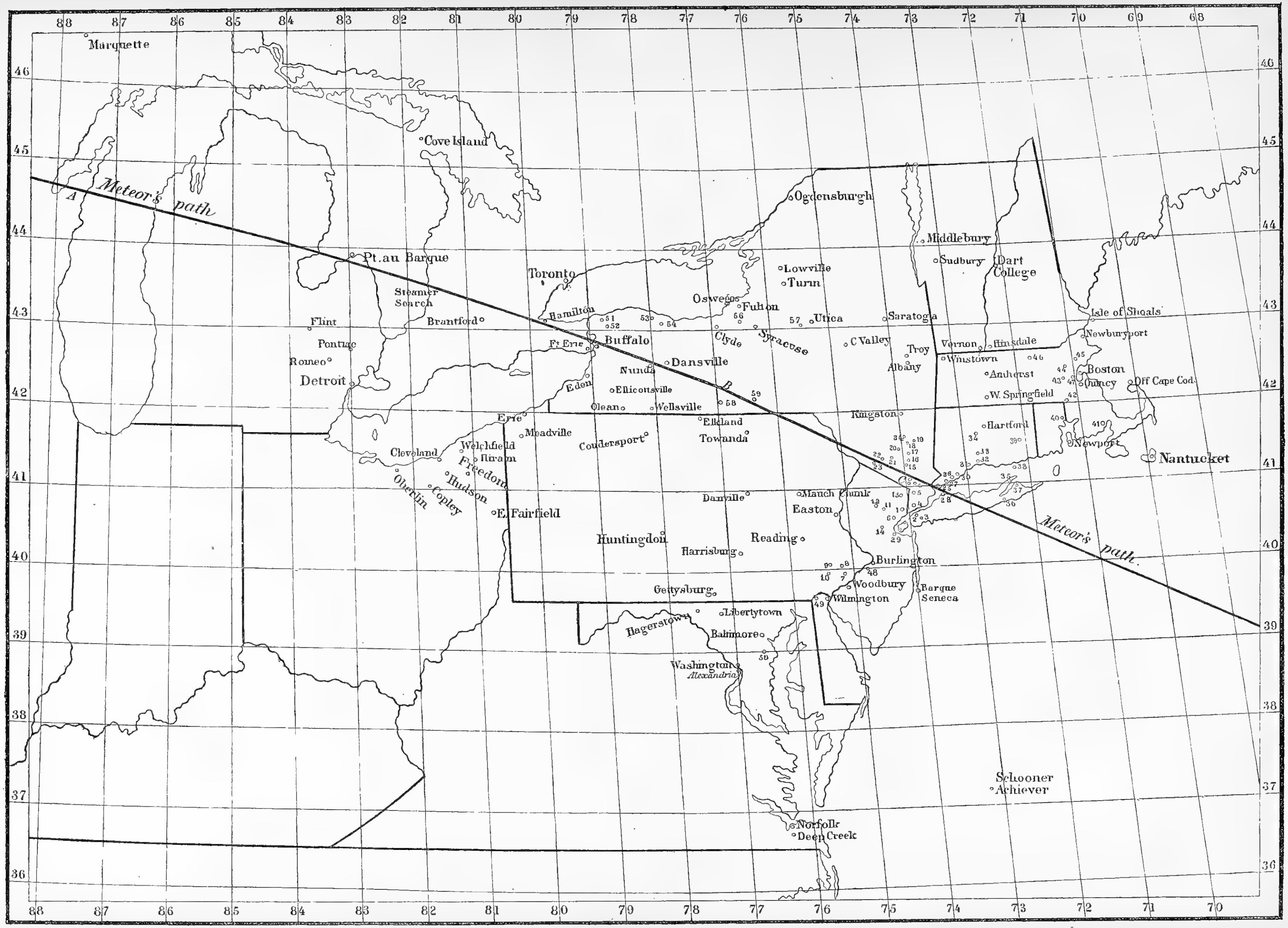
1. Newark.
2. Brooklyn and Bay Ridge.
3. Bedford.
4. Green Point.
5. Riverdale.
6. Elizabeth.
7. Philadelphia.
8. Germantown.
9. Valley Forge, Rockund, and Eagle Station.
10. Lima.
11. Media.
12. Morristown.
13. Paterson.
14. New Brunswick.
15. North Haverstraw.
16. Peekskill, and Steamer New World.
17. West Point.
18. Matteawan.
19. Fishkill.
20. Newburg.
21. Washingtonville.
22. Chester.
23. Edensville.
24. Poughkeepsie.
25. Greenwich and Port Chester.
26. Bridgeport.
27. Near Norwalk.
28. Near Oysterbay Point.
29. Perth Amboy.
30. Stratford.
31. New Haven.
32. Brantford.
33. Wallingford.
34. New Britain.
35. Southold.
36. Southampton.
37. Sag Harbor.
38. Steamer City of Hartford.
39. Norwich.
40. Providence.
41. New Bedford and Fair Haven.
42. Wrentham.
43. Newton Corners.
44. Harvard Observatory.
45. South Danvers.
46. Fitchburg.
47. West Roxbury.
48. Delanco.
49. Newport, Del.
50. Davidsonville.
51. Lockport.
52. Royalton.
53. Rochester.
54. Pittsford.
55. Dansville.
56. Baldwinsville.
57 Hamilton College.
58. Elmira.
59. Owego.

Reference numbers for the following places marked on the map are omitted for want of space.

Cornwall, Lat. 41° 26′, Long. 74°.
Dobb's Ferry, Lat. 41° 3′, Long. 73° 53′.
Fishkill Landing, Lat. 41° 33′, Long. 73° 58′.
Fordham, Lat. 40° 54′, Long. 74° 3′.
Melrose, Lat. "about 41°," Long. 73° 50′.
Montclair (West Bloomfield), Lat. 40° 49′, Long. 74° 13′.
New Brighton, Lat. 40° 39′, Long. 74° 7′.
New York City, Lat. 40° 43½′, Long. 74° 0½′.
Rip Van Winkle (steamer), Lat. 40° 41′, Long. 74° 1′.
Sneden's Landing, Lat. 41° 3′, Long. 74°.
Staten Island, Lat. 40° 35′, Long. 74° 10′.
Tarrytown, Lat. 41° 7′, Long. 73° 57′.
Washington, Dutchess County, N. Y.
Williamsburg, Lat. 40° 43′, Long. 73° 58′.

MAP OF METEOR'S VISIBLE PATH.

Plate 1st.



ON THE

ORBIT AND PHENOMENA OF A METEORIC FIRE-BALL,

WHICH PASSED OVER PORTIONS OF THE UNITED STATES AND CANADA, ON THE 20TH OF JULY, 1860.

On the evening of July 20th, 1860, a meteoric fire-ball passed over the northern parts of the United States and the adjacent parts of Canada, of so extraordinary brilliancy as to attract the attention of numerous observers along its entire visible track of nearly or quite 1300 miles, and on either side of it to the distance of several hundred miles. It was reported to have been first seen moving eastward from a point nearly over the western shore of Lake Michigan, though it not improbably became luminous when it was somewhat further west, as the sky over all that region was obscured by clouds, and it was not till the meteor had reached a point some 150 miles further east that the first reliable determination of its position was made. From thence many eyes watched its course till it disappeared quite out at sea in a southeasterly direction from the island of Nantucket.

From the following series of observations, obtained partly from the newspapers of the time, partly through the co-operation of scientific friends, who, at the request of the writer, kindly made inquiries in regard to the phenomenon in their respective localities, or measurements of the meteor's position, as estimated by themselves or pointed out by those who saw it; and partly from collections kindly put into his hands for the purpose by the Smithsonian Institution, and by Profs. Lyman and Newton, of Yale College, an attempt has been made to determine the elements of its orbit or path.[1] At a few of the places, where estimates of the meteor's altitude at special azimuths were desired, and where the proper instruments for this measurement were not at hand, estimates were made by a sort of extemporized quadrant in the following manner, which, for the sake of brevity, is designated in the following series as the "card method." From a point in a line drawn upon a card (or sheet of paper attached to a piece of board), a small weight was suspended by a string, and the card being held in a vertical position, and the line directed toward the estimated place of the meteor, when it was at the specified azimuth, the position of the string was noted, as it rested against the card, and a line drawn upon the

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[1] In making the computations, valuable aid was contributed by Mr. Benjamin F. Stem, A. M., a gentleman of superior mathematical attainments; by my son, Selden J. Coffin, A.M., and by Messrs. W. P. Montelius and A. P. Reid, members of the Senior Class in Lafayette College.

card to correspond. The angle included between the lines being then measured by an ordinary protractor showed the co-altitude of the meteor. All the estimates of this character were made several weeks after the date of the meteor's appearance, when the vividness of the first impression may be supposed to have in some measure faded from the mind, and must of course be less reliable than observations made under favorable circumstances at the time. Some of them gave positions for the meteor so widely at variance with those deduced from more reliable observations that it was thought better not to include them in the tabular series (Table II), at the end of this memoir, in which the results of calculation are compared with those of observation. The numbers affixed below to the names of most of the places at which the observations were made refer to the aforesaid table.

Description of the Observations and Remarks thereon, the Names of the Places being Arranged in Alphabetical Order.

Achiever (schooner), Lat. 37° 10′, Lon. 73° 15′. Capt. Knowles reports that the meteor "rose in the west and passed to the E.N.E."[1]

Albany, New York, Nos. 34 and 141. Observed by Prof. O. M. Mitchell, who says: "The meteor of July 20th, as seen by me, passed the meridian about 2° or 3° below Antares. It passed under Mars at about an equal distance," and that it disappeared at an altitude of 8° or 10°. Prof. E. Emmons says that it "had an elevation of 12°," "measured by a theodolite and a known object observed at the time it passed," and that it passed a little below Mars. The latter observation is confirmed also by Amos Fish.

Alexandria, Virginia, Nos. 4, 44, 63 and 103. The following extracts are taken from an article written by Caleb S. Hallowell, Principal of the Alexandria High School, dated July 24th, 1860, and published in the Alexandria Gazette: "The most reliable observers here represent this interesting body to have appeared in the northwest, at an azimuth of 20°, and an altitude of 10°; the first intimation of its approach having been the lighting up of a small cloud, from which the meteor shot out toward the east, in a nearly horizontal direction. By the time it had attained an eastern azimuth of 3°,[2] it burst or divided into two bodies, distant from each other about half a degree. The foremost of these bodies was somewhat the larger and brighter, and displayed yellow light, while the hinder was tinged with a pale greenish-blue. The two proceeded onward, retaining their relative positions, like birds flying through the air, hesitating, as it were, for a moment, and then immediately moving onward with a slightly accelerated velocity.

"By the time they had an eastern azimuth of 11°, their altitude had diminished to 9°, and about this time occasional sparks were seen dropping back from the front to the hinder ball, as though the body were in a process of combustion. Each ball,

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[1] According to the computed orbit, the altitude at the latter azimuth must have been about 8°, the maximum altitude about 9°, and the former azimuth a mistake.

[2] The calculated path shows a change of direction at Lat. 42° 18′ 15″, and Lon. 76° 42′ 53″, and if the meteor burst at that point the true azimuth was N. 3° 15′ 41″ E.

during all this time, was surrounded by a faint oblong luminosity, which extended itself somewhat between the two, and thus caused the compound meteor greatly to resemble a dumb-bell.

"On its first appearance, or emergence from the cloud, it was devoid of a train; but after its separation, as above described, a luminous haze was observed to shoot out behind it, which, as the meteor proceeded on its course, gradually extended itself, until it had attained a length of 2°. From the extremity of this tail sparks were occasionally dropped.

"As the meteor advanced to the east, the hindmost ball was gradually consumed, and the foremost continually grew dimmer, until, at an altitude of 5°, the entire body faded from view." "As respects its azimuth at the moment of disappearance, reliable observers differ considerably. Thus, one of our students, who made his observations with especial reference to the determination of this point, reports 55½°E., while my friend A. Jamieson, Esq., from whose country seat the meteor was carefully observed, designates a point which I find by instrumental measurement to have an eastern azimuth of 82°.[1]

"The entire time this wonderful body was in view has been, beyond question, greatly overrated, very few persons being able, without the aid of a time-piece, to estimate correctly the lapse of a minute. On this point, therefore, I have made a series of experiments with several who witnessed the entire passage of the meteor, and am satisfied it was not in view more than 30 seconds, if, indeed, so long. We noted carefully the time of its disappearance, viz.: 9h. 38m. P.M."[2]

Amherst, Massachusetts, Nos. 101 and 154. These observations were made by Prof. H. S. Kelsey, who says: "The meteor appeared in the N.W., and disappeared almost precisely in the S.E. At its highest point it was 16° above the horizon. Diameter of the largest part, 20′. In sight from 60 to 75 seconds. Its path seemed to me to be a straight line, or very nearly so. I did not see it till it had divided. It was in four parts." "When I lost sight of it, it was about 2° above the horizon."[3]

Avon, Ohio, Lat. 41° 27′, Lon. 82° 4′. Observed by Rev. L. F. Ward, and records made at the time, which were subsequently lost. At the request of the writer, however, he was so kind as to go with a theodolite to the place from which he observed it, and take the estimated bearings and altitudes. But it must have been a different meteor that he saw, as it passed *south* of him.

Baldwinsville, New York, No. 16. Observed by John Bowman, who says: "I had an excellent opportunity to get its altitude from a tree in my yard, where it

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[1] The discrepancy is satisfactorily explained in a subsequent note from Mr. Hallowell, in which he states the latter observation was made from "a very elevated point," while the former was made from the shore of the Potomac.

[2] The calculations give for the interval between the first and last observations, 37 seconds; and for the time of disappearance, 9h. 35m. 45s. P.M.

[3] According to the calculated path, the altitude of the meteor when *due* southeast, was 6° 44′, and the time from the first explosion, 54 seconds. The observation can be better satisfied in both particulars by supposing the azimuth to have been about S. 53° E.; for then the calculated altitude would be about 3°, and the time from the first explosion about 80 seconds.

passed in range of the topmost branch—in this I cannot be mistaken more than half a degree of altitude. But this was near 20° east of the line you designate in your letter, and I regret that I cannot give you the elevation on that line, but I prefer to give facts, and you can draw your own conclusions." The altitude at this point was about 15°, and the azimuth "by compass, S. 35° E.," to which add 5° 2′ for magnetic variation.

Baltimore, Maryland, Nos. 32 and 88. Observed by Rev. Henry M. Harman, from a point eleven miles southwest of Baltimore. The latitude and longitude of the place are given in Table II, and are his estimates. No. 32 was observed through an opening between two trees, and the azimuth was measured by the compass, 2° 45′ being allowed by him for magnetic variation. He says: "The altitude of the meteor changed but slightly in a few degrees, as it was almost parallel to the horizon. I think its altitude when $10\frac{2}{3}°$ E., might be put down approximately at 15°."

Barnegat, New Jersey, No. 7. See Seneca.

Bay Ridge (near Brooklyn), Long Island. The writer of an article signed "T. T.," in the New York Independent, No. 608, says the meteor was first seen about W.N.W. at an altitude of about 15° above the horizon; that after about 20 seconds it exploded; then approached nearly overhead, and that the whole duration was about one and a half minutes.[1]

Bedford, Long Island, No. 211. The observer at this place (name not ascertained) says: "It hardly attained an elevation of 45°," and that an explosion was heard about $1\frac{1}{2}$ minutes after it burst.[2]

Boston, Massachusetts, Lat. 42° 21′, Lon. 71° 4′. According to one account, the time of the meteor's passage was "about 10 o'clock." Another account says it was 9h. 56m.[3]

Branford, Connecticut, No. 27. Observed by C. E. Dutton, who says in a letter to Prof. Newton, of Yale College: "The first notice I received of the meteor was a bright glimmer in the horizon at a point a little west of N.W. Soon after it rose to view." It made its appearance near the feet of the Lynx, and moved in a direct line through the Great Bear, not quite touching the stars of the dipper; through the constellation Bootes, a little south of Arcturus, through the upper portion of Ophiuchus." "Second explosion took place nearly overhead." He says that the interval between the two explosions was about ten seconds, and the whole time of flight "75 to 80 seconds;" also, that a report was heard "about five minutes after the explosion," certainly not less than four.[4] Another account received from B.

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[1] According to the calculated path, the altitude, 20 seconds before the first explosion, was but 8°, and the azimuth, N. 61° $38\frac{1}{2}$′ W.; while in one and a half minutes afterward the meteor would have reached about Lon. $65\frac{1}{2}$°, which is further east than it was seen by other reliable observers.

[2] According to the calculated path, the meteor was at no time within about 50 miles of Bedford, and it would be impossible for sound to travel over that distance in less than about four minutes.

[3] According to the calculated path, the meteor crossed the meridian of Boston State House at 9h. 59m. 56 sec.

[4] The calculated path of the meteor fails to satisfy, even approximately, the first part of this description—as far as to its passage "through the constellation Bootes." "The feet of Lynx" had passed

F. Harrison, of Wallingford, says: "At 14 miles south of us it is said to have passed as nearly through the zenith as could be judged."

Brantford, Canada West, No. 165. Communicated by John K. Johnston, Principal of the Grammar School, who says: "I had not myself the good fortune to witness the phenomenon, nor have I been able to find among those who did, in this neighborhood, a single person whose attention was directed at the time to the points you wish to ascertain, or whose experience in estimating angles could give any ground for relying on his testimony, as having any value in relation to them. The vaguest language, 'right overhead,' &c. &c. is used in relation to the place of the meteor's appearance; and an attempt to learn the stars near which it passed has been defeated by the cloudiness of the night on which it occurred."

Bridgeport, Connecticut, Lat. 41° 11′, Long. 73° 13′. An article in the Bridgeport Advertiser, says that the meteor passed almost vertically over that place.[1]

Brooklyn, Long Island, No. 71. Observed from the corner of Fulton and Franklin Avenues. The observer describes the apparent path of the meteor as "commencing at the constellation Ursa Major, and continuing in a straight line to Aquarius (near the triangle called the Waterpot)." Mr. E. Merriam reports the time as 9h. 46m. P.M. In another account the time is said to have been 9h. 45m.[2]

Buffalo, New York, No. 6. My valued friend, Milo R. Eames, took much pains and made many inquiries to ascertain the phenomena exhibited by the meteor as seen from this place, and thus sums up the result in regard to its path: "I think it most probable that its course was slightly south of east, and that it passed a few degrees south of our zenith; as I get more testimony thus than otherwise." The following is from the Buffalo Courier, of July 21, 1860: "Last night, about half past nine, the grandest meteor we ever had the fortune to see, made its way through the heavens to the wonderment of every mortal with eyesight who was out of doors at the time. It sprang into view, as near as we could ascertain, at or near the horizon almost exactly in the west. We were standing, at the moment, in the shadow of buildings that completely shut out the western sky. A flood of light, like that of a vivid, continuous flash of lightning, or like a bright dawn, streamed over the tops of the houses, and grew in intensity for a few seconds, ere the majestic orb sailed sublimely into sight overhead. Over the zenith it sped, reddish in hue, and with a wake of fire that spanned the sky for an instant like a vast arch of celestial flame." The Commercial Advertiser, of the same date, says it "traversed the heavens from west to east, producing a flood of light like that of a

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below the horizon more than an hour before the meteor appeared, and, according to calculation, it must have passed through Leo Major, and entirely south of Ursa Major. The calculated interval between the two explosions is about 16½ seconds, and the whole time from the constellation Leo Major to the point where it was last seen from New Haven, "75 to 80 seconds," while the maximum altitude was less 50°.

[1] According to the calculated path it passed from 17 to 18 miles southwesterly from the zenith of Bridgeport.

[2] According to the calculated path the meteor as seen from Brooklyn passed through Ursa Major, and crossed the meridian of Brooklyn at 9h. 47m. 59 sec.

continuous flash of lightning. It did not dart, but with a steady even motion steered eastward over and down, appearing smaller and paler as it sank away to the verge and beneath the eastern horizon. It must have taken at least 30 seconds in its aerial passage across the heavens."[1]

Burlington, New Jersey, No. 94. Observed by William L. Newbold, who "had a distinct view of it crossing a street running due north and south, and estimated its altitude at just about half that of the pole star."[2]

Cape Cod, Massachusetts, No. 98. Observed by a captain of a vessel off this point, who says that the meteor appeared to him to enter the atmosphere, or become luminous, "in the neighborhood of Spica."[3]

Cherry Valley, New York, No. 93. The latter part of the meteor's visible track was observed from this place by Dr. Titus Powers, who says it disappeared from view before reaching the horizon. He and Mr. C. G. Hazeltine, Principal of the Cherry Valley Female Seminary, made jointly an estimate of its altitude by the "card method," at an azimuth that I had named, but which proved to be west of the point where the meteor came in view of Dr. Powers; and Mr. Hazeltine thinks it "too much a guess-work to be very reliable."

Chester, New York, No. 20. Communicated by Rev. Edson Ferrier, who says that an observer at this place saw the meteor pass just south of his zenith.

City of Hartford (steamer), Long Island Sound, Nos. 207, 213 and 221. Observed by "H. Y.," who says in a communication to the New York Tribune: "At ten minutes before 10 o'clock, just after the steamboat City of Hartford had passed out of the Connecticut River, and before she turned westward for New York, my attention was attracted to a bright light in the N.W., over the village of Saybrook." "As it came nearer, and to the westward of us, it must have been at an elevation of about 50°. It went steadily to the southeast, and slowly out of sight over Long Island, still apparently preserving the same altitude." A communication from Mr. B. F. Harrison, of Wallingford, states that "just outside the bar at the mouth of the Connecticut River" (probably on this same boat), "it was observed by the editor of the Hartford Press, and it appeared to pass north of the zenith."

Cleveland, Ohio, Nos. 51, 52, 83, 89, 160 and 122. These observations were communicated by Leonard Case, Jr., to Prof. Lyman, of Yale College. Nos. 83, 51, and 160 were observed by Dr. C. A. Terry, who "happened to be gazing on a clear portion of the sky, then, directly in his axis of vision, there flashed out a bright spot, which afterward grew into a meteor."—No. 52 was the maximum altitude, and No. 83, a point where the meteor became hidden behind trees.

Nos. 89 and 122 were observed by four gentlemen, who sat in couples, 40 feet

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[1] If we suppose the meteor to have been first seen 20 seconds before it passed the meridian of Buffalo, its altitude at that point, according to the calculated path, was about 21°, and its azimuth about N. 73° W. Also, according to calculation, it passed the meridian of Buffalo at 9h. 27m. 45 sec., but did not descend below the horizon till more than a minute afterward, when it was far out at sea. Mr. George Webb, of Elizabeth, New Jersey, states in a letter to me—I know not on what authority—that "the meteor passed directly over the south part of Buffalo."

[2] Communicated by Mr. B. V. Marsh, of Germantown, Pennsylvania.

[3] Communicated by Dr. H. C. Perkins, of Newburyport, Massachusetts.

apart, and 35 rods from Dr. Terry, in a direction S. 34° E.; and Mr. Case says: "Their *independent* accounts agree too exactly for rough measurements to detect a difference." He adds also: "No observed elevation, that can be measured, gives more than 25° for the maximum elevation. One with good 'markers' gives (No. 52) N. 5° E., elevation 25°, which is, perhaps, nearest correct. I think it would be right (for I made the measurements myself) to substitute this for Dr. Terry's second observation, as his position at that time is slightly uncertain."

Clyde, New York, No. 184. At this place two estimates of the altitude of the meteor at designated azimuths were kindly made at my request, by the "card method," but not till more than two months had elapsed after the phenomenon occurred, and the results, showing a maximum altitude of not more than 19° (if I interpret the marks rightly), are widely at variance with the indications of other reliable observations.

Copley, Ohio, No. 162. Observed by Dr. Ward, of Medina. "The meteor seemed to be due north when first seen, at an altitude nearly equal to that of the polar star. It passed in a southeasterly direction, and disappeared behind a cloud at an elevation of 20°. Was visible about five seconds."[1]

Cornwall, New York, Lat. 41° 26′, Lon. 74° 0′. Time by observation, 9h. 40m. to 9h. 45m.[2]

Coudersport, Pennsylvania, Nos. 170 and 195. Observed by Dr. E. Joerg, who says of the meteor, in a letter to Prof. Lyman, of Yale College: "It traversed the Ursa Major between Alioth and Megrez." Also, that a report was heard exactly 5 minutes after it disappeared in the horizon exactly in the east. Time of flight estimated at two minutes, and nearly that time after it passed between Alioth and Megrez; motion apparently due east.[3]

Cove Island, Lake Huron, Nos. 50 and 116. Observed by Mr. Bailey, Observatory Attendant, U. S. Lake Survey. His statement is that, when first seen, the meteor appeared as one ball nearly as large as the moon, and at an altitude of 30° in a southwesterly direction—that it appeared to move horizontally, and in an easterly direction, for about 30°, when it burst, and one piece fell directly to the ground near the place of observation, setting fire to the vegetable matter around it; that the fire was put out, but the piece could not be found; that the remaining portion continued in the original direction, but seemed to be approaching the earth; that after passing over an arc of about 60° from the point where it was first seen, it disappeared in the S.S.E. "No other pieces except the one spoken of, were seen to detach themselves. The time when the meteor was

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[1] Communicated by W. P. Clark, of Medina, Ohio.

According to the calculated path, the altitude, five seconds after it passed the azimuth of the north star, was about 24°.

[2] According to calculation, it passed the meridian of Cornwall at 9h. 47m. 55 sec.

[3] According to the calculated path, the meteor reached a due east azimuth 28 seconds after it passed that of the middle point between Alioth and Megrez; but did not descend below the horizon till some 25 seconds later still, and then at about the azimuth S. 75° E. If the explosion heard was that which seems to have occurred nearly over Elmira in New York, it would not have been heard, according to calculation, till more than 8 minutes after the meteor disappeared.

first seen was about 9 o'clock P.M., and the duration of its visibility about 45 seconds."[1]

Dansville, New York, Nos. 8, 9, 59, and 178. Nos. 8, 9, and 59 were communicated by Prof. J. J. Brown, who says that he asked a number of persons who saw the meteor, to point out its apparent path, by means of a board, which he had attached by a pivot to a post, and that they invariably swept the heavens "through the zenith;" that in size it was spoken of vaguely as "about the size of the moon;" that one observer said he saw it "run right over that big star" (α Lyræ). In a letter received some weeks later, he says: "I have just finished mounting an equatorial telescope, and the first purpose to which I have applied it is to determine the altitude and direction of the meteor, in regard to which you wrote me. The mean altitude of six observers, who were requested to point the telescope to the spot where the meteor appeared when S. 76° 30′ E., is 77° 2′." No. 178 was taken from an article in the Rochester Democrat, and communicated by Prof. Chester Dewey.

Danville, Pennsylvania, Lat. 40° 58′, Lon. 76° 39′. The following article appeared in the Pottsville Mining Journal: "Danville, July 21.—A very brilliant meteor passed over this place last evening at ten o'clock, giving as much light as a full moon. It came in view at the horizon, west of northwest, and passed due east, being about six seconds in passing. It went out of sight below the horizon, east of northeast. When directly northeast, it broke, forming two, one following the other. Some minutes" (another account says *four*) "after it disappeared, a sound resembling thunder was distinctly heard. No clouds were in sight."[2]

Davidsonville, Maryland, No. 186. Observed by Henry U. Thorpe, who says the altitude of the meteor was about 20° when a little west of north; that it seemed to divide when "a little east of the meridian."[3]

Deep Creek, Virginia, No. 131. Observed by James Smith, eleven miles nearly due south from Norfolk. He says that the meteor appeared about due north at an altitude of about 10°, and that it travelled about 30° in about one minute.[4]

Delanco, New Jersey, Lat. 40° 4′, Lon. 75° 5′. Time, near 10 o'clock.[5]

Detroit, Michigan, Nos. 10, 74 and 159. One account says of the meteor, "It appeared at 9h. 15m. P.M., 40° above the horizon, 30° west of north, taking an easterly direction. It moved slowly to the east till it was lost sight of behind a

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[1] Communicated by Capt. George G. Meade and Lieut. Orlando M. Poe, of the U. S. Lake Survey. According to the calculated path, the altitude of the meteor increased about 1½° during the first half of its visible track, and then decreased 9½° during the last half. Time of first appearance, 9h. 16m. 3 sec., and visible 17 seconds.

[2] According to calculation, the meteor was 23 seconds in passing from a northwest to a northeast azimuth; the time when it passed the meridian was 9h. 37m. 2 sec.; the azimuth at the first explosion almost due north, and at the second about N. 79° E.; and the sound, if it was caused by the first explosion, should have been heard about 8 minutes after the meteor disappeared.

[3] According to the calculated path, the division took place about one-eighth of a second before the meteor crossed the meridian; but it is allowable to suppose that the separation was not noticed till a second or so afterward.

[4] According to the calculated path, the meteor was 21 seconds in passing from "due north" to N. 30° E.

[5] According to calculation, the meteor crossed the meridian at 9h. 43m. 28 sec.

house at an elevation of 7°; and approaching the earth more quickly in the east, it formed a curve. It was in sight 19 seconds." Another account says, "It appeared a little above the north star, and to the west of it." Another observer still, says that he saw it in the direction of the north star, and that it had a "plunging or ricochet motion."[1]

Dobb's Ferry, New York, Lat. 41° 3′, Long. 73° 53′. The post-master at this place says that the time was 9h. 46m. "precisely," and that the meteor was in sight about one and a half minutes.[2]

Eagle Station, Pennsylvania, Nos. 187 and 201. Observed by H. B. Hoff. Appeared 9h. 42m. in the N. N. W., and disappeared at 9h. 45m. 30 sec.; exploded at an altitude of 15 to 20°; greatest altitude 40°; moved faster at some times than at others; path horizontal, but at times slightly undulating.[3]

East Fairfield, Ohio, Nos. 55 and 119. Communicated by S. B. McMillan, who assisted in measuring the altitudes "with a quadrant." He says: "There was no fixed object between the observer and the meteor, the nearest being a lightning rod the point of which was a few degrees below its path," which assisted so greatly in the determination of the position that he thinks it varies little from accuracy.

Easton, Pennsylvania, Nos. 60, 76, 80, 85, 92, 111, 126, 132, 140, 150, 190, 192, 194, 198, 200, and 215. Observations to determine positions of the meteor were greatly facilitated here by the prevalent custom of our people, to sit at the front doors of their houses in summer evenings; and also by the fact that the altitude of the meteor, as seen from the south side of streets running east and west, varied but little from that of the tops of the houses on the north side, so that it was alternately concealed by the higher houses, and then came into view again over the lower ones. The measurements of altitude and azimuth were all made by the author with a theodolite, each observer taking the position that he occupied when he saw the meteor, and pointing out its place with reference to some fixed object.

No. 60 was observed by Dr. C. C. Jennings, who saw the meteor over the vertex of a roof, between two chimneys. It would have been invisible at this azimuth from the place of observation if its altitude had been less than 19°.

No. 76 was observed by a lady who was sitting on her door-step, facing north, as the meteor burst into view, apparently in range of the cornice at the northeast corner of a three story brick house on the opposite side of the street, so that her first exclamation was that the house was on fire. It was found, however, both by observation in the daytime, and by going upon the roof and suspending a lantern

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[1] The last two accounts were communicated by Rev. George Duffield, D. D., he having taken them from the Detroit Free Press of July 22, 1860. According to calculation, the meteor occupied "19 seconds" in passing from N. 30° W. to about N. 56½° E., and did not reach a due east azimuth till about 27 seconds later; also the time of its first appearance was 9h. 11m. 3 sec.

[2] Time of meridian passage by calculation 9h. 48m. 25 sec.

[3] According to calculation, it appeared in the N. N.W. at 9h. 42m. 6 sec., and if it disappeared at a due east azimuth, as it did at Rockund, one mile distant, the calculated time of its disappearance is 9h. 42m. 43 sec., making the time of passage only 37 seconds instead of 3½ minutes. The calculated altitude at the time of the first explosion is 16° 48′.

at night, that the above point was not visible from the place where the lady sat, owing to the dense foliage of intervening trees, and the point, whose altitude and azimuth were measured, was nearly five feet from the aforesaid corner.

No. 80 was observed by Dr. C. C. Field, as the meteor came in sight, over the edge of the roof of an adjoining building.

No. 85 was observed by Alexander Wilson, who said it appeared to pass just below the gilt ball on the spire of one of our churches. He thought also that it passed near the planet Mars.

No. 92 was observed by Prof. Traill Green, M. D., and his lady from their north parlor window. They noticed the meteor as it passed behind the steeple of a church on the opposite side of the street. By repeating, watch in hand, certain operations that he performed during the passage of the meteor (such as leaving his seat after being called twice, going across the parlor, looking out of the window, and noticing the passage of the meteor behind the steeple, then running out of the house and across the street) Prof. Green estimates the time occupied by the meteor in passing from an azimuth of about N. 40° W. to the range of the steeple at 13 seconds, and from thence to due east at about 20 seconds.[1]

No. 111 was observed by John Swift, through an opening between two buildings. The possible limits of the altitude are 3° 38′ and 8° 22′.

No. 126 was observed by a lady, who was sitting upon her front door-step, facing north, a few feet from the observer of No. 85, and with reference to the same object as No. 60. The meteor could not have been seen at this azimuth if its altitude had been less than 20°.

Nos. 132 and 140 were observed by a lady and her two daughters, who were in the portico in front of her house, on the north side. They say that the meteor came into view from behind the hipped roof of a house on the opposite side of the street, just below the upper cornice, and that it then passed a little above another house which stands further east.

No. 150 was observed by J. Tidd with reference to the chimney of a building.

No. 190 was observed by Mr. Thompson with reference to the corner of a building.

No. 192 was observed with reference to the top of a house; same observer as No. 76.

No. 194 was observed by John Swift with reference to a tree top.

No. 198 was observed by William W. Cottingham with reference to a tree top.

No. 200 was observed by a young woman at the house of Rev. Dr. Vanderveer, who kindly lent his aid in determining the position of the meteor (as also No. 76, his house being the one there referred to). Startled by the light she ran out of doors, and leaning against a tree, saw the meteor through an opening in the dense foliage of another tree.

No. 215 was observed by Dr. J. B. Clemens, who, sitting in a chair on the pavement in front of his office, which faces south, saw the meteor come into view over

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[1] The times by calculation are 13 seconds and 17 seconds.

the front cornice of a building in range with his office. He sat facing east, and sprang to his feet when the meteor appeared, but is not sure whether he was sitting or standing when he first saw it.

It was stated in a dispatch from this place to the Philadelphia Bulletin (I know not from what observer) that the meteor moved "with immense velocity, with a *pulsating* motion;" time said to be about 9h. 45m. P. M.[1]

Eden, New York, No. 164. Observed and position determined by the "card method," by William Paxon.

Edensville, New York, No. 19. Communicated by Rev. Edson Ferrier, who says that an observer at that place saw the meteor pass just northeast of his zenith.

Elizabeth, New Jersey, No. 39. Observed and position estimated by George Webb.

Elkland, Pennsylvania, No. 61. Observed by Rev. William H. Dean, who having remarked to me some time afterward that his impression of the path was very distinct, I adjusted the telescope of my theodolite to the azimuth N. 33° 39′ E., and at my request he elevated it so as to correspond with his impression of the altitude.

Ellicottsville, New York, Nos. 5, 77, 107, and 169. Observed by D. G. Bingham, who says that the meteor "rose N. 72½ W. and set S. 72½ E. (true);" that "it passed near Alioth, between the 'guards' of Ursa Minor, and about midway between Chi and Zeta, Ursa Minor," and that it was visible 20 to 30 seconds.[2]

Elmira, New York, No. 185. Observed by Rev. T. K. Beecher, who says that the observations were taken "under unusual advantages, and with care;" and that "the meteor rose from 7° to 10° north of west;"[3] passed so near α Lyræ, then near the zenith—apparently within 2°—as to quench if not eclipse it." "When ascending within say 10°[4] of the culmination, the globe threw back two unequal fragments. One of them lingered and expired within 20 or 30 degrees. The other, being nearly or quite as large as the primary, fell into line with it, and the two disappeared below our horizon, like a chain shot. From the time of the apparent explosion I took note of time, by counting and pacing, between 90 and 100 seconds."[5] He says again: "The meteor attracted my attention by casting my shadow before me. Turning, I saw and watched it with care from (say) 15° or 20° above the west horizon. My impression is that it was only 10° high when I first saw it." * * * "I noted landmarks for rising and setting, and when the body was passed I took bearings from the north star, pacing off lines from east and west to make sure of my observations."

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[1] According to calculation, the time of first observation at this place was 9h. 42m. 6 sec., and of the last 9h. 43m. 16 sec.; duration 1m. 10 sec.

[2] According to the calculated path, the western azimuth of the meteor was at no time so great as "72½°." Probably it did not exceed 50° when first seen.

[3] According to the calculated path, the western azimuth of the meteor was at no time so great as stated in the text, and when its altitude was 10°, it was about 20° north of west.

[4] According to the calculated path, the altitude of the meteor at the time of the explosion was 73° 14′, or 16° 46′ from the zenith.

[5] Ninety seconds from the time of the explosion would, according to calculation, carry the meteor to Long. 63°, which is 260 miles further east than it was seen by any other reliable observer.

Erie, Pennsylvania, Nos. 54, 134, 163, 171, and 172. Nos. 134 and 163 were observed, and instrumental measurements carefully made, by Wilson King, a land surveyor, who says that his position was "peculiarly favorable for fixing its elevation and disappearance." He was sitting on the door-step in front of his house, which faces N. 64° E., and when the meteor came in range of the east wall, at the azimuth N. 26° W., he fixed its elevation (44½°) by a bracket of the cornice. From this point he says it "appeared to rise higher;" but finally "passed out of sight, in a cloud near the eastern horizon, at an elevation of 7½°, in a due east course." He adds, that his wife, who was sitting at his side, corroborates all his "observations as to its first appearance, its passage, and its exit." The time of flight from N. 26° W. to due east he estimated at about a minute, and says that an explosion was heard 3 to 5 minutes after the meteor disappeared.[1]

The remaining observations at this place were communicated by J. W. Wetmore, the altitudes having been estimated, by the "card method," by himself in connection with the other observers. No. 172 is the estimate by J. Spooner. No. 54 by J. W. Wetmore and T. M. Walker jointly; and No. 171 by Miss Kate Walker. Mr. Wetmore says the time was about 9 o'clock P. M.

Fair Haven, Massachusetts, Nos. 217 and 222. Observed by Capt. Jabez Delano, who says: "At 9h. 55m. I discovered a most wonderful object, resembling a globular body of fire bearing W. N.W., and approaching apparently directly towards me. In magnitude it equalled the moon. In a few seconds it bore south of me, and then exhibited the phase of a double headed meteor, the one head preceding the other." "When abreast of our house its light was so strong that our rooms were lit up for a moment with daylight splendor. The meteor held on its course E. S. E. until lost in the distance." "The like object I think was never before seen." Captain Delano was at the moment engaged in observing the heavens with his telescope, and says the meteor passed about 15° above Antares.[2]

Fishkill, New York, Lat. 41° 34′, Long. 73° 52′. Time by observation 9h. 40m.[3]

Fishkill Landing, New York, No. 210. In an article in the New York Tribune signed "W. H," it is stated that the meteor appeared to separate when at an altitude of 30° to 40°, and that it crossed the meridian at an altitude of 75° to 80°[4].

Fitchburg, Massachusetts, Lat. 42° 35′, Long. 71° 47′. Reported time "precisely 10 o'clock."[5]

Flint, Michigan, Nos. 1 and 161. Communicated by Daniel Clark, some months after the passage of the meteor. He says that "Mr. D. Stewart, a highly intelli-

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[1] According to calculation, the time from N. 26° W. to due east was but 27 seconds, and if the explosion heard was that which occurred near Elmira, N. Y., it would not have been heard till 14 minutes after the meteor disappeared.

[2] From the description, it would seem that the meteor was first seen before its first explosion, but we can hardly suppose it to have been further west than the meridian of Buffalo, where its altitude, according to calculation, would have been less than 5½°. At that point its calculated azimuth was nearly W. N. W. (a few degrees further west), and the time was 9h. 59m. 45 sec. P. M.

[3] According to calculation, the meteor passed the meridian of Fishkill at 9h. 48m. 28 sec. P. M.

[4] According to calculation, the altitude at the first explosion was 19° 30′.

[5] According to calculation, the meteor passed the meridian of Fitchburg at 9h. 57m. 1 sec. P. M.

gent young man," reports having seen a very bright meteor appear in N. W. at an altitude of about 35°; pass north of him, and disappear in the N. E., or perhaps a little further east, at about the same altitude as when it first appeared. The time was in July, but Mr. D. is not certain as to the day; thinks it was earlier than the 20th. But his description corresponds so well with the phenomena that the meteor of July 20th must have exhibited; and there being proof from independent testimony that the latter was seen at Flint, it seems probable that the two were identical.

Mrs. Rankin, wife of the publisher of a newspaper in Flint, also reports having seen a very bright meteor appear in the N. W. on the evening of July 20th; but is unable to locate its exact position or course.

Dr. Clark himself saw the light of it, which he says was so brilliant as to illuminate the whole street that he was crossing, but the body of the meteor was concealed by the dense foliage of intervening trees. The time was about 9 o'clock, and the light so strongly resembled that of a lantern near by, that he at the instant turned his eyes in the direction of the supposed bearer of it; and it was not till his little son, who saw the meteor from the other side of the street, had twice uttered an exclamation of surprise, that he comprehended the true cause of the phenomenon, and it was then too late to get a sight of it.[1]

Fordham, New York, Lat. 40° 54′, Long. 74° 3′. Reported in the newspapers as visible 1½ minutes.

Fort Erie, Canada West, Lat. 42° 52′, Long. 78° 57′. "Visible for a minute;" "moved from W. N. W. to E. S. E.;" "appeared, from the intensity of its action, as if about to burst, but emitted no sparks."[2]

Freedom, Ohio, No. 120. Communicated by S. M. Luther from observations made by others; mode of observation not specified.

Fulton, New York, No. 142. The meteor is reported to have occulted the planet Mars. Observer's name not ascertained.

Germantown, Pennsylvania, Nos. 14, 18, 21, 40, 43, 45, 49, 56, and 173. No. 173 was observed by Charles J. Wister, Jr. All the others were communicated by Benjamin V. Marsh in a letter from which the following extracts are taken:—

"1st. As to the point of appearance. Robert Aertsen, at Germantown, 6 miles N. N. W. from the State house, was sitting on his piazza fronting N. W., and saw it emerge from behind W. Gummere's house opposite, or else originating near it—he cannot say which—but he was very positive as to the part of the building near which he first saw it. I got him to direct the telescope of a theodolite to the point, and the result was—

"Azimuth N. 45° W. (true). Altitude 12°.

"When I caught sight of it, several seconds after its first appearance, I thought it was about 5° west of north, at an elevation of near 20°, but I do not feel anything like the confidence in this, that I do in my idea of the later part of its course.

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[1] According to calculation, the meteor passed the meridian of Flint at 9h. 8m. 14 sec.

[2] Communicated by Milo R. Eames, of Buffalo, from a newspaper report. According to the calculated path, it "burst" about 12 or 13 seconds after it passed the meridian of this place.

"2d. Its maximum elevation I thought to be in the N. E., near Cassiopeia. At the moment, my attention was so completely engrossed by the peculiar features of the meteor itself, that I did not see any stars whatever; but immediately after it had disappeared, and before changing my position, I endeavored to fix its path among the stars, and concluded that it passed very nearly in the line of the *two lowest bright stars* in Cassiopeia, if anything different, perhaps a little below them. I afterwards conversed with Mr. Aertsen, whose view was obstructed during the whole flight, and he thought it passed just about in the line of the above-mentioned stars.

"3d. As to the approximate point of disappearance I can speak more confidently. I was standing on the roof of a shed at W. Gummere's, directly opposite Mr. R. Aertsen, and the meteor disappeared behind a cloud (from which flashes of lightning were seen directly after, making the existence of the cloud certain) between the cupola of the Town Hall and the N. E. side of Mr. Gummere's house, which limited my view; and as this space subtended an angle of only 13°, I could not well be many degrees in error as to the actual point of disappearance. I noted the relative positions of this point and the cupola at the time, with a view to subsequent measurement, and upon taking a theodolite to the spot, and directing the telescope to the point as near as possible, I found the result to be—

"Azimuth (true) S. 81° E. Altitude 5° 27′.

"We afterward took the instrument to Mr. Aertsen, who went to the spot where he stood, and fixed the telescope. The readings were—

"Azimuth (true) S. 81¾° E. Altitude 5° 32′.

"I got two of my friends to try the same instrument. They had had an equally good view, but had not noted the positions at the time, with any view to measurement, and did not feel at all confident (as Mr. A. and myself were) of being able to give tolerable results. They were—

"1. Azimuth S. 88° 30′. Altitude 9°.
"2. Azimuth S. 85° 45′. Altitude 8°."

"4th. As to the time occupied by the flight, the first remark I made was that it exceeded half a minute, notwithstanding that I was fairly on my guard against the tendency to overestimate short intervals.—I had nothing definite to determine it by; but it fortunately happened that some of our party were in motion during nearly the whole time, and this afforded evidence of a positive character." Mr. Marsh here gives an accurate drawing, showing the exact plan of Mr. Gummere's house and the adjacent grounds, and the route taken by two different persons around the house, in order to keep sight of the meteor. One went 240 feet, and the other 220, and, at his request, both repeated their respective movements, while he carefully noted the time by a watch. The results, after allowing 5 seconds for time spent in viewing the meteor after they stopped, were 40 seconds and 45 seconds.[1]

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[1] According to calculations, as shown in Table II, Mr. Aertsen first saw the meteor at 9h. 42m. 37 sec., Mr. Marsh at 9h. 42m. 58 sec., and it went out of sight of the latter at 9h. 43m. 40 sec.; so that it was visible to Mr. Marsh for 42 seconds, and to Mr. Aertsen probably for more than a minute. It is probable, too, that those who went around the house did not see it sooner than Mr. Marsh did, as the house was, at first, directly between them and the meteor.

Gettysburg, Pennsylvania, No. 218. Communicated by Prof. M. Jacobs, from a description obtained from members of his family who saw the meteor. He estimates the time of flight at 50 to 60 seconds, and that it separated into *two* parts at the azimuth N. 10° W., and into *three* after it passed the meridian; also that the azimuth of the point of its first appearance was N. 75° W., and the altitude 20°; but not seeing it himself till it had nearly completed its course across the heavens, he does not express confidence in these determinations.[1]

Green Point, Long Island (3 miles N. E. of the City Hall in New York). Estimated time "near 10 o'clock P. M."[2]

Greenwich, Connecticut, Lat. 41° 3′, Long. 73° 39′. Visible nearly two minutes.

Hagerstown, Maryland, No. 189. Observed by John H. Heyser, who says the meteor was visible for 15 seconds, and disappeared in the direction E. S. E. at an altitude of 8° to 10°. He also says that its "elevation when opposite me, that is, when my position was at right angles to its course," was 45°.

Hamilton, Canada West, Nos. 76(a) and 168. No. 76(a) is from a somewhat elaborate article on the meteor, by J. Hurlburt, published in the Hamilton Spectator, in which it is stated that "it was seen in this city at 9h. 20m. by the Great Western time, as decided by a conductor of one of the trains just coming into the depot. Its altitude was somewhat nearly ascertained to be about 15° south of the zenith." He says also that the apparent direction of the path was a little north of east. No. 168 was communicated by Dr. William Craigie, who took much pains, at the time, to ascertain the facts in regard to the meteor's path. He says: "The general account was that it passed *right overhead from west to east;*" but he could find no one who saw it much west of the meridian. One man, who was sitting at his own door, fronting easterly, saw the light, and, looking up, saw the meteor come in sight "in a line with the corner of the eaves-trough of an adjoining house; but he was not sure whether he had not started to his feet ere he saw it. The bearing was about S. 15° W., and the altitude, if seen when sitting, about 80°; or, if standing, about 75°. The meteor, he says, was visible to him 15 to 20 seconds, and "disappeared behind a house in a direction east, or perhaps a little north of east, and at least 15° above the horizon."[3]

Hamilton College Observatory, New York, Nos. 12, 23, and 181. Observed by Dr. C. H. F. Peters, and communicated in a letter, from which the following extract is taken: "The beautiful aspect of the meteor of July 20th, I must confess, surprised me so, that I paid but a secondary attention to its path among the stars. The following notes, however, were taken at the moment: 'Moving slowly from the northwestern horizon, near α *Virginis*, the meteor passed a little above η Ophiuci,

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[1] According to the calculated path, the first separation occurred at the azimuth N. 8° 48′ E., and and the second at N. 58° 42′ E. Its altitude was at no time so great as 20°, nor its western azimuth so great as 75°. If it disappeared, as is stated, in the direction N. 75° E., and was visible one minute, it must have first appeared at the azimuth N. 44° W., and at an altitude of about 8½°.

[2] According to calculation, it passed the meridian of Green Point at 9h. 48m. P. M.

[3] According to calculation, it was first seen at 9h. 23m. 31 sec. by Hamilton time, and reached an altitude of 15° from the eastern horizon at 9h. 23m. 47½ sec., making it visible 16½ seconds; but the eastern azimuth was some 38° more southerly than is stated in the text.

then a little above Mars, and disappeared on the horizon in the southeast, as it seemed, nearly opposite to where it arose, thus describing a great circle. Its duration I estimated at 15 or 20 seconds,[1] and the time was 9h. 44m. (mean time). When arrived in a southwest azimuth, it exploded like a bomb-shell, scattering about several pieces with white and blue colors. This explosion, however, did not seem to disturb the principal mass, which proceeded in its course, now followed closely by two or three smaller pieces as a train." In another letter he adds: "The distance the meteor passed above Mars was certainly less than 11°, and that above η Ophiuci still less, since this latter seemed almost covered by the spray."

Hanover, New Hampshire, No. 206. Observer's name not ascertained. "Throughout its passage from W. to S. 70° E. it presented nearly a uniform distance of 20° above the horizon." Time of passage at least one minute."[2]

Harrisburg, Pennsyslvania, No. 231. Observed by Cromwell F. Varley, who says of the meteor: "By Baltimore (or Relay) time it was 9h. 38m. P. M." "When I first caught sight of it, it was about as far to the north of α Aquilæ, or rather a line from the zenith passing through that star, as that line was from the planet Mars. Its elevation above the horizon, at that time, was about as much as that of Mars, or 1° lower. Its course was toward Mars, and if continued would have passed about 5° or 10° below that planet." But he says that the view was obstructed before the meteor reached the azimuth of Mars.

Another observer says it passed "a few minutes before 10 o'clock."[3]

Hartford, Connecticut, Nos. 112(a) and 156. Observed by Mr. Mason, a gardener, and communicated by Prof. Brocklesby, of Trinity College, who writes: "Not more than a minute before the appearance of the meteor, Mr. Mason looked at his watch, and found it was a quarter to ten. The place of the appearance of the meteor he fixed by the bough of a tree, and the point of disappearance also by a tree, and he marked the place where he stood. I have taken the bearings and altitudes of the places of appearance and disappearance with a theodolite, and find them to be as follows —

Place of appearance	N. 64° W.	Altitude 8° 30′
Place of disappearance	S. 48° E.	Altitude 1° 10′

Mr. Mason is *sure* as to the place of appearance, but has a trifle less confidence as to the place of disappearance."[4]

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[1] According to calculation, it occupied 20 seconds in passing from the azimuth of α Virginis to that of Mars, reaching the latter at 9h. 42m. 18 sec.; but did not descend to the horizon at all. The calculated azimuth at the time of the first explosion is S. 53° 25′ W.

[2] According to the calculated path, its apparent motion was nearly parallel to the horizon, the altitude not varying more than 2° for a full half minute before it passed the meridian; but this altitude instead of being 20° was only 9° to 11°. If seen due west, its altitude was only 4° 44′, and it could at no time have been seen so far east as is stated in the text.

[3] By calculation, the meteor passed the meridian of Harrisburg at 9h. 36m. 56 sec. by Relay time. The different parts of the description do not seem to harmonize, as the eastern azimuth of α Aquilæ, at that time, considerably exceeded that of Mars.

[4] It is presumed that the bearings here given were *magnetic*, and if we add 6½° for the variation of the needle, they become N. 70½° W. and S. 54½° E. Both of these observations would be better

Another observer says the time was "about 10 o'clock."

Harvard Observatory, Massachusetts, Nos. 102 and 157. Observed by Prof. G. P. Bond, who says the time was 10 o'clock, the interval between the two observations 20 seconds, and the apparent diameter of the meteor 15.′ The mode by which the positions were determined, viz., S. W. altitude 12° and S. 50° E. altitude 10°, is not reported, nor the degree of accuracy with which they are supposed to be given.[1]

Hinsdale, New Hampshire, No. 220. Observed by Dr. J. H. Nutting from a point "on Connecticut River, three miles north of Massachusetts line." He says that the altitude of the meteor when due south was about 30°, as near as he could judge, and that it was in sight from 30 to 40 seconds.

Hiram, Ohio, No. 117. The position of the meteor, as pointed out by the observer, whose name is not reported, was determined by the "card method," and communicated by S. M. Luther. He adds also: "The point at which the meteor disappeared, I am informed, was about N. 50° E."

Hudson, Ohio, No. 121. In reply to inquiries by the author in regard to the meteor, Prof. Charles A. Young, of the Western Reserve College, writes: "It occurred during our college vacation, and since my return, I have not been able to learn of any observations of it in this place, worth recording. A few persons saw it low in the N. E. horizon; if I understand them right, not more than 10° or 15° high; but they seem to be very uncertain and indefinite as to the direction of its appearance, motion, and disappearance."

Huntingdon, Pennsylvania, No. 125. Position determined by Joseph Saxton, by the "card method."

Isle of Shoals (Appledore Island), New Hampshire, Lat. 42° 58′, Long. 70° 37′. The observer, whose name is not reported, says that the meteor first appeared at an azimuth 30° south of that at which the sun set; that it passed between δ and β Corvi; described an arc of 145° in azimuth, and was several degrees higher when it disappeared than when first seen.[2]

Kingston, New York, Lat. 41° 55′, Long. 74° 2′. Reported time of the meteor's passage 9h. 30m.[3]

Libertytown, Maryland, No. 180. Observed by R. L. Brocket, who reports that the meteor first appeared "a *little* west of north, at an altitude of about 25°; that

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satisfied if we suppose the variation at the time to have been 7° instead of 6½°. The calculated time when the meteor was at the latter of the two azimuths is 9h. 52m. 43 sec.

[1] According to calculation, 24 seconds elapsed, after the first observation, before the meteor descended to an altitude of 10°, and then the easterly azimuth was only about 28°; nor did it reach the azimuth S. 50° E. till 50 seconds later, when it was out at sea several hundred miles farther than it was seen by any other observer.

[2] The calculated path fails utterly to satisfy this description. Both the stars mentioned had set some time before the meteor appeared. The azimuth of the sun at setting was about N. 61° W., which would make that of the point where the meteor was first seen about S. 89° W., and that of its disappearance S. 56° E. The calculated altitude at the former point is about 6°, and at the latter much less.

[3] By calculation the meteor passed the meridian of Kingston at 9h. 47m. 47 sec.

it exploded when a little east of north; and that the duration of its passage was three minutes."[1]

Lima, Pennsylvania, No. 135. Observed by Minshall Painter, who reports that the meteor was "first seen at an elevation of 20° to 25°;" that it was a little higher when it passed the meridian; and that the duration of its passage was "not over one minute."

Lockport, New York, No. 177. Communicated by George Berk in reply to a letter from me. The following is an extract from his reply: "I found one gentleman, who saw the meteor, and observed it carefully, and verified his observations by visiting the ground the next day. He says that its course, through the greater part of its path, appeared to be nearly horizontal, and that its apparent altitude, when in the direction you name, S. 48½° E., was about 40°. I was not able to visit the place of observation with him to make any measurements, but as he has given considerable attention to this, and to astronomical phenomena generally, I have no doubt that the angle, as it appeared to him, is nearly correct."[2]

Lowville, New York, Nos. 58, 62, 95, 109, 115, and 128. Communicated by Dr. Franklin B. Hough, in reply to a letter from the author. The following is an extract from his reply: "In compliance with your request, I have made inquiries of several persons who saw the meteor of July 20th, and with a theodolite have taken the angles observed by them.

"Mr. Sweeney first saw it *due west* at an elevation of 9°. It issued from behind a cloud, and was rising (apparently). Soon after, it gave off sparks compared to Roman candles; seen over half a minute. It passed a point S. 9° E. at an elevation of 18° 15′, and disappeared at a point S. 38° E. at an elevation of 1° 12′.[3]

"Mr. D. A. Smith saw it S. 68° W. at an elevation of 22°; also S. 22° W. at an elevation of 24° 45′.

"Mr. W. H. Greeley and W. Watson saw it S. 38° W. 20° high.

"All agree upon its division into two parts, one following the other. The time is usually put at from 30 to 50 seconds.

"All the horizontal angles above given are from the magnetic meridian, which now varies 5° 45′ W. at this place."

Madison, New Jersey, Lat. 40° 46′, Long. 74° 29′. Reported time of the meteor's appearance "nearly 10 o'clock P. M."[4]

Marcy, New York, Lat. 43° 9′, Long. 75° 16′. Meteor exploded "when it passed the meridian."[5]

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[1] According to the calculated path, it exploded in the direction N. 7° 44′ E., but the meteor occupied less than 70 seconds in passing from the meridian of Libertytown to the farthest point east at which it was seen by any reliable observer.

[2] According to calculation, the meteor must have appeared to rise till it reached the azimuth S. 15° or 20° W., where its altitude was over 68°, and then apparently descended, reaching the altitude "40," at an easterly azimuth of about 50°.

[3] According to calculation, the interval between Mr. Sweeney's first and last observations was 61 seconds.

[4] By calculation, the meteor passed the meridian of Madison at 9h. 45m. 56 sec.

[5] According to calculation, the first disruption occurred some eight seconds earlier. See note under Washingtonville, page 31.

Marquette, Michigan, Lat. 46° 32′, Long. 87° 33′. According to the meteorological record kept by Dr. G. H. Blaker, of this place, the sky at 9 o'clock P. M., which, according to calculation, was about six minutes after the meteor passed the meridian of Marquette, was completely overspread with cirro-cumulus clouds, which he thinks prevented it being seen; though in a subsequent letter he says, "I am informed that a very bright meteor was seen on that evening by two persons" "immediately at the lower margin of the clouds in the south;" "it was moving toward the east, but very slowly."[1]

Matteawan, New York, Lat. 41° 30′, Long. 74°. Duration reported to be 40 to 60 seconds. Explosion heard two or three minutes after its disappearance.

Mauch Chunk, Pennsylvania, Lat. 40° 52′, Long. 75° 47′. Reported time 9h. 40′.[2]

Meadville, Pennsylvania, Nos. 110, 133, and 166. These positions were carefully determined by Prof. Huidekoper, of the Theological Seminary, and communicated to Prof. Lyman, of Yale College, who kindly furnished them to me. Prof. Huidekoper says that the apparent course of the meteor was about S. 65° E., and the time from crossing the meridian till disappearance 10 to 12 seconds.[3]

Melrose, New York, Lat. about 41°, Long. about 73° 50′. Reported time 9h. 45m.[4]

Middlebury, Vermont, Nos. 47, 130, and 139. Communicated by Prof. W. H. Parker, from observations made by George E. Plumbe, a member of the senior class in the college. Prof. Parker writes that Mr. Plumbe "first saw the meteor emerging from behind the cupola of a cotton factory, he standing at a certain point on the railroad bridge, some ten rods distant from the factory. My measurements with the theodolite give an altitude of 8°, and azimuth S. 52½° W. This must be very near the truth, the position being so well marked by fixed objects in range." "In the direction S. 24½° W. the apparent elevation, as nearly as he could determine, was 18°. At that point it had just passed behind a building. This was about the highest elevation it reached. Soon after this it separated into fragments;[5] several smaller ones that soon disappeared. Two remained visible as long as the meteor was in sight. It passed out of sight in the direction S. 36° E. It was obscured then by buildings in the distance, but very near the horizon. Mr. Plumbe says it seemed at the time to be very near. He thought it was not over a hundred feet high."

Mont Clair, or *West Bloomfield*, New Jersey, Nos. 96 and 193. The observer, under the signature "R. F. B.," says that the meteor was first seen in the direction N. 41° W., at an elevation of 6°, "when at right angles to my position, the eleva-

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[1] While this description seems to correspond very well with the calculated path in other particulars, it fails to do so in regard to the *altitude* of the meteor. For as the sky, if not entirely overspread with clouds at the instant, was so nearly so that the "lower margin" must have been near the horizon, while the calculated altitude of the meteor as seen due south from Marquette is about 40°.

[2] Time of meridian passage, by calculation, 9h. 40m. 35 sec.

[3] According to calculation, the interval was 23 seconds.

[4] Time of meridian passage, by calculation, 9h. 48m. 32 sec.

[5] According to the calculated path, the greatest elevation was reached at about the azimuth S. 40° W., and was then only about 14°. Also, the second dismemberment of the meteor occurred about four seconds after this observation; the first having taken place just before the meteor came in sight.

tion was near 50°"—that it exploded at an altitude of 30° to 40°, and that it disappeared S. 46° or 47° E., at an altitude of 4½° to 5°.[1]

Morristown, New Jersey, Nos. 138, 196, 204, and 209. No. 138 was observed by Dr. Rust, and the position estimated by the "card method" by himself and Mr. B. Harrison, by the latter of whom it was kindly communicated to the author. The others were observed by Prof. Quimby, of Rochester University, and communicated to Dr. B. A. Gould, of Cambridge, by whom they were furnished to the author. Prof. Quimby reports 35° as its greatest altitude, 20° as its altitude at the time of exploding,[2] and that it passed just above Cassiopeia. This latter gives the position No. 209.

Nantucket, Massachusetts, Nos. 39, 41, 105, 151, 152, 197, 199, 228, and 230. Communicated by Hon. William Mitchell, from observations made by others. The following is an extract from his letter:—

"I regret extremely that I could not have seen the interesting meteor of July 20th. If I had seen it myself, I am persuaded I could have given reliable localities. In collecting what I have, I confess I am astonished at the absurdity of the results. I send them, however, just as they are, in the hope that *something* may be gathered from them. * * * * * The directions were obtained by William C. Folger, Esq., an excellent surveyor; the angles were obtained by myself at the same time, by placing a sector on the compass, made perfectly level, the observer opening it until the estimated position of the meteor was seen in the direction and along the upper edge of the elevated leg of the sector." "All observers agree that it divided after they first saw it, and the mean of the estimated size is one-third of the moon's disk; and the time 10 o'clock.[3] Every observation was within 1500 feet of my observatory, whose Lon. is 70° 6′, and Lat. 41° 16′ 53.3″."

No. 39 was observed by George Clark, Esq., No. 41 by Lucy Starbuck, No. 105 by Rebecca Clapp, Nos. 151, 197, and 230 by Asa G. Bunker, Esq., and Nos. 152, 199, and 228 by Peter Folger, Esq.

Newark, New Jersey, Lat. 40° 45′, Lon. 74° 10′. Reported time 9h. 45m.[4] "Visible about half a minute."

New Bedford, Massachusetts, No. 224. An account of the meteor, published in the New Bedford Mercury, says that "it appeared to pass in a direction nearly parallel with the horizon, at an elevation of 34° or 35°," time 9h. 57m.[5] In a note

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[1] According to the calculated path, the meteor passed the meridian of Mont Clair at an altitude of 50° 39′; but if by the words, "at right angles to his position," the observer intends to designate the point where a line drawn from his eye would intersect the meteor's path at right angles, the altitude at that point was over 53°, as shown in the table (No. 96). The calculated altitude, at the first explosion, is less than 30°, and at the second over 50°. The azimuth S. 46° or 47° E., is much too southerly for any point in the calculated path.

[2] According to the calculated path, the greatest altitude, and the altitude at the time of the second explosion, were both over 45°. The first explosion occurred before the meteor was seen by Prof. Quimby.

[3] Time of meridian passage, by calculation, 10h. 3m. 55 sec.

[4] Calculated time of meridian passage, 9h. 47m. 12 sec.

[5] Calculated time of meridian passage, 10h. 0m. 30 sec.

received from Mr. Horatio Hathaway, through his father-in-law, S. Rodman, Esq., the time of its appearance is given as 9h. 50m.,[1] and he says the meteor seemed to be quite a minute in view, but intimates that this estimate is probably exaggerated.

New Brighton, New York, Nos. 15 and 22. Extracted from a newspaper, in which the observer says: "The head was then nearly in a line, from where I stood, with the lower star of the Great Bear." * * * * "It passed me at an elevation angle of 45°, or more, to the north." Duration about 30 seconds.

New Britain, Connecticut, No. 217. Observed by L. M. Guernsey, who says the altitude was "about 60° above the horizon while passing the point at which I stood."

New Brunswick, New Jersey, No. 17. Communicated by Prof. Theodore Strong, who says: "The most reliable account is that of Mr. Philip Meyers, who says that he had a very fine view of the meteor when it was nearly north, and that its apparent motion was nearly horizontal, at an angle of elevation between 30 and 35 degrees."

Newburgh, New York, Lat. 41° 30′, Lon. 74° 5′. Observed by Mr. McCoy, who says that it was visible about 2½ minutes. Time 9h. 50m.[2]

Newburyport, Massachusetts, Nos. 38, 100, 112, and 188. No. 38, 100, and 112 were communicated by Dr. H. C. Perkins, as follows: "Yours of the 16th was duly received, and I hasten to reply, that from the statement of a reliable individual I have drawn the line as you desired" (*i. e.*, by the "card method"), "standing where he stood, and observing the point where he saw it.

"I would also inform you that, according to the observation of Mr. N. C. Greenough, it was not far from 11° above the horizon when it passed the meridian of this place. He thinks it was about 4° or 5° above the horizon, in the S.S.E.,[3] when last seen."

No. 188 was communicated by Mr. Greenough to the Smithsonian Institution. He says it commenced about midway between Arcturus and the horizon, and disappeared 10° to 15° southeast of Mars.

New Haven, Connecticut, Nos. 24, 31, 33, 36, 42, 48, 69, 99, and 214. All these observations, except Nos. 69 and 214, were communicated by Profs. C. S. Lyman and H. A. Newton, of Yale College. Prof. Newton writes: "There was one observation" (No. 99) "by Prof. Lyman, S. 63° W. (Ast.) from New Haven. Altitude 42°. He saw it first near the top of a tree, and the discussion was raised, whether it came from behind the tree, or had passed entirely above it. He measured the top of the tree as above." In regard to this observation, Prof. Lyman says: "I attach very little importance to this observation. I did not see the meteor myself till after it had passed the tree—none of the gentlemen made any definite observation with respect to the tree. All were crowded inside of a bay-window, and saw the meteor

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[1] Calculated time of meridian passage 10h. 0m. 30 sec.

[2] Calculated time of meridian passage 9h. 47m. 34 sec.

[3] From the statement that follows, viz: That the meteor disappeared 10° to 15° southeast of Mars, it would appear that instead of S.S.E. the azimuth must have been about S. 34° E., and accordingly the computation is made for this latter azimuth.

under great disadvantages. I can readily allow the impression, with regard to its touching the tree-top, to be in error 4° or 5°."

Prof. Newton continues: "At S. 28° W." (No. 31) "we concluded that it was 53° high," and in relation to this position Prof. Lyman adds, that "being the average of a large number of observations, as determined from a celestial globe, it is undoubtedly far superior to all others for New Haven."

Prof. Newton proceeds farther: "The track did not pass far from Arcturus, probably a trifle south of it" (No. 24). "In the S. E. the meteor disappeared to most of us (our observers; I did not see it) in clouds. One person saw it S. 47° E. Alt. 20°. Another, S. 57° E., Alt. 10°. Another, S. 54° E., Alt. 13°, Seven degrees we allowed here for variation of the compass."

Prof. Lyman, alluding to a previously published statement, says: "The observation of altitude at S. 17° W." (No. 41) "I thought, at the time, a close approximation, yet liable to possible error of 1° or 2°—possibly more."

No. 69 is from a communication signed "E," in the New Haven Courier.

No. 214 is from a New Haven newspaper, in which the editor says: "It rose near the horizon at about N. 60° W., swept along the southern quarter of the heavens, at an altitude on the meridian of 30° to 40°, and passed from view S. 62° E." * * * * "For many of these facts I am indebted to E. C. Herrick, Esq."

"The time of flight, for the different observers, determined by repeating various acts performed while it was in sight, ranged from 10 to 20 seconds, giving an average of 14 or 15 seconds." Time of the middle of the flight 9h. 52m. 15 sec.[1]

Newport, Delaware, No. 203. Maximum height "may have been 25°." Name of observer not ascertained.

Newport, Rhode Island, Lat. 41° 29′, Lon. 71° 19′. Reported time "about 10 o'clock"[2]—in sight about two minutes. Name of observer not ascertained.

Newton Corners, Massachusetts, Lat. 42° 19′, Lon. 71° 13′. Reported time "about 10 o'clock."[2]

New World (steamer), New York, No. 26. The observer, who signs himself W. H. S. in a newspaper article, was on board this steamer, just entering the Highlands, on her passage up from New York, at 9½ o'clock.[2] He says that the meteor passed just south of his zenith, and that the time of flight was "certainly not less than a minute, because there was ample time, during the flight, to form, discuss, and alter opinions" in regard to it.

New York City, Nos. 28, 64, 123, 145, and 226. Observed by W. S. Prime and J. D. Lawson, from the S. W. corner of Broadway and Fourth Street; angles, &c. measured by Prof. Newton, of Yale College, from whom we have the following

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[1] According to the calculated path, the meteor was seen in azimuth S. 63° W. at 9h. 52m. 9 sec., and disappeared in azimuth S. 47° E. at 9h. 52m. 23 sec., thus making the time of flight 14 seconds, and that of the middle of its passage 9h. 52m. 16 sec. To those who traced the meteor to a more easterly azimuth, the time of flight was, of course, a few seconds longer, and that of the middle of its passage proportionally later.

[2] Calculated time of meridian passage at Newport, R. I., 9h. 58m. 52 sec.; at Newton Corners, 9h. 59m. 20 sec.; and at the New World, 9h. 48m. 7 sec.

description of the observations: "The meteor was first seen on the line of Fourth Street, just by the cornice of a building which was noted at the time. Alt. 3° 45′. When 14° 30′ from the line of the street, the altitude was 23° 45′. On the line of Broadway it was $52\frac{3}{4}°$ to 53°. The meteor passed behind the steeple (about one degree broad) 15° azimuth from the line of Fourth Street, at an altitude of 24°." The position on the line of Broadway was determined by the cornice of a building on the N. W. corner of Broadway and Fourth Street, the height of which above the eye of Mr. Prime was, according to the measurement of Prof. Newton, 64 feet, and the horizontal distance 45 feet. This gives an altitude of 54° 53′; but Mr. Lawson says, that the meteor passed "for a second or two" behind the cornice, which would make the altitude less. In the calculations it is assumed that Fourth Street is perpendicular to Broadway, whose course, according to the map of the Harbor Commissioners, Prof. Newton says, is N. 32° 31′ E., thus making that of the former street N. 57° 29′ W. But the observations will be better satisfied, if we suppose them to vary a degree or so from right angles, so as to make the latter course about N. $58\frac{1}{2}°$ or 59° W. It was visible, according to the estimate of Mr. Prime, about 27 seconds. A correspondent of the New York World estimated it to be $1\frac{3}{4}$ minutes. Edward L. Gill, No. 281 Hudson Street, estimated it to be 1 minute. Reported time 9h. 40m. to 9h. 45m., more generally the latter. Mr. Prime compares the velocity to that of "a flock of wild pigeons two hundred yards in the air."[1]

Norfolk, Virginia, No. 11. An observer (name not reported) says it "appeared near the northern horizon."

North Haverstraw, New York, Lat. 41° 15′, Lon. 73° 58′. Visible "about $1\frac{1}{2}$ minutes."

Norwalk, Connecticut, Lat. 41° 6′, Lon. 73° 24′. It is stated, in an article in the New York Herald, that a sailor saw it pass vertically over his vessel, on Long Island Sound, near this place.

Norwich, Connecticut, Lat. 41° 33′, Lon. 72° 7′. Visible "a full minute"—"disappeared at a point about 15° east of the planet Mars."

Oberlin, Ohio, Nos. 73, 113, 114, 124, and 137. Communicated by Prof. J. H. Fairchild, as follows: "I am sorry that we have no exact measurements upon the altitude of the meteor. I had myself the pleasure of a fair view of it through its entire course along our sky, but did not think to raise the question of altitude until the next day. Prof. Morgan and myself were standing at the corner of the street, in conversation—my face toward the northwest. To my observation, the meteor did not rise from the horizon, but burst into view in the northwest, in the constellation Ursa Major, below the 'dipper.' Its altitude could not have

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[1] According to the calculated path, the meteor passed the meridian of New York at 9h. 47m. 51 sec.—the interval between Mr. Prime's first and last observation was 50 seconds; and the apparent velocity the same as the pigeons would have at the distance of 200 yards, if flying at the rate of about 80 miles per hour. If the whole visible arc was passed over in 27 seconds, the pigeons would have to fly about 150 miles an hour in order to have the same apparent velocity as the meteor.

varied greatly from 25° at the position 'N. 26½° W.' Its altitude increased but slightly, if at all; it crossed the meridian 12° to 15° below the pole star (perhaps a little less), finally disappearing without falling below the horizon, at a point N. 85° E., and at an altitude of perhaps 8°. For the last few seconds it seemed nearly stationary, comparing well with Venus in brightness, then with Jupiter, and so on to its disappearance. Its altitude diminished slowly after it crossed the meridian—more rapidly, I think, as it approached the east. At a point 'N. 61¼° E.' it may have been 20°. These are the results of my reconsideration of the matter next day, and of a careful comparison of my impressions with those of several of my colleagues, who also witnessed it. Their attention was, I think, in all instances attracted by the *reflected* light. No one of them saw it at its first appearance. I think I cannot be mistaken in the conviction that I saw it when it first became visible." * * * * "There were various estimates among us, as to the time during which it was visible—ranging from 10 to 30 seconds. My own feeling inclines to the latter estimate.[1] Upon reviewing what I have written, I think I may have put the point of the disappearance of the meteor a little too low. When it comes again (!) I hope to have my wits about me, so as to furnish you more reliable information."

Ogdensburg, New York, No. 13. Communicated by William E. Guest, Esq., from the observations of several persons who were standing near each other, and who all agreed as to the point upon a factory steeple with which the meteor came in range. The angle was measured by Mr. G. by the "card method."

Olean, New York, Lat. 42° 5′, Lon. 78° 34′. Visible "nearly or quite two minutes"—passed near the zenith.

Osceola, Illinois, Lat. about 41°, Lon. about 90°. Communicated by Dr. John S. Pashley, as follows, under date of September 12, 1860: "On the evening of July 20th, our attention was directed to a phenomenon similar to a falling star of unusual magnitude and brilliancy, but so rapid was its motion, and so comparatively small was the appearance of the same, that we paid very little attention to it, not suspecting that it was anything of rare occurrence, nor have I since been decided as to whether it was the meteor spoken of, although the time of its appearance, and its erratic course, in many published accounts, correspond with our observation. Its general course here (if my memory serves me) was from N.W. to S.E., and it was north of the zenith."[2]

Oswego, New York, Lat. 43° 28′, Lon. 76° 35′. Reported time 9h. 40m.[3]

Owego, New York, Lat. 42° 7′, Lon. 76° 18′. Rev. Thomas K. Beecher, of Elmira,

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[1] The calculated interval between Prof. F.'s first and last observation is 58 seconds.

[2] This description is inserted, not as affording any material aid in developing the path of the meteor under discussion, but because Osceola is considerably farther west than any other place at which the meteor was seen. If it was really seen from Osceola, the line of vision must have been above the clouds that obscured the sky farther north—which might easily be. Its meridian altitude must have been about 28½°, and the time about 8h. 42m. P. M. Its apparent motion must have been only about 2° per second, which could hardly be called "rapid."

[3] Calculated time of meridian passage, 9h. 37m. 19 sec.

says that the time from the disruption of the meteor to its disappearance, as noted by two observers at this place, was 90 to 100 seconds.[1]

Oysterbay Point, New York, No. 30. Observed by Dr. William Stimpson, from a vessel on the Sound, near this place, to pass near the zenith—"if anything, a little north."

Paterson, New Jersey, Lat. 40° 55′, Lon. 74° 10′. Reported time 9h. 40m. to 9h. 45m.[2]

Peekskill, New York, Lat. 41° 18′, Lon. 73° 57′. Mr. Connor, on the Hudson River Railroad, opposite this place, and going north, saw the meteor ahead of him.[3] (Reported in the New York Herald, July 21, 1860.)

Perth Amboy, New Jersey, No. 202. The observer, under the signature of "R. M. C.," reports the maximum altitude as 65°.

Philadelphia, Pennsylvania, Nos. 91, 143, and 148. The observer, A. Zumbrock, in his report to the Smithsonian Institution, says that the meteor passed midway between γ and δ Cassiopeiæ, parallel to a and γ, which, he says, "would make its altitude about 24°"—that its path from the azimuth of Polaris, where it was first seen, to that of Cassiopeia, seemed horizontal; from thence to Deneb downwards, being about 2° lower at the latter azimuth. Time of passage from azimuth of Polaris to that of Deneb, 5 to 6 seconds. Time of disappearance 9h. 43m. It consisted of two parts.[4] By another observer's report the time was 9h. 30m.

Pittsford, New York, No. 79. The observer, L. L. Nichols, reporting to the Smithsonian Institution, says that the greatest altitude of the meteor was about 60°; that it was visible about 30 seconds, at about 10 o'clock P. M., and that it described an arc of about 120°.[5]

Point au Barque, Michigan, Lat. 44° 4′, Lon. 82° 57′. The information from this place was obtained after much labor and many fruitless inquiries. The meteor being supposed to have passed nearly through the zenith of Saginaw, letters were addressed in the summer and autumn of 1860, to a number of persons residing in that region and beyond, soliciting their aid in obtaining data with regard to it. The request was kindly acceded to, and among others Rev. Dr. Duffield, of Detroit, Dr. J. C. Willson, of Flint, Dr. Geo. B. Willson, of Marquette, Lieut. Orlando M. Poe, of the U. S. Lake Survey, Dr. Seth L. Andrews, of Romeo, and, through him, Dr. George A. Lathrop, of East Saginaw, gave particular attention to the matter. For a long time the only information obtained was that

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[1] The calculated time from the disruption near the zenith of Ithaca to the point where it was last seen by any reliable observer, is 69 seconds.

[2] Calculated time of meridian passage 9h. 47m. 14 sec.

[3] According to the calculated path the meteor passed 8 miles *south* of the zenith of Peekskill.

[4] In the calculations, a first disruption is assumed to have occurred just before the meteor came in view, and a second while it was passing Cassiopeia—from Polaris to Cassiopeia the meteor rose 5′, according to the calculated path, and from thence to Deneb, fell 4° 28′. Time from Polaris to Cassiopeia, 6 seconds, and from thence to Deneb 8 seconds, reaching the latter at 9h. 43m. 22 sec.

[5] According to calculation the arc described in 30 seconds, as seen from Pittsford, was about 140°, and the time of meridian passage 9h. 32m. 30 sec.

the meteor was not seen; but at length, June 8th, 1865, a letter was received by Dr. Andrews, from Dr. Lathrop, from which the following extract was forwarded to the author: "I have seen recently at Port Austin, a Mr. Larned, proprietor of the large saw-mill there, who informed me that one of his men was fishing on the lake that night, about a mile from the shore, who saw the meteor, and was extremely frightened by the same. According to his statement the meteor was directly over his head. He was under the impression that it would strike him, as it came directly towards him, and hence his fright." Immediately on the receipt of Dr. Andrews' letter, I wrote to Mr. Larned, who, in his reply, gave the following additional particulars: "The men were returning from the fishing-ground as near 9 o'clock P. M.[1] as they could judge, and when about four miles northwest of Point au Barque, they saw the meteor coming, they say, from a point a little south of east (!), and passing midway between them and the Point (au B.). It appeared to them (one says as large as a shanty) 20 by 30 feet in size, and made a hissing noise, and emitted sparks in passing. They say it moved through the air in an undulatory course, being, as they supposed, sometimes within 20 feet of the water, and then again two or three hundred feet from it. It was seen also by the fishermen at Pigeon River and the Au Sable River (40 miles across the bay). Our men think they saw it from 3 to 5 minutes. They were much excited, and had the ropes over the sides of the boat, ready for a bath if it came too near."

Pontiac, Michigan, Nos. 2 and 84. The observer, under the signature C. H. B., in a newspaper report, says: "At about 12 minutes past 9 (Cleveland time)[2] I saw a meteor apparently coming towards me from a little north of west, and but a few degrees above the horizon, emerging from the 'heat lightning,' which at that time illuminated the entire western horizon." He says further, that "throughout its entire course it seemed to ricochet or bound through the air;" that it disappeared "some 5° above the eastern horizon, nearly 1½ minutes from its first appearance."[3]

Port Chester, New York, Lat. 41° 1′, Lon. 73° 42′. "Passed almost vertically, and exploded when almost at the meridian."[4]

Poughkeepsie, New York, Lat. 41° 41′, Lon. 73° 55′. Reported time 9h. 30m.[5]

Providence, Rhode Island, No. 223. Communicated to the Providence Journal. The writer says: "It appeared to be double, and to pass in a direction nearly parallel with the horizon, and elevated about 35° or 40° above it. An observer who was in Hope Street at the time, saw it explode when nearly south of him." Time 9h. 57m.[5]

Quincy, Massachusetts, Lat. 42° 15′, Lon. 71° 2′. Reported time 10h. 2m.[5]

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[1] Calculated time of meridian passage "4 miles N. W. of Point au Barque, 9h. 10m. 55 sec."

[2] Calculated time of meridian passage at Pontiac, by Cleveland time, 9h. 16m. 21 sec., or at 9h. 10m. 5 sec., by local time.

[3] By calculation the meteor was seen for 34 seconds after it passed the meridian, and if it was seen as long before, the whole time would be 1m. 8 sec.

[4] According to the calculated path, it passed about 4 miles from the zenith, and exploded 2 seconds before it reached that point.

[5] Calculated time of meridian passage at Poughkeepsie, 9h. 48m. 15 sec.; at Providence, 9h. 58m. 27 sec.; at Quincy, 10h. 0m. 5 sec.

Reading, Pennsylvania, Nos. 53, 108, and 136. Observed by James F. Smith, who says: "The angles were taken with a transit instrument on the morning of the 21st, and are believed to be a close approximation to the truth, as the impression of the elevations was still very distinct." Time 9h. 50m.[1] L. H. Kendall, who also observed the meteor at this place, says it was in sight 1½ minutes.

Rip Van Winkle (steamer), No. 144. Observed opposite the Atlantic Docks, Brooklyn, and reported under the signature "* * *" in the Newark Advertiser of July 27th. The observer says that the time was 9h. 45m.;[1] the altitude, when first seen, in the W.N.W. 10°; the maximum altitude "considerably more than 45°," "somewhere near 60°," and says it "finally appeared to merge in Mars—the position of that planet being in the precise point of disappearance; so nearly so, that for several seconds I thought the meteor was still in sight."[2]

Riverdale, New York, Lat. 40° 55′, Lon. 73° 56′. Visible over 45 sec.

Rochester, New York, Nos. 81, 175, and 182. No. 81 was reported in the Rochester Union of July 21st; Nos. 175 and 182 were received from Prof. Chester Dewey, who, after remarking upon the poorness of the observations, says: "From my best knowledge the elevation of the meteor here was, at the highest, about 30° above the horizon, and its course S. 70° or 72° E.[3] In the direction S. 39° 20′ E. it could have been about 25° to 26°, or some less. A report was heard here about *three* minutes after the meteor passed out of sight—for it seemed to explode as it disappeared, and then appeared double." Another account makes the interval four seconds.[4]

Rockund, Pennsylvania, No. 158. Observed by John F. Frazer, who says that it appeared N. 60° W., and disappeared S. 85° E. (magnetic); that it passed through Cassiopeia at an altitude of about 35°, but eclipsed all the stars in the vicinity, and that the time was 9h. 45m.[5]

Romeo, Michigan, No. 179. Observed by Dr. Seth L. Andrews, who writes: "I was out and saw the light of the meteor after it had passed the meridian, and perhaps 60° or 70° above the eastern horizon; but it was cloudy and I only had glimpses through the rifts, and did not see the body. At an elevation of 40° or 50° it passed behind a dense cloud, and did not appear again until very near the horizon, when a narrow rift in the clouds showed me that it set very nearly in the east. Its passage was very slow, so that I stopped my horse (I was riding in my carriage) to

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[1] Calculated time of meridian passage at Reading, 9h. 40m. 3 sec.; and on board the Rip Van Winkle 9h. 47m. 51 sec.

[2] According to the calculated path, neither the western nor the southern azimuth was so great as reported by this observer. At the altitude 10°, the western azimuth was somewhat less than 60°, and the southeastern azimuth of Mars at the time was 28° 32′ 38″, while that of the meteor exceeded 60°.

[3] The calculated course of the meteor, as it passed the meridian of Rochester, is S. 74° 30′ E.

[4] If the "report" was caused by the disruption near the zenith of Ithaca, and assuming the sound to travel 1130 feet per second, the interval should have been, according to the calculated path, about 7½ minutes.

[5] Calculated time of meridian passage 9h. 42m. 10 sec.

gaze; but after it passed behind the dense cloud, and having waited a little I was about to start, it reappeared near the horizon. There were no stars visible by which I could fix its point of appearance, or its track; but its course seemed to me very nearly east—perhaps a little south of east.[1]

Royalton, New York, Lat. 43° 6′, Lon. 78° 40′. Observed by Lewis Swift, who says that the meteor passed from W.N.W. to E.S.E. "a little south of the zenith,"[2] and that it was in sight probably about 1½ minutes.

Sag Harbor, New York, Nos. 106, 147, 153, 212, and 231. Communicated by Ephraim N. Byram, by whom also the measurements were made of positions estimated by the observer, John C. Smith. These estimates and measurements were kindly made at the request of the author, more than two months after the meteor appeared, and must of course be less reliable than if they had been made at the time.

Saratoga, New York, Lat. 43° 6′, Lon. 74°. Reported time 10 o'clock.[3]

Search (steamer), No. 3. Communicated by Capt. George G. Meade, Superintendent of the U. S. Lake Survey, and Lieut. Orlando M. Poe, Engineer and Astronomer, from observations made by the latter. After remarking that he had a very distinct view of the meteor at times, though the sky was so much obscured by light clouds as to render it impossible to project its path upon the heavens by reference to the stars, Lieut. Poe says that when first seen in a direction between E. by S. and E.S.E., "it appeared to be a brilliant ball, of one-half the moon's diameter, and at an altitude of about 40°. The direction of its path was from N.W. to S.E., and extended through nearly 10° of arc. It brilliantly illuminated the clouds in its vicinity, and moved very slowly, occupying about 20 seconds of time in passing over the space estimated above.[4] It did not, while visible to me, break into fragments."

Seneca (barque), No. 11. Observed by Capt. Feinhagen of this vessel, off Barnegat light. Another account of this observation adds that the motion was "tremulous," and the duration about 30 seconds. Time 9h. 45m.

Sneeden's Landing, New York, Lat. 41° 3′, Lon. 74°. Reported in the New York Evening Post to have passed almost vertically over this place.[5]

Southampton, New York, Nos. 66, 70, and 149. Copied from a newspaper report, in which the observer, under the signature "H," says of the meteor, that, "At about 9h. 50m.[6] o'clock it was seen about 25° high to shoot upwards, like a rocket, from the constellation Leo Major;" that it "passed near Corona Borealis, crossing the meridian a little south of the zenith;" that it separated when near the

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[1] According to the calculated path, the course of the meteor, when it passed the meridian of Romeo, was S. 78° 12′ E.

[2] According to the calculated path, the meteor passed about 20 miles south of the zenith.

[3] Calculated time of meridian passage 9h. 47m. 49 sec.

[4] According to the calculated path, the apparent arc described in 20 seconds was over 30°, and the meteor, at the end of that interval, was within 10° of the eastern horizon.

[5] According to the calculated path, the meteor passed 9 or 10 miles N.E. from the zenith.

[6] Calculated time of meridian passage at Southampton, 9h. 54m. 29 sec.

meridian—passed 3° or 4° south of the Eagle, and disappeared at an altitude of about 30°, having been in sight about a minute.[1]

South Danvers, Massachusetts, No. 46. Observed by Mr. Marsh, one mile west of the town, who says the meteor passed below Mars about one-third of the way down to the horizon.

Southold, New York, Lat. 41° 2′, Lon. 72° 30′. Reported time about 10 o'clock P. M.[2]

Staten Island, New York, Lat. 40° 35′, Lon. 74° 10′ Reported time 9h. 45m. to 9h. 50m.[3]

Stratford, Connecticut, Lat. 41° 11′, Lon. 73° 8′. Reported time about 10 o'clock P. M.[4]

Sudbury, Vermont, No. 225. The observer, under the signature "J. H.," says the meteor was first seen W.N.W., and disappeared a few degrees east of south; that it was visible 30 to 40 seconds, and that it resembled Mars so much that some of the spectators, mistaking the latter for it, exclaimed that it was standing still.[5]

Syracuse, New York, Lat. 43° 1′, Lon. 76° 12′. Reported time 9h. 40m.[6]

Tarrytown, New York, Lat. 41° 7′, Lon. 73° 57′. The observer reports that the meteor appeared to separate at an altitude of about 60°, and that it was visible a little more than one minute.

Toronto, Canada West, Nos. 57 and 118. Communicated by G. T. Kingston, of the Magnetic Observatory, as follows, under date of August 31, 1860:—

"I did not see the great meteor of July 20th, and as I left Toronto early next morning, on a visit to the country for some weeks, I had no opportunity of questioning such persons as had casually seen it, till after my return. The observer on duty at the time was in the office, and was unable, therefore, to give any independent testimony with regard to it; and the few persons that it has been in my power to question, were evidently not much accustomed to take accurate note of such phenomena. However, as far as I can learn, the following were the facts:—

"The meteor appeared about 9h. 30m. P. M., Toronto mean time, and was visible (including partial interruptions by clouds) about 15 seconds. Its diameter was nearly equal to that of the full moon, and its light was considerably more brilliant. It appeared first at a point bearing S.S.W. from Toronto, and at an elevation of about 50°; it then seemed to move in a direction from W.N.W. to E.S.E., nearly parallel to the horizon, and disappeared at a point bearing S.S.E., with an altitude about 45°. It was not seen to separate into two or more parts. The view was

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[1] According to the calculated path, the meteor passed 20 miles south of the zenith, and the interval, from the time of the first observation till its eastern altitude was 30°, was 31 seconds.

[2] Calculated time of meridian passage at Southold, 9h. 54m. 4 sec.

[3] Ibid., Staten Island, 9h. 47m. 14 sec.

[4] Ibid., Stratford, 9h. 51m. 28 sec.

[5] According to the calculated path, the azimuth of the meteor, 40 seconds before it passed that of Mars, was W.S.W., at an altitude of about 10°; but at no time could it have been "W.N.W." May there not be a mistake of a letter in the record?

[6] Calculated time of meridian passage at Syracuse 9h. 38m. 53 sec.

much interrupted by clouds, so that during the course of the meteor, sometimes its general glare only was seen, and at others there was absolute darkness."[1]

Towanda, Pennsylvania, No. 87. Communicated by Selden J. Coffin, from an observation by J. H. Kingsbury, with reference to the eaves of a house near which he was sitting.

Troy, New York, Nos. 127 and 146. No. 146 was observed by D. A. Wells and Prof. Drowne, and No. 127 by another professor in Troy University. The observations are claimed to be of the "first class." The meteor appeared "exactly 10 minutes to ten," and was visible from 35 to 40 seconds.[2]

Turin, New York, No. 97. Observed by Dr. Franklin B. Hough, who estimates the time of flight at "about 40 seconds," and says, "I think it passed very near the planet Mars, but I was so absorbed in observing its appearance and changes that its track was not noted with precision. Its course was from a little north of west to the southeast, and it vanished nearly 2° above the horizon."

Utica, New York, Lat. 43° 5′, Lon. 75° 16′. Reported time 9h. 45m.[3]

Valley Forge, Pennsylvania, Nos. 37 and 191. Communicated to the Smithsonian Institution by Caleb P. Jones, who says that according to the testimony of one observer at this place, the meteor set behind hills in the east, at an elevation of 6° to 8°; that it consisted of three parts, and that the time was near 10 o'clock P. M.[4] Also, that another observer reports it as setting behind the hills at an altitude of 10°; that it was first seen just before its culmination; that the time of passage was estimated at some 15 to 20 seconds, and that the greatest altitude was "40°, or a little less."

Vernon, Vermont, No. 219. Observed by "A. P. C.," who reports to the Utica Herald that the greatest altitude of the meteor was 30°; that it was visible from one to three minutes, and that the time was 9h. 50m. P. M.[5]

Wallingford, Connecticut, Nos. 104, 129, 155, and 229. Communicated by Benjamin F. Harrison, who says that the observations are "very reliable, particularly No. 129. In the calculations for this place 6° 30′ is allowed for magnetic variation."[6]

Washington City, Nos. 68, 82, 86, 90, and 183. No. 68 was copied from an article published the following day (July 21) in one of the newspapers, as follows: "About half past 9 o'clock[7] last night a meteor appeared in the northeast, at an

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[1] According to calculation, the meteor was S.S.W. at 9h. 25m. 57 sec., was visible only 5 seconds, and disappeared 12 seconds before the first disruption. Apparent course when it crossed the meridian, S. 71° 20′ E.

[2] Time of first appearance of the meteor according to calculation, 9h. 49m. 9 sec.; time thence to the meridian, 14 seconds, and at the end of the "35 or 40 seconds" it must have been very low towards the southeastern horizon.

[3] Calculated time of meridian passage at Utica, 9h. 42m. 43 sec.

[4] Calculated time of meridian passage at Valley Forge, 9h 42m. 6 sec.

[5] Calculated time of meridian passage at Vernon, 9h. 49m. 58 sec. The calculated path would satisfy this observation much better, if we suppose it to have been made at Vernon, New York.

[6] The observations would be better satisfied if we suppose the magnetic variation at the time to have been 7° instead of 6½°.

[7] Calculated time of meridian passage at Washington, 9h. 35m. 51 sec.

elevation of about 10° above the horizon. It moved through a descending path to the E.N.E., and faded away in the clouds. It consisted of two bodies, each as bright as Venus when close to the earth, and lasted about 30 seconds." Nos. 82, 86, and 90 were observed by Mr. Yeatman, of the Coast Survey, with reference to the towers of the Smithsonian Institution, and the altitude estimated by W. S. Nicholson, also of the Coast Survey. No. 183 was observed by Prof. S. F. Baird, who says that the meteor "emerged from behind a house at the north at an altitude of about 20°;" that it "became invisible about E.N.E.," and that it was seen "about 20 or 30 seconds."[1]

In the Washington Star of July 23d, it is stated that the meteor was seen about 20 seconds before the first disruption; about 15 seconds between that and the second disruption, and that the whole time was about a minute.

Dr. A. W. Miller, who observed the meteor from Sixth Street, says it exploded when N.N.E., and disappeared nearly due east, at 9h. 35m., by Navy Yard time.[2]

In another report from this place it is said to have been visible 30 seconds after the first disruption. All observers at Washington agree that the motion at first appeared perfectly horizontal.[1]

Washington, New York (Dutchess County). Reported time 9h. 30m.[3]

Washingtonville, New York, No. 65. Communicated to Profs. Lyman and Newton, of Yale College, as follows: "As it approached, and when at an angle of 40°, it appeared to separate into two bodies."[4] * * * * "As it passed over our heads it appeared to be about 300 or 400 feet directly over us, or a little to the south." Another report says that the meteor passed about 10° south of the zenith.

Welchfield, Ohio, No. 78. Communicated by B. Z. Abell, who measured the altitude by the "card method," from an observation by others, which he thus describes: "Four persons (good judges) had the rare opportunity of seeing the meteor pass over about three-fourths of its arc, and were so situated with reference to the meteor, that in the required direction, N. 58¼° E., a material object very nearly marked its altitude," and adds that he thinks the angle as measured must be very near the truth.

Wellsville, New York, Lat. 42° 7′, Lon. 78° 6′. The following estimates of the altitude of the meteor at different azimuths that I had designated, were kindly made for me by Dr. H. M. Sheerar, by the "card method," from observations by Charles Collins, Esq.:—

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[1] According to the calculated path, the altitude did not vary half a degree through the first 30° of azimuth, and the meteor occupied 32 seconds in passing from due north to E.N.E., viz: 2 seconds before the first disruption, 16½ seconds between the first and second disruptions, and 13½ seconds after the second disruption.

[2] If seen at a due east azimuth it must, according to calculation, have been within 3° of the horizon, and the time of its disappearance must have been 9h. 36m. 33 sec., 59 seconds after the first disruption.

[3] Calculated time of meridian passage about 9h. 48m. 15 sec.

[4] According to the calculated path, the meteor did not attain an altitude of 40° (if that is what is intended by the word "angle") till some 5 or 6 seconds after the disruption. Possibly the parts were not separated far enough at first to attract notice.

Azimuths.	Altitudes.[1]
N. 57½° W.	62° 50′
N. 47¼° W.	65° 50′
N. 22° W.	70° 0′
North.	71° 30′

West Bloomfield, New Jersey. See Mont Clair, Nos. 97 and 190.

West Point, New York, Nos. 205 and 208. No. 205 was observed by Prof. Bartlett, who says in a communication to Prof. Lyman, of Yale College: "The meteor passed very near λ Cor Borealis, which at the time was near the meridian, so that the result is but an approximation." He estimates the time of flight at about a minute and a quarter. No. 208 was observed by Lieut. G. K. Warner, who says that the greatest altitude was 60° to 65°; the direction of its motion S. 48° E. by compass, and that it was seen for 45 seconds after it passed a due west point.[2]

West Roxbury, Massachusetts, Lat. 42° 19′, Lon. 71° 5′. Reported time about 10 o'clock.[3]

West Springfield, Massachusetts, Nos. 35, 67, and 72. Communicated by Rev. Theron H. Hawkes, from observations by a gentleman whose name he does not give. Of No. 67 he says: "The meteor was seen distinctly, and the locality of it accurately defined by two trees, before the house, whose branches formed an arch, in the centre of which it appeared." The altitude at this point was measured by the "card method." Nos. 35 and 72 were estimated without instruments, and the altitude at the former (viz. at S. 14° E.—an azimuth previously designated), Mr. H. says, "is partly a matter of conjecture, as at that point it was hidden from view by the thick foliage of the trees. But as nearly as we could judge, it must have been about 20°." The altitude at the point of the meteor's disappearance, he says, was "perhaps 6° or 8°."

Williamsburg, New York, Lat. 40° 43′, Lon. 73° 58′. Visible about a minute; second disruption when near its greatest altitude.[4]

Williamstown, Massachusetts, No. 25. Observed by Prof. Albert Hopkins, who says the meteor "passed through the constellation Scorpio, probably a little below Antares," and disappeared at 9h. 49m. 59 sec.[5]

Wilmington, Delaware, Lat. 39° 41′, Lon. 75° 28′. Reported time, 9h. 45m.[6]

Woodbury, New Jersey, No. 227. Copied from a newspaper report, over the

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[1] More than three months had elapsed when these altitudes were estimated, which renders them less reliable than if they had been made at the time of the passage of the meteor. According to the calculated path they are considerably too high.

[2] If we allow 6½° for magnetic variation, the course of the meteor "by compass," when it crossed the meridian, according to the calculated path, was about S. 52½° E., and 45 seconds after the meteor was due west its azimuth was about S. 62¼° E., and its altitude about 5¼°.

[3] Calculated time of meridian passage 9h. 59m. 53 sec.

[4] According to the calculated path, the second disruption occurred two or three seconds before the meteor attained its greatest altitude. See note under Washingtonville.

[5] Calculated time of meridian passage at Williamstown, 9h. 51m. 8 sec.

[6] Calculated time of meridian passage at Wilmington 9h. 41m. 54 sec.

signature "G. G.," in which the writer, who was on a visit here from his residence at No. 216 Walnut street, Philadelphia, thus describes the phenomena:—

"A large ball of fire of intense brilliancy appeared in the sky, at an apparent height of from twenty to twenty-five degrees above the horizon, a little to the north of a due west direction, moving to the east. It was at first partially obscured by the light clouds, from which in a few moments it emerged. In size it appeared from eight to twelve inches in diameter. Its color was that of the most pure and white flame. Its movement was so comparatively slow and regular that the idea occurred to us both, while looking at it, that it might be an artificial contrivance sent up from Fort Mifflin or the Gas Works, by some experimenter in rockets or balloon fire works. It appeared to be between us and the city. It quickly separated into two balls of similar appearance, one closely following the other. These again soon began to throw out, at first a trail of their own white appearance, and quickly after, large, distinct, and numerous fragments of the most beautiful red and pink colors, the effect being like that of the bursting of an ordinary rocket, only on a scale much more magnificent and grand. This continued gradually diminishing until the meteor, which now had assumed a red hue, had reached a point nearly due east, where it disappeared from our view at a height apparently nearly the same as that at which it started.

"The movement of this meteor appeared to be not much more rapid than the flight of an eagle. I think I could have kept sight on it easily with a gun throughout its course. The length of time we enjoyed this wonderful sight, it seems to me, must have been considerably more than a minute. The ladies and children had retired, but they all had time to go to the windows, in response to our calls, and witness it."

Wrentham, Massachusetts, Lat. 42° 1′, Lon. 71° 23′. Reported time "about 10 o'clock."[1]

Whatever may have been the orbit of the meteor before it became visible, it is obvious that the portion of the path that was subject to observation, being so near the earth, must have been controlled almost entirely by its attraction—that of the sun, or of the other planets, exerting so little disturbing influence as scarcely to be appreciable. The orbit about to be described is not, therefore, the path of the meteor in space, but only its orbit relative to the earth, and having the centre of the earth in one of its foci, according to well-known principles.

A phenomenon of this kind being unexpected, and therefore not admitting of previous preparation on the part of observers, it was not supposed, when the investigation was commenced, that the observations were accurate enough to warrant any very refined analysis, and I proceeded to determine the path upon the assumption that the earth was a sphere, 7912 miles in diameter, and so did not take into account its spheroidal form, nor the difference between the true and the apparent zenith. The error was an unfortunate one, and has, in some degree, vitiated the results; but I shrink from the labor of cancelling all that has been done, and begin-

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[1] Calculated time of meridian passage at Wrentham 9h. 58m. 39 sec.

ning anew, and would gladly leave the work to other hands, for a more critical investigation.

In prosecuting the investigation, the method of procedure was as follows: The first effort was to obtain approximately the parallax and position of the meteor at different points along its path, by means of pairs of observations taken on or near the same vertical circle. And not suspecting any change in the elements of the path, but supposing it to be one and the same curve throughout, I endeavored from about a dozen such pairs, which the series of observations furnished, to select three that seemed most reliable, in order that, by means of a polar equation of the orbit for each of the three points determined by them, I might find the major axis, eccentricity, and true anomaly, and consequently the longitude of the perigee. As the orbit, if undisturbed, must necessarily be in the plane of a great circle about the earth, either of the two points thus found would, moreover, determine the inclination of the orbit, and the longitude of the node. Could these equations have been obtained, they would have read

$$r = \frac{a\,(1-e^2)}{1+e\cos\omega} \qquad r' = \frac{a\,(1-e^2)}{1+e\cos(\omega+\delta)} \qquad \text{and } r'' = \frac{a\,(1-e^2)}{1+e\cos(\omega+\delta')}$$

in which r, r' and r'' represent the radii vectores at the three different points, a the semi-axis major, e the eccentricity expressed in decimals of the semi-axis major, ω the true anomaly at the point farthest east, and δ and δ' the differences between this anomaly and those of the other two points respectively, as determined by the observations. Unfortunately, however, there were but two pairs of observations that I felt could be relied upon sufficiently to use them for this purpose; but having what seemed to be a careful determination of the velocity of the meteor's motion near the point indicated by one of them, I used, instead of the third equation, the following, which expresses the relation between this velocity and the major axis of the orbit, viz:—

$$a = \frac{h\,r}{2h - r\,v^2}$$

in which v represents the velocity, and h the force of gravity, at the unit of distance (one mile) $= 32\frac{1}{6}$ feet × $(3956)^2$.

Having thus obtained an approximate orbit, I proceeded to compare azimuths and altitudes deduced from it, with those given by the various observations, to see what modifications were required in the orbit, in order to satisfy them. And by repeated modifications in this way—over fifty in the aggregate—the results given in the tables at the end of this memoir were finally arrived at. The value of v as deduced from the foregoing equations, was $7\frac{2}{9}$ miles per second, relative to the earth's centre; but this was found to be too small, rendering the orbit too much curved, and after trying other values, ranging from $7\frac{2}{9}$ to 11 miles, the value $9\frac{3}{4}$ miles was finally adopted, as best satisfying the observations; thus showing that the orbit was hyperbolic. As thus modified, the first approximate orbit satisfied tolerably well most of the reliable observations west of about longitude 76° or 77°, near which the most easterly of the two points, from which the orbit was determined, was located; but further east the discrepancies were so great that they could be reconciled only by introducing changes in the elements of the orbit, one at the point just named, and another near Lon. 74°. And it is worthy of note that, in the vicinity of these points, observers report remarkable ruptures in the body of the meteor—particularly at the former, where it separated into two parts that seemed nearly equal in size, thus affording a rational explanation of the change in the elements. The points of rupture are generally placed a few miles further east than I have indicated, but it is allowable to suppose that two or three seconds may have intervened after the rupture, before the parts became separated far enough to attract attention.

The first change in the elements, near the point of the chief explosion, became evident early in the investigation, but great effort was used to avoid the necessity of introducing the second. The most important phenomenon to be explained was, that, while the meteor descended quite rapidly toward the earth till it reached the meridian of about 74°, it afterward rose, and the change was too great to be accounted for on the supposition that at that point it reached the perigee of its hyperbolic orbit. The next most plausible explanation was that suggested by Prof. Lyman in his article in the American Journal of Science and Arts, published shortly after the meteor appeared, viz., that the change was due to the increased resistance of the air, as the meteor descended into the denser portions of it. To test this explanation, and, if possible, to deduce therefrom an orbit that would satisfy the observations, I proceeded as follows, using data which, from the necessity of the case, were in a good degree conjectural, so that the results, though correct in kind, were only approximately so in amount.

Starting with the fundamental equations

$$Log.\ s' = \frac{log.\ .24763}{7} h', \text{ and } R = \frac{v^2\ s'}{d\ s} p\ t$$

in which s' represents the specific gravity of the air at the height h' above the surface of the earth, d the diameter of a sphere moving through it, s its specific gravity, v its velocity, p a constant quantity determined by experiment, and R the retardation or loss in its velocity in the time t, it was necessary, in the first place to find or assume probable values for d, s, and p. If we assume that the meteor when cold was a sphere 100 feet in diameter, and having a specific gravity equal to that of ordinary meteorites (3.54); but that it was expanded by the heat produced by the condensation of the atmosphere till its diameter (d) was 500 feet, or 6000 inches, the specific gravity (s) would then become .02832. The only experiment that I could find, embracing all the data requisite for determining the value of p, was one at the Woolwich Arsenal in England, described in the article on "Gunnery" in the Encyclopædia Britannica, in which a bullet $\frac{78}{100}$ of an inch in diameter, and weighing 90 grains, was projected with a velocity of 2109 feet per second, and the velocity lost in $\frac{1}{192}$ of a second was found to be 335 feet. The value of p as determined by this experiment is 85.201.

In applying the foregoing equations to the orbit of the meteor, it was assumed that the retardation in a small arc of the orbit, 12 to 14 miles long, included between two given values of ω, was the same as though the meteor had been projected along the chord of that arc, with a velocity equal to half the sum of the velocities at the two extremities of the arc, the specific gravity of the air being taken at the mean height of the chord above the surface of the earth. Representing now the anomalies of the meteor at the two extremities of the arc by ω and ω', the velocities by v and v', the radii vectores by r and r', and the times of the meteor's arriving at them by t and t', the above equations will read

$$Log.\, s' = \frac{log.\ .24763}{7}\left(\frac{r+r'}{2} - 3956\right), \text{ and } R = \frac{p\, s'}{d\, s}\left(\frac{v+v'}{2}\right)^2 (t - t').$$

Substituting for the factor $t - t'$, in the latter equation, its value as given by the equation

$$t - t' = \frac{r'^2 + r^2 - 2rr' \cos(\omega - \omega')}{\frac{1}{2}(v+v')},$$

putting the angle included between the radius vector and tangent to the path $= \theta$, and resolving R into its horizontal and vertical components, the expression for the former will read

$$\frac{p\, s'}{d\, s}\left(\frac{v+v'}{2}\right)^2 \frac{r'^2 + r^2 - 2rr' \cos(\omega - \omega')}{\frac{1}{2}(v+v')} \cos\theta,$$

and for the latter

$$\frac{p\, s'}{d\, s}\left(\frac{v+v'}{2}\right)^2 \frac{r'^2 + r^2 - 2rr' \cos(\omega - \omega')}{\frac{1}{2}(v+v')}\, n \sin\theta.$$

in which n represents the ratio in which the resistance in the vertical direction was increased by the increasing density of the air, as the meteor descended.

Knowing from the elements the values of a, e, and ω at the commencement of the disturbed part of the orbit, the values of r, v, and θ at the end of the first small arc, if the orbit were undisturbed, were readily computed from the equations $r = \dfrac{a(1-e^2)}{1+e\cos\omega}$, $v = \sqrt{\dfrac{(2a-r)h}{ar}}$, and $\sin\theta = \dfrac{c}{rv}$ in which latter, c represents the constant area described by the radius vector in a unit of time. Or, by substituting for c its value in terms of a, e, and h, the latter equation becomes $\sin\theta = \dfrac{\sqrt{a(1-e^2)h}}{rv}$. To these values of r, v, and θ corrections were applied for the resistance of the atmosphere in the horizontal and vertical directions, computed from the expressions for them given above, and from their values, thus corrected, new values of a, e, and ω, were computed, with which to commence the next arc, the equations used for the purpose being as follows, viz:—

$$a = \frac{hr}{2h - rv^2},\ c = rv\sin\theta,\ e = \sqrt{1 - \frac{c^2}{ah}}, \text{ and } \cos\omega = \frac{a(1-e^2) - r}{re}$$

Proceeding in the same way with the 2d arc, elements were found with which to commence the 3d arc, and so on from arc to arc till the whole disturbed portion of the path was computed; consisting, therefore, of a series of small hyperbolic arcs, each differing slightly in its elements from the one preceding. The value of n having never been investigated practically, so far as appears, and knowing no satisfactory way of computing it from physical causes, various arbitrary values were assumed for it, by way of experiment, ranging from 2 to 160. The latter afforded an orbit which satisfied the observations tolerably well, but the assumption seemed so extravagant that this line of research was abandoned, and a change being introduced in the elements near longitude 74°, as already remarked, an orbit was computed, using only the unresolved value of R, and so taking no account of the difference of resistance in the horizontal and vertical directions. The path thus divides itself into three sections, the 1st and 3d of indefinite length, over only a small portion of which the meteor was visible, and the second an intermediate one, 160 miles long, where it was most brilliant. The calculations for the resistance of the atmosphere were commenced at the point where the first change in the elements was made, the height of the meteor being there about 56 miles; but as the effect of this resistance was appreciable, while the meteor was receding, up to the height of not less than 64 miles, within the limits of accuracy to which the computations extended, allowance should properly have been made for it through the latter part of the 1st section, though at that height it was but very trifling. Indeed, the entire modification of the path occasioned by it was so small, compared with that which the consideration of the spheroidal form of the earth would occasion, that it seemed to savor of useless refinement to allow for the former, while the latter was omitted. And with the hope that the subject might hereafter receive, at the hands of others, a more thorough discussion, in which both might be taken into account, I concluded to slightly modify the elements so as to afford an undisturbed orbit that would differ so little from the disturbed one just described, that the azimuths and altitudes in Table II, which had been already computed for the one, might answer for the other. This undisturbed orbit is given in Table I. The computed changes in the values of semi-axis major, eccentricity, velocity, longitude of perigee and perigeal distance, caused by the unresolved resistance of the atmosphere, in the 2d and 3d sections of path were as follows:—

SECOND SECTION.						
POSITION AND MOTION OF METEOR.			CHANGES IN THE ELEMENTS OF ITS ORBIT.			
Mean height above sea level in miles.	Mean distance from perigee.	Length of arc described.	Increase in length of semi-axis major, in miles.	Loss of velocity in decimals of a mile per second.	Diminution of eccentricity in decimals of the semi-axis major.	Direct motion of the perigee in seconds.
55.08	9° 1′ 5″	11′ 52″	1.0	.0012	.0009	2″
53.56	8 49 58	10 25	1.1	.0014	.0012	2
52.16	8 39 37	10 22	1.5	.0019	.0015	3
50.80	8 29 19	10 19½	2.0	.0024	.0019	4½
49.40	8 19 5	10 17	2.5	.0031	.0025	6
48.20	8 8 55	10 14½	3.3	.0039	.0032	7
46.93	7 58 48	10 12	4.2	.0050	.0041	9¼
45.70	7 48 46	10 9½	5.3	.0064	.0052	12½
44.51	7 38 48	10 7	6.8	.0081	.0065	15
43.34	7 28 57	10 4½	8.6	.0101	.0082	19½
42.21	7 19 11	10 2	10.8	.0126	.0102	23½
41.10	7 9 30	10 1½	13.5	.0157	.0127	29
39.87	6 58 20	13 9½	23.1	.0264	.0212	44
Total changes			83.7	.0982	.0793	2′ 57½″

Total decrease in perigeal distance 1109 feet.

THIRD SECTION.						
POSITION AND MOTION OF METEOR.			CHANGES IN THE ELEMENTS OF ITS ORBIT.			
Mean height above sea level in miles.	Mean distance from perigee.	Length of arc described.	Increase in length of semi-axis major, in miles.	Loss of velocity in decimals of a mile per second.	Diminution of eccentricity in decimals of the semi-axis major.	Retrograde motion of the perigee in seconds.
39.22	0° 53′ 9″	7′ 58	16.3	.0183	.0149	5″
39.37	1 3 1	11 41	23.2	.0257	.0207	7
39.57	1 14 47	11 38	22.5	.0244	.0196	9
39.80	1 26 31	11 34	21.7	.0231	.0186	10
40.07	1 38 12	11 30	20.8	.0217	.0174	10
40.36	1 49 50	11 27	19.8	.0203	.0162	10
40.69	2 1 26	11 23	18.6	.0189	.0151	11
41.06	2 12 57	11 19	17.4	.0175	.0139	10
41.45	2 24 25	11 16	16.3	.0161	.0128	11
41.87	2 35 50	11 13	15.1	.0147	.0116	12
42.32	2 47 12	11 9	13.8	.0133	.0105	11
42.79	2 58 22	11 6	12.5	.0120	.0095	10
43.30	3 9 46	11 3	11.4	.0108	.0086	10
43.83	3 20 58	11 0	10.4	.0097	.0076	10
44.40	3 32 6	10 57	9.3	.0086	.0068	10
44.99	3 43 11	10 53	8.1	.0076	.0060	9
45.60	3 54 12	10 50	7.3	.0068	.0052	7
46.24	4 5 9	10 48	6.4	.0060	.0046	7
46.91	4 16 3	10 45	5.6	.0052	.0040	7
47.60	4 26 53	10 42	4.9	.0045	.0035	6
48.32	4 37 40	10 39	4.2	.0038	.0030	5
49.07	4 48 23	10 36	3.7	.0033	.0026	4
49.84	4 59 3	10 34	3.1	.0028	.0022	3
50.63	5 9 44	10 32	2.6	.0024	.0019	3
51.45	5 20 13	10 29	2.3	.0020	.0016	2
52.29	5 30 43	10 26	1.9	.0017	.0013	2
53.16	5 41 10	10 24	1.6	.0014	.0011	2
54.05	5 51 35	10 22	1.3	.0012	.0009	2
54.96	6 1 57	10 19	1.1	.0010	.0008	2
55.89	6 12 17	10 16	.9	.0008	.0006	1
56.85	6 22 33	10 14	.8	.0007	.0005	1
57.83	6 32 47	10 12	.6	.0006	.0005	1
58.83	6 42 59	10 10	.5	.0005	.0003	1
59.86	6 53 9	10 8	.4	.0004	.0003	1
60.91	7 3 17	10 6	.3	.0003	.0002	1
61.98	7 13 23	10 4	.3	.0002	.0002	1
63.07	7 23 27	10 1	.2	.0002	.0002	1
64.18	7 33 28	9 59	.2	.0002	.0001	0
65.32	7 43 27	9 57	.1	.0001	.0001	0
66.47	7 53 23	9 55	.1	.0001	.0001	0
67.63	8 3 17	9 53	.1	.0001	.0000	0
Total changes . . .			307.7	.3090	.2456	3′ 35″

Total decrease in perigeal distance 422 feet.

In regard to the effect on the different elements, as shown in the foregoing tabular statement, it is to be remarked that, while the changes in the major axis, velocity, and eccentricity were cumulative, and would at length, if continued, have rendered the orbit parabolic and then elliptical, those in the longitude of the perigee were oscillatory, the motion being direct in the 2d section, where the meteor was approaching the perigee, and retrograde in the 3d section, where it receded from it, and so may not be at variance with the conclusion arrived at by La Place, in his investigation of Encke's comet, that a resisting medium does not permanently affect the position of the line of apsides of an orbit. Another fact noticeable in this connection, viz., that in section 3d the retrograde motion of the perigee increased up to a certain limit, and then diminished, is easily explained, when we consider that at the commencement of the section, near the perigee, the motion of the meteor was nearly horizontal, so that there was but little change in the density of the air through which it passed. If the density were uniform, the retrograde motion, commencing with zero at the perigee, would have continued to increase; but as the meteor continued to rise higher above the surface of the earth, the diminished density of the atmosphere at length neutralized this increase; after which the motion became slower and slower, till at the height of near 64 miles it became wholly unappreciable. In the determination of quantities so minute, more accurate tables are needed than any which were accessible, and could such have been obtained, the results would doubtless have exhibited more conformity to law. In those employed, the decimals were carried to only seven places, which were extended, in the calculations, two places farther by proportional parts.

As the body of the meteor continued to throw off fragments in the lower portion of its path, it is not improbable that there were other slight changes in the elements beside the two already mentioned. Indeed, the observations would be better satisfied by supposing a very slight one to have occurred in the horizontal elements (viz., the inclination of the orbit and the longitude of its nodes), not far from the meridian of Nantucket; but if it truly occurred, it was so small as to be hardly worth noticing. At each rupture there was doubtless a change in the velocity, and consequently in the length of the major axis, but there were no satisfactory data for determining the amount, and it too was disregarded.

The elements of the three sections, as finally adopted, were as follows:—

	1st Section.	2d Section.	3d Section.
Longitude of Descending Node	332° 56′ 14″	325° 10″ 39″	329° 23′ 56″
Inclination to the Ecliptic	66° 12′ 11″	67° 9′ 41″	66° 25′ 52″.
Semi-axis major (in miles)	2005.32	2005.32	2005.32
Eccentricity . . .	2.99836	2.98170	2.99214
Longitude of Perigee .	264° 56′ 43″	275° 37′ 1″	261° 2′ 6″
Perigeal distance (in miles)	4007.32	3973.94	3994.88

and according to these elements, the meteor entered the sphere of the earth's dominant attraction from the direction of the constellation Sextans, near the left forefoot of Leo, Right Ascension 147° 41′, Declination 3° 8′ north; and left toward a point in Right Ascension 355° 2′ 9″, Declination 30° 56′ 42″ south.

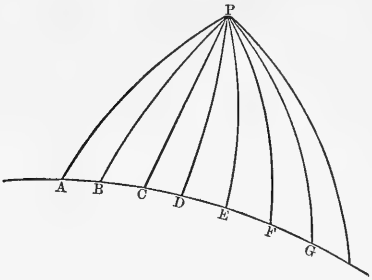
By means of equations already given, viz.:—

$$r = \frac{a\,(1 - e^2)}{1 + e\cos w},\ v = \sqrt{\frac{(2\,a - r)\,h}{a\,r}} \text{ and } \sin\theta = \sqrt{\frac{a\,(1 - e^2)\,h}{r\,v}}$$

the values of $r - 3956$, v and the complement of θ (Table 1st, columns 5, 14 and 12) were computed for the different values of ω assumed in column 13th.

The linear values of the several arcs intercepted between the points thus indicated, and the time occupied in describing each, were next required, but instead of computing them from the customary differential equations of space and time, I employed the easier, though less scientific, method based on the assumption, as above, that the chords of small arcs of the orbit were sensibly equal to the arcs themselves, and that the time of describing each arc was equal to the quotient resulting from dividing the length of the chord by the mean of the velocities at its two extremities. So slight was the curvature of the orbit, even at its maximum, that the error in linear distance, resulting from the foregoing assumption, was less than $\frac{1}{20}$ of an inch in any one arc, or less than four inches in the aggregate of these arcs for the whole visible track of 1300 miles. And the error in time was still more inconsiderable, being less than seven millionths of a second for the whole distance. The quantities in column 6th were obtained by adding these arcs successively together, commencing at the point where the meteor first became visible. Those in column 7th were obtained by adding in like manner the linear values of the arcs, and those in column 8th, by adding in the same way the times occupied in describing them. The absolute time when the meteor passed the meridian of Washington, was estimated approximately, from direct observations of the time at several places, at 9h. 35m. to 9h. 37m; and, after several trials between these limits, to see what time would best satisfy the observations in which the position of the meteor was referred to the heavenly bodies, the time 9h. 35m. 32s. was finally adopted. By applying to this the quantities given in column 8th those in column 9th were obtained.

In the following diagram, in which *A* and *G* represent two known points in the meteor's orbit, *A B*, *B C*, *C D*, &c., the arcs of the same spoken above, and *P* the north pole of the earth—the arcs *A P* and *G P*, being the co-declinations of the points *A* and *G* were known, and also the angle *A P G*, being their difference of right ascension. Hence the angle *P A G* of the spherical triangle *APG* was readily found, which in connection with the known sides *A P* and *A B* of the triangle *A P B*, made known the angles at *P* and *B*, and the side *P B*. In like manner, in the triangle *A P C*, the angles at *P* and *C* and the side *P C* were found;—and so on through each successive triangle *A P D*, *A P E*, &c. The sides *PB*, *P C*, &c., are the co-declinations of the meteor at the points *B*, *C*, &c., from which the declinations or terrestrial latitudes in column 2d were obtained. The angles at *P* measure differences of right ascension, which added severally to the right ascension of the point *A*, gave the quantities in column 3d.[1] The angles at *B*, *C*, &c., show the true course of the meteor at these points (column 10th), and having its velocity given in column 14th, and knowing also that of the earth's rotation directly beneath it—viz., the velocity at the equator multiplied by the cosine of the latitude—it was easy to compute the apparent course (column 11th).



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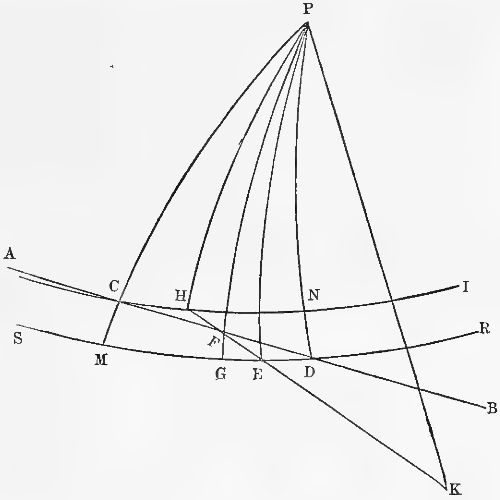
[1] Over a part of the visible track it was found more convenient to reverse the process, and compute the anomaly (column 14th) and right ascension, for given differences of declination in column 2d.

In Table 2d, the only columns that require explanation as to the mode of their computation are the 8th and the last five. The 12th and 13th show the points on the surface of the earth where the planes of the meteor's path cut the vertical planes in which the different observations were made; and inasmuch as, owing to the earth's rotation, the intersections of the former planes with its surface were not great circles, a rigid formula for computing these points would be quite complicated, I adopted, instead, the following method, which, though not scientifically accurate, was made practically so within the limit of 1″.



Let $A\,B$ represent the projection of a section of the meteor's path upon the earth's surface, C and D two contiguous points of the same as given in columns 2d and 4th of Table 1st, $C\,I$ and $S\,R$ two parallels of latitude passing through these points, K the place where the observation was made in a vertical plane whose intersection with the earth's surface is $K\,H$, cutting the foregoing parallels in E and H, and the projection of the meteor's path in F. Also let P represent the north pole of the earth, and $P\,M$, $P\,H$, $P\,G$, $P\,E$, $P\,D$ and $P\,K$ meridians. Then will the angle at K be the observed azimuth of the meteor; and knowing also the latitudes of E and H, and the latitude and longitude of K, the spherical triangles $P\,E\,K$ and $P\,H\,K$ will give the longitudes of E and H. Now the surface $C\,N\,D\,M$ being small, the curvature of the lines lying upon it may be disregarded, and the figure itself may be considered a trapezoid; and if we represent the longitudes of C and D by L and l, those of H and E by L' and l', and the arcs $N\,D$, $G\,D$ and $F\,G$ by d, x and y we can readily, from the figure, obtain the equations

$$x = \frac{(L - l)\ (l' - l)}{(L - l) - (L' - l')}, \text{ and } y = \frac{d\,x}{L - l}$$

and by adding the values of y and x to the latitude and longitude of D, the latitude and longitude of F for each observation, as given in the columns above mentioned, was obtained.[1] Each result was then verified by computing from the

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[1] This is strictly true only of the first three series, extending down as far as No. 112. In the other two series, where less accuracy seemed necessary, the positions of F were determined, for the most part, by delineation and measurement on a large map, carefully drawn on a scale of about ten miles to an inch.

spherical triangle $P F K$, the longitude of F corresponding to its latitude as given by the foregoing formulæ, and if the difference between the two determinations amounted to 2″ (as it sometimes did, when the azimuth of the line of observation was nearly coincident with that of the meteor's path), the arc $C D$ was subdivided, thus reducing the size of the trapezoid $C N D M$, and the consequent error. Also, from this same triangle the arc $F K$ was computed.

The heights of the meteor (column 14th), for the different positions of F, were readily obtained by proportional parts from the 5th column of Table 1st, and the mean time at Washington was obtained, in the same way, from the 9th column of that table, which, corrected for the difference of longitude, gave the local time (column 15th).

The altitude and parallax of the meteor, at the several points (columns 8th and 11th) were computed thus: Let C in the following diagram represent the centre of the earth, M the meteor, K the place of observation, $H K$ the sensible horizon, $K F G$ the vertical circle in whose plane the altitude $M K H$ was measured, and $K F$ an arc of the same, as in the preceding diagram. Then in the plane triangle $K M C$, the sides $K C$ and $M C$ being known, and also the angle at C, since it is measured by the arc $K F$, already found, the angles at M and K were readily found, the former of which is the parallax, and the latter, diminished by the right angle $H K C$, gave the altitude.

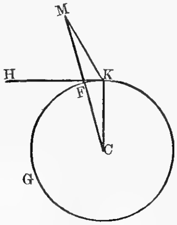

TABLE I.—ORBIT OF THE METEORIC FIRE-BALL OF JULY 20, 1860.

No. of section.	Position of the Meteor.				Distance traveled from point of first appearance.		Time of flight.		Direction of motion.			True anomaly.	Velocity in miles per second.
	North declination or terrestrial latitude.	Right Ascension.	Terrestrial longitude west from Greenwich.	Height above sea level.	In arc.	In miles.	Seconds of time from point where first seen.	Mean time at Washington.[1]	True course.	Apparent course relative to the earth's surface.	Inclination to the horizon.[2]		
First section.	3° 8′	147° 41′	Indefinite	Infinite	—97°57′12⅓″	— ∞	— ∞	Infinite past	N 44° 4′ E	Due west	90° 0′ 0″	250° 31′ 3½″	6.8952
	4 6	148 38	147° 42′	236044	—96 36 20	—242058	—96798	19d 6h 40m 40s P. M.	N 44 8 E	N 56° 2′ W	88 39 28	251 51 55½	6 9525
	6 21	150 49	118 7	67895	—93 28 16	—73112	—16972	20 4 51 6 "	N 44 20 E	N 17 11 E	85 35 48	255 0 0	7.0850
	9 56	154 22	161 50	29474	—88 28 16	—34052	—5629	" 8 0 9 "	N 44 50 E	N 33 7 E	80 46 49	260 0 0	7.2971
	13 26	157 59	168 27	17735	—83 28 16	—21873	—3172	" 8 41 6 "	N 45 34 E	N 38 35 E	76 6 33	265 0 0	7.5057
	16 55	161 43	169 2	12067	—78 28 16	—15837	—2137	" 8 58 11 "	N 46 33 E	N 41 43 E	71 33 22	270 0 0	7.7101
	20 19	165 35	167 31	8747.5	—73 28 16	—12188	—1572	" 9 7 46 "	N 47 47 E	N 44 10 E	67 6 26	275 0 0	7.9090
	23 37	169 37	164 58	6580.5	—68 28 16	—9717	—1217	" 9 13 41 "	N 49 17 E	N 46 29 E	62 45 6	280 0 0	8.1018
	26 49	173 52	161 44	5065.9	—63 28 16	—7914	—972	" 9 18 22 "	N 51 6 E	N 48 52 E	58 28 58	285 0 0	8.2872
	29 54	178 21	158 0	3955.4	—58 28 16	—6528	—792	" 9 21 22 "	N 53 14 E	N 51 26 E	54 17 30	290 0 0	8.4613
	32 48	183 7	153 49	3111.2	—53 28 16	—5413	—654	" 9 23 40 "	N 55 43 E	N 54 15 E	50 9 40	295 0 0	8.6327
	35 31	188 12	149 11	2455.2	—48 28 16	—4992	—544	" 9 25 30 "	N 58 34 E	N 57 23 E	46 5 45	300 0 0	8.7911
	38 0	193 37	144 9	1935.2	—43 28 16	—4205	—453	" 9 27 1 "	N 61 49 E	N 60 50 E	42 5 2	305 0 0	8.9392
	40 14	199 23	138 42	1517.6	—38 28 16	—3528	—376	" 9 28 18 "	N 65 27 E	N 64 40 E	38 7 46	310 0 0	9.0762
	42 9	205 31	132 51	1179.2	—33 28 16	—2930	—310	" 9 29 24 "	N 69 30 E	N 68 54 E	34 11 44	315 0 0	9.2018
	43 43	212 1	126 35	904.0	—28 25 16	—2393	—252	" 9 30 22 "	N 73 55 E	N 73 28 E	30 18 36	320 0 0	9.3154
	44 54	218 48	120 1	680.1	—23 28 16	—1905	—200	" 9 31 14 "	N 78 40 E	N 78 22 E	26 27 22	325 0 0	9.4166
	45 40	225 49	113 12	498.9	—18 28 16	—1455	—152	" 9 32 2 "	N 83 40 E	N 83 30 E	22 33 49	330 0 0	9.5050
	46 0	232 59	106 11	354.2	—13 28 16	—1035	—108	" 9 32 46 "	N 88 48 E	N 88 45 E	18 49 29	335 0 0	9.5802
	45 53	240 11	99 12	241 1	— 8 28 16	— 637	—67	" 9 33 27 "	S 86 2 E	S 85 58 E	15 2 20	340 0 0	9.6422
	45 19	247 17	92 15	156.4	— 3 28 16	— 258	—28	" 9 34 6 "	S 80 57 E	S 80 45 E	11 12 19	345 0 0	9.6906
	44 39 45″	252 5 40″	87 33 14″	112.5	0 0 0	0	.00	" 9 34 33.03 "	S 77 32 E	S 77 17 E	8 39 25	348 28 16	9.7165
	44 30 8	253 5 4	86 35 9	105.4	0 43 23	51	5.29	" 9 34 38 32 "	S 76 51 E	S 76 36 E	8 6 20	349 11 39	9.7207
	44 22 52	253 47 42	85 53 29	100 2	1 14 41	88	9.12	" 9 34 42.15 "	S 76 21 E	S 76 6 E	7 43 11	349 42 57	9 7238
	44 15 44	254 28 3	85 14 2	95.59	1 44 25	124	12 75	" 9 34 45.78 "	S 75 53 E	S 75 37 E	7 20 53	350 12 41	9.7266
	44 8 42	255 6 29	84 36 28	91.38	2 12 50	157	16 22	" 9 34 49 25 "	S 75 26 E	S 75 9 E	6 59 35	350 41 6	9.7291
	44 1 45	255 43 11	84 0 36	87 56	2 40 6	189	19.55	" 9 34 52 58 "	S 75 0 E	S 74 43 E	6 39 17	351 8 22	9.7313
	43 54 52	256 18 23	83 26 12	84.05	3 6 21	221	22 76	" 9 34 55.79 "	S 74 36 E	S 74 18 E	6 19 32	351 34 37	9 7331
	43 48 3	256 52 13	82 53 8	80.83	3 31 41	250	25.84	" 9 34 58.87 "	S 74 13 E	S 73 55 E	6 0 33	351 59 57	9.7354
	43 41 18	257 24 48	82 21 18	77 89	3 56 10	279	28.81	" 9 35 1.84 "	S 73 50 E	S 73 31 E	5 42 10	352 24 26	9.7372
	43 34 37	257 56 17	81 50 32	75.19	4 19 55	307	31 68	" 9 35 4.61 "	S 73 28 E	S 73 9 E	5 24 20	352 48 11	9.7388
	43 27 59	258 26 47	81 20 44	72.70	4 43 0	335	34 47	" 9 35 7.50 "	S 73 7 E	S 72 47 E	5 7 2	353 11 16	9.7403
	43 21 54	258 56 21	80 51 51	70.41	5 5 28	362	37.18	" 9 35 10 21 "	S 72 47 E	S 72 27 E	4 50 7	353 33 44	9.7417
	43 14 51	259 25 5	80 23 47	68.31	5 27 23	388	39.82	" 9 35 12 85 "	S 72 27 E	S 72 6 E	4 33 42	353 55 39	9.7429
	43 8 21	259 53 2	79 56 28	66.37	5 48 46	413	42.40	" 9 35 15.43 "	S 72 8 E	S 71 47 E	4 17 42	354 17 2	9.7441
	43 1 53	260 20 15	79 29 52	64.59	6 9 40	437	44.91	" 9 35 17.94 "	S 71 49 E	S 71 27 E	4 2 5	354 37 56	9.7452
	42 55 27	260 46 48	79 3 56	62.96	6 30 7	461	47.37	" 9 35 20 40 "	S 71 31 E	S 71 9 E	3 46 40	354 58 23	9.7462
	42 49 4	261 12 41	78 38 39	61.47	6 50 8	485	49.78	" 9 35 22 81 "	S 71 14 E	S 70 51 E	3 31 40	355 18 24	9.7471
	42 42 42	261 37 59	78 13 57	60.10	7 9 46	508	52.13	" 9 35 25 16 "	S 70 57 E	S 70 34 E	3 16 55	355 38 2	9.7479
	42 36 22	262 2 44	77 49 47	58.84	7 29 2	530	54.45	" 9 35 27.48 "	S 70 40 E	S 70 16 E	3 2 20	355 59 18	9 7487
	42 30 4	262 26 57	77 26 8	57.72	7 47 57	552	56 71	" 9 35 29.74 "	S 70 23 E	S 69 59 E	2 48 5	356 16 13	9 7494
	42 23 47	262 50 39	77 2 59	56.71	8 6 32	574	58 94	" 9 35 31.97 "	S 70 7 E	S 69 42 E	2 34 20	356 34 48	9.7500
	42 18 15	263 11 14	76 42 53	55.90	8 22 43	593	60.88	" 9 35 33.91 "	S 69 54 E	S 69 29 E	2 22 20	356 50 59	9.7504
Second section.	42 18 15	263 11 14	76 42 53	55.90	8 22 43	593	60.88	" 9 35 33.91 "	S 62 42 E	S 62 4 E	6 49 50	350 52 59	9.7504
	42 12 47	263 25 28	76 29 0	54.26	8 34 35	607	62.31	" 9 35 35.34 "	S 62 33 E	S 61 55 E	6 40 49	351 4 51	9.7514
	42 7 58	263 37 55	76 16 52	52 85	8 45 0	619	63 56	" 9 35 36.59 "	S 62 24 E	S 61 46 E	6 33 12	351 15 16	9.7523
	42 3 9	263 50 17	76 4 40	51 47	8 55 22	631	64 81	" 9 35 37 84 "	S 62 16 E	S 61 38 E	6 25 22	351 25 38	9.7531
	41 58 20	264 2 35	75 52 50	50.12	9 5 41	643	66 05	" 9 35 39.08 "	S 62 8 E	S 61 30 E	6 17 32	351 35 57	9.7539
	41 53 31	264 14 48	75 40 55	48.82	9 15 58	655	67 29	" 9 35 40.32 "	S 62 0 E	S 61 22 E	6 9 52	351 46 14	9.7547
	41 48 43	264 26 56	75 29 6	47.55	9 26 13	667	68.52	" 9 35 41 55 "	S 61 52 E	S 61 14 E	6 2 10	351 56 29	9.7555
	41 43 53	264 38 59	75 17 21	46.31	9 36 25	679	69 75	" 9 35 42.78 "	S 61 44 E	S 61 6 E	5 54 32	352 6 41	9.7563
	41 39 5	264 50 57	75 5 41	45.10	9 46 34	691	70 97	" 9 35 44.00 "	S 61 36 E	S 60 58 E	5 46 58	352 16 50	9.7570
	41 34 15	265 2 51	74 54 6	43.92	9 56 41	703	72.18	" 9 35 45 21 "	S 61 28 E	S 60 50 E	5 39 22	352 26 57	9.7577
	41 29 25	265 14 39	74 42 36	42.77	10 6 46	715	73.39	" 9 35 46.42 "	S 61 20 E	S 60 42 E	5 31 48	252 37 2	9 7584
	41 24 36	265 26 24	74 31 9	41.65	10 16 48	727	74.60	" 9 35 47.63 "	S 61 12 E	S 60 33 E	5 24 18	352 47 4	9 7591
	41 19 46	265 38 6	74 19 45	40.56	10 26 49	739	75 81	" 9 35 48.84 "	S 61 4 E	S 60 25 E	5 16 45	352 57 5	9.7598
	41 13 23	265 53 26	74 4 49	39.17	10 39 59	754	77.39	" 9 35 50.42 "	S 60 54 E	S 60 15 E	5 6 55	353 10 15	9.7606
Third section.	41 13 23	265 53 26	74 4 49	39.17	10 39 59	754	77.39	" 9 35 50.42 "	S 64 51 E	S 64 18 E	0 36 8	0 47 57	9.7606
	41 10 0	266 3 0	73 55 29	39 28	10 47 57	763	78.34	" 9 35 51.37 "	S 64 45 E	S 64 12 E	0 42 3	0 55 55	9.7605
	41 5 0	266 17 1	73 41 49	39.46	10 59 38	777	79.73	" 9 35 52.76 "	S 64 36 E	S 64 3 E	0 50 48	1 7 36	9.7604
	40 59 59	266 30 56	73 28 15	39.68	11 11 16	790	81.11	" 9 35 54.14 "	S 64 27 E	S 63 53 E	0 59 31	1 19 14	9 7603
	40 54 59	266 44 45	73 14 46	39.93	11 22 50	804	82.49	" 9 35 55.52 "	S 64 18 E	S 63 44 E	1 8 8	1 30 48	9 7602
	40 49 59	266 58 27	73 1 25	40 21	11 34 20	817	83.86	" 9 35 56 89 "	S 64 9 E	S 63 35 E	1 16 45	1 42 18	9.7600
	40 44 59	267 12 3	72 48 9	40.52	11 45 47	830	85 22	" 9 35 58.25 "	S 64 0 E	S 63 26 E	1 25 23	1 53 45	9.7598
	40 39 59	267 25 32	72 35 1	40.87	11 57 10	844	86.58	" 9 35 59.61 "	S 63 51 E	S 63 16 E	1 33 55	2 5 8	9.7596
	40 34 58	267 38 55	72 21 58	41 24	12 8 29	857	87 93	" 9 36 0.96 "	S 63 42 E	S 63 7 E	1 42 20	2 16 27	9.7594
	40 29 58	267 52 12	72 9 1	41.65	12 19 45	870	89.27	" 9 36 2.30 "	S 63 34 E	S 62 59 E	1 50 44	2 27 43	9 7591
	40 24 58	268 5 23	71 56 10	42.08	12 30 58	883	90.61	" 9 36 3.64 "	S 63 25 E	S 62 50 E	1 59 7	2 38 56	9.7588
	40 19 58	268 18 28	71 43 25	42.55	12 42 7	896	91.94	" 9 36 4.97 "	S 63 17 E	S 62 42 E	2 7 30	2 50 5	9.7586
	40 14 58	268 31 27	71 30 46	43.04	12 53 13	909	93 27	" 9 36 6.30 "	S 63 8 E	S 62 32 E	2 15 50	3 1 11	9.7583
	40 9 57	268 44 21	71 18 12	43.56	13 4 16	922	94.59	" 9 36 7.62 "	S 63 0 E	S 62 24 E	2 24 8	3 12 14	9 7580
	40 4 57	268 57 10	71 5 43	44.11	13 15 16	935	95.90	" 9 36 8.93 "	S 62 52 E	S 62 16 E	2 32 23	3 23 14	9 7576
	39 59 57	269 9 53	70 53 19	44 69	13 26 13	947	97 20	" 9 36 10 23 "	S 62 43 E	S 62 7 E	2 40 35	3 34 11	9 7573
	39 54 57	269 22 30	70 41 2	45.30	13 37 6	960	98.50	" 9 38 11.53 "	S 62 35 E	S 61 58 E	2 48 45	3 45 4	9.7569
	39 49 57	269 35 1	70 28 50	45.94	13 47 56	973	99.80	" 9 36 12.83 "	S 52 27 E	S 61 50 E	2 56 53	3 55 54	9 7565
	39 44 56	269 47 28	70 16 43	46 60	13 58 44	985	101 09	" 9 36 14.12 "	S 62 19 E	S 61 42 E	3 4 59	4 6 42	9 7561
	39 39 56	269 59 50	70 4 40	47 29	14 9 29	998	102.37	" 9 36 15.40 "	S 62 11 E	S 61 34 E	3 13 3	4 17 27	9.7557
	39 34 56	270 12 7	69 52 42	48.01	14 20 11	1010	103.65	" 9 36 16.68 "	S 62 4 E	S 61 27 E	3 21 5	4 28 9	9.7552½
	39 29 56	270 24 18	69 40 50	48.75	14 30 50	1023	104.93	" 9 36 17.96 "	S 61 56 E	S 61 18 E	3 29 5	4 38 48	9.7548
	39 24 56	270 36 25	69 29 2	49.51	14 41 26	1035	106.20	" 9 36 19.23 "	S 61 48 E	S 61 10 E	3 37 2	4 49 24	9.7543
	39 19 56	270 48 28	69 17 18	50 30	14 52 0	1047	107.46	" 9 36 20.49 "	S 61 40 E	S 61 2 E	3 44 57	4 59 58	9.7538
	39 14 55	271 0 26	69 5 39	51.12	15 2 32	1060	108.72	" 9 36 21.75 "	S 61 33 E	S 60 55 E	3 52 50	5 10 30	9.7533
	39 9 55	271 12 19	68 54 5	51.96	15 13 1	1072	109.98	" 9 36 23 01 "	S 61 25 E	S 60 47 E	4 0 41	5 20 59	9.7528

[1] Except in the first line in this column the month of July, 1860, is to be supplied.
[2] Descending in the first and second sections and ascending in the third.

TABLE I.—*Continued.*

No. of section.	Position of the Meteor.				Distance traveled from point of first appearance.		Time of flight.		Direction of motion.			True anomaly.	Velocity in miles per second.
	North declination or terrestrial latitude.	Right Ascension.	Terrestrial longitude west from Greenwich	Height above sea level.	In arc.	In miles.	Seconds of time from point where first seen.	Mean time at Washington.[1]	True course.	Apparent course relative to the earth's surface.	Inclination to the horizon.[2]		
Third section.	39° 4′ 55″	271° 24′ 7″	68° 42′ 36″	52.83	15° 23′ 27″	1084	111.23	20d 9h 36m 24.26 P.M.	S 61° 18′ E	S 60° 39′ E	4° 8′ 30″	5° 31′ 25″	9.7523
	38 59 55	271 35 51	68 31 10	53.72	15 33 51	1096	112.48	" 9 36 25.51 "	S 61 10 E	S 60 31 E	4 16 17	5 41 49	9.7517½
	38 54 54	271 47 31	68 19 49	54.64	15 44 13	1108	113.72	" 9 36 26.75 "	S 61 3 E	S 60 24 E	4 24 2	5 52 11	9.7512
	38 49 54	271 59 6	68 8 33	55.58	15 54 32	1120	114.96	" 9 36 27.99 "	S 60 56 E	S 60 17 E	4 31 46	6 2 30	9.7506½
	38 44 54	272 10 36	67 57 21	56.54	16 4 48	1132	116.19	" 9 36 29.22 "	S 60 49 E	S 60 10 E	4 39 28	6 12 46	9.7501
	38 39 54	272 22 3	67 46 12	57.52	16 15 2	1144	117.42	" 9 36 30.45 "	S 60 42 E	S 60 2 E	4 47 8	6 23 0	9.7495
	38 34 54	272 33 27	67 35 7	58.53	16 25 14	1156	118.65	" 9 36 31.68 "	S 60 34 E	S 59 54 E	4 54 46	6 33 12	9.7488½
	38 29 53	272 44 46	67 24 6	59.56	16 35 24	1168	119.87	" 9 36 32.90 "	S 60 27 E	S 59 47 E	5 2 23	6 43 22	9.7482
	38 24 53	272 56 1	67 13 9	60.62	16 45 32	1180	121.09	" 9 36 34.12 "	S 60 20 E	S 59 40 E	5 9 58	6 53 30	9.7475½
	38 19 53	273 7 12	67 2 16	61.70	16 55 38	1192	122.30	" 9 36 35.33 "	S 60 13 E	S 59 32 E	5 17 31	7 3 36	9.7469
	38 14 53	273 18 19	66 51 28	62.80	17 5 42	1204	123.51	" 9 36 36.54 "	S 60 6 E	S 59 25 E	5 25 3	7 13 40	9.7462½
	38 9 53	273 29 22	66 40 43	63.93	17 15 43	1216	124.72	" 9 36 37.75 "	S 60 0 E	S 59 19 E	5 32 34	7 23 41	9.7455
	38 4 52	273 40 21	66 30 2	65.08	17 25 42	1227	125.93	" 9 36 38.96 "	S 59 53 E	S 59 12 E	5 40 4	7 33 40	9.7449
	37 59 52	273 51 16	66 19 25	66.25	17 35 39	1239	127.13	" 9 36 40.16 "	S 59 46 E	S 59 5 E	5 47 33	7 43 37	9.7442
	37 54 52	274 2 8	66 8 51	67.44	17 45 34	1251	128.33	" 9 36 41.36 "	S 59 40 E	S 58 59 E	5 55 0	7 53 32	9.7435
	37 49 52	274 12 56	65 58 21	68.65	17 55 26	1262	129.52	" 9 36 42.55 "	S 59 33 E	S 58 51 E	6 2 26	8 3 24	9.7427
	37 39 51	274 34 22	65 37 31	71.14	18 15 8	1286	131.90	" 9 36 44.93 "	S 59 20 E	S 58 38 E	6 17 15	8 23 6	9.7412
	37 29 51	274 55 34	65 16 54	73.72	18 34 41	1309	134.26	" 9 36 47.29 "	S 59 7 E	S 58 25 E	6 31 57	3 42 39	9.7397
	37 19 51	275 16 32	64 56 31	76.38	18 56 7	1332	136.62	" 9 36 49.65 "	S 58 54 E	S 58 12 E	6 46 33	9 2 5	9.7381
	37 9 50	275 37 17	64 36 22	79.12	19 13 26	1354	138.96	" 9 36 51.99 "	S 58 42 E	S 57 59 E	7 1 2	9 21 24	9.7364
	36 59 50	275 57 50	64 16 24	81.94	19 32 38	1377	141.30	" 9 36 54.33 "	S 58 29 E	S 57 46 E	7 15 25	9 40 36	9.7347
	36 49 50	276 18 10	63 56 38	84.84	19 51 43	1400	143.62	" 9 36 56.65 "	S 58 17 E	S 57 33 E	7 29 44	9 59 41	9.7330
	36 39 49	276 38 18	63 37 5	87.82	20 10 42	1422	145.93	" 9 36 58.96 "	S 58 5 E	S 57 21 E	7 43 59	10 18 40	9.7312
	36 29 49	276 58 13	63 17 45	90.89	20 29 34	1445	148.23	" 9 37 1.26 "	S 57 53 E	S 57 9 E	7 58 10	10 37 32	9.7294
	36 19 49	277 17 57	62 58 35	94.03	20 48 20	1467	150.53	" 9 37 3.56 "	S 57 41 E	S 56 56 E	8 12 16	10 56 18	9.7275
	36 9 49	277 37 29	62 39 37	97.25	21 7 0	1489	152.82	" 9 37 5.85 "	S 57 30 E	S 56 45 E	8 26 17	11 14 58	9.7256
	35 59 48	277 56 50	62 20 51	100.54	21 25 34	1511	155.10	" 9 37 8.13 "	S 57 18 E	S 56 33 E	8 40 13	11 33 32	9.7236
	35 49 48	278 16 0	62 2 15	103.91	21 44 2	1533	157.36	" 9 37 10.39 "	S 57 7 E	S 56 21 E	8 54 6	11 52 0	9.7215½
	35 39 48	278 35 0	61 43 48	107.35	22 2 25	1555	159.62	" 9 37 12.65 "	S 56 56 E	S 56 10 E	9 7 56	12 10 23	9.7195
	35 29 47	278 53 51	61 25 31	110.87	22 20 43	1577	161.88	" 9 37 14.91 "	S 56 45 E	S 55 58 E	9 21 43	12 28 41	9.7174
	35 14 47	279 21 47	60 58 26	116.30	22 48 0	1610	165.25	" 9 37 18.28 "	S 56 29 E	S 55 41 E	9 42 15	12 55 58	9.7142
	34 59 47	279 49 23	60 31 40	121.59	23 15 5	1643	168.61	" 9 37 21.64 "	S 56 13 E	S 55 25 E	10 2 35	13 23 3	9.7109
	34 39 46	280 25 32	59 56 38	129.59	23 50 54	1686	173.06	" 9 37 26.09 "	S 55 52 E	S 55 3 E	10 29 33	13 58 52	9.7064
	34 19 46	281 1 7	59 22 9	137.58	24 26 24	1729	177.48	" 9 37 30.51 "	S 55 32 E	S 54 43 E	10 56 15	14 34 22	9.7017
	33 59 45	281 36 9	58 48 13	145.86	25 1 37	1772	181.89	" 9 37 34.92 "	S 55 13 E	S 54 23 E	11 22 41	15 9 35	9.6968
	33 29 44	282 27 39	57 58 22	158.82	25 53 55	1835	188.48	" 9 37 41.51 "	S 54 44 E	S 53 53 E	12 2 5	16 1 53	9.6893
	32 59 44	283 17 57	57 9 42	172.40	26 45 35	1899	195.02	" 9 37 48.05 "	S 54 16 E	S 53 24 E	12 41 3	16 53 33	9.6814
	32 29 43	284 7 9	56 22 8	186.59	27 36 42	1962	201.54	" 9 37 54.57 "	S 53 50 E	S 52 57 E	13 19 33	17 44 40	9.6732
	31 59 42	284 55 19	55 35 36	201.42	28 27 19	2025	208.04	" 9 38 1.07 "	S 53 24 E	S 52 30 E	13 57 34	18 35 17	9.6647
	30 59 40	286 28 43	54 5 26	232.94	30 7 2	2150	220.98	" 9 38 14.01 "	S 52 35 E	S 51 39 E	15 13 1	20 15 0	9.6469
	29 59 39	287 58 28	52 38 54	266.91	31 44 58	2274	223.89	" 9 38 26.92 "	S 51 50 E	S 50 52 E	16 27 5	21 52 56	9.6279
	28 59 38	289 25 7	51 15 29	303.99	33 21 19	2398	246.80	" 9 38 39.83 "	S 51 7 E	S 50 6 E	17 40 0	23 29 17	9.6078
	27 59 36	290 48 49	49 55 1	342.40	34 56 15	2523	259.75	" 9 38 52.78 "	S 50 27 E	S 49 24 E	18 51 49	25 4 13	9.5866
	26 59 35	292 9 50	48 37 16	383.96	36 29 53	2647	272.76	" 9 39 5.79 "	S 49 50 E	S 48 45 E	20 3 4	26 37 51	9.5644
	25 59 34	293 28 27	47 21 55	428.15	38 2 22	2772	285.87	" 9 39 18.90 "	S 49 15 E	S 48 8 E	21 13 22	28 10 20	9.5412
	23 59 32	295 59 14	44 57 44	524.69	41 4 15	3024	312.26	" 9 39 45.29 "	S 48 11 E	S 47 0 E	23 32 2	31 12 13	6.4920
	21 59 30	298 22 35	42 41 9	632.86	44 2 38	3280	339.34	" 9 40 12.37 "	S 47 15 E	S 46 0 E	25 48 35	34 10 36	9.4390
	19 59 28	300 39 38	40 31 6	753.21	46 58 4	3543	367.31	" 9 40 40.34 "	S 46 26 E	S 45 6 E	28 3 14	37 6 2	9.3827
	17 59 26	302 51 24	38 26 40	887.56	49 51 4	3815	396.43	" 9 41 9.46 "	S 45 43 E	S 44 19 E	30 16 55	39 59 2	9.3226
	15 59 25	304 58 30	36 27 8	1036.7	52 42 0	4098	426.91	" 9 41 39.94 "	S 45 6 E	S 43 38 E	32 29 24	42 49 58	9.2593
	13 59 23	307 2 10	34 31 30	1202.7	55 31 13	4395	459.05	" 9 42 12.08 "	S 44 34 E	S 43 1 E	34 41 19	45 39 11	9.1927
	11 59 22	309 2 30	32 39 41	1387.5	58 19 0	4707	493.14	" 9 42 46.17 "	S 44 7 E	S 42 20 E	36 52 47	48 26 58	9.1229
	9 59 20	311 0 15	30 51 3	1593.5	61 5 38	5038	529.56	" 9 43 22.59 "	S 43 44 E	S 42 1 E	39 4 3	51 13 36	9.0500
	4 59 17	315 46 26	26 30 26	2223.5	67 58 32	5954	631.86	" 9 45 4.89 "	S 43 7 E	S 41 9 E	44 32 55	58 6 30	8.8513
	—0 0 45	320 24 58	22 24 12	3081.3	74 48 39	7084	761.09	" 9 47 14.12 "	S 42 55 E	S 40 40 E	50 5 23	64 56 37	8.6400
	—5 0 47	325 6 19	18 25 55	4287.2	81 38 57	8552	932.34	" 9 50 6.37 "	S 43 7 E	S 40 29 E	55 45 36	71 46 44	8.4071
	—10 0 50	329 52 33	14 41 37	6085.0	88 31 51	10604	1181.1	" 9 54 14.1 "	S 43 37 E	S 40 26 E	61 34 9	78 39 38	8.1568
	—15 0 52	334 52 0	11 22 5	9037.9	95 30 30	13809	1580.7	" 10 0 53.7 "	S 44 49 E	S 40 48 E	67 38 19	85 38 28	7.8878
	—20 0 54	340 13 17	9 11 8	14707	102 39 18	19704	2342.1	" 10 13 35.1 "	S 46 26 E	S 40 42 E	74 2 33	92 47 12	7.5996
	—25 0 55	346 8 12	11 53 42	29925	110 3 31	35112	4412.0	" 10 48 50 "	S 48 42 E	S 38 12 E	80 55 9	100 11 29	7.2918
	—30 0 56	352 54 41	109 32 34	208402	117 52 20	213645	29473	21 5 45 46 A.M.	S 51 51 E	S 48 53 W	88 27 9	108 0 18	6.9600
	—30 56 42	355 2 9	Indefinite	Infinite	119 23 30	Infinite	Infinite	Infinite future	S 52 33 E	Due west	90 0 0	109 31 28	6.8951

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[1] Except in the last line in this column, the month of July, 1860, is to be supplied.
[2] Descending in the first and second sections and ascending in the third.

TABLE II.—Comparison of Observations with the Results of Calculation.

Description of series.	Serial Number.	Place of Observation.				Angular Determination of the Meteor's Position.					Geographical Position of Meteor.			Local mean time.
		Name.	Geographical position.			Altitude.			Azimuth.	Parallax.	North latitude.	Longitude west from Greenwich.	Height above the sea in miles.	
			North latitude.	Longitude W. from Greenwich.	Height above the sea in decimals of a mile.	By observation.	By calculation.	Difference.						
First Series—In which the difference between the observed and calculated positions of the meteor does not exceed 1°.	1	Flint, Michigan	42°57′	83°41′	.12	35°	34°23′	—0° 37′	Northwest	53°38′ 18′	44°19′ 57′	85°37′ 21′	98 31	9h 8m 3s
	2	Pontiac, Michigan	42 36	83 14	.15(?)	40° to 45°	42 20	—0 10	North	46 23 34	43 52 21	83 14 0	82.86	9 10 5
	3	Steamer Search, Lake Huron	43 30	81 50	.11	40°	40	0 0	E S E to E by S†	48 51 44	43 13 46	80 18 49	67.97	9 15 57
	4	Alexandria, Virginia	38 49	77 4	.01	10°	9 26	—0 34	N 20° W	76 9 39	42 56 19	79 7 23	63 18	9 35 8
	5	Ellicottsville, New York	42 16 26″	78 42	.25(?)	see note †	53 57	0 0	N 15° 55′ W	35 24 37	42 53 32	78 56 28	62.50	9 28 37
	6	Buffalo, New York	42 53	78 55	.11	near zenith †	89 53½	—0 6½	N 15° E	0 6 21	42 53 5	78 54 58	62.41	9 27 45†
	7	Off Barnegat, New Jersey	39¾ (?)	74 (?)	.00	10°	9 21	—0 39	Northwest	76 29 45	42 39 58	78 3 24	59.56	9 47 32†
	8	Dansville, New York	42 34 41	77 50	.13	77° 30′	see note†	0 31	S 79° 0′ 48″ E	12 19 18	42 32 35	77 35 19	58.15	9 38 45
	9	Dansville, New York	42 34 41	77 50	.13	77° 2′	see note†	0 15	S 76° 30′ E	12 46 34	42 32 27	77 34 49	58.14	9 38 45
	10	Detroit, Michigan	42 24	82 58	.11	7°	6 51	—0 9	Easterly†	78 22 2	42 13 4	76 29 5	54.28	9 11 49
	11	Norfolk, Virginia	36 51	76 19	.01	near horizon	5 33	?	North	79 9 9	42 8 50	76 19 0	53.10	9 38 23
	12	Hamilton College, New York	43 3 16	75 24 17″	.10	30° 47′	30 12	—0 35	S 10° 25′ W	58 37 19	41 53 43	75 41 28	48.88	9 42 7†
	13	Ogdensburg, New York	44 43	75 26	.05	11°	11 35½	+0 35½	South	75 28 47	41 47 20	75 26 0	47.22	9 42 2
	14	Germantown, Pennsylvania	40 2	75 12	.02	20° (?)	20 15	+0 15	N 5° (?) W	67 59 39	41 46 43	75 24 18	47.05	9 42 58
	15	New Brighton, New York	40 39	74 7	.01	27° 0′	27 12	+0 12	N 36° 11½′ W	61 32 38	41 39 20	75 6 11	45.87	9 47 19
	16	Baldwinsville, New York	43 5	76 26	.08	15° 4′	14 49	—0 15	S 40° E	73 2 38	41 27 20	74 37 35	42.29	9 38 7
	17	New Brunswick, New Jersey	40 31	74 32	.01	30° to 35°	33 18	+0 48	North	55 47 50	41 24 58	74 32 0	41.73	9 45 43
	18	Germantown, Pennsylvania	40 2	75 12	.02	see note †	21 11½	see note †	N 24° 54′ E	67 20 49	41 21 26	74 22 48	40.87	9 43 4
	19	Edensville, New York	41 18	74 33	.09	near zenith	79 7	?	Northeasterly†	10 45 54	41 23 58	74 23 30	41.43	9 45 40
	20	Chester, New York	41 23	74 21	.09	near zenith	86 41	?	Southerly†	3 17 12	41 21 30	74 22 0	40.79	9 46 29
	21	Germantown, Pennsylvania	40 2	75 12	.02	see note †	20 43 36	see note †	N 30° 7′ 50″ E	67 44 1	41 17 20	74 13 37	39.97	9 43 5
	22	New Brighton, New York	40 39	74 7	.01	"45° or more"	45 14 15	?	North	44 10 25	41 14 22	74 7	39.38	9 47 26
	23	Hamilton College, New York	43 3 16	75 24 17	.10	13° 42 34″	14 6 10	+0 33½	S 29° 8′ 58″ E	73 48 53	41 12 46	74 3 6	39.19	9 42 18
	24	New Haven, Connecticut	41 18	72 57	.01	see note †	35 40 43	see note †	S 82° 34′ 49″ W	53 32 25	41 11 37	73 59 8	39.24	9 52 7
	25	Williamstown, Massachusetts	42 42 49	73 13	.15	see note †	18 15½	see note †	S 20° 32′ 44″ W	70 6 42	41 11 8	73 58 37	39.24	9 51 3
	26	Steamer New World	41 18	73 57	.00	near zenith	77 30 34	see note †	South	12 21 57	41 10 33	73 57	39.26	9 48 7
	27	Branford, Connecticut	41 18	72 50	.01	see note †	38 43	see note †	S 74° W	50 35 19	41 5 37	73 43 30	39.43	9 52 36
	28	New York City	40 43⅓	74 0½	.01	52¾° to 53°	52 47	—0 5½	N 32° 31′ E	36 47 18	41 5 0	73 41 50	39.46	9 47 53
	29	Elizabeth, New Jersey	40 39 43	74 12 37	.01	40° to 45°	43 13	+0 43	Northeast	46 12 12	41 4 18	73 39 54	39.49	9 47 3
	30	(near) Oysterbay Point, New York	40 57	73 34	.00	see note †	81 31	see note †	North	8 24 53	41 2 7	73 34	39.59	9 49 42
	31	New Haven, Connecticut	41 18	72 57	.01	53°	52 13	—0 47	S 28° W	37 20 41	40 54 32	73 13 28	39.96	9 52 12
	32	(near) Baltimore, Maryland	39 11	76 46	.01	9°	8 33	—0 23*	N 56° 25′ E	78 14 26	40 54 30	73 13 23	39.96	9 36 56
	33	New Haven, Connecticut	41 18	72 57	.01	51°	50 33	—0 27	S 17° W	38 58 33	40 51 43	73 5 58	40.11	9 52 13
	34	Albany, New York	42 40	73 45	.02	11° 59′	12 54	+0 55†	S 27° 45′ 20″ E	74 43 12	40 33 24	72 17 43	41.39	9 49 5
	35	West Springfield, Massachusetts	42 6	72 38	.04	20° (?)	19 0 29	—0 59½	S 14° E	69 20 19	40 28 53	72 6 11	41.76	9 53 35
	36	New Haven, Connecticut	41 18	72 57	.01	20°	20 58½	+0 58½	S 47° E	67 27 52	40 13 40	71 27 29	43.18	9 52 23
	37	Valley Forge, Pennsylvania	40 5	75 25	.04	7° to 10°	8 45	+0 3*	East	77 46 24	39 59 40	70 52 38	44.73	9 42 34
	38	Newburyport, Massachusetts	42 48	70 52	.01	11°	11 51	+0 51	South	75 20 16	39 59 25	70 52	44.76	10 0 46
	39	Nantucket, Massachusetts	41 17	70 6	.01	23°	23 54	+0 54	S 14° 45′ W	64 39 58	39 52 24	70 34 48	45.63	10 3 52
	40	Germantown, Pennsylvania	40 2	75 12	.02	9°	8 29½	—0 26*	S 88° 30′ E	77 52 35	39 50 13	70 29 28	45.91	9 43 29
	41	Nantucket, Massachusetts	41 17	70 6	.01	23°	23 24	+0 24	S 11° W	65 7 26	39 49 55	70 28 0	45.94	10 3 53
	42	New Haven, Connecticut	41 18	72 57	.01	13°	12 44½	—0 15½	S 51° E	74 33 56	39 42 30	70 10 50	46.94	9 52 28
	43	Germantown, Pennsylvania	40 2	75 12	.02	8°	7 35	—0 20½*	S 85° 45 E	78 20 38	39 35 4	69 53 1	47.99	9 43 33
	44	(near) Alexandria, Virginia	see note†	see note†	note †	5°	3 53	—0 59½*	N 82° E	80 10 27	39 23 48	69 26 23	49.69	9 36 (?)
	45	Germantown, Pennsylvania	40 2	75 12	.02	5° 32′	6 6½*	+0 41½*	S 81° 45 E	78 56 32	39 9 55	68 54 6	51.96	9 43 39
	46	South Danvers, Massachusetts	42 32	70 57	.02	10° 22′ 23″	9 23 29	—0 59	S 25° 16′ 52″ E	76 51 29	39 9 27	68 53	52.04	10 0 39
	47	Middlebury, Vermont	44 3	73 16	.10	"very near the horizon"	4 15	?	S 36° E	79 50 33	39 4 39	68 42	52.88	9 51 24
	48	New Haven, Connecticut	41 18	72 57	.01	10°	8 57	—0 59*	S 57° E	77 7 6	39 4 32	68 44 43	52.90	9 52 40
	49	Germantown, Pennsylvania	40 2	75 12	.02	5° 27′	5 53	+0 33*	S 81° E	78 56 50	39 1 1	68 33 34	53.54	9 43 40
2d Series—In which the observed and the calculated positions of the meteor differ from 1° to 2°.	50	Cove Island, Lake Huron	45 20	81 44	.11	30°	31 20	+1 20	Southwest	56 44 8	43 57 10	83 37 45	85.23	9 16 3
	51	Cleveland, Ohio	41 35	81 40	.12	25°	26 24	+1 24	N 1° E	61 33 53	43 31 21	81 35 50	73.85	9 16 30
	52	Cleveland, Ohio	41 35	81 40	.12	25°	26 27	+1 27	N 5° E	61 31 11	43 29 53	81 29 25	73.43	9 16 31
	53	Reading, Pennsylvania	40 19	75 55	.05	9°	10 25	+1 29*	N 46½° W	75 15 2	43 11 59	80 11 44	67.45	9 39 38
	54	Erie, Pennsylvania	42 10	80 8	.11	42° 20′	43 27	+1 7	N 21° 40 E	45 34 24	43 4 0	79 38 36	65.17	9 22 49
	55	East Fairfield, Ohio	40 47	80 45	.22	17°	18 42	+1 42	N 30° E	68 48 59	42 55 17	79 3 18	62.93	9 20 24
	56	Germantown, Pennsylvania	40 2	75 12	.02	12°	10 7	—1 53	N 45° W	75 42 45	42 54 58	79 1 59	62.85	9 42 37
	57	Toronto, Canada West	43 39	79 21	.05	45°	46 59½	+1 59½	S S E	42 11 5	42 53 15	78 55 10	62.43	9 26 2
	58	Lowville, New York	43 46	75 38	.15	22°	20 28½	—1 31½	S 62° 15′ W	67 20 25	42 43 11	78 15 50	60.20	9 40 57
	59	Dansville, New York	42 34 41	77 50	.13	90°	88 4	—1 56	N 15° E†	1 59 2	42 36 20	77 49 20	58.82	9 38 43
	60	Easton, Pennsylvania	40 39½	75 17	.03	20° 35′	18 40½	—1 54½	N 38° 7′ W	69 2 51	42 26 1	77 11 12	57.07	9 42 27
	61	Elkland, Pennsylvania	41 59	77 17	.26	59°	60 10	+1 10	N 33° 29′ E	29 22 13	42 21 57	76 56 18	56.57	9 35 37
	62	Lowville, New York	43 46	75 38	.15	24° 45′	23 8½	—1 36½	S 16° 15′ W	65 9 28	42 7 50	76 16 33	52.81	9 41 9
	63	Alexandria, Virginia	38 49	77 4	.01	9°	10 59	+1 59	N 11° E	75 39 59	42 6 18	76 15 39	52.36	9 35 25
	64	New York City	40 43½	74 0½	.01	23° 45′	25 12½	+1 27½	N 42° 59′ W	63 25 16	41 43 6	75 15 18	46.09	9 47 44†
	65	Washingtonville, New York	41 23	74 13	.09	80°	78 51	—1 9	South	11 2 21	41 16 16	74 13 0	39.80	9 47 1
	66	Southampton, New York	40 53	72 24	.01	25°	23 40½	—1 19½	N 75° W	65 4 22	41 11 46	74 0 22	39.22	9 54 19
	67	West Springfield, Massachusetts	42 6	72 38	.04	23½°	22 10½	—1 19½	S 47° 22′ W	66 29 7	41 10 33	73 57 0	39.26	9 53 23
	68	Washington City	38 53	77 1	.01	10°	8 8	—1 48*	Northeast	78 34 52	41 10 0	73 55 30	39.28	9 35 39†
	69	New Haven, Connecticut	41 18	72 57	.01	48°	49 18	+1 18	South	40 12 44	40 48 17	72 57 0	40.32	9 52 13
	70	Southampton, New York	40 53	72 24	.01	57° 38′	56 11	—1 27	S 75° 45′ W	33 25 56	40 47 10	72 53 56	40.38	9 54 26
	71	Brooklyn, New York	40 41	73 59	.01	14° 45′	12 45¼	—1 59¾	S 74° 6′ E	74 39 10	39 55 43	70 43 0	45.20	9 48 19
	72	West Springfield, Massachusetts	42 6	72 38	.04	6° to 8°	8 23	+1 28*	Southeast	77 34 43	39 12 3	68 59 0	51.60	9 53 54

* A correction being applied for refraction. Since the meteor was within the limits of the earth's atmosphere, the effect of refraction must be less than if its light proceeded from a star, or other body, beyond those limits. It is here assumed to be *two-thirds* as great; and throughout this table it is applied in all cases where the observed altitude does not exceed 10°.

† See the notes on p. 48, which are numbered so as to correspond with the serial numbers of this table.

TABLE II.—*Continued.*

Description of series.	Serial Number.	Place of Observation.				Angular Determination of the Meteor's Position.					Geographical Position of Meteor.			Local mean time.
			Geographical position.			Altitude.								
		Name.	North latitude.	Longitude W. from Greenwich.	Height above the sea in decimals of a mile.	By observation.	By calculation.	Difference.	Azimuth.	Parallax.	North latitude.	Longitude west from Greenwich.	Height above the sea in miles.	
3d Series—In which the observed and calculated positions of the meteor differ from 2° to 4°.	73	Oberlin, Ohio	41°20′	82 15′	.15	see note †	19° 4′	see note †	N 39° 25′ 33″ W	66°58′	44°22′	85°48′	99.56	9h 13m 51s
	74	Detroit, Michigan	41 24	82 58	.11	41° 28′	37 29	—3° 59′	N 15° (?) W	50 59 49″	43 53 35″	83 19 57″	83.45	9 11 8
	75	Detroit, Michigan	41 24	82 58	.11	41° 28′	38 47½	—2 40½	N 1° 39′ E	49 48 4	43 48 24	82 54 47	81.00	9 11 11
	76	Easton, Pennsylvania	40 39½	75 17	.03	11° 32′	8 58	—2 34	N 55° 16′ W	76 2 3	43 22 34	80 56 48	70.80	9 42 6
	76(a)	Hamilton, Canada	43 15	79 57	.05	80°	83 46	—3 46	S 15° W	6 7 37	43 9 2	79 59 12	66.57	9 23 31†
	77	Ellicottsville, New York	42 16 26″	78 42	.25	54° 1′	56 3	+2 2	N 7° 43′ 51″ W	33 21 26	42 51 33	78 48 30	62 01	9 28 38
	78	Welchfield, Ohio	41 23	81 12	.23	20° 45′	17 6	—3 39	N 58¼° E	70 19 14	42 42 19	78 12 30	60.02	9 18 41
	79	Pittsford, New York	43 4	77 46	.10	60°	62 52½	+2 52½	See note†	26 41 27	42 39 33	78 2 24	59.50	9 32 26
	80	Easton, Pennsylvania	40 39½	75 17	.03	18° 3′	15 26	—2 37	N 44° 20′ W	71 45 11	42 38 19	77 57 12	59.23	9 42 23
	81	Rochester, New York	43 8 17	77 51	.10	60°	57 49	—2 11	South	31 39 42	42 36 41	77 51 0	58.90	9 32 7
	82	Washington City	38 53	77 1	.01	13° 30′	10 45	—2 45	N 9° W	75 28 46	42 36 10	77 49 2	58.80	9 35 28
	83	Cleveland, Ohio	41 29	81 44	.12	11°	13 1	+2 1	N 69° E	73 46 5	42 33 44	77 39 53	58.37	9 16 52
	84	Pontiac, Michigan	42 36	83 14	.15	5°	8 0½	+3 0½	Nearly east†	77 31 10	42 26 30	77 13 0	57.15	9 10 38
	85	Easton, Pennsylvania	40 39½	75 17	.03	16° 23′	19 21½	+2 58½	N 36° 43′ W	68 27 19	42 23 50	77 3 10	56.73	9 42 28
	86	Washington City	38 53	77 1	.01	13° 30′	11 19½	—2 10½	North	75 10 12	42 23 14	77 1 0	56.63	9 35 32
	87	Towanda, Pennsylvania	41 47	76 30	.16	54° to 59°	59 42½	+3 12½	N 3° to 4° W	29 50 7	42 14 11	76 32 16	54.68	9 37 39
	88	(near) Baltimore, Maryland	39 11	76 46	.01	15°	12 46	—2 14	N 10° 40′ E	74 19 24	42 2 14	76 2 33	51.22	9 36 38
	89	Cleveland, Ohio	41 29	81 44	.12	10°	7 25½	—2 31*	N 81° E	78 15 25	42 1 0	75 59 20	50.80	9 17 2
	80	Washington City	38 53	77 1	.01	13° 30′	10 58	—2 32	N 17° E	75 50 51	41 55 31	75 45 52	49.36	9 35 40
	91	Philadelphia, Pennsylvania	39 58 24	75 9 54″	.01	24°	20 14	—3 46	North	68 4 12	41 40 27	75 9 54	45.54	9 43 8
	92	Easton, Pennsylvania	40 39½	75 17	.03	34° 50′†	32 27	—2 23 †	N 8° 35 E	56 33 18	41 38 48	75 5 1	45.03	9 42 40
	93	Cherry Valley, New York	42 48	74 47	.25	25°	27 52	+2 52	S 9¼° W†	60 56 41	41 37 50	75 2 42	44.88	9 32 40
	94	Burlington, New Jersey	40 5	74 53	.01	20°	22 21	+2 21	North	66 9 53	41 33 47	74 53 0	43 81	9 44 17
	95	Lowville, New York	43 46	75 38	.15	18° 15′	14 17	—3 58	S 14° 45′ E	73 26 48	41 33 5	74 51 20	43.64	9 41 16
	96	West Bloomfield, New Jersey	40 49	74 13	.03	50°	53 58	+3 58	N 29° E†	33 38	41 10 55	73 58	39.28	9 47 3
	97	Turin, New York	43 36	75 38	.15	13° 1′	10	—3 1	S 29° 38 W	77 9 26	41 6 44	73 46 34	39.40	9 41 24
	98	Off Cape Cod, Massachusetts	42 10(?)	70 10 (?)	.00	6° 55′	9 47	+2 52	S 69° 8′ 34″ W	77 20 48	41 5 29	73 43 8	39.44	10 3 17
	99	New Haven, Connecticut	41 18	72 57	.01	42°	45 40	+3 40	S 63° W	43 46 55	41 2 52	73 36 4	39.55	9 52 9
	100	Newburyport, Massachusetts	42 48	70 52	.01	7½°	11 9½	+3 44½*	Southwest	76 14 39	40 56 11	73 17 55	39.87	10 0 31
	101	Amherst, Massachusetts	42 22	72 34	.05	16°	19 47	+3 47	S 20° (?) W†	68 31 21	40 55 21	73 15 40	39.91	9 53 43
	102	Harvard Observatory, Massach'tts	42 22 49	71 8	.02	12°	14 12½	+2 12½	Southwest	73 40 32	40 52 0	73 6 44	40 10	9 59 28
	103	Alexandria, Virginia	38 49	77 4	.01	5° 10′	7 4	+2 10*	N 55½° E	79 14 40	40 50 26	73 2 33	40.13	9 35 45
	104	Wallingford, Connecticut	41 26	72 50	.03	46° to 47°	42 51	—3 39	S 13½° W	46 32 11	40 49 59	73 1 25	40.16	9 52 41
	105	Nantucket, Massachusetts	41 17	70 6	.01	18° 30′	15 44	—2 46	S 72° W	42 18 30	50 39 1	72 32 38	40.93	10 3 40
	106	Sag Harbor, New York	41 0	72 18½	.01	56¼°	53 23	—2 52	South	36 10 32	40 33 38	72 18 30	41.35	9 54 50
	107	Ellicottsville, New York	42 16 26	78 42	.25(?)	0°	3 57	+3 57	S 72° 30′ E	80 52	40 31 53	72 14	41.49	9 29 18
	108	Reading, Pennsylvania	40 19	75 55	.05(?)	6°	9 27½	+3 34*	N 88° 15′ E	77 21	40 20 19	71 44 19	42 52	9 40 29
	109	Lowville, New York	43 46	75 38	.15	1° 12′	4 48½	+3 54*	S 43° 45′ E	80 15 25	40 6 53	71 10 33	43.90	9 41 41
	110	Meadville, Pennsylvania	41 39	80 11	.21	3° 30′	1 8	—2 12*	S 79° 15′ E	81 14 24	39 48 24	70 25	46.15	9 23 33
	111	Easton, Pennsylvania	40 39½	75 17	.03	4° 3′	6 22	+2 28*	S 75° 32′ E	78 58 7	39 23 39	69 26	49 71	9 43 16
	112	Newburyport, Massachusetts	42 48	70 52	.01	4° to 5°	6 57	+2 35*	S 34° E	77 45 58	38 21 49	67 6 30	61.28	10 1 11
4th Series—In which the observed and calculated positions of the meteor differ from 4° to 7°.	112(a)	Haverford, Connecticut	41 46	72 41	.02	8° 30′	3 21	—5 9	N 70° 30′ W	77 0	44 18	85 26	97.00	9 52 5
	113	Oberlin, Ohio	41 20	82 15	.15	25°	20 55½	—4 4½	N 26½° W	66 1	44 3	84 9	88 45	9 13 56
	114	Oberlin, Ohio	41 20	82 15	.15	29° 20′	24 13½	—5 6½	North	63 27	43 40	82 15	77.34	9 14 6
	115	Lowville, New York	43 46	75 38	.15	9°	13 22	+4 22	S 84° 15′ W	72 59	43 18	80 36	69.22	9 40 44
	116	Cove Island, Lake Huron	45 20	81 44	.11	30°	23 21	—6 39	S S E	64 28	43 18	80 35	69.15	9 16 20
	117	Hiram, Ohio	41 20	81 8	.24	18°	24 54	+6 54	N 15° E	63 5	43 15	80 26	68.46	9 18 45
	118	Toronto, Canada West	43 39	79 21	.05	50°	55 51½	+5 51½	S S W	33 31	43 4	79 40	65.27	9 25 57†
	119	East Fairfield, Ohio	40 47	80 45	.22	14° 55′	19 45	+4 50	N 19° 41′ E	67 49	43 3	79 38	65.13	9 20 21
	120	Freedom, Ohio	41 13	81 8	.21	14° 50′	21 26	+6 36	N 35° E	66 21	43 1	79 25	64.28	9 18 50
	121	Hudson, Ohio	41 15	81 24	.22	12° 30′	19 6½	+6 36½	Northeast	68 28	42 56	79 4	62.96	9 17 48
	122	Cleveland, Ohio	41 35	81 44	.12	12°	17 43	+5 43	N 56° E	69 42	42 52	78 51	62 20	9 16 30
	123	New York City	40 43½	74 0½	.01	3° 45′	10 8	+6 23	N 57° 29′ W†	75 46	42 50	78 42	61.67	9 47 25
	124	Oberlin, Ohio	41 20	82 15	.15	20°	13 51	—6 9	N 61¼° E	72 59	42 48	78 30	60 99	9 14 28
	125	Huntingdon, Pennsylvania	40 31	78 1	.14	15° 30′	20 59	+5 29	"a little east of north"†	66 56	42 36	77 48	58 76	9 31 28
	126	Easton, Pennsylvania	40 39½	75 17	.03	21° 38′	16 42	—4 56	N 41° 28′ W	70 44	42 31	77 31	57.95	9 42 25
	127	Troy, New York	42 44	73 36	.01	9°	14 57	+5 57	S 78° 45′ W	72 13	42 31	77 30	57.88	9 49 9
	128	Lowville, New York	43 46	75 38	.15	20°	24 48	+4 48	S 32° 15′ W	63 31	42 20½	76 51	56.22	9 41 5
	129	Wallingford, Connecticut	41 26	72 50	.03	8°	14 3	+6 3	N 73° 30′ W	73 8½	42 12	76 27	54.00	9 52 19
	130	Middlebury, Vermont	44 3	73 16	.10(?)	8°	13 14	+5 14	S 52½° W	73 49	42 12	76 26	53.94	9 50 36
	131	Deep Creek, Virginia	36 47	76 19	.02	10°	5 25	—4 35	North	79 13	42 9	76 19	53.10	9 38 25
	132	Easton, Pennsylvania	40 39½	75 17	.03	16° 45′	23 18½	+6 23½	N 26° 15′ W	64 59½	42 9	76 18	53.04	9 42 33
	133	Meadville, Pennsylvania	41 39	80 11	.21	7° 30′†	12 48½	+5 18½	N 79° 15′ E†	74 13	42 8	76 16	52.76	9 22 57
	134	Erie, Pennsylvania	42 10	80 8	.11	7° 30′	12 59	+5 29	East	74 6	42 7	76 12	52.32	9 23 9
	135	Lima, Pennsylvania	39 55	75 25	.03	over 25°	18 41	— ?	North	69 25	41 49	75 25	47.12	9 42 6
	136	Reading, Pennsylvania	40 19	75 55	.05(?)	30°	23 16	—6 44	N 22° 16′ E	65 15	41 42	75 14	45.93	9 40 7
	137	Oberlin, Ohio	41 20	82 15	.15	8° or 9°	4 16	—4 14	N 85° E	80 30	41 35	74 55	44.01	9 14 49
	138	Morristown, New Jersey	40 48	74 33	.03	44¾°	38 27½	—6 7½	N 14° 45′ W	50 46	41 32½	74 48	43 36	9 45 38
	139	Middlebury, Vermont	44 3	73 16	.10(?)	18°	11 27	—6 33	S 24° 30′ W	75 49	41 32	74 47	43.26	9 50 46
	140	Easton, Pennsylvania	40 39½	75 17	.03	25° 30′	32 21	+6 51	N 28° 10′ E	56 42	41 29	74 40	42.56	9 42 43
	141	Albany, New York	42 40	73 45	.02	16° 57′	22 44	+5 47	S 20° 9′ 15″ W	65 54½	41 21	74 22½	40 84	9 48 53
	142	Fulton, New York	43 18	76 30	.07	12° 54′	17 11	+4 17	S 30° 5′ 22″ E	71 2	41 19½	74 18½	40.46	9 37 53
	143	Philadelphia, Pennsylvania	39 58 24″	75 9 54	.01	24° 49′	20 1	—4 48	N 31° 20′ 28″ E	68 29	41 15	74 8	39.47	9 43 14
	144	Steamer Rip Van Winkle, New York	40 41 20	74 1	.00	'near 60°'	48 24	see note †	say N 25° E†	41 35	41 5	73 42	39.46	9 47 53†
	145	New York City	40 43½	74 0½	.01	55°	59 31	+4 31	say N 25° E†	30 9	41 5	73 42	39.46	9 47 55
	146	Troy, New York	42 44	73 40	.02	25°	18 12	—6 48	South	70 9	41 5	73 40	39.50	9 49 23
	147	Sag Harbor, New York	41 0	72 18½	.01	42½°	38 25½	—4 4½	S 83¼° W	50 52	40 54½	73 14	39.94	9 54 46
	148	Philadelphia, Pennsylvania	39 58 24	75 9 54	.01	22° or 23°	15 33	—6 57	N 65° 52′ 29″ E	72 29	40 45	72 48	40.52	9 43 22†
	149	Southampton, New York	40 53	72 24	.01	see note †	see note †	—4 30	S 31° 15′ E	40 17	40 27	72 1	41.92	9 54 31
	150	Easton, Pennsylvania	40 39½	75 17	.03	5°	11 52	+6 59½*	S 86° 13′ E	75 27½	40 21½	71 47½	42.41	9 43 1
	151	Nantucket, Massachusetts	41 17	70 6	.01	26°	21 2	—4 58	S 51° 30′ W	68 26	40 19	71 41	42.73	10 3 9
	152	Nantucket, Massachusetts	41 17	70 6	.01	18°	23 37	+5 37	S 15° W	64 56	40 17	70 36	45.56	10 3 10
	153	Sag Harbor, New York	41 0	72 18½	.01	14°	9 23	—4 37	S 57° E	76 42	38 55	68 20	54.50	9 55 17
	154	Amherst, Massachusetts	42 22	72 34	.05	2°	6 44	+4 58*	Southeast	78 21	38 50	68 9½	55 37	9 54 16
	155	Wallingford, Connecticut	41 26	72 50	.03	2°	6 37	+4 51*	S 58° E	78 8½	38 31	67 26	59 35	9 53 17
	156	Hartford, Connecticut	41 46	72 41	.02	1° 10′	5 36	+4 44*	S 54° 30 E	78 9	37 57½	66 14½	66 75	9 54 1
	157	Harvard Observatory, Massach'tts	42 22 49	71 8	.02	10°	3 53	—6 3*	S 50° E	76 33	35 52	62 6	102.10	10 0 42

TABLE II.—*Continued.*

Description of series.	Serial Number.	Place of Observation.				Angular Determination of the Meteor's Position.					Geographical Position of Meteor.			Local mean time.
		Name.	Geographical position.			Altitude.			Azimuth.	Parallax.	North latitude.	Longitude west from Greenwich.	Height above the sea in miles.	
			North latitude.	Longitude W. from Greenwich.	Height above the sea in decimals of a mile.	By observation.	By calculation.	Difference.						
5th Series—In which the difference between the observed and calculated positions of the meteor exceeds 7°.	158	Rockund, Pennsylvania	40° 3′	75°24′	.04(?)	35°	3°33′	—31°27′	N 60° W	75°11′	44°54′	89°14′	128.40	9h 40m 28s
	159	Detroit, Michigan	42 24	82 58	.11	40°	32 8½	— 7 5½	N 30° W	55 53	44 6	84 21	89.73	9 11 3
	160	Cleveland, Ohio	41 29	81 40	.12	10°	20 29	+10 29	N 34° W	66 23	44 4	84 12	88.77	9 16 15
	161	Flint, Michigan	42 57	83 41	.12	35°	44 43	+ 9 43	Northeast	44 9	43 44	82 35	79 16	9 8 21
	162	Copley, Ohio	41 8	81 47	?	"nearly as high the north star"	22 41	note †	N 1° 40′ E	64 55	43 32	81 41	74.34	9 16 1
	163	Erie, Pennsylvania	42 11	80 8	.11	44° 30′	36 38	— 7 52	N 26° W	52 2	43 22	80 57	70.82	9 22 42
	164	Eden, New York	42 37	79 7	.13	49¾°	33 38	—16 7	N 59½° W	54 53	43 21	80 52	70.42	9 26 46
	165	Brantford, Canada West	43 3	80 38	.06	90°	74 43	—15 17	"right over head"†	14 2	43 17	80 34	69 07	9 20 44
	166	Meadville, Pennsylvania	41 39	80 11	.21	39° 30′	31 8	— 8 22	North	57 19	43 12	80 11	67.40	9 22 34
	168	Hamilton, Canada West	43 15	79 57	.05	75°	83 26	+ 8 26	South	6 27	43 8½	79 57	66.41	9 23 31
	169	Ellicottsville, New York	42 16 26″	78 42	.25(?)	44° 48′	36 7½	— 8 40½	N 46° 25′ W	52 36	43 9	79 58	66.47	9 28 31
	170	Coudersport, Pennsylvania	41 47	78 6	.30(?)	39° 18′ to 44° 8½′	23 27 to 26 36	—15 51 to —17 32½	N 42° 40½′ to 45° 58′ W	61 36 to 64 33	43 6 to 43 11	79 49 to 80 6	65 55 to 66.98	9 30 55
	171	Erie, Pennsylvania	42 10	80 8	.11	32°	43 27½	+11 27½	N 21° 40′ E	45 34	43 4	79 38½	65 17	9 22 56
	172	Erie, Pennsylvania	42 10	80 8	.11	54°	43 27½	—10 32½	N 21° 40′ E	45 34	43 4	79 38½	65.17	9 22 56
	173	Germantown, Pennsylvania	40 2	75 12	.02	25°	9 55	—15 5	Northwest	75 53	42 55	79 2	62.85	9 42 16
	174	Elkland, Pennsylvania	41	77 17	.26	55°	31 54	—23 6	N 50° 45′ W	56 43	42 51	78 45	61.81	9 36 18
	175	Rochester, New York	43 8	77 51	.10	30°	59 51	+29 51	S 20° W (nearly)†	29 39	42 43	78 11	59.92	9 32 5
	176	Nunda, New York	42 36	78 3	.13	80°	94 30	+14 30	South	4 26	42 40	78 3	59.51	9 31 18
	177	Lockport, New York	43 10	78 47	.11	40°	51 4	+11 4	S 48½° E	38 15	42 41	78 6	59.66	9 28 22
	178	Dansville, New York	42 35	77 50	.13	77° to 80°	91 57½	+13 27½	South	1 56	42 36½	77 50	58 85	9 32 13
	179	Romeo, Michigan	42 44	83 0	.14	0°	10 57	+10 57	East ("nearly")†	75 21	42 35	77 46	58.67	9 11 32
	180	Libertytown, Maryland	39 28	77 13	.12(?)	25°	13 41	—11 19	"a little west of north"†	73 17	42 30	77 20	57.45	9 34 42
	181	Hamilton College, New York	43 3 16	75 24 17″	.10	10° 8′	28 30	+18 22	S 65° 15′ 5″ W	60 2	42 26	77 6	56.86	9 41 55
	182	Rochester, New York	43 8	77 51	.10	25° 30′	39 35	+14 5	S 39° 20′ E	49 27	42 23	77 1	56.63	9 32 12
	183	Washington City	38 53	77 1	.01	20°	11 22	— 8 38	North	75 8½	42 23	77 1	56.63	9 35 32
	184	Clyde, New York	43 4	76 56	.08	17°	48 29	+31 29	South	41 48	42 21	76 56	56.43	9 35 52
	185	Elmira, New York	42 7	76 55	.16(?)	see note †	73 49	15	N 38 E	16 58	42 18	76 43	56.10	9 35 58
	186	Davidsonville, Maryland	38 58	76 40	.01	20°	11 53	— 8 7	"a little west of north"	74 48	42 17	76 40	55.56	9 36 58
	187	Eagle Station, Pennsylvania	40 3	75 23	.04(?)	5°	17 0	+12	N N W	70 35	42 16	76 38	55.33	9 42 6†
	188	Newburyport, Massachusetts	42 48	70 52	.01	18° 49′	8 36	—10 13	S 82° 50′ W	77 19	42 10	76 21	53.33	10 0 12
	189	Hagerstown, Maryland	39 37	77 35	.12(?)	45°	13 30	—31 30	N 28° E	73 48	41 59	75 52	50.03	9 33 23
	190	Easton, Pennsylvania	40 39½	75 17	.03	18° 55′	27 34	+ 8 41	N 16° W	61 6½	41 55	75 46	49.43	9 42 35
	191	Valley Forge, Pennsylvania	40 5	75 25	.04	"40 or a little less"	20 29	—19 31	North	67 47	41 49	75 25	47.12	9 42 6
	192	Easton, Pennsylvania	40 39½	75 17	.03	19° 23′	28 42	+ 9 19	N 5° 40′ W	59 6	41 50	75 28	47.44	9 42 38
	193	West Bloomfield, New Jersey	40 49	74 13	.04	6°	27 2	+21 2	N 41° W	61 41	41 47	75 22	46.80	9 46 55
	194	Easton, Pennsylvania	40 39½	75 17	.03	21° 43′	30 3	+ 8 20	N 1° 36′ W	58 51	41 46	75 20	46.59	9 42 39
	195	Coudersport, Pennsylvania	41 47	78 6	.30(?)	0°	16 22	+16 22	East	71 32	41 46	75 20	46.59	9 31 23
	196	Morristown, New Jersey	40 48	74 33	.04	15°	30 24	+15 24	N 30° W	58 30	41 45	75 19	46.38	9 45 35
	197	Nantucket, Massachusetts	41 17	70 6	.01	26°	7 57	—18 3	N 82° 30′ W	78 18	41 40	75 5	45.10	10 3 24
	198	Easton, Pennsylvania	40 39½	75 17	.03	22° 53′	31 33	+ 8 40	N 9° E	57 25	41 40	75 4	44.99	9 42 40
	199	Nantucket, Massachusetts	41 17	70 6	.01	27° 30′	7 59	—19 31	N 83° W	78 19	41 38	75 0	44.59	10 3 25
	200	Easton, Pennsylvania	40 39½	75 17	.03	25° 30′	32 46	+ 7 16	N 22° 28′ E	56 18	41 32	74 47	43.26	9 42 42
	201	Eagle Station, Pennsylvania	40 3	75 23	.04(?)	40°	9 41½	—30 18½	N 25° E	77 16½	41 25	74 32	41.77	9 42 20
	202	Perth Amboy, New Jersey	40 32	74 23	.01	65°	34 50	—30 10	North	54 20	41 22	74 23	40.89	9 46 21
	203	Newport, Delaware	39 43	75 34	.02	25°	16 37	— 8 23	N 28° E	71 31	41 21	74 22	40.82	9 41 45
	204	Morristown, New Jersey	40 48	74 33	.04	35°	45 42½	+10 42½	N 30° E†	43 44	41 18	74 17	40.30	9 41 41
	205	West Point, New York	41 23 31	73 58	.02	see note †	67 29	— 8 33	S 69° W	22 17	41 18	74 16	40.24	9 48 1
	206	Hanover, New Hampshire	43 42	72 17	.10	20°	10 17	— 9 43	S 32° W†	76 56	41 17	74 12	39.89	9 54 46
	207	Steamer City of Hartford	41 16	72 22	.00	50°	32 46	—27 14	West	65 54½	41 15	74 9	39 60	9 54 26†
	208	West Point, New York	41 23 31	73 58	.02	60° to 65°	72	+ 9 30	S 31° W†	17 50	41 14	74 7	39.38	9 48 2
	209	Morristown, New Jersey	40 48	74 33	.04	31° 17′	45 37	+14 20	N 37° 40′ E	43 50	41 14	74 6	39.30	9 45 42
	210	Fishkill Landing, New York	41 33	73 58	.01	75° to 80°	56 45	—18 15	South	32 52	41 11	73 58	39.25	9 48 3
	211	Bedford, New York	40 40	73 56	.01	"hardly 45°"	51 14	?	N 25° E†	38 19	41 5	73 41	39.48	9 48 13
	212	Sag Harbor, New York	41 0	72 18½	.01	41°	32 27	— 8 33	N 89° W	56 40	41 0	73 30	39.66	9 54 44
	213	Steamer City of Hartford	41 16	72 22	.00	50°	42 12	— 7 48	Southwest	47 10	40 49	72 58	40.29	9 54 33
	214	New Haven, Connecticut	41 18	72 57	.01	30° to 40°	49 18	+14 18	South	40 13	40 48	72 57	40 32	9 52 13
	215	Easton, Pennsylvania	40 39½	75 17	.03	8° 23′	16 33	+ 8 14*	N 84° 22′ E	71 36	40 46	72 51	40.46	9 42 54
	216	Off Brauford, Connecticut	41 14	72 50	.00	90°	49 38	—40 22	South	39 53	40 45½	72 50	40.48	9 52 42
	217	New Britain, Connecticut	41 41	72 48	.05	60°	31 32	—28 28	South	57 32	40 45	72 48	40.52	9 53 50
	218	Gettysburg, Pennsylvania	39 49	77 15	.12	0°	7 16	+ 7 41*	N 75° E	79 4	40 40	22 34	40 90	9 35 4
	219	Vernon, Vermont	42 46	72 30	.05	30°	14 26	—15 34	South	73 31	40 38	72 30	41.01	9 54 4†
	220	Hinsdale, New Hampshire	42 46	72 27	.05	30°	14 18	—15 42	South	73 33	40 37	72 27	41.10	9 54 17
	221	Steamer City of Hartford	41 16	72 22	.00	50°	40 40	— 9 20	South	48 39	40 35	72 22	41.25	9 54 37
	222	Fair Haven, Massachusetts	41 39	70 55	.01	33° 38′	22 11	—11 17	S 22° 49′ W	66 22	40 18	71 39	42.71	10 0 29†
	223	Providence, Rhode Island	41 49	71 25	.01	35° to 40°	20 25	—17 30	South	67 59	40 13	71 25	43.28	9 58 31
	224	New Bedford, Massachusetts	41 38	70 56	.01	"34° to 45° (35°?)"	20 51	—13 39	South	67 32	40 1	70 56	44.57	10 0 30
	225	Sudbury, Vermont	43 49	73 10	.12	13° 40′	6 8	— 7 32	S 27° 7′ E	79 24	39 51	70 32	45.76	9 51 34
	226	New York City	40 43½	74 0½	.01	24°	11 11	—12 49	S 72° 20′ E	75 55	39 45	70 17	46.57	9 48 16
	227	Woodbury, New Jersey	39 50	75 13	.02	20° to 25°	8 2	—14 28	East	78 8	39 44	70 14	46.79	9 43 26
	228	Nantucket, Massachusetts	41 17	70 6	.01	6°	21 21	+15 21	S 4° 30′ E	66 58	39 37	69 57	47.71	10 3 56
	229	Wallingford, Connecticut	41 26	72 50	.03	2°	11 39	+ 9 39	S 51° 30′ E	75 23	39 34	69 50	48.13	9 53 1
	230	Nantucket, Massachusetts	41 17	70 6	.01	4° 30′	13 34	+ 9 4	S 34° 30′ E	73 25	38 44	67 66	56.51	10 4 9
	231	Harrisburg, Pennsylvania	40 16	76 50	.06	14½°	0 1	—14 39	S 73° E	83 1	34 59	60 30	120.10	9 38 6

NOTES ON THE FOREGOING TABLES.

No. 3. Assumed azimuth S. 76° 46½′ E.

No. 5. The observer says that the meteor "passed between the Guards (β and γ) of Ursa Minor." The altitude of β at the time was 53° 13′ 55″, and its azimuth N. 15° 42′ 32″ W. The altitude of γ was 56° 49′ 1″, and its azimuth N. 15° 57′ 45″ W. The meteor, according to calculation, passed 42′ 8″ above the former, and 2° 49′ 28″ below the latter; being in a direct line between the two at about the azimuth given in the text.

No. 6. Time by observation $9^h\ 30^m$.

No. 7. Time by observation $9^h\ 45^m$.

No. 8. At the altitude of α Lyræ (77° 29′ 46″) the calculated azimuth of the meteor's centre is S. 76° 53′ E., which gives for its distance from that star about 3½′; so that if the apparent semi-diameter of the meteor exceeded 3½′ it occulted the star.

No. 9. At the observed altitude (77° 2′) the calculated azimuth is S. 78° 39′ 9″ E., which gives 14′ 39″ E. as the angular distance between the observed and calculated positions of the meteor.

No. 10. Assumed azimuth, due east.

No. 12. Time by observation $9^h\ 44^m$.

No. 18. The meteor was observed to pass "very nearly in the line of the two lowest bright stars of Cassiopeia" (δ and ε), "if anything different, perhaps a little below them." The geocentric altitude of ε at the time was 22° 44′ 51.″

No. 19. Assumed azimuth N. 30° E.

No. 20. Assumed azimuth S. 31° W.

No. 21. See No. 18. Geocentric altitude of δ Cassiopeiæ 23° 0′ 59.″

No. 24. The meteor was observed to pass near Arcturus, "probably a trifle below." Geocentric altitude of Arcturus 39° 18′ 15″.

No. 25. Passed "through the constellation Scorpio, probably a little below Antares." Geocentric altitude of Antares 18° 34′ 24″.

No. 26. "Passed just south of the zenith."

No. 27. Passed "through the constellation Bootes, a little south of Arcturus," whose altitude was 39° 13′ 16″, and azimuth S. 82° 36′ W. Hence, at the point of nearest approach, the distance between the meteor and the star was 6° 47.′

No. 30. Passed "near the zenith, if anything a little north."

No. 34. Passed "about 2° or 3° below Antares," whose altitude was 14° 28′ 49″—say 14° 29′—from which deduct 2½°, and we have the results given in the text.

No. 44. In making the calculations for this observation the latitude and longitude of Alexandria were used, the exact geographical position of the observer not being known.

No. 59. The azimuth, when the altitude was a maximum, was about N. 15° E.

No. 64. Time by observation $9^h\ 40^m$ to $9^h\ 45^m$.

No. 66. Time by observation "about $9^h\ 50^m$."

No. 68. Time by observation "about half-past nine." Another observer says the meteor disappeared in the east at $9^h\ 35^m$.

No. 73. The meteor "burst into view in the constellation Ursa Major below the dipper." Geocentric altitude of β Ursæ Majoris, the lowest star of the "dipper," 31° 31′ 49″.

No. 76 (a). Time by observation $9^h\ 20^m$.

No. 79. Assumed azimuth for maximum altitude S. 20° W.

No. 84. Assumed azimuth due east. In order to satisfy the observation of the altitude, the azimuth must be a little south of east.

No. 92. "Or perhaps a little less."

No. 93. The altitude at this azimuth was somewhat conjectural on the part of the observer, as he did not see the meteor till it was some 10° further east.

No. 96. This azimuth is assumed from the statement of the observer that the meteor was "at right angles to his position."

No. 101. Assumed azimuth for maximum altitude.

No. 118. Time by observation $9^h\ 30^m$.

Nos. 123 and 226. The azimuths of both these observations were measured from the course of Fourth Street, which being assumed to be at right angles with Broadway, and the course of the latter street being, according to the map of the Harbor Commissioners, from S. 32° 31′ W. to N. 32° 31′ E., that of the former varies 57° 29′ from the meridian. Both these observations will be much better satisfied, if the course of Fourth Street varies 58½° or 59° from the meridian.

No. 125. Assumed azimuth N. 1° E.

No. 133. This is the altitude and azimuth as observed at the time of the disruption of the meteor. According to the calculated path, the disruption occurred three seconds earlier, when the azimuth was about N. 74° E. It is not improbable that a few seconds may have elapsed after the disruption, before the parts became separated far enough to attract notice.

No. 144. Observed maximum altitude "considerably more than 45°;" "somewhere near 60°." The assumed azimuth is that of the greatest altitude very nearly. Time by observation 9ʰ 45ᵐ.

No. 148. Time by observation 9ʰ 43ᵐ.

No. 149. "Passed 3° or 4° south of the Eagle." At the point of nearest approach to Altair (α Aquilæ) the distance by calculation was about 8°.

No. 162. Geocentric altitude of "the north star" (Polaris) 40° 14′ 53″.

No. 165. Assumed azimuth when nearest the zenith N. 10° E.

No. 175. Corresponding to the maximum altitude.

No. 179. In order to satisfy this observation the azimuth must have been about S. 82° E.

No. 180. Assumed azimuth N. 1° W.

No. 185. The meteor was observed to pass within 2° of α Lyræ, whose altitude was 78° 3′ 38″, and azimuth S. 79° 7′ 23″ E. The point of nearest approach, according to the calculated path, was when the azimuth of the meteor was about N. 38° E., and its altitude about 73° 49′; the distance being then about 15°.

No. 187. Time by observation 9ʰ 42ᵐ.

No. 204. Approximate azimuth when the altitude was a maximum.

No. 205. "Passed very near λ Cor. Borealis," whose altitude was 68° 9′ 9″, and azimuth N. 88° 8′ 23″ W. The point of nearest approach, according to the calculated path, was when the azimuth of the meteor was about S. 69° W. and its altitude 67° 29′; the distance being then about 8° 33′.

No. 206. Approximate azimuth when the altitude was a maximum.

No. 207. Time by observation 9ʰ 50ᵐ.

No. 208. Approximate azimuth when the altitude was a maximum.

No. 211. Approximate azimuth when the altitude was a maximum.

No. 219. Time by observation 9ʰ 50ᵐ.

No. 222. Time by observation 9ʰ 55ᵐ.

No. 226. See No. 123.

The following map (Plate 1st) shows the line over which the meteor is computed to have passed vertically, A being the point over which it is assumed to have first become visible, and B and C points over which disruptions occurred. It shows also the places where observations were made, indicated by dots, and where space allows, the name is given, or a reference number. The rest may be identified by their geographical positions.

Plate 2d is a profile section, in which the vertical lines show the heights of the meteor at different points along its path, as given in Table I.

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MAY, 1869.

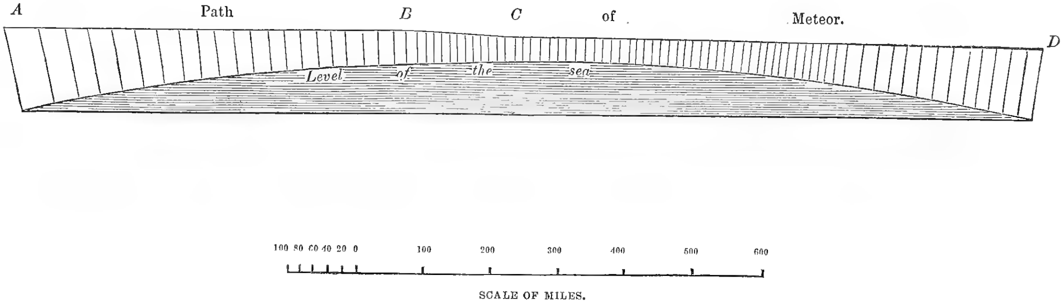
Plate II.—*Profile Section of the Meteor's Visible Path.*

A.—Point of first appearance.

B.—Point of first rupture.

C.—Point of second rupture.

D.—Point of disappearance.



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THE
TRANSATLANTIC LONGITUDE,
AS DETERMINED BY THE
COAST SURVEY EXPEDITION OF 1866.

A REPORT

TO THE SUPERINTENDENT OF THE

U. S. COAST SURVEY.

BY

BENJAMIN APTHORP GOULD,
LATE ASSISTANT.

[ACCEPTED FOR PUBLICATION, FEBRUARY, 1869.]

THE principal results contained in the following report were communicated to the National Academy of Sciences, and the report in full was afterwards presented for publication to the Smithsonian Institution by the author, Dr. B. A. Gould, with the consent of Prof. Benjamin Peirce, Superintendent of the Coast Survey.

JOSEPH HENRY,
Secretary S. I.

SMITHSONIAN INSTITUTION.
October, 1869.

PREFACE.

THE main facts here presented, together with the numerical results of the field reductions, were communicated to the National Academy of Sciences at their session of January, 1867.

The definite reductions were made during the spring and summer of 1867, Mr. A. T. Mosman assisting in them until May, when he was ordered elsewhere, and Mr. S. C. Chandler, jr., then taking the principal part in them, until they were essentially completed in the following October.

This report, in its present form, was prepared during the year 1867, except the final chapter upon the velocity of the signals, which has chiefly been written during the present month, since receiving from the Superintendent of the Survey permission to print the report.

B. A. GOULD.

CAMBRIDGE, MASSACHUSETTS,
February, 1869.

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ON THE

TRANSATLANTIC LONGITUDE.

I.

ORIGIN OF THE COAST-SURVEY EXPEDITION.

THE determination of longitudes by means of the electro-magnetic telegraph, was, as is well known, first practised by the U. S. Coast Survey; and the methods by which it attained its full development were here in use for several years before they began to be employed elsewhere. From the year 1849 until the beginning of the late war, early in 1861, they were unremittingly prosecuted. At that time, 24 independent determinations had been made, no pains having been spared for the attainment of all possible precision; and the series of telegraphic longitudes extended from the northeastern boundary to New Orleans, covering $2\frac{1}{2}$ hours of longitude and 15° of latitude within our own territory, as well as some portions of the British provinces. Upon the completion of the Pacific Telegraph, arrangements were made[1] for extending the connection to San Francisco; but these were reluctantly deferred in consequence of the condition of the country.

For longitudes reckoned from any trans-Atlantic zero, much coarser methods only have hitherto been available; and the uncertainty of the determinations has been twenty or thirty times greater than that between any of the points which form the series of American determinations, and very much larger than that between any points referred to these fundamental ones, by the geodetic operations of the Survey.

The Atlantic cable promised at last to afford an opportunity of connecting the American with the European longitudes, and thus of reducing the two independent series of determinations into what should practically be but one. The large views of the late honored head of the Coast Survey, Prof. Bache, led him to take immediate steps for the attainment of this end; and upon the first organization of the Atlantic Telegraph Company, to the assistance of which he gave his hearty and effective support, he obtained[2] from the officers of this and of the Newfoundland

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[1] Coast Survey Report, 1861, p. 2.

[2] Ibid. 1858, pp. 33, 34, 43; 1859, p. 6.

companies their ready promise of all needful facilities for determining the relative longitude of their terminal stations.

Immediately upon the landing of the cable at Trinity Bay, Mr. Hilgard was dispatched to this remote spot, in order to decide from personal inspection whether the communication was sufficiently good to permit of satisfactory longitude-signals, without delay; but his report was necessarily adverse.

Upon the organization of the telegraphic cable-expedition of 1865, Mr. Hilgard, who during Prof. Bache's illness was acting in his behalf, obtained anew from the respective companies permission for the use of the cable, if successfully laid; and the Hon. Secretary of the Treasury authorized the necessary outlays. Mr. L. F. Pourtales repaired to Heart's Content, and there awaited the arrival of the Great Eastern, in order to inform me without delay of the character and availability of the signals, should the cable be successfully laid; but the rupture of the cable in mid-ocean made his expedition unavailing.

The same preliminary steps were again taken in 1866, Mr. G. W. Dean awaiting the arrival of the Great Eastern at Heart's Content. The expedition of this year was happily successful, and Mr. Dean reported by telegraph that the sharpness of the signals was all that could be desired. Measures were at once taken for organizing the parties. Mr. Dean returned only a few hours too late to present his report while we were attending the session of the National Academy of Sciences at Northampton; but he found Mr. Hilgard and myself at the meeting of the American Association in Buffalo, where all the details for the expedition were arranged without delay, and the needful directions for preparation of instruments and observers given by Mr. Hilgard.

The large interval between the meridians of the two extremities of the cable precluded the employment of the method of star-signals, for many reasons. This method requires a more protracted occupation of the cable than it seemed right or reasonable to solicit; the climate of Newfoundland, according to the best information received, is too uncertain and variable to warrant reliance upon the continuance of a clear sky for three hours, while unless the promise should be favorable it would be unwise to employ the cable for transmitting observations from Valencia, which would be useless unless combined with subsequent observations of the same stars from Heart's Content. Moreover, for a longitude so great as that to be measured, the special advantages of the method of star-signals chiefly disappear; the clock-rates becoming matters of serious importance, and entailing errors of the same order of magnitude as those of the absolute time-determination, while the wide separation of the observers precludes that thorough elimination and control of personal equation which is feasible when the longitude-observations are restricted to zenithal stars, and the observers can easily exchange positions and frequently meet at one or the other station.

There was also ground for confidence that the catalogue of standard stars to be employed for determining time was so well freed from systematic errors, that the difference of half a quadrant in the meridians would introduce no error depending on the right-ascensions, no matter at what hour the comparisons might be made—a confidence which the event has fully justified.

II.

PREVIOUS DETERMINATIONS OF THE TRANSATLANTIC LONGITUDE.

The several determinations of longitude between European and American stations, which have hitherto served as the basis for astronomical and nautical computations, may be classified under the three heads—from moon-culminations, from eclipses and occultations, and from chronometers. Most of them have been referred to one or the other of two American points, the College Observatory at Cambridge, and the Naval Observatory at Washington. The former has presented especial conveniences for the chronometric expeditions, both from its close vicinity to the point of landing and shipment in Boston, and from the charge of these expeditions being confided to the director of the observatory, who was specially versed in chronometric matters, and whose office in Boston was connected with the Cambridge clock by a telegraph wire, so that not even the transportation to the observatory was requisite. The latter, as situated at the national capital, and administered by one of the departments of government, has been naturally selected, in most cases during recent years, as the fundamental point for other determinations. As the European point of reference, Greenwich has been employed in all cases.

The telegraphic longitudes of the Coast Survey have, since the first year, been uniformly referred to a third American point, the "Seaton Station" of the Coast Survey in the city of Washington. But the longitudes of New York and Philadelphia, upon which that of Cambridge depends, were referred to the Washington Observatory, which is situated[1] $12^s.44$ westward from the Seaton Station, by geodetic measurement. The longitude between Cambridge and Washington, as determined by my predecessor, Mr. Walker, in 1848 and 1849,[2] is as follows:—

Cambridge east from Mr. Rutherfurd's Observatory, New York .	0^h	11^m	$26^s.07$
Mr. Rutherfurd's east from Jersey City Station (geodetic) . . .			11.93
Jersey City Station east from Washington	0	12	3.54
Cambridge (dome) east from Washington	0	23	41.54

and this value has since that time been adopted in all computations, and in the standard books of reference. It must be very near the truth; yet it depends in part upon a geodetic measurement across the Hudson River, where no telegraph wire then existed, and was the earliest determination by the new method, before the employment of many refinements and precautions since introduced. Moreover, the portion between Jersey City and Washington was deduced from the simple telegraphic comparison of clocks—a method which repeated experience, as well as theory, shows to be entirely inferior in precision to the Coast Survey method of star-signals. For this reason, I have more than once urged a redetermination of the only weak link in our chain of telegraphic longitudes, by connecting Mr. Rutherfurd's observatory at New York with the Seaton Station, as well as the Washington

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[1] Value determined since that given in the Coast Survey Report, 1851, p. 322.

[2] Coast Survey Report, 1848, p. 22; 1849, pp. 19, 20, 31.

Observatory, by the same methods which have been employed for all the other measurements from our boundary to New Orleans.

Using the values above cited, the following are the determinations of the longitude of Washington from Greenwich which have appeared best entitled to confidence in recent years.

I. *From Eclipses and Occultations.*—These furnished the values generally adopted prior to the year 1848, namely, not less than $5^h\ 8^m\ 14^s$. Thus Gilliss in 1846 used[1] $5^h\ 8^m\ 4^s.6$ for the provisional observatory on Capitol Hill which was,[2] geodetically, $10^s.05$ east of the present observatory. And in the volume of observations made in 1845, the first issued by the Washington Observatory, the adopted longitude is given[3] as $5^h\ 8^m\ 14^s.64$.

Peirce's reductions, in 1845, of occultations observed by Bond at Dorchester from 1839 to 1841 gave[4] $5^h\ 8^m\ 13^s.9$; and Walker, from an elaborate discussion of all available observations between 1769 and 1842, inclusive, obtained[5] $5^h\ 3^m\ 14^s.16$, a value subsequently[6] reduced to $13^s.85$ by change in the adopted longitude of Philadelphia, Cambridge, and Washington.

In 1839 Walker had deduced a new value for the moon's horizontal parallax from a discussion[7] of the eclipse of 1836 May 14, according to which the mean value used by Burckhardt, in the lunar tables employed in the computation of the longitude, required an increase of $1''.52$; and he discovered[8] that, although the probable accidental error of his former result for the longitude of Philadelphia was but $\pm\ 0^s.35$, (subject, however, to the influence of any error in the adopted parallax and semidiameter of the moon,) yet the employment of his new value of the horizontal parallax would diminish the longitudes assigned to all the stations of the Coast Survey by about two seconds of time. Prof. Airy, at Greenwich, had, in reducing the Greenwich observations of 1840, already adopted[9] Henderson's determination,[10] according to which Burckhardt's constant required to be increased by its twenty-six hundredth part. So, too, Olufsen, from discussions,[11] in 1837, of Lacaille's meridian altitudes at the Cape of Good Hope, had inferred the need of an increase of this constant by $2''.24$, and Henderson, in the same year, from his own observations with the mural circle at Capetown, deduced[12] $1''.3$ as the requisite increase. All these investigations, though greatly varying among themselves, agreed in the results that Burckhardt's value was decidedly too small, and thus corroborated the change which Walker's computation of the eclipse of 1836 showed to be necessary. Relying on these confirmations, Walker adopted[6] the correction $+\ 1''.5$ to Burckhardt's constant, and found that the trans-Atlantic longitude deduced from eclipses was thus diminished by $2^s.67$ for the whole coast of the United States. The report

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[1] Gilliss, Astr. Obs. p. x.

[2] By Ellicott's original survey of Washington City. See Coast Survey Report, 1846, p. 72.

[3] Wash. Obs., 1845, p. 87.

[4] Coast Survey Report, 1846, p. 71.

[5] Coast Survey Report, 1848, p. 113.

[6] Ibid. 1851, p. 480.

[7] Transactions Amer. Phil. Soc., VI. 383.

[8] Coast Survey Report, p. 115.

[9] Greenwich Observations, 1840, p. xlviii.

[10] Mem. R. Astr. Soc., X. 283.

[11] Astr. Nachr. XIV. 226.

[12] Mem. R. Astr. Soc., X. 284.

of the Astronomer Royal concerning the reductions of the Greenwich Lunar Observations appeared soon after, and indicated[1] that Burckhardt's coefficient required an increase by its twelve-hundredth part, or $2''.85$, thus dissipating any yet remaining doubts as to the necessity of a large diminution of all American longitudes counted from a European meridian.

We thus have at present, from observations of eclipses and occultations—

Walker,[2] corrected value from observations before 1843	$5^h\ 8^m\ 11^s.14$
Peirce,[3] from eclipse of 1851, July 28	11.57
Peirce,[4] from emersions of Pleiades, 1839, Sept. 26	11.45 ± 0.3
Peirce,[5] " " " 1856—1861	13.13

but neither of the last three determinations is considered by Prof. Peirce as final.

II. *From Moon Culminations:—*

Walker,[6] from	Cambridge	observations	1843—45	$5^h\ 8^m\ 10^s.01$
Loomis,[7] "	Hudson	"	1838—44	9.3
Gilliss,[8] "	Capitol Hill	"	1838—42	10.04
Walker,[6] "	Washington	"	1845	9.60
Newcomb,[9] from	"	"	1846—60	11.6 ± 0.4
Newcomb,[10] "	"	"	1862—3	9.8

Walker considered $9^s.96$ as the most probable value from moon-culminations, and Newcomb assigned $11^s.1$ as that indicated by those observed at the Naval Observatory from 1846 to 1863, inclusive.

III. *From chronometers transported between Boston and Liverpool.*

Indiscriminate mean[11] from 373 chronometers previous to 1849	$5^h\ 8^m\ 12^s.46$
Bond's[12] discussion of 175 chronometers, Expedition of 1849	11.14
Walker's[6] " " " " "	12.00
Bond's[13] " " " " "	12.20 ± 0.20
Bond's[14] " of 52 chronometers, 6 trips, Expedition of 1855	13.43 ± 0.19

All of these values require to be increased by $0^s.06$, to conform to the new telegraphic determination by the Astronomer Royal of the longitude between Liverpool and Greenwich.

The discordance of results which individually would have appeared entitled to full reliance is thus seen to exceed four seconds; the most recent determinations, and those which would be most relied upon, being among the most discordant. No amount of labor, effort, or expense had been spared by the Coast Survey for its chronometric expeditions, inasmuch as the most accurate possible determination of the trans-

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[1] Monthly Notices R. Astr. Soc., VIII. 186; Mem. R. Astr. Soc., XVII. 52.

[2] Coast Survey Report, 1851, p. 480.

[3] Ibid. 1861, p. 195.

[4] Ibid. 1861, p. 220.

[5] MS. Coast Survey Report.

[6] Ibid. 1851, p. 480.

[7] Astr. Journal, I. 67, using telegraphic longitude of Hudson from Washington as given by Walker, Coast Survey Report, 1851, p. 481. See also Trans. Amer. Phil. Soc., X. 10.

[8] Trans. Am. Philos. Soc., X. 123; Wash. Obs. 1862, vii.

[9] Wash. Obs. 1862, lii.

[10] Ibid. 1864, p. 46.

[11] Coast Survey Report, 1851, p. 480.

[12] Ibid. 1850, pp. 17, 79.

[13] Ibid. 1854, pp. 120, 138, 141.

[14] Ibid. 1856, p. 182.

Atlantic longitude was specially required[1] by law; and the thorough accuracy of Prof. Newcomb's investigations is well known to astronomers. Yet the result of the latest chronometric expedition differs from that deduced by Newcomb,—from moon-culminations observed at the Washington Observatory since its reorganization, compared with those observed at Greenwich,—by more than three and a half seconds of time.

The value employed by the Coast Survey from 1852 to 1859 was $5^h\ 8^m 11^s.2$; since 1859 it has been $5^h\ 8^m\ 11^s.8$.

III.

HISTORY OF THE EXPEDITION.

The building erected in Calais, Maine, and occupied as a longitude-station in 1857, was still in existence, though much dilapidated, the stone piers being undisturbed. Mr. George Davidson, Assistant in the Coast Survey, was to take charge of this station, with Mr. S. C. Chandler, Jr., as aid. Mr. Dean was assigned to the station at Heart's Content, with the assistance of Mr. Edward Goodfellow; while I was to occupy the Valencia station, Mr. A. T. Mosman accompanying. Each station required a small transit-instrument, a chronograph, and an astronomical clock.

The most questionable feature of the arrangement was the use of the land line of wire, about 1100 miles long, between Heart's Content and Calais. Hitherto all our telegraphic longitudes have been determined without any use of "repeaters," or double relay-magnets, which have been most carefully avoided as inevitably introducing an additional element of error, or at least of uncertainty, into the result. The armature-times of different electro-magnets, acted on by galvanic currents of different intensities, enter into the result, and only their mean amount is eliminated, while one-half their difference remains inseparably merged with the resultant longitude. Between Calais and Heart's Content there were known to be not only several of these repeaters, but also one or two stations at least where the messages were received and re-sent by hand, without the intervention even of an automatic "repeater." Yet not only our financial resources, but also our available time and our supply of instruments, precluded the occupation of more than three stations at once, and it was reluctantly decided to make use of so many repeaters in this interval as careful investigation should show to be absolutely necessary.

Messrs. Davidson and Dean left Boston for Halifax in the steamer of Sept. 5, to make an examination of the condition of the telegraph line, and a week later Messrs. Goodfellow, Mosman, and myself sailed in the Cunard steamship Asia, bound for Liverpool, *via* Halifax and Queenstown, taking the instruments for Newfoundland and Ireland. But a short time before our departure the welcome tidings had arrived of the recovery, in mid-ocean, of the lost cable of 1865, and of the successful continuation of this second line to Newfoundland.

To the courtesy and interest of the officers of the Cunard Company we were indebted, from the beginning to the end of our expedition, for many favors and

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[1] Coast Survey Report, 1858, p. 32.

much assistance. The cordial and effective aid of Captain J. P. Anderson, of H. B. M. mail steamer Africa, then temporarily in command of the Asia, was of peculiar value, and calls for the sincerest acknowledgments. I may also mention here our obligations to Mr. Grierson, agent of the Cunard steamship at Queenstown, who, both at the debarkation and reshipment of the instruments, assisted us in the most effective manner.

At Halifax the accounts given by Messrs. Davidson and Dean were far from encouraging. Between the terminus of the Atlantic cable and the American frontier there proved to be four "repeaters" and two stations at which messages were rewritten. Repeaters and batteries were at once provided by us for use at these last-named stations, and it was decided that Mr. Davidson should charter a schooner, in which to visit the various points along the coast of Nova Scotia, Cape Breton Island, and Newfoundland, carrying with him the necessary outfit, and giving the requisite instructions to the operators.

This Mr. Davidson successfully accomplished through great energy and personal exertion, while Mr. Chandler, at his direction, refitted the Calais station, and mounted the instruments; the first observations made there being on the 25th October.

Messrs. Dean and Goodfellow reached Heart's Content on the 20th September, and proceeded to the immediate preparation of an astronomical station; but were not favored with the sight of any celestial luminary until the 16th October, on which day they brought the transit and clock into tolerable adjustment, and on the 18th their regular observations commenced.

On the morning of Saturday, September 22, the Asia arrived off Queenstown, where Mr. Mosman landed with the instruments, while I kept on to Liverpool, and thence to London, to confer with the officers of the Company.

The management and control of the cables being with the Anglo-American Telegraph Company, which had conducted the expedition of 1866, and not with the Atlantic Telegraph Company, on whose friendly promises of assistance we had depended, it became necessary to apply anew for permission to use the lines, and for the needful facilities at Valencia. To the cordial friendliness of George Saward, Esq., Secretary of the Atlantic Company, we had already been indebted for many acts of courtesy, and he aided me without delay in the most effective manner.

The use of the cables was at once granted by John C. Deane, Esq., Secretary of the Anglo-American Company, subject, of course, to the condition that the observations and experiments should not interfere with the regular business of the Company; and I was furnished by him with letters to the telegraphic staff at Valencia. From the eminent Electrician to the Company, Latimer Clark, Esq., I received much valuable information and important practical suggestions, as well as full authority for the trial of electro-magnets in connection with the cables, besides the needle-galvanometers in use by the Company.

The Astronomer Royal also gave his ready sympathy to the undertaking. His own plans had been formed, authority obtained, and some of the preparations already commenced, for making a telegraphic longitude-determination between Valencia and Newfoundland in June following; but, with extreme kindness, he placed me in possession of all his special information pertaining to the subject, and aided our operations with word and deed. Subsequently,—when, to my own regret as well as to his, it proved necessary to establish our station at the cable terminus, near the western end of the island of Valencia, rather than at either of the two points for which he had already determined the longitude from Greenwich,—he carried out a third determination of longitude for Valencia, by a telegraphic interchange of signals between Greenwich and our station at Foilhommerum Bay.

On the 1st October I met Mr. Mosman at Killarney. According to previous arrangement he had already brought the instruments to that point by rail, and had visited Valencia to examine the ground, and learn what provision would be required for the stone piers of our transit-instrument and clock, and for the materials of our astronomical station. From his report it was manifest that the requisite supplies could be obtained upon the island, or in its immediate vicinity, and early on the morning of October 2 we started westward. The six large boxes of instruments were piled and carefully made fast upon a large "Irish car," the only vehicle upon springs to be found in the town; and the transportation of this huge tower on wheels for 42 miles, to the ferry across the Straits of Valencia, and the deposit of the instruments in a place of shelter, were accomplished without accident before daylight had wholly disappeared.

The longitude-stations occupied by Mr. Airy in the great chronometer expedition of 1844 (Greenw. Obs'ns, 1845), was at *Feagh Main*, an elevated position previously used as a station by the British Trigonometrical Survey; his transit instrument being placed upon the station-point. For the telegraphic determination of 1862, the instrument used in determining time was mounted in the village of Knightstown, at the eastern extremity of the island. The employment of the same station-point, the position of which was well marked, was, of course, highly desirable. Moreover, it was situated at that point of the island which afforded by far the greatest conveniences, and it was close to the hotel. But the electricians of the Company have always been extremely averse to any connection, however brief, between the cable and any land lines, on account of the possibility of injury to the cable by lightning. This fact, to say nothing of others connected with prompt exchange of messages with Newfoundland, and a readiness to avail ourselves of any sudden change of weather at either place, rendered it imperative that our station should be established very near the building of the Telegraph Company at Foilhommerum Bay, 5½ miles west of Knightstown, and remote from any other dwelling-house except the unattractive cabins of the peasantry.

Here, as close to the telegraph house as was consistent with an unobstructed meridian, the astronomical station was established, and a building constructed, 11 feet wide and 23 in length. This was divided by a transverse partition into two apartments, the larger of these serving as an observatory, while the eastern end was used as a dwelling-place. This building was bolted to six heavy stones buried in the earth, and was protected from the southwest gales by the telegraph house, the corner of which was within a very few yards at the nearest point, while rising ground to the northwest guarded us against the winds from that quarter.

In the observing-room were mounted the transit instrument clock and chronograph. It also contained a table for a relay-magnet and Morse register, and a recording table.

For the kind reception which we met at Valencia, I know not how to give an adequate expression of my thanks. A more hearty welcome, a more thorough and delightful hospitality, a more friendly aid, could have been found at no time or place. The inevitable hardships and exposure of our life, at a distance from any permanent habitation other than the over-tenanted house of the Telegraph Company, and under circumstances apparently incompatible with comfort, were thus mitigated and compensated to an incredible degree. To the Knight of Kerry we were indebted not only for a hospitality worthy the traditional reputation of the land, and for which we shall always remain personally grateful, but also for the most practical and efficient aid in furtherance of our operations. All his agents received instructions to assist us by every means in their power; his buildings afforded storage for our instruments at Knightstown; his quarries and stonecutters furnished piers; his factor enabled us to obtain lumber; and his carpenter was detailed for expediting the work upon our building.

The gentlemen of the telegraphic staff received us with a kindliness to which there was no exception, welcoming us to their quarters, and sharing with us their comforts. Of the sixteen electricians and operators in the service of four different companies, there is no one to whom we are not indebted for essential aid in our work, as well as under personal obligations for many acts of kindness. To Messrs. James Graves, superintendent of the station, and Edgar George, second in charge, we owe especial acknowledgments.

The peculiarly unastronomical sky of Valencia delayed adjustments for a while; but one or two glimpses of the sun at noon enabled us to establish our meridian, and, on the 14th October, at 3 A. M., we obtained transits of a few stars. At that time the observers in Newfoundland had seen neither sun, moon, nor stars; and I am inclined to believe that, excepting the short period when sharp frosts prevail there, the climate of Newfoundland is nearly as unfavorable for astronomical purposes as that of Valencia itself. As regards the Valencia climate, I was informed, on our arrival, that it had rained every day, without exception, for eight weeks. During the seven weeks of our sojourn, there were but four days on which no rain fell; and there was but one really clear night during the period while the instruments were in position. The observations were, in general, made during the intervals of showers; and it was an event of frequent occurrence for the observer to be disturbed by a copious fall of rain while actually engaged in noting the transit of a star.

The method of telegraphing through the Atlantic cable is based upon the ingenious device of Prof. Thomson, in applying to a delicate galvanometer the principle of reflection used by Gauss for heavy magnets. A small mirror, to the back of which is attached a permanent magnet, the joint weight of the two being from five to six centigrams, is held, by means of a single fibre above and below, in the centre of a coil of fine wire, which forms part of the galvanic circuit; and its position and sensitiveness are regulated by movable bar-magnets placed in the immediate vicinity. Upon the mirror is thrown a beam of light through a slit in front of a bright kerosene lamp, and the deflections of the needle are noted by the movements of the reflected beam, which is received upon a strip of white paper. The exquisite delicacy of this galvanometer, as well as the electrical excellence of the telegraph cables, may readily be appreciated after the beautiful experiment in which the electricians at Valencia and Newfoundland conversed with each other on a circuit not far from 700 myriameters (4320 statute miles) in length, formed of the two cables joined at the ends, using a battery composed of a percussion gun-cap, a morsel of zinc, and a drop of acidulated water.

The absence of any means for the automatic registration of signals received, presented, of course, a very serious obstacle in the way of an accurate longitude determination, inasmuch as the loss of time in noting the signals was not only very considerable, but quite uncertain; but the programme of operations which I had prepared before leaving home was based upon the assumption that the use of self-registering electro-magnetic signals would not be acceptable to the Telegraph Company. All objections to these were, however, waived in our favor by Mr. Latimer Clark in the most cordial manner, and considerable time was expended on two evenings in endeavoring to obtain satisfactory signals which should be self-registering. Unfortunately, these efforts were unsuccessful. The cable could not be discharged with sufficient rapidity for the purpose when the charge was sufficiently strong to actuate our most sensitive electro-magnet. A permanent deflection only was observed at Newfoundland, while the Valencia clock was breaking the circuit during an eighth part of every second; nor did any modification in the character of the battery render these interruptions of continuity perceptible at the other extremity of the cable.

I had previously designed availing myself of an ingenious suggestion of Dr. Gibbs, by which the heat from the lamp should be concentrated and reflected, together with the light, by the mirror-galvanometer; being then received on a very delicate thermo-electric pile, which should thus record upon the chronograph the time of the signals. But too little time was available for the purpose, and although Mr. Farmer, whom I had requested to prepare some apparatus based on this principle, made sufficient progress with his experiments to show the practicability of the suggestion, he was obliged to abandon all hopes of constructing any satisfactory instrument in season to be available for our purposes.

Thus it became necessary to fall back upon the original programme which had been prepared before leaving Boston, and furnished to Messrs. Dean and Davidson. This was as follows:—

PROGRAMME FOR TRANSATLANTIC LONGITUDE CAMPAIGN.

This campaign will consist of two parts, "Heart's Content—Calais," and "Valencia—Heart's Content."

Star-signals being impracticable in each case, the only determinations of longitude will be by comparisons of clocks between the stations; consequently no precautions should be omitted which can in any way increase the precision of the clock-corrections and rates. Only stars of the American Ephemeris should be employed; levels should be continually read during the observations; all circumpolars should be reversed upon; and stars as far north as 80° should be observed by the old method of eye and ear, instead of the chronograph.

Whenever possible, sets of observations should be made at least twice during the night, each set consisting of not less than three circumpolars (not all at the same culmination), and three time-stars north of the equator, together with any southern time-star which may be convenient. A set of observations should always precede, and another set follow, the exchange of signals, when the weather permits.

One or more of these sets should be computed promptly, that observers may constantly be acquainted with the condition of their instruments. The azimuth error should never remain for more than a day larger than $0^s.2$, nor the collimation error larger than $0^s.1$. For the field computations it will suffice to read off a single tally for each star.

The amount of battery-power and condition of the wire is always to be noted when telegraphic signals are exchanged; also any indications of aurora.

Heart's Content—Calais.

So soon as the instruments are in adjustment, the exchange of clock-signals should commence, and it should be continued nightly, whatever the weather, until the operations for trans-Atlantic longitude are completed at Heart's Content. At the time of the exchange, Calais should notify Heart's Content whether it can determine the clock-correction on the same night; and should transmit the correction deduced for the time of the signals sent on the preceding night.

To exchange clock-signals, put the Calais clock into circuit two or three times, for not more than half a minute at each time and at intervals of at least a minute, while the Heart's Content clock is graduating the chronograph. Arrange the time for putting on the Calais clock, so that the record of 0^s shall be included in the series of its signals. It is very desirable that both chronographs should record this comparison, but if this should be found impossible, the Heart's Content chronograph is the proper one to keep the record. If any confusion is likely to arise as to the precise seconds recorded by the Calais clock, this can be readily obviated by making a couple of quick taps immediately after 15^s, 30^s, or 45^s of the clock-time, entering this fact upon the day-book, and communicating it to Heart's Content.

Valencia—Heart's Content.

1. For this determination, three nights' exchanges through each cable will suffice, provided the clock-corrections are well determined at each station, before and after the exchange. Should circumstances be especially favorable on any occasion, there is no reason why work should not be done with both cables on the same night, thus reducing the requisite number of nights to five.

2. The times at which exchanges will be made must necessarily depend upon the convenience of the Telegraph Company; but the hours between 10 P. M. and 6 A. M. are preferable. (All civil times in this programme are understood to be Greenwich mean times.) Whenever exchanges are to be undertaken, Valencia will notify Heart's Content as early as 6 P. M., if practicable, naming the hour when this can be done. Should no such notice be received by midnight, Heart's Content need not feel obliged to attend farther.

3. At the appointed hour, Valencia will telegraph the word *Gould*, as a notice that all is ready; and upon the reception of the word *Dean* in reply, will begin the signals.

4. The exchange of signals will be effected as follows:—

a). Beginning with a positive current, sets of alternate positive and negative signals will be made, each signal consisting of a single tap half a second in length. The first group will consist of four taps, at intervals of five seconds. Then, after a pause of ten seconds, will follow a group of three taps, five seconds apart; and, after a second pause of ten seconds, yet another group of three taps at five-second intervals; these ten taps, in three groups, constituting a "set." The arrangement of the set will then be thus:—

$$P_{5s}\,N_{5s}\,P_{5s}\,N_{10s}\quad P_{5s}\,N_{5s}\,P_{10s}\quad N_{5s}\,P_{5s}\,N$$

and each set will occupy one minute.

b). Two such sets, following one another at an interval of ten seconds, will be sent first from

Valencia; then two sets returned from Heart's Content; and this exchange will be made three times, which will suffice for the telegraphic work of the night. The time requisite will therefore be 2m. 10s. for each series of two sets. Three such series being sent from each station, the time actually consumed for the signals will be but 13m.; so that 20m. will probably suffice for the whole operation.

c). Before sending each series of taps, the sender will call attention by a few rapid alternations of positive and negative signals, to be answered in the same way before he begins the series; consequently the order of proceedings will be as follows:—

First Exchange.	Valencia gives rapid signals, and Heart's Content responds. Valencia sends two series of taps, occupying 2m. 10s. Heart's Content gives rapid signals, and Valencia responds. Heart's Content sends two series of taps, occupying 2m. 10s.

Valencia then proceeds to give the preliminary signals for a second exchange, and in this way the three exchanges are made. If possible, each observer should then state whether the signals have been successfully received.

5. The length of the taps, and of the intervals between them, is a matter of some importance. Hence a mean-time watch or clock should be used, and the same care taken in giving signals as in making observations. Especially should all the taps be of equal length.

The observer of signals should have the break-circuit key of the chronograph in his hand, and record the earliest indication of deflection. Should the deflection ever be in the reverse direction of that indicated by the programme, this fact should be noted.

6. It may conduce to a better determination of the time of transmission if exchanges are made at different hours of the day. One "set" of ten taps as already described, exchanged at the beginning of each third hour, would probably suffice for this purpose, although each alternate hour would be preferable. These experiments should be made on both cables separately, and, if possible, on the circuit formed by connecting the two cables, without any earth-connection to either. The times for these experiments must be left to subsequent arrangement.

If possible, the following experiments for velocity should be made by use of both cables. They are more important than the system of observations at different hours of the day.

I. The two cables being connected at Heart's Content, but without battery there, Valencia first, and then Heart's Content, will send two sets:—

1. With the two ends to earth at Valencia through battery.
2. With the two ends to earth at Valencia, one through battery, the other direct.
3. With the two ends at Valencia to the two poles of battery without earth connection.

II. The same connection with the Heart's Content battery included in the circuit.

III. (Like I., *vice versâ*). The cables being connected at Valencia without battery; Valencia first, and then Heart's Content will send two sets:—

1. With both ends to earth at Heart's Content through battery.
2. With both ends to earth at Heart's Content, one through battery, the other direct.

IV. The same, with the Valencia battery included in the circuit.

7. At the earliest convenient opportunity after an exchange of signals, each observer will communicate to the other his corrected sidereal time, corresponding to the means of the last set of ten taps received, and the last set of ten taps sent.

On the 24th October, longitude-signals were exchanged with Newfoundland for the first time. Between that date and November 20, four more opportunities had been found, and the entire series of experiments for determining the velocity of signals under different circumstances had been satisfactorily tried, as well as some others which I found practicable at Valencia, although not provided for in the programme.

Meanwhile the Astronomer Royal, who had, with his usual kindness, acceded to my request for a telegraphic connection between our station-point and Greenwich, and assumed all the labor and embarrassment of the necessary arrangements, had carried out the series of exchanges with Foilhommerum, an undertaking attended with no little inconvenience and vexation from the various difficulties attending land lines, especially when a submarine cable of the length of that across the Irish Channel forms a part of the circuit. After many fruitless attempts, clock-signals were exchanged on three nights, upon two of which the time was well determined at both places.

Upon the 20th November, the weather at Heart's Content, as well as at Valencia, was extremely unpromising; no communication had yet been obtained between that station and Calais, and it seemed best, on all accounts, to bring our cable signals also to an end. After visiting Greenwich to offer such aid in the reduction of the longitude-exchanges with that Observatory as might be acceptable to the Astronomer Royal, Mr. Mosman reached home on the 22d December, and I followed four weeks later.

The personal error, with other loss of time in observing signals, has happily proved more constant and more measurable than I had ventured to anticipate. No matter how great the interval, the resultant longitude will only be affected by one-half the difference of the values for the two observers; while the average value for the two observers could be merged with the time of transmission for the signals. It is not the least satisfactory of our results that this interval proved capable of measurement with a degree of accuracy which leaves no ground for apprehension that it has appreciably affected our value for the longitude, and which enables us to infer the velocity of transmission within restricted limits of probable error.

The exchanges between Heart's Content and Calais were far less satisfactory. Notwithstanding the laborious precautions taken by Mr. Davidson, all efforts at direct communication proved unavailing, day after day, and week after week. Mr. Davidson's health became seriously impaired, and Mr. F. W. Perkins was added to the Calais party, joining it on the 12th November. Finally, Mr. Davidson being called to important duties at the Isthmus of Darien, was compelled to leave Calais, and Mr. Charles O. Boutelle, one of the most experienced officers of the Survey, was assigned to the charge of the station. Still, the necessity of an intermediate astronomical station at Port Hood or Aspy Bay seemed inevitable, when suddenly, on the 11th December, only a couple of hours before Mr. Boutelle's arrival, the long-desired communication was found to be established. A sharp frost had thrown the otherwise defective line into a condition of admirable insulation, so that an interchange of clock-signals was effected without difficulty. Comparisons of clock-time at the two stations were also made on the 12th, 14th, and 16th December, though not in a manner wholly satisfactory, since clouds interfered with the attainment of sufficient observations for time. At this juncture Mr. Dean, at Heart's Content, decided to discontinue observations, and dismount his instruments, so that the work was brought to a close, the Newfoundland observers reaching Boston again in the last week of December.

In reducing the observations, I have been aided to some extent by Mr. Mosman, but chiefly by Mr. Chandler, who has for several years rendered efficient and skilful service in computations of this kind, as well as in numerous other astronomical observations and reductions. To both these gentlemen I desire to make acknowledgment for their valuable services in the office as well as in the field.

The nature of the undertaking had, of course, thus far precluded any determination of personal equation between the observers. This was provided for with as little delay as possible. My plan had contemplated the entire elimination of this disturbing element at Heart's Content, since it would affect the longitudes of Calais and Valencia equally, but with opposite signs. It proved that this precaution had been overlooked, and that the time had been determined by Mr. Dean during the exchanges of signals with Europe, and by Mr. Goodfellow during those with the United States; but, as will be seen, this proved of no practical importance. During a long series of years the personal equation between these two gentlemen, as determined several times annually, was inappreciable; and so, too, it proved in the comparisons made after their return from the present expedition. At the earliest practicable date extensive observations were made for the determination of the personal equations between each pair of observers. The results of these will be given in their place.

It may, perhaps, be well to add a few words concerning the instruments used, which were the regular apparatus of the telegraphic party of the Coast Survey, consisting at each station of a transit-instrument, a chronograph, and a circuit-breaking clock.

The transit-instruments have an aperture of about 7 centimeters, and a focal length of about 116 centimeters. Each is provided with a reversing apparatus attached to an iron stand, and capable of reversing the instrument with ease in about twenty seconds; so that it is not difficult to observe a star, in one position of the axis, within 30 or 35 seconds after observing it in the other. The illuminating lamps are placed on brackets unconnected with the instrument, and as far from it as possible. The reticule carries five "tallies" or sets, of five spider-lines each, at intervals of about $2\frac{1}{2}$ equatorial seconds of time, the several tallies being separated from each other by twice this distance. The tallies are denoted by letters of the alphabet from B to F inclusive, and the individual threads by subjacent numbers, the numeration beginning with the "Lamp End" or end at which the illumination is admitted to the field, so that when this end is west, a star at its upper culmination traverses the threads in the direct order of their numeration from B_1 to F_5. The instruments are provided with diagonal eye-pieces of magnifying power not far from 100, and signal keys are permanently fixed on each side in convenient positions. The chronographs at Valencia and Heart's Content were "Spring Governors" by Messrs. Bond & Son; that at Calais was a "Kerrison's Regulator," with modifications by Mr. Saxton. Upon all of them one pen, which is constantly tracing a line upon a revolving cylinder, records the signals both of the clock and of the observer by offsets from this normal line.

The experience of eighteen years has shown that the greater simplicity of the apparatus, when provided with but a single electro-magnet and recording pen, far overbalances in the longitude work of the survey any inconveniences arising from a possible confusion of the clock-signals with those given by the observer. The offsets produced by the former are of practically equal length, this length depending on the adjustment of the armature and strength of the battery; while those produced by the observation-signals are for a practised observer quite near enough to equality to preclude any difficulty in reading off the records, except in very rare instances. For portable instruments there seems to be no room for reasonable doubt as to the superiority of an instrument with a single pen; and for the fixed instruments of an observatory I should personally give this construction a decided preference. All signals are given by the interruption of a closed circuit, so that, when the observing key is properly adjusted, no interval elapses between the first pressure and the transmission of the telegraphic signal; while the moment of release of the armature from the electro-magnet is distinctly recorded. The clocks are all provided, according to Saxton's plan, with delicate platinum tilt-hammers resting on platinum disks, and so adjusted that a small pin fixed in the pendulum-rod at its centre of percussion shall strike the tilt-hammer at the instant when the rod is vertical, and thus lift the hammer from the disk for a very brief period, generally about the one-hundredth part of a second. The galvanic circuit to the chronograph being conducted through this tilt-hammer and disk, the circuit becomes interrupted for a moment at each oscillation of the pendulum.

The advantages of this mode of recording the clock-signals over any in which the galvanic current traverses any portion of the clock itself, or in which the signals are produced according to Saxton's original plan by contact with a globule of mercury, have been sufficiently set forth in previous reports, and require no repetition here.

IV.

OBSERVATIONS AT VALENCIA.

Here the Krille clock and Transit-instrument No. 4 were employed. I had supposed all precautions taken to insure that the instruments should be in good order; but, owing probably in part to the haste with which the expedition was organized in view of the approach of winter, this was not the case, and the want of proper condition of both these instruments, as well as of the minor telegraphic apparatus, much augmented the unavoidably serious difficulties of the enterprise.

Observations were obtained on fifteen nights during our sojourn at Valencia, on no one of which the sky was unclouded. On only two of the five nights on which longitude-signals were exchanged with Newfoundland was it possible to obtain observations after the exchange, and this was possible, too, on only one of the three nights when signals were successfully exchanged with Greenwich. Observations of circumpolar stars for the special purpose of determining the intervals of the transit threads, were out of the question. Indeed there was but one instance when a transit of any star north of 60° declination was observed over all twenty-five threads. In those rare instances when this would have been possible, the stars were needed for determining the error of collimation.

At the close of the series of observations, it was found that 53 complete transits had been observed over all the threads; and since the equatorial intervals of the same reticule had been very thoroughly and satisfactorily deduced from an ample series of observations in 1860–61 at Pensacola, it appears that little would probably be gained by an attempt to obtain additional data at Valencia. Indeed, after assorting the thread-intervals deduced from the Valencia observations into three classes, the accordance of the mean values for these classes showed a probable error amounting for but few of the threads to so much as 0^{s}.02 of a great circle.

The Pensacola values had been deduced from 121 transits of 21 stars,—the average declination of 9 of them being 75$\frac{1}{2}$°. The probable error of but few of the intervals was so large as 0^{s}.005; and the combination of these values with those derived from the Valencia observations gives all needful accuracy. The Pensacola values were therefore reduced to the focal adjustment of the instrument at Valencia by diminishing each interval by its three-thousandth part, and a triple weight was assigned to the resultant values.

We thus have, for the equatorial intervals of the several threads from the mean of all, the following determinations:—

EQUATORIAL THREAD-INTERVALS OF TRANSIT NO. 4.

	Pensacola values		Valencia, 1866.	Adopted value.
	1860–61.	Reduced to Valencia focus.		
B_1	+34^{s}.156	+34^{s}.145	+34^{s}.117	+34^{s}.138
B_2	31.784	31.774	31.834	31.789
B_3	29.255	29.245	29.311	29.261
B_4	26.850	26.841	26.829	26.838
B_5	24.317	24.309	24.289	24.304
C_1	19.450	19.444	19.424	19.439
C_2	17.136	17.130	17.134	17.131
C_3	14.574	14.569	14.570	14.569
C_4	12.204	12.200	12.187	12.197
C_5	9.799	9.796	9.755	9.786
D_1	4.909	4.908	4.904	4.907
D_2	+2.456	+ 2.455	+ 2.462	+ 2.457
D_3	—0.034	— 0.034	— 0.038	— 0.035
D_4	2.372	2.371	2.366	2.370
D_5	4.717	4.716	4.750	4.724
E_1	9.677	9.674	9.693	9.679
E_2	12.220	12.216	12.175	12.206
E_3	14.634	14.629	14.647	14.634
E_4	17.154	17.148	17.166	17.152
E_5	19.467	19.461	19.442	19.456
F_1	24.438	24.430	24.433	24.431
F_2	26.858	26.849	26.837	26.846
F_3	29.382	29.372	29.361	29.369
F_4	31.770	31.760	31.789	31.767
F_5	—34.168	—34.157	—34.119	—34.147

Levelings of the axis were of course made as frequently as possible, and the correction for inequality of the pivots thence deduced is —0^{s}.013, the perforated end of the axis being the larger. The value resulting from Pensacola levelings was $0^s.015$; and the mean of these has been applied to all level-readings as correction for inequality of pivots.

On and after November 5, the transit-observations upon which the longitudes depend were made by Mr. Mosman alone. On the 25th and 28th October, they were made by myself; and on the other dates which enter in any way, however implicitly, into the longitude-determinations transits were observed by both of us. This circumstance, undesirable in itself, was, from the necessities of the case, not to be avoided. I have, however, whenever possible, employed Mr. Mosman's observations only for determining the clock-correction, and for those cases where this was not feasible have applied to my own observations the constant correction of $-0^s.08$ for personal equation to reduce them to Mr. Mosman's, as will be explained in a subsequent chapter.

With these few explanations, and the added remark that the observations for time were almost without exception obtained with extreme difficulty in the intervals of clouds and rain in one of the most unfavorable climates of the globe for an astronomer, I give the crude observations, and their reduction for the groups immediately preceding and following each series of longitude-signals, omitting the others generally as needless. The notation and methods of observation and reduction are those prepared by me for the longitude work of the Coast Survey some fifteen years ago, and are described in detail by Mr. Dean in the appendix to the Coast Survey Report for 1856. The conditional equations for clock-correction and azimuth are solved by least squares, after correcting for level-error and clock-rate; the normal equations and resultant values being appended to each group. As already stated, my own observations have been referred to Mr. Mosman in every case, by subtracting $0^s.08$ from the observed times.

1866, October 25.—G., Obs.

Star.	Lamp.	Threads	M	b_0	R	Bb_0+k
γ Aquilæ . . .	E.	B_1—F_5	$19^h 40^m 3^s.67$	$+0^s.128$	$0^m 0^s.000$	$+0^s.087$
α " . . .	"	B_1—F_5 [F_4 lost]	44 26.42	+0.132	—0 1.338	+0.087
ε Draconis,[1] U.C. .	"	D_4 $E_{1\,3\,5}$	48 11.45	+0.136	+0 33.603	+0.337
" " .	W.	E_5 $F_{1\,4\,5}$	50 5.12	+0.138	—1 19.972	+0.342
τ Aquilæ . . .	"	C_1—E_5	19 57 45.94	+0.143	+0 0.015	+0.092

$T = 19^h.8.$ $\theta = -8^s.3.$ $\rho = 0^s.00.$ $c = -0^s.019.$

Star.	t	a	Cc	ω_0'	Aa	Δt
γ Aquilæ . . .	$19^h 40^m 3^s.76$	$39^m 55^s.43$	$-0^s.020$	$-0.{}^s04$	$+0^s.17$	$-8^s.51$
α " . . .	44 25.17	44 16.86	—0.020	—0.03	+0.17	8.50
ε Draconis, U. C. .	48 45.44	48 36.77	- - - - -	—0.37	—0.22	8.45
τ Aquilæ . . .	19 57 46.05	57 37.85	—0.020	+0.12	+0.18	—8.36

$$4\,\Delta\theta + 1.159\,a = -0^s.316$$
$$+1.159\,\Delta\theta + 2.259\,a = +0.375$$
$$a = +0^s.243,\quad \Delta\theta = -0^s.147,\quad \Delta t = -8^s.447.$$

1866, October 27.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
θ′ Ceti	E.	B_1—F_5	$1^h 17^m 31^s.77$	$-0^s.160$	$0^m 0^s.000$	$-0^s.089$
γ Piscium . . .	"	B_1—F_5 [$E_{1\,3\,4}$ lost]	24 33.53	—0.132	—0 1.945	—0.119
o " . . .	"	B_1—F_5	38 31.67	—0.104	0 0.000	—0.086
β Arietis . . .	"	B_1—F_5	47 27.40	—0.098	0 0.000	—0.106
50 Cassiopeiæ, U.C.	"	E_1—F_5 [$F_{2\,3}$ lost]	51 16.84	—0.091	+0 5.330	—0.314
" " "	W.	D_5—F_2 [E_3 lost]	1 53 14.49	—0.089	—0 53.402	—0.308

$T = 1^h.7.$ $\theta = -8^s.5.$ $\rho = -0^s.010.$ $c = +0^s.170.$

Star.	t	a	Cc	ω_0'	Aa	Δt
θ′ Ceti	$1^h 17^m 31^s.68$	$17^m 23^s.11$	$+0^s.172$	$+0^s.10$	$+0^s.08$	$-8^s.48$
γ Piscium . . .	24 31.47	24 22.92	0.175	+0.13	+0.06	8.43
o " . . .	38 31.58	38 23.15	0.172	+0.24	+0.06	8.32
β Arietis . . .	47 27.29	47 18.73	+0.181	+0.12	+0.05	8.43
50 Cassiopeiæ, U.C.	1 52 21.31	52 12.78	- - - -	—0.03	—0.10	—8.43

$$5\,\Delta\theta + 1.675\,a = +0^s.551$$
$$+1.675\,\Delta\theta + 3.156\,a = +0.420$$
$$a = +0^s.091,\quad \Delta\theta = +0^s.080,\quad \Delta t = -8^s.420.$$

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[1] Illumination very bad.

1866, October 28.—G., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Cygni	E.	B_1—F_5	$20^h\,37^m\;2^s.92$	$-0^s.059$	$0^m\,0^s.000$	$-0^s.102$
μ Aquarii . . .	"	B_1—F_5	45 37.04	-0.063	0 0.000	-0.041
12 Y. Cat. 1879 U.C.	"	D_4—F_5	51 55.63	-0.069	$+1$ 49.390	-0.422
" " "	W.	E_4—F_4 [F_3 lost]	56 5.04	-0.076	-2 21.419	-0.458
σ² Urs. Majoris L. C.	"	B_1—E_3 [E_1 lost]	20 59 15.35	-0.079	-0 29.862	$+0.132$
ζ Cygni . . .	"	B_1—F_5	21 7 25.42	-0.085	0 0.000	-0.101

$T = 21^h$ $\theta = -8^s.7$ $\rho = -0^s.025$ $c = +0^s.124.$

Star.	t	α	Cc	ω_0'	Δa	Δt
α Cygni	$20^h\,37\;\;2^s.82$	$36^m\,53^s.91$	$+0^s.177$	$-0^s.04$	$0^s.00$	$-8^s.74$
μ Aquarii . . .	45 37.00	45 28.03	$+0.125$	-0.15	-0.01	8.84
12 Y. Cat. 1879 U.C.	53 43.88	53 35.11	- - - -	-0.07	$+0.04$	8.81
σ² Urs. Maj. L.C.	20 59 45.62	58 36.48	$+0.329$	-0.11	-0.03	8.78
ζ Cygni	21 7 25.32	7 16.56	-0.144	-0.20	-0.01	-8.89

$$5\,\Delta\theta + 1.058\,a = -0^s.347.$$
$$+1.058\,\Delta\theta + 13.708\,a = +0.101.$$
$$a = -0^s.013,\;\; \Delta\theta = -0^s.112,\;\; \Delta t = -8^s.812.$$

1866, October 30.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
G. γ Cygni . . .	E.	B_1—F_5	$20^h 52^m 22^s.13$	—$0^s.067$	0^m $0^s.000$	—$0^s.107$
" σ^2 Urs. Maj. L.C.	"	B_1—C_5 exc. C_3	57 45.98	—0.067	+0 59.920	+0.117
" " " "	W.	B_1—C_5 exc. C_3	20 59 45.12	—0.067	—0 59.920	+0.117
" ζ Cygni . . .	"	B_1—F_5 [C_4 lost]	21 7 26.54	—0.063	—0 0.577	—0.077
M. 226 Ceph. U.C.	"	C_4—D_2	22 29 40.24	—0.041	+0 29.371	—0.200
" " " "	E.	B_1—C_5	31 37.52	—0.090	—1 27.850	—0.378
" ι Cephei U.C. .	"	E_1—F_5	44 16.12	—0.097	+0 52.953	—0.257
" " "	W.	E_1—F_5	46 2.28	—0.099	—0 52.953	—0.262
" α Pegasi . . .	"	B_1—F_5	22 58 17.89	—0.102	0 0.000	—0.093
G. ι Piscium . . .	"	B_1—F_5	23 33 16.48	—0.104	0 0.000	—0.081
" Grmbr. 4163 U.C.[1]	W	B_1—C_5 exc. B_5	47 21.36	—0.107	+1 17.140	—0.403
" " " "	E.	B_1—C_5 exc. B_4	49 53.75	—0.108	—1 16.140	—0.397
" ω Piscium . . .	"	B_1—F_5	23 52 38.63	—0.108	0 0.000	—0.086

$T = 22^h \qquad \theta = -9^s.3 \qquad \rho = -0^s.030 \qquad c = -0^s.080.$

Star.	t	α	Cc	ϖ_0'	$A\alpha$	Δt
γ Cygni	$20^h 52^m 22^s.02$	52^m $12^s.94$	—$0^s.106$	+$0^s.08$	+$0^s.02$	—$9^s.24$
σ^2 Ursæ Majoris L.C.	20 58 45.67	58 36.70	- - - -	+0.30	+0.13	9.13
ζ Cygni	21 7 25.89	7 16.52	+0.092	0.00	+0.03	9.32
226 Cephei U.C. .	22 30 9.35	30 0.06	- - - -	+0.02	—0.09	9.18
ι Cephei U.C. .	45 8.94	44 59.55	- - - -	—0.07	—0.03	9.33
α Pegasi	22 58 17.80	58 8.57	+0.083	+0.19	+0.04	9.15
ι Piscium . . .	23 33 16.40	33 7.01	+0.080	+0.12	+0.04	9.23
Groombr. 4163 U.C.	48 37.65	48 28.45	- - - -	+0.16	—0.08	9.07
ω Piscium . . .	23 52 38.54	52 29.42	—0.080	+0.15	+0.04	—9.19

$$9\,\Delta\theta + 1.571\,a = +0^s.954.$$
$$+1.571\,\Delta\theta + 11.581\,a = +0.818.$$
$$a = +0^s.058,\ \Delta\theta = +0^s.096,\ \Delta t = -9^s.204.$$

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[1] Very faint; observation difficult.

1866, November 3.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
M. ω Aquarii	E.	B_1—5	$20^h\ 46^m\ 10^s.28$	$-0^s.055$	$-0^m\ 29^s.673$	$-0^s.037$
G. γ Cygni	"	B_1—F_5	52 25.44	—0.053	0 0.000	—0.089
G. σ^2 Urs. Majoris L. C.	"	E_2—F_5	20 59 51.41	—0.046	—1 1.386	+0.090

$T = 21^h \qquad \theta = -12^s.4 \qquad \rho = -0^s.015 \qquad c = +0^s.009.$

Star.	t	a	Cc	ω_0'	Aa	Δt
ω Aquarii	$20^h\ 45^m\ 40^s.57$	$45^m\ 27^s.94$	$+0^s.009$	$-0^s.22$	$-0^s.32$	$-12^s.30$
γ Cygni	52 25.35	52 12.84	+0.012	—0.18	—0.09	—12.41
σ^2 Urs. Majoris L. C. .	20 58 50.11	58 36.93	—0.023	—0.81	—0.82	—12.30

$$3\ \Delta\theta + 3.437\ a = -1^s.132.$$
$$+3.437\ \Delta\theta + 6.102\ a = -2.074.$$
$$a = -0^s.360,\ \Delta\theta + 0^s.035,\ \Delta t = -12^s.365.$$

1866, November 5.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ζ Pegasi	E.	B_1—F_5	$22^h\ 35^m\ 3^s.28$	$-0^s.027$	$0^m\ 0^s.000$	$-0^s.030$
ι Cephei U. C.	"	E_1—F_5	44 19.29	—0.033	+0 52.952	—0.107
" "	W.	E_1—F_5	46 5.35	—0.036	—0 52.952	—0.114
α Pegasi	"	B_1—F_5	22 58 21.88	—0.048	0 0.000	—0.049
ο Cephei U. C.	"	B_1—C_5	23 12 28.87	—0.050	+0 57.061	—0.155
" "	E.	B_1—D_1	14 19.32	—0.083	—0 53.034	—0.238
θ Piscium	"	B_1—F_5	23 21 27.13	—0.096	0 0.200	—0.177

$T = 23^h \qquad \theta = -13^s.1 \qquad \rho = -0^s.015 \qquad c = +0^s.009.$

Star.	t	a	Cc	ω_0'	Aa	Δt
ζ Pegasi	$22^h\ 35^m\ 3^s.25$	$34^m\ 49^s.79$	$+0^s.009$	$-0^s.36$	$-0^s.39$	$-13^s.07$
ι Cephei U. C.	45 12.21	44 59.32	- - - -	+0.21	+0.32	13.21
α Pegasi	22 58 21.83	58 8.49	—0.009	—0.28	—0.36	13.02
ο Cephei U. C.	23 13 25.91	13 13.39	- - - -	+0.58	+0.40	12.92
θ Piscium	23 21 27.05	21 13.56	+0.009	—0.38	—0.41	13.06

$$5\ \Delta\theta + 0.767\ a = -0^s.225$$
$$+0.767\ \Delta\theta + 2.184\ a = -1.215.$$
$$a = -0^s.571,\ \Delta\theta = +0^s.042,\ \Delta t = -13^s.058.$$

1866, November 6.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
σ^2 Urs. Majoris L.C.	E.	E_1—F_1	$20^h\ 59^m\ 32^s.45$	$-0^s.020$	$-0^m\ 42^s.798$	$+0^s.056$
β Cephei[1] U. C. . .	"	D_1—F_5 [F_4 lost]	21 26 32.07	—0.053	+0 39.124	—0.187
θ Aquarii[2] . . .	"	B_{12} $C_{3\ 4\ 5}$	22 10 22.46	—0.053	—0 20.719	—0.036
π "	"	B_1—F_5	18 42.11	—0.061	0 0.000	—0.048
ρ Draconis[3] . . .	"	C_1—$_5$ $E_{1\ 2}$	23 17.83	—0.068	+0 31.132	+0.229
ζ Pegasi	"	B_1—D_5	35 17.91	—0.083	—0 14.873	—0.073
α "	"	B_1—F_5	22 58 21.79	—0.072	0 0.000	—0.069
o Cephei[4] U. C. . .	"	E_1—F_5	23 12 29.70	—0.060	+0 57.094	—0.180
" " . .	W.	F_1—$_5$	14 42.73	—0.058	—1 16.158	—0.176
λ Draconis L. C. .	"	B_1—D_5 [B_5 lost]	24 18.09	—0.052	—0 40.896	+0.071
ι Piscium	"	B_1—F_5	33 20.20	—0.051	0 0.000	—0.045
ω " [5]. . . .	"	B_1—E_5[E_{13} lost]	23 52 33.14	—0.038	+0 9.548	—0.037

$T = 26^h$ $\theta = -13^s.2$ $\rho = -0^s.039$ $c = +0^s.050.$

Star.	t	a	Cc	ω_0'	Aa	Δt
σ^2 Urs. Majoris L. C. . .	$20^h\ 58^m\ 49^s.71$	$58^m\ 37^s.13$	$-0^s.132$			
β Cephei U. C. . . .	21 27 11.01	26 57.47	+0.146	$-0^s.24$	$-0^s.04$	$-13^s.40$
θ Aquarii	22 10 1.71	9 48.54	+0 051	+0.05	+0.04	13.19
π "	18 42.06	18 28.92	+0.050	+0.08	+0.04	13.16
ζ Pegasi	35 2.96	34 49.78	+0.051	+0.05	+0.03	13.18
α "	22 58 21.72	58 8.48	+0.051	+0.01	+0.03	13.22
λ Draconis	23 37 27	23 23 95	+0.147	+0.05	+0.12	13.27
ι Piscium	33 20.16	33 6.94	—0.050	—0.05	+0.04	13.28
ω "	23 52 42.65	52 29.37	—0.050	—0.10	+0.04	—13.33

$$9\ \Delta\theta + 5.303\ a = -0^s.073.$$
$$+5.303\ \Delta\theta + 10.765\ a = +0.325.$$
$$a = +0^s.048,\ \Delta\theta = -0^s.036,\ \Delta t = -13^s.236.$$

1866, November 6.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ζ Arietis .	W.	B_1—F_5 [F_{15} lost]	$3^h\ 7^m\ 26^s.87$	$-0^s.015$	$+0^m\ 3^s.061$	$-0^s.024$
α Persei .	"	B_1—F_5 [C_5 D_1 E_5 F_3 lost]	3 15 2.96	—0.015	+0 2.495	—0.043

$T = 3^h$ $\theta = \ldots\ldots$ $\rho = \ldots\ldots$ $c = +0^s.050.$

Star.	t	a	Cc	ω_0'	Aa	Δt
ζ Arietis.	$3^h\ 7^m\ 29^s.91$	$7^m\ 16^s.61$	$-0^s.053$	- - - -	$+0^s.03$	$-13^s.38$
α Persei	3 15 5.41	14 52.14	—0.076	- - - -	0.00	—13.35

Assumed $a = +0^s.048$, $\Delta t = -13^s.364$.

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[1] Very faint through clouds.
[2] Very faint through clouds.
[3] "Observation doubtful."
[4] Very bad, observation doubtful.
[5] Faint, observation uncertain.

1866, November 8.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ε Delphini . . .	W.	B_1—F_5	$20^h 27^m 4^s.83$	$+0^s.050$	$0^m 0^s.000$	$+0^s.028$
Groombr. 3241 U.C.	"	C_1—D_3	30 15.47	+0.044	+0 32.676	+0.094
" " "	E.	C_1—$_5$	20 31 36.26	+0.022	—0 47.521	+0.024
ζ Cygni	"	B_1—F_5	21 7 30.70	—0.032	0 0.000	—0.044
α Cephei U.C. . .	"	E_1—F_5	14 52.61	—0.018	+0 46.794	—0.068
" " . .	W.	D_1—F_5	16 22.55	—0.008	—0 43.455	—0.047
β Aquarii . . .	"	B_1—F_5	21 24 46.94	+0.021	0 0.000	+0.001
θ " . . .	"	B_1—F_5	22 10 2.68	—0.012	0 0.000	—0.016
η " . . .	"	B_1—$_5D_{12}E_1$—F_1F_4	22 28 43.67	—0.025	+0 1.741	—0.025

$T = 21^h$ $\theta = -14^s.3$ $\rho = -0^s.068$ $c = +0^s.075.$

Star.	t	α	Cc	ω_0'	Aa	Δt
ε Delphini	$20^h 27^m 4^s.86$	$26^m 50^s.80$	$-0^s.051$	$+0^s.15$	$+0^s.14$	$-14^s.29$
Groombr. 3241 U.C. .	20 30 48.50	30 33.93	- - - -	—0.31	—0.24	14.37
ζ Cygni	21 7 30.66	7 16.35	+0.057	+0.06	+0.09	14.33
α Cephei U.C.	21 15 39.19	15 24.84	- - - -	—0.04	—0.08	14.26
β Aquarii	21 24 46.94	24 32.80	—0.050	+0.14	+0.17	14.34
θ "	22 10 2.66	9 48.51	—0.051	+0.18	+0.19	14.31
η "	22 28 45.38	28 31.14	—0.050	+0.11	+0.17	—14.36

$$7\,\Delta\theta + 2.134\,a = +0^s.287$$
$$+2.134\,\Delta\theta + 4.161\,a = +0.840$$
$$a = +0^s.214,\ \Delta\theta = -0^s.023,\ \Delta t = -14^s.323.$$

1866, November 9.—M., Obs.

Star.	Lamp.	Threads.	*M*	b_0	*R*	Bb_0+k
γ Aquilæ	W.	B_2—F_5	$19^h\ 40^m\ 12^s.43$	$-0^s.016$	$-0^m\ 1^s.445$	$-0^s.021$
α "	"	B_1—F_5	44 32.40	—0.015	0 0.000	—0.021
β "	"	B_1—F_5	49 1.61	—0.013	0 0.000	—0.020
τ "	"	B_1—F_5	19 57 53.42	—0.010	0 0.000	—0.017
α^2 Capricorni	"	B_1—F_5	20 10 55.13	+0.004	0 0.000	—0.012
ϰ Cephei U. C. . . .	"	D_1—F_5	14 41.58	+0.012	—1 6.549	—0.011
π Capricorni	"	C_2—F_5	20 6.34	+0.021	—0 9.201	—0.003
ε Delphini	"	B_1—F_5	27 6.62	+0.021	0 0.000	+0.006
Groombr. 3241 U. C. .	"	B_3—C_5	29 47.39	+0.017	+1 2.357	+0.011
" " " .	E.	B_1—D_3	31 47.02	+0.015	—0 56.685	+0.006
α Cygni.	"	B_1—F_5	37 9.75	—0.008	0 0.000	—0.031
ω Aquarii	"	B_1—F_5	20 45 43.72	—0.011	0 0.000	—0.015

$T = 20^h$ $\theta = -15^s.9$ $\rho = -0^s.090$ $c = +0^s.050.$

Star.	*t*	α	*Cc*	ϖ_0'	*Aa*	Δ*t*
γ Aquilæ	$19^h\ 40^m\ 10^s.96$	$39^m\ 55^s.19$	$-0^s.051$	$+0^s.05$	$+0^s.11$	$-15^s.97$
α "	44 32.38	44 16.62	—0.051	+0.07	+0.12	15.95
β "	49 1.59	48 45.81	—0.050	+0.05	+0.12	15.97
τ "	19 57 53.40	57 37.62	—0.050	+0.06	+0.12	15.96
α^2 Capricorni	20 10 55.12	10 39.34	—0.051	+0.09	+0.16	15.97
ϰ Cephei U. C. . . .	13 35 02	13 18.93	—0.237	—0.41	—0.33	15.97
π Capricorni	19 57.14	19 41.27	—0.152	+0.01	+0.17	16.06
ε Delphini	27 6.63	26 50.78	—0.051	+0.04	+0.11	15.97
Groombr. 3241 U. C. .	30 50.05	30 33.85	- - - -	—0.26	—0.19	15.96
α Cygni.	37 9.72	36 53.58	+0.070	—0.12	+0.02	16.04
ω Aquarii	45 43.70	45 27.85	+0.051	+0.16	+0.15	—15.89

$$11\,\Delta\theta + 3.361\,a = -0^s.252.$$
$$+3.361\,\Delta\theta + 10.096\,a = +1.488.$$
$$a = +0^s\,171,\ \Delta\theta = -0^s.077,\ \Delta t = -15^s.977.$$

1866, November 9.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
σ² Ursæ Majoris L. C. .	E.	B_1—C_5	$20^h 57^m 54^s.82$	$-0^s.008$	$+0^m\ 57.754$	$+0^s.040$
" " " . .	W.	B_1—D_2	20 59 42.25	-0.006	$-0\ 49.772$	$+0.038$
ζ Persei	"	B_1—C_1 F_5	3 46 10.41	-0.006	$-0\ \ 6.259$	-0.017
γ Tauri	"	C_1—D_5	4 12 23.26	-0.019	$+0\ \ 7\ 606$	-0.026
ε "	"	B_1—F_5	21 8.42	-0.021	0 0.000	-0.028
α "	"	B_1—F_5	28 34.62	-0.016	0 0 000	$-0\ 022$
α Camelop. U. C. . .	"	B_1—F_5	4 41 10.10	-0.015	0 0.000	-0.066

$T = 4^h \qquad \theta = -16^s.7 \qquad \rho = -0^s.090 \qquad c = +0^s.050.$

Star.	t	α	Cc	ω_0'	Aa	Δt
σ² Ursæ Majoris L. C. .	$20^h 58^m 52^s.57$	$58^m 37^s\ 35$	- - - -	$+0^s.84$	$+0^s.77$	$-16^s.63$
ζ Persei	3 46 4.13	45 47.72	$-0^s.058$	$+0.21$	$+0.14$	16.63
γ Tauri	4 12 30.84	12 14.45	-0.052	$+0.28$	$+0.21$	16.63
ε "	21 8.39	20 52.01	-0.053	$+0.30$	$+0.20$	16.60
α "	28 34.60	28 18.30	-0.052	$+0.39$	$+0.21$	16.51
α Camelop. U. C. . . .	4 41 10.03	40 53.25	-0.123	-0.14	$+0.21$	-16.64

$$6\ \Delta\theta + 3.893\ a = +1^s.870.$$
$$+3.893\ \Delta\theta + 6.863\ a = +2.680.$$
$$a = +0^s.338, \quad \Delta\theta = +0^s.092, \quad \Delta t = -16^s.608.$$

1866, November 13.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ι Cephei U. C. . .	E.	B_1—D_5	$22^h 45^m 52^s.21$	$-0^s.073$	$-0^m\ 35^s.320$	$-0^s.201$
α Pegasi	"	$E_{2\ 3}$ F_1	22 58 8.53	-0.073	$+0\ \ 17.650$	-0.069
θ Piscium . . .	"	B_1—F_5 [D_3 lost]	23 21 31.31	-0.073	0 0.000	-0.060
ω "	"	B_1—F_5	23 52 47.23	-0.073	0 0.000	-0.061

$T = 23^h \qquad \theta = -17^s.8 \qquad \rho = -0^s.015 \qquad c = +0^s.050.$

Star.	t	α	Cc	ω_0'	Aa	Δt
ι Cephei U. C. . . .	$22^h 45^m 16^s.69$	$44^m 58^s\ 97$	$+0^s.121$	$+0^s.20$	$+0^s.07$	$-17^s.67$
α Pegasi	22 58 26.11	58 8.39	$+0.051$	$+0\ 13$	-0.07	17.60
θ Piscium	23 21 31.25	21 13.46	$+0.050$	$+0.17$	-0.08	17.65
ω "	23 52 47.17	52 29.29	$+0.050$	-0.02	-0.08	-17.73

$$4\ \Delta\theta + 1.506\ a = +0^s.377$$
$$+1.506\ \Delta\theta + 1.736\ a = +0.006$$
$$a = -0^s.115, \quad \Delta\theta = +0^s.137, \quad \Delta t = -17^s.663$$

1866, November 13.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Ceti	E.	B_1—F_2 [$C_{1\,4\,5}$ D_1 lost]	$2^h\,55^m\,41^s.23$	$-0^s.064$	$-0^m\,2^s.731$	$-0^s.053$
α Persei	"	B_1—F_5 [B_5 C_{12} D_{13} do.]	3 15 5 07	-0.064	$+0$ 5.047	-0.118
γ^2 Ursæ Minoris L.C.	"	$D_{3\,4\,5}$ E_4—F_5	3 22 12.26	-0.064	-1 2.569	$+0.158$
Groombr. 2320 L.C.	"	B_1—C_3	4 5 5.21	$+0.003$	$+1$ 6.312	$+0.296$
γ Tauri	W.	B_1—F_5	12 32.30	$+0.014$	0 0.000	$+0.002$
ϵ "	"	B_1—F_5	21 9.85	$+0.010$	0 0.000	-0.001
α "	"	B_{1}—$_4$ D_1—$_5$ $F_{2\,3}$	28 29.90	-0.007	$+0$ 6.254	-0.016
α Camelop. U. C. .	"	B_1—C_5 [C_4 lost]	40 14.35	-0.007	$+0$ 56.866	-0.047
" " .	E.	B_1—C_5	42 5.63	-0.005	-0 54.192	-0 042
ι Aurigæ	"	B_1—F_5	48 39.08	-0.015	0 0.000	-0 026
11 Orionis . . .	"	B_1—C_5	4 57 16.94	-0.057	0 0.000	-0.057

$T = 4^h$ $\theta = -17^s.8$ $\rho = -0^s.015$ $c = +0^s.050.$

Star.	t	a	Cc	ϖ_0'	Aa	Δt
α Ceti	$2^h\,55^m\,38^s.45$	$55^m\,20^s.58$	$+0^s.050$	$-0^s.03$	$-0^s.02$	$-17^s.82$
α Persei	3 15 10.00	14 52.24	$+0.076$	$+0.11$	0.00	17.70
γ^2 Ursæ Minoris L. C. .	3 21 9.85	20 52.11	$+0.165$	-0.11	-0.05	17.86
Groombr. 2320 L. C. .	4 6 11 55	5 53.80	-0.134	-0.08	-0 04	17.84
γ Tauri	12 32.30	12 14.51	-0.052	-0.04	-0.01	17.83
ϵ "	21 9.85	20 52.07	-0.053	-0.03	-0.01	17.82
α "	28 36.13	28 18.35	-0.052	-0.03	-0 01	17.82
α Camelop. U. C. . . .	45 11.28	40 53.39	- - - -	-0.08	$+0.01$	17.89
ι Aurigæ	48 39.05	48 21.13	$+0.060$	-0.05	-0.01	17.84
11 Orionis	4 57 16.88	56 59.09	$+0.052$	$+0.07$	-0.01	-17.71

$$10\,\Delta\theta + 8.063\,a = -0^s.279$$
$$+\,8.063\,\Delta\theta + 15.376\,a = -0.159$$
$$a = -0^s.019,\ \Delta\theta = -0^s.013,\ \Delta t = -17^s\,813.$$

1866, November 16.—M., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
η Aquarii	E.	B_1—F_5	$22^h\,28^m\,49^s.85$	$-0^s.003$	$0^m\,0^s.000$	$-0^s.039$
ι Cephei U. C. . . .	"	B_1—F_1	45 31.69	-0.003	-0 14.021	-0.037
α Pegasi	"	B_1—F_5	22 58 27.12	$+0.001$	0 0.000	-0.009
o Cephei U. C. . . .	"	B_1—F_5	23 12 34.54	$+0.008$	$+0$ 57.094	-0.010
" "	W.	B_1—F_5	14 28.88	$+0.009$	-0 57.094	-0.007
θ Piscium	"	B_1—F_5	21 32.18	-0.004	0 0.000	-0.013
λ Draconis L. C. . . .	"	B_1—C_5	24 47.81	-0.020	-0 4.370	-0.043
ι Piscium	"	B_1—F_5	23 23 25.52	-0.050	0 0.000	-0.013

$T = 23^h \qquad \theta = -18^s.8 \qquad \rho = -0^s.013 \qquad c = 0^s.000.$

Star.	t	α	Cc	ϖ_0'	Aa	Δt
η Aquarii	$22^h\,28^m\,49^s.81$	$28^m\,31^s.04$	$0^s.000$	$+0^s.02$	$-0^s.03$	$-18^s.75$
ι Cephei U. C. . . .	45 17.63	44 58.85	0.000	$+0.01$	$+0.02$	18.77
α Pegasi	22 58 27.11	58 8.35	0.000	$+0.04$	-0 02	18.78
o Cephei U. C. . . .	23 13 31.70	13 12.94	- - - -	$+0.04$	$+0.03$	18.78
θ Piscium	21 32.17	21 13.43	0.000	$+0.07$	-0.03	18.71
λ Draconis L. C. . . .	23 43.48	23 24.57	0.000	-0.11	-0.10	18.81
ι Piscium	23 33 25.51	33 6.84	0.000	$+0.14$	-0.03	-18.63

$$7\,\Delta\theta + 4.107\,a = +\,0^s.215$$
$$+\,4.107\,\Delta\theta + 9.097\,a = -\,0.112$$
$$a = -\,0^s.036,\ \Delta\theta = +\,0^s.052,\ \Delta t = -\,18^s.748.$$

V.

OBSERVATIONS AT NEWFOUNDLAND.

Here the Kessels clock was used, and the C. S. transit-instrument No. 6. For determining the intervals of the threads, 100 complete transits of 43 stars are available, which were assorted into seven classes, and the several results of these combined according to weights.

Happily the reticule of this instrument had remained unchanged and unharmed during ten previous longitude-expeditions, for each one of which the equatorial intervals had been carefully determined. The subjoined values are already reduced to the focus used at Heart's Content; those in the first column being derived from eight, and those in the second from two, independent expeditions. In forming the series of adopted values, they received the weights 4 and 1 respectively; the Heart's Content results having the weight 1 also.

Equatorial Thread-intervals of Transit No. 6.

	From 8 campaigns before 1859.	Macon and Appalachicola, 1859, 1860.	Heart's Content, 1866.	Adopted.
B_1	+35^{s}.650	+35^{s}.687	+35^{s}.604	+35^{s}.648
B_2	33.120	33.111	33.117	33.118
B_3	30.623	30.614	30.616	30.620
B_4	28.054	28.062	28.052	28.054
B_5	25.437	25.426	25.425	25.433
C_1	20.565	20.552	20.610	20.570
C_2	17.950	17.937	17.954	17.952
C_3	15.407	15.405	15.403	15.406
C_4	12.703	12.695	12.686	12.699
C_5	10.249	10.240	10.228	10.244
D_1	5.100	5.106	5.116	5.104
D_2	2.585	2.590	2.600	2.588
D_3	+0.052	+ 0.068	+ 0.084	+ 0.060
D_4	—2.461	— 2.469	— 2.474	— 2.464
D_5	5.066	5.085	5.078	5.071
E_1	10.112	10.097	10.092	10.106
E_2	12.828	12.837	12.813	12.827
E_3	15.341	15.344	15.343	15.342
E_4	17.969	17.968	17.964	17.968
E_5	20.447	20.460	20.441	20.448
F_1	25.543	25.532	25.535	25.540
F_2	28.120	28.116	28.103	28.116
F_3	30.692	30.691	30.684	30.691
F_4	33.147	33.152	33.134	33.146
F_5	—35.770	—35.746	—35.834	—35.777

The correction for inequality of pivots, resulting from the Newfoundland observations is —0^{s}.019, and since the average value deduced from the last five previous expeditions was $-0^s.017$, the mean of these, or $-0^s.018$, has been employed, the perforated pivot being the larger.

Although the climate of Newfoundland proved by no means favorable for observation of the heavens, the observers had the satisfaction of obtaining excellent series of transits for time-determinations, both before and after exchanges, upon every date on which longitude-signals were exchanged, whether with Valencia or with Calais. Here, as in the Valencia series, those observations are given, together with their reductions, upon which the longitudes depend; all the transits for Valencia exchanges having been observed by Mr. Dean, and those for the Calais exchanges by Mr. Goodfellow.

1866, October 25.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
κ Cephei U. C. . .	W.	B_1—C_5	$20^h\ 11^m\ 31^s.94$	$-0^s.124$	$+1^m 44^s.553$	$-0^s.555$
" " .	E.	B_1—C_5	15 0.30	-0.148	-1 44.553	-0.650
α Cygni	"	B_1—F_5	36 49.22	-0.154	0 0.000	-0.236
μ Aquarii	"	C_1—E_5	45 23.66	-0.153	-0 0.028	-0.098
ν Cygni	"	B_1—C_5	20 52 38.64	-0.132	-0 30.200	-0.191
ζ "	W.	B_1—$_4$ D_3—F_5 [E_2 lost]	21 7 19.11	-0.101	-0 6.990	-0.126
α Cephei	"	B_1—C_5	14 32.13	-0.124	$+0$ 48.960	-0.286
ι Pegasi	"	C_1—F_5	15 59.75	-0.127	-0 8.095	-0.132
24 Urs. Majoris L.C.	"	E_1—F_5	21 23.62	-0.138	$+1$ 8.610	-0.236
" " "	E.	E_1—F_5	23 41.48	-0.138	-1 8.610	$+0.236$
ξ Aquarii	"	C_1—E_5	30 35.41	-0.142	-0 0.028	$+0.094$
11 Cephei U. C. . .	"	E_1—F_5	38 45.96	-0.146	$+1$ 9.560	-0.451
" " " . .	W	E_1—F_5	21 41 5.67	-0.146	-1 9.560	-0.451

$T=21^h$ $\theta=+4^s.7.$ $\rho=0^s.000.$ $c=-0^s.110.$

Star.	t	a	Cc	ω_0'	Aa	Δt
κ Cephei U. C. . . .	$20^h\ 13^m\ 15^s.52$	$13^m\ 20^s.51$	- - - -	$+0^s.29$	$+0^s.60$	$+4^s.39$
α Cygni	36 48.98	36 53.99	$-0^s.155$	$+0.15$	-0.02	4.87
μ Aquarii	45 23.54	45 28.08	-0.111	-0.27	-0 23	4.66
ν Cygni	20 52 8.17	52 13.06	-0.145	$+0.05$	-0.04	4.79
ζ "	21 7 11.99	7 16.62	$+0.127$	$+0.05$	-0.10	4.85
α Cephei	15 20.80	15 25.44	$+0.234$	$+0.17$	$+0$ 14	4.73
ι Pegasi	15 51.52	15 56.15	$+0.116$	$+0.04$	-0.14	4.88
24 Urs. Majoris U. C. .	22 32.79	22 36.65	- - - -	-0.84	-0.71	4.57
ξ Aquarii	30 35 29	30 39.85	-0.111	-0.25	-0.23	4.68
11 Cephei U.C. . . .	21 39 55.36	40 0.40	- - - -	$+0.34$	$+0.32$	$+4.72$

$$10\,\Delta\theta + 1.499\,a = -0^s.260$$
$$+1.499\,\Delta\theta + 15.420\,a = -3.918$$
$$a = -0^s.268,\quad \Delta\theta = +0^s.014,\quad \Delta t = +4^s.714.$$

1366, October 25.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
γ Cephei U. C. . . .	W.	B_3—C_5	23^{h}32^m 27^s.93	—0^s.168	+1^{m}28^s.678	—0^s.723
" "	E.	B_1—C_5	35 37.32	—0.138	—1 41.250	—0.601
ω Piscium	"	B_1—F_5	23 52 24.79	—0.147	0 0.000	—0.124
α Andromedæ	"	B_1—F_5	0 1 27.22	—0.154	0 0.000	—0.181
γ Pegasi.	"	B_2—F_5	6 19.40	—0.138	0 0.000	—0.133
$\varkappa$ Draconis L. C. . . .	"	B_1—C_5	26 29 25	—0.150	+1 8.916	+0.255
" " . . .	W.	B_1—C_5	29 46.16	—0.152	—1 8.916	+0.255
α Cassiopeæ	"	B_2—E_5	32 42.79	—0.155	+0 13.637	—0.297
β Ceti	"	C_1—E_5	36 50.98	—0.151	+0 0.030	—0.078
32 Camelop. (foll.) L. C.	"	E_1—F_3	44 31.74	—0.133	+2 17.218	+1.007
" " "	E.	D_1—E_3	0 48 37.30	—0.164	—0 46.605	+1.211

$T = 0^h$ $\theta = +\ 4^s.7$ $\rho =\ 0^s.000$ $c = -\ 0^s.110.$

Star.	t	a	Cc	ω_0'	Aa	Δt
γ Cephei U. C. . . .	23^{h}33^m 56^s.34	34^m 0^s.93	- - - -	+0^s.55	+0^s.64	+4^s.62
ω Piscium	23 52 24 79	52 29.45	—0^s.111	—0.03	—0.20	4.87
α Andromedæ	0 1 27.22	1 31.93	—0.125	—0.03	—0.11	4.78
γ Pegasi.	6 19.40	6 24.01	—0.114	—0.07	—0.17	4.80
$\varkappa$ Draconis, L.C. . . .	27 37.70	27 41.86	- - - -	—0.80	—0.78	4.68
α Cassiopeæ	32 56.43	33 0.83	+0.196	+0.20	+0.07	4.82
β Ceti	36 50.96	36 55.11	+0.116	—0.36	—0.29	4.63
32 Camelop. (foll.) L.C. .	0 47 49.83	47 53.52	- - - -	—2.11	—2.16	+4.75

$$8\ \Delta\theta + 10.124\ a = -\ 2^s.651$$
$$+\ 10.214\ \Delta\theta + 66.556\ a = -\ 19.293$$
$$a = -\ 0^s.297,\ \Delta\theta = +\ 0^s.045,\ \Delta t = +\ 4^s.745$$

1866, October 28.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ξ Aquarii	W.	B_1—F_5	$21^h 30^m 34^s.77$	$+0^s.011$	$0^m 0^s.000$	$-0^s.020$
11 Cephei U. C. . .	“	B_1—C_5	38 46.28	+0.009	+1 9.493	—0.019
“ “ “ .	E.	B_1—C_5	41 2.59	+0.007	—1 9.493	—0.024
μ Capricorni . . .	“	B_1—F_5	45 56.13	+0.005	0 0.000	—0.012
α Aquarii	“	B_1—F_5	21 58 50.94	—0.019	0 0.000	—0.027
π “	“	B_1—F_5	22 18 22.95	—0.019	0 0.000	—0.027
9 Draconis L. C. .	“	$B_{45}\ C_{45}\ D_{123}$	22 41.66	—0.009	+0 51.148	+0.081
“ “ “ .	W.	B_1—C_5	25 7.02	—0.005	—1 37.712	+0.071
η Aquarii	“	B_1—F_5	28 26.32	+0.003	0 0.000	—0.012
ζ Pegasi	“	B_1—F_5	34 44.83	+0.004	0 0.000	—0.011
ι Cephei U. C. . .	“	B_1—C_5	43 59.64	—0.016	+0 55.394	—0.069
“ “ . .	E.	B_1—C_5	22 45 48.35	—0.031	—0 55.394	—0.103

$T = 22^h$. $\theta = +5^s.7$. $\rho = +0^s.040$. $c = -0^s.416$.

Star.	t	α	Cc	ω_0'	Aa	Δt
ξ Aquarii . . .	$21^h 30^m 34^s.75$	$30^m 39^s.80$	$+0^s.421$	$-0^s.21$	$-0^s.04$	$+5^s.54$
11 Cephei U. C. .	39 54.41	40 0.20	- - - -	+0.11	+0.06	5.75
μ Capricorni . .	45 56.12	46 2.20	—0.429	—0.04	—0.05	5.71
α Aquarii . . .	21 58 50.91	58 56.96	—0.313	+0.03	—0.04	5.77
π “ . . .	22 18 22.92	18 29.02	—0.416	—0.03	—0.04	5.71
9 Draconis L. C. .	23 31.14	23 36.64	- - - -	—0.22	—0.19	5.67
η Aquarii . . .	28 26.31	28 31.31	+0.416	—0.30	—0.04	5.44
ζ Persei	34 44.82	34 49.92	+0.423	—0.19	—0.03	5.54
ι Cephei U. C. . .	22 44 53.90	44 59.62	- - - -	—0.02	+0.04	+5.64

$$9\,\Delta\theta + 6.222\,a = +0^s.872.$$
$$+6.222\,\Delta\theta + 17.817\,a = +1.425.$$
$$a = -0^s.053,\ \Delta\theta = -0^s.060,\ \Delta t = +5^s.640.$$

1866, October 28.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Cassiopeæ, ...	E.	B_1—F_5	$0^h\,32^m\,54^s.28$	$-0^s.071$	$0^m\ 0^s.000$	$-0^s.149$
21 " U.C. . .	"	B_5—C_3	38 6.40	-0.071	-1 13.113	-0.285
ε Piscium	"	B_1—F_5	0 54 57.15	-0.071	0 0.000	-0.068
Polaris U.C. . . .	"	D_3—E_4	1 4 48.10	-0.071	$+6$ 11.875	-2.759
" "	W.	D_4—E_3	17 46.90	-0.004	-6 13.717	-0.687
η Piscium	"	B_1—F_5	24 17.86	-0.032	0 0.000	-0.041
ο "	"	B_1—F_5	38 18.00	-0.076	0 0.000	-0.073
β Arietis.	"	B_1—F_5	47 13.61	-0.095	0 0.000	-0.105
50 Cassiopeæ U.C. . .	"	B_1—C_5	50 55.18	-0.111	$+1$ 13.440	-0.368
" " " . .	E.	B_1—C_5	53 19.08	-0.127	-1 13.440	-0.415
α Arietis	"	B_1—F_5	1 59 35.66	-0.138	0 0.000	-0.151

$T = 1^h$ $\theta = +5^s.8$ $\rho = +0^s.040$ $c = -0^s.416.$

Star.	t	α	Cc	ϖ_0'	Aa	Δt
α Cassiopeæ	$0^h\,32^m\,54^s.13$	$33^m\ 0^s.82$	$-0^s.740$	$+0^s.17$	$+0^s.07$	$+5^s.90$
21 " U.C. . .	36 53.00	37 0.45	-1.533	$+0.13$	$+0.44$	5.49
ε Piscium	0 55 57.08	56 3.10	-0.419	-0.20	-0.18	5.78
Polaris U.C. . . .	1 11 14.87	11 27.75	- - - -	$+7.08$	$+7.13$	5.75
η Piscium	24 17.82	24 22.93	$+0.430$	-0.28	-0.15	5.67
ο "	38 17.93	38 23.16	$+0.421$	-0.18	-0.17	5.79
β Arietis	47 13.51	47 18.73	$+0.442$	-0.17	-0.13	5.77
50 Cassiopeæ U.C. . .	52 7.06	52 12.79	- - - -	-0.11	$+0.35$	5.34
α Arietis.	1 59 35.51	59 41.80	$+0.451$	0.00	-0.12	$+5.92$

$$9\,\Delta\theta - 26.964\,a = +\ 6^s.439$$
$$-26.964\,\Delta\theta + 713.993\,a = -188.899$$
$$a = -0^s.268,\ \Delta\theta = -0^s.087,\ \Delta t = +5^s.713.$$

1866, November 5.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
9 Draconis L.C. .	W.	E_1—F_5	$22^h 22^m 51^s.74$	—$0^s.038$	+1^m $37^s.810$	+$0^s.150$
" " " . .	E.	E_1—F_3 [F_2 lost]	24 49.73	—0.044	—1 20.762	+0.164
ζ Pegasi	"	B_1—F_5	34 41.58	—0.061	0 0.000	—0.063
ι Cephei U. C. . .	"	E_1—F_5	43 55.93	—0.032	+0 55.442	—0.106
" " " . . .	W.	E_1—F_5	45 46.44	—0.016	—0 55.442	—0.069
α Pegasi : . . .	"	D_2—F_3 [D_2 lost]	22 58 18.68	—0.036	—0 18.462	—0.046
ι Piscium	"	C_2—F_5	23 33 7.81	—0.063	—0 9.162	—0.060
γ Cephei U.C. . .	"	E_3—F_5	35 46.01	—0.063	—1 54.045	—0.304
ω Piscium . . .	E.	B_1—F_5	23 52 21.10	—0.136	0 0.000	—0.116
α Andromedæ . .	"	B_1—F_5	0 1 23.60	—0.018	0 0.000	—0.035
γ Pegasi	W.	B_1—F_5	0 6 15.69	0.000	0 0.000	—0.014

$T = 23^h$ $\theta = +\,8^s.3$ $\rho = 0^s.000$ $c = +\,0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
9 Draconis L. C. . . .	$22^h 23^m 42^s.42$	23^m 37^s 34	- - - -	—$0^s.43$	—$0^s.34$	+$8^s.21$
ζ Pegasi	34 41.52	34 49.79	+$0^s.034$	+0 01	—0.06	8.37
ι Cephei U.C.. . . .	44 51.10	44 59.32	- - - -	—0.08	+0.07	8.15
α Pegasi	22 58 0.17	58 8.49	—0.034	—0.02	—0.06	8.34
ι Piscium	23 32 58.59	33 6.95	—0.033	+0.03	—0.07	8.40
γ Cephei U.C.. . . .	33 51.66	34 0.30	—0.147	+0.19	+0.21	8.28
ω Piscium	23 52 20.95	52 29.38	+0.033	+0.16	—0.07	8.53
α Andromedæ. . . .	0 1 23.57	1 31.86	+0.038	+0.03	—0.04	8.37
γ Pegasi	0 6 15.68	6 23.94	—0.034	—0.07	—0.06	+8.29

$$9\,\Delta\theta + 4.140\,a = -\,0^s.170.$$
$$+\,4.140\,\Delta\theta + 19.703\,a = -\,1.755.$$
$$a = -\,0^s.171,\ \Delta\theta + 0^s.026,\ \Delta t = +\,8^s.326.$$

1866, November 5.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
θ′ Ceti	W.	B_1—F_5	$1^h17^m14^s.92$	—$0^s.101$	0^m $0^s.000$	—$0^s.070$
A Cassiopeæ U.C. . .	"	B_1—C_5	20 12.71	—0.098	+1 5.828	—0.301
" " " . .	E.	B_1—C_5	22 24.44	—0.098	—1 5.828	—0.301
η Piscium	"	B_1—E_5	24 22.66	—0.095	—0 7.922	—0.096
o "	"	B_1—F_5	38 14.92	—0.104	0 0.000	—0.095
β Arietis	"	B_1—F_5	47 10.56	—0.107	0 0.000	—0.116
50 Cassiop. U.C. . . .	"	E_1—F_1	50 51.22	—0.106	+1 13.510	—0.354
" " " . .	W.	E_1—F_5	53 18.13	—0.103	—1 13.510	—0.345
α Arietis	"	B_1—F_5	1 59 33.58	—0.099	0 0.000	—0.112
65 Ceti	"	B_1—F_5	2 5 49.83	—0.087	0 0.000	—0.082
ι Cassiopeæ U. C. . .	"	B_1—C_5	17 5.84	—0.103	+0 58.307	—0.282
" " " . . .	E.	B_1—C_5	19 2.63	—0.123	—0 58.307	—0.331
5 Urs. Minoris L. C. .	"	B_1—C_5	25 58.14	—0.126	+1 36.946	+0.357
" " " .	W.	B_1—D_3	2 28 52.39	—0.114	—1 17.092	+0.327

$T = 2^h$. $\theta = +\ 8^s.3$ $\rho = 0^s.000$ $c = +\ 0^s.033.$

Star.	t	α	Cc	ϖ_0'	Aa	Δt
θ′ Ceti	1^h $17^m14^s.85$	$17^m23^s.11$	—$0^s.034$	—$0^s.07$	—$0^s.16$	+$8^s.38$
A Cassiopeæ U.C. . .	21 18.27	21 26.77	- - - -	+0.20	+0.20	8.30
η Piscium	24 14.64	24 22.93	+0.034	+0.02	—0.11	8.43
o "	38 14.82	38 23.18	+0.034	+0.09	—0.12	8.51
β Arietis	47 10.44	47 18.76	+0.036	+0.05	—0.09	8.44
50 Cassiopeæ U. C. . .	52 4.33	52 12.81	- - - -	+0.18	+0.24	8.24
α Arietis	1 59 33.47	59 41.84	—0.036	+0.04	—0.09	8.42
65 Ceti	2 5 49.75	5 57.95	—0.034	—0 13	—0.12	8.29
ι Cassiopeæ U.C. . .	18 3.93	18 12.24	- - - -	+0.01	+0.15	8.16
5 Urs. Minoris L.C. . .	2 27 35.53	27 43.04	- - - -	—0.79	—0.66	+8.16

$$10\ \Delta\theta + 3.969\ a = -\ 0^s.427$$
$$+\ 3.969\ \Delta\theta + 17.993\ a = -\ 3.258$$
$$a = -\ 0^s.188,\ \Delta\theta = +\ 0^s.032,\ \Delta t = +\ 8^s.332.$$

1866, November 6.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α^3 Capricorni	W.	$B_1—C_5$	$20^h\,10^m\;\;7^s.83$	$+0^s.087$	$+0^m\;23^s.574$	$+0^s.030$
$\varkappa$ Cephei U.C.	"	$B_4—D_3$	12 8.24	+0.061	+1 2.852	+0.179
" " ".	E.	$B_1—C_5$	14 55.99	+0.037	—1 44.555	+0.084
π Capricorni	"	$B_{1\,2\,3}\,E_1—_5$	19 36.36	+0.006	—0 2.994	—0.012
ε Delphini	"	$B_1—F_5$	26 42.81	—0.032	0 0.000	—0.040
Groombr. 3241 U.C. .	"	$C_5—F_5$	29 41.77	—0 038	+0 44.580	—0.174
α Cygni.	"	$B_1—F_5$	36 45.74	—0.059	0 0.000	—0.102
μ Aquarii	"	$B_1—F_5$	45 20.03	—0.079	0 0.000	—0.057
12–Y. Cat. 1879 U. C. .	"	$D_3—F_2$	52 6.36	—0.059	+1 19.774	—0.369
" " "	W.	$E_1—F_5$	20 55 39 03	—0.040	—2 13.109	—0.376
ζ Cygni	"	$B_1—F_5$	21 7 8.38	—0.002	0 0.000	—0.018
α Cephei	"	$B_1—C_5$	14 28.01	—0.026	+0 48.960	—0.082
1 Pegasi	"	$C_3—E_5$	15 50.96	—0.038	—0 3.106	—0.049
24 Ursæ Majoris L. C. .	"	$E_1—F_5$	21 21.51	—0.074	+1 8.610	+0.146
" " " .	E.	$E_1—F_5$	21 23 38.33	—0.088	—1 8 610	+0.165

$T = 21^h \qquad \theta = +\,7^s.9 \qquad \rho = +\,0^s.030 \qquad c = +\,0^s.033.$

Star.	t	α	Cc	ϖ_0'	Aa	Δt
α^3 Capricorni	$20^h\,10^m\,31^s.43$	$10^m\;39^s.38$	$—0^s.034$	$+0^s.04$	$—0^s.06$	$+8^s.00$
$\varkappa$ Cephei U. C. . . .	13 11.39	13 19.24	- - - -	—0.08	+0.16	7.71
π Capricorni	19 33.35	19 41.32	+0.035	+0.12	—0.07	8.09
ε Delphini	26 42.77	36 50.83	+0.034	+0.21	—0.04	8.15
Groombr. 3241 U. C. .	30 26.18	30 34.07	+0.108	+0.12	+0.09	7.92
α Cygni	36 45.64	36 53.67	+0.037	+0.18	—0 01	8.09
μ Aquarii	45 19.97	45 27.89	+0.034	+0.06	—0.06	8 02
12–Y. Cat. 1879 U. C. .	20 53 25.70	53 33.91	- - - -	+0.31	+0.22	7.99
ζ Cygni	21 7 8.36	7 16.39	—0.038	+0.09	—0.03	8.01
α Cephei U. C. . . .	15 16.89	15 24.93	—0.071	+0.06	+0.04	7.93
1 Pegasi	15 47.80	15 55.95	—0.035	+0.20	—0.04	8.14
24 Ursæ Majoris L. C. .	21 22 30.07	22 37.52	- - - -	—0.47	—0.18	+7 62

$$12\,\Delta\theta - 0.272\,a = +\,0^s.889$$
$$+\,0.272\,\Delta\theta + 26.685\,a = -\,1.844$$
$$a = -\,0^s.070,\ \Delta\theta = +\,0^s.073,\ \Delta t = +\,7^s.973.$$

1866, November 6.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ι Cephei U. C.	E.	E_1—F_5	$22^h\,43^m\,56^s.08$	—$0^s.003$	+$0^m\,55^s.448$	—$0^s.039$
" "	W.	E_1—F_5	45 46.76	0.000	—0 55.448	—0.032
α Pegasi.	"	B_1—F_5	22 58 0.52	—0.056	0 0.000	—0.062
ο Cephei U. C.	"	B_1—C_5	23 12 5.69	—0.069	+0 59.729	—0.205
" "	E.	B_1—C_3	14 12.84	—0.057	—1 7.205	—0.176
θ Piscium	"	C_1—F_5	20 58.08	—0.072	+0 7.681	—0.068
λ Draconis L. C.	"	C_1—F_5	23 38.76	—0.092	—0 22.424	+0.168
ι Piscium	"	B_1—F_5	32 59.08	—0.126	0 0.000	—0.107
ω "	"	B_1—F_5	23 52 21.48	—0.162	0 0.000	—0.026
α Andromedæ	W.	B_1—F_5	1 23.93	—0.128	0 0.000	—0.153
γ Pegasi	"	B_1—F_5	6 16.04	—0.097	0 0.000	—0.098

$T = 23^h$ $\theta = +\,8^s.0$ $\rho = +\,0^s.030$ $c = +\,0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
ι Cephei U.C.	$22^h\,44^m\,51^s.38$	$44^m\,59^s.28$	- - - -	—$0^s.10$	+$0^s.12$	+$7^s.79$
α Pegasi	22 58 0.46	58 8.48	—$0^s.034$	—0.01	—0.09	8.08
ο Cephei U.C.	23 13 5.34	13 13.36	- - - -	+0.02	+0.14	7.88
θ Piscium	21 5.69	21 13.55	+0.033	—0.12	—0.11	7.99
λ Draconis L.C.	23 16.50	23 23.96	—0.098	—0.66	—0.42	7.76
ι Piscium	32 58.97	33 6.94	+0 033	—0.02	—0.11	8.10
ω "	23 52 21.45	52 29.37	+0.033	—0.08	—0.11	8.03
α Andromedæ	1 23.78	1 31.85	—0.038	0.00	—0.06	8.07
γ Pegasi	6 15.94	6 23.93	—0.035	—0.08	—0.08	+8.00

$$9\,\Delta\theta + 4.540\,a = -\,1^s.034.$$
$$+\,4.540\,\Delta\theta + 10.441\,a = -\,1.845.$$
$$a = -\,0^s.162,\ \Delta\theta = -\,0^s.033,\ \Delta t = +\,7^s.967.$$

1866, November 9.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
Groombr. 3241 U.C.	W.	B_1—E_4 [$D_{4\,5}$ lost]	$20^h\,30^m\,18^s.36$	—$0^s.055$	+$0^m\;7^s.685$	—$0^s.208$
α Cygni	"	B_4—D_4 [D_1 lost]	36 27.42	—0.055	+0 18.397	—0.096
μ Aquarii . . .	"	B_1—F_5 [$D_{1\,2}$ lost]	45 20.75	—0.055	—0 0.339	—0.044
ν Cygni	"	B_1—F_5	52 4.93	—0.071	0 0.000	—0.111
σ^3 Urs. Majoris U.C.	"	D_3—E_5	20 58 1.96	—0.095	+0 27.697	+0.144
ζ Cygni	E.	B_1—F_5	21 5 8.63	—0.121	0 0.000	—0.148
α Cephei . . .	"	D_1—F_5	14 44.56	—0.175	+0 32.640	—0.392
24 Ursæ Majoris U.C.	"	B_1—C_5	21 21.51	—0.143	+1 8.544	+0.244
" " "	W.	B_1—D_3	23 29.05	—0.107	—0 59.024	+0.193
β Cephei U.C.. .	"	E_1—F_5	27 56.94	—0.105	—1 7.150	—0.324
ξ Aquarii . . .	"	B_1—F_5	30 32.07	—0.113	0 0.000	—0.077
11 Cephei U.C.. .	"	B_1—C_5	38 42.40	—0.141	+1 9.493	—0.437
" " . .	E.	B_1—C_5	41 1.54	—0.153	—1 9.493	—0.471
μ Capricorni . .	"	B_1—F_5	45 54.36	—0.163	0 0.000	—0.093
79 Draconis U.C. .	"	E_1—F_5	49 48.56	—0.170	+1 8.962	—0.575
" " ". .	W.	D_3—F_5	21 52 10.23	—0.170	—1 2.713	—0.575

$T = 2^h$ $\theta = + 7^s.8$ $\rho = 0^s.000$ $c = + 0^s.033.$

Star.	t	α	Cc	α_0'	Aa	Δt
Groombr. 3241 U.C. .	$20^h\,30^m\,25^s.84$	$30^m\,33^s.85$	—$0^s.108$	+$0^s.11$	+$0^s.12$	+$7^s.78$
α Cygni	36 45.72	36 53.58	—0.047	+0.01	—0.01	7.82
μ Aquarii	45 20.37	45 27.94	—0.034	—0.26	—0.08	7.62
ν Cygni	52 4.82	52 12.70	—0.044	+0.04	—0.01	7.85
σ^3 Ursæ Majoris L.C. .	20 58 29.80	58 37.35	+0.088	—0.16	—0.22	7.86
ζ Cygni	21 5 8.48	5 16.33	+0.038	+0.09	—0.03	7.92
α Cephei	15 16.81	15 24.80	+0.071	+0.26	+0.05	8.02
24 Ursæ Majoris L.C. .	22 30.26	22 37.75	- - - -	—0.31	—0.24	7.73
β Cephei U. C. . . .	26 49.47	26 57.28	—0.097	—0.09	+0.10	7.61
ξ Aquarii	30 31.99	30 39.63	—0.034	—0.20	—0.08	7.68
11 Cephei U.C. . . .	39 51.52	39 59.49	- - - -	+0.17	+0.11	7.87
μ Capricorni	45 54.27	46 2.02	+0.035	—0.01	—0.08	7.87
79 Draconis	21 51 6.94	51 14.98	- - - -	+0.23	+0.13	+7.90

$$13\,\Delta\theta + 2.620\,a = -\,0^s.125.$$
$$+\,2.620\,\Delta\theta + 21.728\,a = -\,2.008.$$
$$a = -\,0^s.093,\ \Delta\theta + 0^s.010,\ \Delta t = +\,7^s.810.$$

1366, November 9.—D., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
β Ceti	W.	B_1—F_5	$0^h\,36^m\,47^s.47$	—$0^s.138$	$0^m\,0^s.000$	—$0^s.073$
32 Camelop. (foll.) L. C.	"	D_3—F_3	45 33.60	—0.156	+2 15.030	+1.158
" " "	E.	E_1—F_5	51 32 00	—0.173	—3 45.318	+1.270
ε Piscium	"	B_1—F_5	0 55 55.58	—0.185	0 0.000	—0.155
o "	"	B_1—F_5	1 38 15.55	—0.233	0 0.000	—0.196
β Arietis	"	B_1—F_5	47 11.24	—0.206	0 0.000	—0.209
50 Cassiopeæ U. C. .	"	E_1—F_5	50 52.01	—0.188	+1 13.510	—0.594
" " "	W.	E_1—F_5	53 18.82	—0.180	—1 13.510	—0.570
α Arietis	"	B_1—F_5	1 59 34.22	—0.186	0 0.000	—0.198
65 Ceti	"	B_1—F_5 [$B_{4\,5}$ C_5 F_1 lost]	2 5 52.21	—0.221	—0 1.838	—0.186
ι Cassiopeæ U.C. .	"	B_1—C_5 [B_3 lost]	17 8.71	—0.203	—0 0.203	—0.522
" " " . . .	E.	B_1—C_5 [C_1 lost]	2 18 4.13	—0.195	—0 0.195	—0.503

$T = 1^h$. $\theta = +\,7^s.8$ $\rho = 0^s.000$ $c = +\,0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
β Ceti	$0^h\,36^m\,47^s.40$	$36^m\,55^s.04$	—$0^s.035$	—$0^s.19$	—$0^s.23$	$+7^s.84$
32 Camelop. (foll.) L. C.	47 48.87	47 54.84	- - - -	—1.83	—1.75	7.72
ε Piscium	55 55.42	56 3.07	+0.033	—0.12	—0.16	7.84
o "	1 38 15.35	38 23.18	+0.034	+0.06	—0.15	8.01
β Arietis	47 11.03	47 18.76	+0.035	—0.04	—0.12	7.88
50 Cassiopeæ U.C. . .	52 4.83	52 12.80	- - - -	+0.17	+0.31	7.66
α Arietis	1 59 34.02	59 41 85	—0.036	—0.01	—0.07	7.86
65 Ceti	2 5 50.19	5 57.96	—0.034	—0.06	—0 16	7.90
ι Cassiopeæ U.C. . .	2 18 4.49	18 12.26	- - - - -	—0.03	—0.20	+7.58

$$9\,\Delta\theta + 9.039\,a = -\,2^s.050.$$
$$+\,9.039\,\Delta\theta + 58.021\,a = -\,13.809.$$
$$a = -\,0^s.240,\ \Delta\theta = +\,0^s.013,\ \Delta t = +\,7^s.813.$$

1866, December 11.—Gf., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
9 Draconis L.C. .	E.	B_1—C_5	$22^h 22^m 1^s.36$	$—0^s.099$	$+1^m 37^s.712$	$+0^s.296$
" " . .	W.	B_1—D_5 [D_4 lost]	24 49.70	—0.089	—1 10.610	+0.272
ζ Pegasi	"	E_2—$_5$	35 4.27	—0.054	—0 16.909	—0.057
ι Cephei U.C. . .	"	B_1—F_5	44 55.55	—0.068	0 0.000	—0.188
α Pegasi	"	C_1—C_4	22 57 48.82	—0.084	+0 17.202	—0.094
θ Piscium . . .	"	B_1—F_5	23 21 11.16	—0.108	0 0.000	—0.094
γ Cephei U.C. . .	"	B_1—C_5	32 14.29	—0.121	+1 41.250	—0.528
" " . . .	E.	B_1—C_5	35 37.21	—0.127	—1 41.250	—0.550
Groombr. 4163 U.C.	"	B_4—F_5	48 24.20	—0.144	0 0.000	—0.511
ω Piscium . . .	"	B_1—E_5	23 52 34.61	—0.148	—0 7.708	—0.125
α Andromedæ . .	"	C_1—E_5	1 29.34	—0.147	—0 0.032	—0.173
4 Draconis L.C. .	"	B_1—C_5	3 55.23	—0.145	+1 53.865	+0.493
" " . .	W.	B_1—D_5	7 5.11	—0.141	—1 15.985	+0.481

$T = 23^h \qquad \theta = +\,2^s.1 \qquad \rho = -\,0^s.02 \qquad c = +\,0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
9 Draconis L. C. . . .	$22^h 23^m 39^s.37$	$23^m 41^s.18$	- - - -	$—0^s.30$	$—0^s.36$	$+2^s.17$
ζ Pegasi.	34 47.30	34 49.32	$—0^s.034$	—0.13	—0.06	2 04
ι Cephei U.C.	44 55.36	44 57.72	—0.080	+0.17	+0.08	2.20
α Pegasi	22 58 5.93	58 8.03	—0.034	—0.03	—0.06	2.13
θ Piscium	23 21 11.07	21 13.13	—0.033	—0.06	—0.07	2.11
γ Cephei U.C.	33 55.21	33 57.53	- - - -	+0.22	+0.22	2.10
Groombr. 4163 U.C. . .	48 23.69	48 26.12	+0.119	+0.47	+0.16	2.40
ω Piscium	23 52 27.03	52 29.00	+0.033	—0.08	—0.07	2.09
α Andromedæ	1 29.14	1 31.43	+0.038	+0.24	—0.04	2.38
4 Draconis L. C. . . .	5 49.60	5 51.42	- - - -	—0.25	—0.42	+2.26

$$10\,\Delta\theta + 6.015\,a = +\,0^s.257.$$
$$+\,6.015\,\Delta\theta + 37.765\,a = -\,3.483.$$
$$a = -\,0^s.104,\ \Delta\theta = +\,0^s.088,\ \Delta t = +2^s.188.$$

1866, December 11.—Gf., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
δ Draconis L. C.	W.	E_1—F_5	$7^h 11^m 26^s 58$	—$0^s.137$	+$0^m 59^s.903$	+$0^s.188$
" "	E.	D_3—F_5	13 13.84	—0.151	—0 47 577	+0.204
β Geminorum	"	B_1—F_5	37 9.45	—0.223	0 0.000	—0.255
φ "	"	D_1—F_5	45 3.06	—0.208	+0 17.205	—0.235
ε Draconis L. C. . . .	"	B_1—C_5	47 25.07	—0.197	+1 6.936	+0.308
" "	W.	B_1—D_3	49 25.45	—0.187	—0 53.228	+0.294
3 Ursæ Majoris U. C. .	"	B_1—D_5	7 58 49.83	—0.154	+0 42.513	—0.437
Groombr. 3241 L. C. . .	"	C_4—E_5	8 30 30.04	—0.107	—0 0.091	+0.219
ε Hydræ	"	B_1—F_5	8 39 42.64	—0.103	0 0.000	—0.092
ϰ Cancri	"	B_1—F_2	9 0 31.11	—0.129	0 0 000	—0.120

$T = 8^h$ $\theta = +1^s.9$ $\rho = -0^s.020$ $c = +0^s 033.$

Star.	t	a	Cc	ω_0'	Aa	Δt
δ Draconis L. C.	$7^h 12^m 26^s.54$	$12^m 28^s.33$	- - - -	—$0^s.12$	—$0^s.28$	+$2^s.06$
β Geminorum	37 9.20	37 11.34	+$0^s.038$	+0.27	—0.05	2.22
φ "	45 20.03	45 22.13	+0.038	+0.23	—0.05	2.18
ε Draconis L. C. . . .	48 32.41	48 34.09	- - - -	—0.23	—0.31	1.98
3 Ursæ Majoris U. C. .	7 59 31.94	59 34.07	—0.092	+0.13	+0.12	1.91
Groombr. 3241 L. C. . .	8 30 30.17	30 31.77	+0.108	—0.18	—0.34	2.06
ε Hydræ	8 39 42.55	39 44.53	—0.033	+0.06	—0.08	2.04
ϰ Cancri	9 0 30.99	0 32.95	—0.034	+0.06	—0.07	+2.03

$$8\,\Delta\theta + 8.801\,a = +0^s.227.$$
$$+8\,801\,\Delta\theta + 22.225\,a = -1.252.$$
$$a = -0^s.120,\ \Delta\theta = +0^s.160,\ \Delta t = +2^s.060.$$

1866, December 12.—Gf., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
θ' Ceti	W.	B_1—F_5	$1^h 17^m 21^s.45$	$+0^s.077$	$0^m 0^s.000$	$+0^s.028$
A Cassiopeæ U. C.	"	B_1—C_5	20 17.80	+0.074	+1 5.828	+0.157
η Piscium . . .	"	C_1—F_5	24 29.23	+0.068	—0 7.901	+0.045
β Arietis	"	B_1—C_2 E_3—F_4	1 47 15.58	+0.061	+0 1.533	+0.043
ζ Urs. Minoris L.C.	"	E_1—F_3	3 47 5.96	+0.009	+1 38.478	+0.042
" " "	E.	D_1—F_5 [F_1 lost]	3 49 55.34	—0.001	—1 11.358	+0.071
γ Tauri	"	B_1—F_5	4 12 13.38	—0.039	0 0.000	—0.048
ε "	"	B_1—F_5	20 50.98	—0.037	0 0.000	—0.049
α "	"	B_1—F_5	28 17.19	—0.030	0 0.000	—0.041
α Camelop. U. C. .	"	E_1—F_5	39 55.70	+0.002	+0 56.784	—0.029
" " .	W.	D_3—F_5	4 41 37.50	+0.008	—0 45.099	—0.016

$T = 3^h$ $\theta = +1^s.6$ $\rho = 0^s.000$ $c = +0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
θ' Ceti	$1^h 17^m 21^s.48$	$17^m 22^s.90$	$-0^s.034$	$-0^s.21$	$-0^s.22$	$+1^s.61$
A Cassiopeæ U. C.	21 23.78	21 25.82	—0.096	+0.34	+0.28	1.66
η Piscium . . .	24 21.37	24 22.75	—0.035	—0.26	—0.15	1.49
β Arietis	1 47 17.16	47 18.66	—0.036	—0.13	—0.13	1.60
ζ Urs. Minoris L.C.	3 48 44.07	48 44.68	- - - -	—0.99	—1.03	1.65
γ Tauri	4 12 13.33	12 14.80	+0.035	—0.10	—0.15	1.65
ε "	20 50.93	20 52.38	+0.035	—0.12	—0.13	1.62
α "	28 17.15	28 18.68	+0.035	—0.03	—0.14	1.71
α Camelop. U. C. .	4 40 52.42	40 54.11	- - - -	+0.09	+0.20	+1.49

$$9\,\Delta\theta + 5.646\,a = -1^s.407$$
$$+5.646\,\Delta\theta + 19.478\,a = -4.845$$
$$a = -0^s.261,\ \Delta\theta = +0^s.007,\ \Delta t = +1^s.607.$$

1866, December 12.—Gf., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ε Hydræ	W.	B_1—F_5	$8^h\,39^m\,43^s.37$	$-0^s.079$	$0^m\,0^s.000$	$-0^s.074$
σ^2 Urs. Majoris U. C.	"	B_1—C_5	57 37.69	-0.113	$+1$ 0.481	-0.316
" "	E.	B_1—D_3	8 59 26.54	-0.116	-0 48.095	-0.323
1 Draconis U. C.	"	D_1—F_5	9 16 3.71	-0.117	$+1$ 48.775	-0.787
α Hydræ	"	B_1—F_5	21 2.38	-0.107	0 0.000	-0.075
θ Ursæ Majoris	"	E_1—F_5	23 17.91	-0.104	$+0$ 37.589	-0.192
β Cephei L. C.	"	B_3—C_5	25 55 51	-0.100	$+0$ 58.759	$+0.176$
" "	W.	B_1—C_5	28 1.60	-0.094	-1 7.086	$+0.168$
ε Leonis	"	B_1—F_5	38 16.67	-0.083	0 0.000	-0.099
μ "	"	B_1—E_5	9 45 0.38	-0.083	$+0$ 10.228	-0.103

$T = 9^h$ $\theta = +\,1^s.6$ $\rho = 0^s.000$ $c = +\,0^s.033.$

Star.	t	α	Cc	ω_0'	$A\alpha$	Δt
ε Hydræ	$8^h\,39^m\,43^s.30$	$39^m\,44^s.48$	$-0^s.033$	$-0^s.45$	$-0^s.18$	$+1^s.33$
σ^2 Urs. Majoris U. C.	8 58 37.99	58 39.72	- - - - -	$+0.13$	$+0.24$	1.49
1 Draconis U. C.	9 17 51.70	17 53.88	$+0.237$	$+0$ 82	$+0.07$	1 34
α Hydræ	21 2.30	21 3.70	$+0.034$	-0.17	-0.23	1.65
θ Ursæ Majoris	23 55.31	23 56.88	$+0.054$	$+0.03$	$+0.03$	1.59
β Cephei L C.	26 54.56	26 55.31	- - - - -	-0.75	-0.70	1.54
ε Leonis	38 16.57	38 18.08	-0.036	-0.13	-0.12	1.59
μ "	9 45 10.52	45 11.77	-0 037	-0.39	-0.11	$+1.32$

$$8\,\Delta\theta - 0.076\,a = -\,0^s.916$$
$$+\,0.076\,\Delta\theta + 24.801\,a = -\,5.712$$
$$a = -\,0^s.270,\ \Delta\theta = -\,0^s.117,\ \Delta t = +\,1^s.483.$$

1866, December 14.—Gr., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
9 Draconis L. C.	W.	E_1—F_5	22^{h}22^m 4^s.27	—0^s.029	+1^{m}37^s.808	+0^s.128
" "	E.	D_3—F_5 [F_1 lost]	24 56.68	—0.035	—1 34.548	+0.143
ι Cephei U. C.	"	E_1—F_5 [E_2 lost]	22 43 59.64	—0.059	+0 58.181	—0.168
o Piscium	"	B_1—F_5	1 38 23.14	—0.024	0 0.000	—0.033
β Arietis	W.	B_1—F_5	47 18.78	—0.022	0 0.000	—0.035
α "	"	B_1—F_5	1 59 41.81	—0.010	0 0.000	—0.025
α Persei	"	C_1—F_5	3 15 4.22	—0.074	—0 11.741	—0.135
γ^2 Urs. Minoris L. C.	"	E_1—F_5	19 37.46	—0.104	+1 15.680	+0.217
" " "	E.	D_3—F_5	21 48.14	—0.124	—0 55.205	+0.250
η Tauri	"	C_1—E_5	39 36.36	—0.156	—0 0.031	—0.170
ζ Persei	"	C_1—E_5	45 48.38	—0.134	—0 0 033	—0.167
ζ Urs. Minoris L. C.	"	C_1—C_5	47 29.83	—0.130	+1 15.212	+0.442
" " "	W.	B_1—D_4	3 50 7.21	—0.120	—1 22.130	+0.414
Groombr. 2320 L. C.	"	B_1—F_5 [D_5 lost]	4 5 55.28	—0.127	—0 0 567	+0.187
γ Tauri	"	B_1—F_5	12 15.11	—0.145	0 0.000	—0.141
ε "	"	B_1—F_5	20 52.79	—0.167	0 0.000	—0.169
α "	E.	B_1—F_5	4 28 18.90	—0.183	0 0.000	—0.176

$T = 2^h$ $\theta = -0^s.05$ $\rho = -0^s.030$ $c = +0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
9 Draconis L. C.	22^{h}23^{m}42^s.09	23^{m}41^s.43	- - - -	—0.^{s}72	—0^s.81	+0^s.04
ι Cephei U. C.	22 44 57.66	44 57.59	+0^s.080	—0.04	+0.17	—0.25
o Piscium	1 38 23.11	38 23.02	+0.034	—0.02	—0.15	+0.08
β Arietis	47 18.74	47 18.64	—0.036	—0.10	—0.12	—0.03
α "	1 59 41.79	59 41.75	—0.036	—0.02	—0.11	+0.04
α Persei	3 14 52.34	14 52.34	—0.051	+0.03	+0.01	—0.03
γ^2 Urs. Minoris L. C.	20 53.27	20 52.63	- - - - - -	—0.55	—0.66	+0.06
η Tauri	39 36.16	39 36.18	+0.036	+0.16	—0.10	+0.21
ζ Persei	45 48.18	45 48.02	+0.039	—0.02	—0.08	+0.01
ζ Urs. Minoris L. C.	3 48 45.49	48 44.72	- - - - -	—0 67	—0.91	+0.20
Groombr. 2320 L. C.	4 5 54.90	5 53.89	+0.089	—0.81	—0.56	—0.30
γ Tauri	12 14.97	12 14.80	—0.035	—0.09	—0.13	—0.01
ε "	20 52.62	20 52.40	—0.035	—0.14	—0.12	—0.07
α "	4 28 18.72	28 18.70	+0.038	+0.14	—0.12	+0.21

$$14\,\Delta\theta + 15.950\,a = -2^s.826$$
$$+15.950\,\Delta\theta + 44.430\,a = -8.695$$
$$a = -0^s.231,\quad \Delta\theta = +0^s.061,\quad \Delta t = +0^s.011.$$

1866, December 14.—Gr., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
γ Geminorum . . .	E.	B_1—F_5	$6^h\,30^m\;3^s.18$	—$0^s.207$	$0^m\;0^s.000$	—$0^s.158$
51 Cephei U. C. . . .	"	D_1—E_2	36 30.90	—0.222	+1 7.471	—3.856
" " " . . .	W.	E_1—F_5	45 31.60	—0.244	—7 58.244	—4.209
ε Canis Majoris . . .	"	C_1—E_5	6 53 25.97	—0.273	+0 0.032	—0.088
δ " " . . .	"	B_1—F_5	7 3 0.98	—0.307	0 0.000	—0.109
δ Geminorum	"	B_1—F_5	12 12.25	—0.318	0 0.000	—0.325
τ Draconis L. C. . . .	"	D_1—E_5	17 36.76	—0.318	+0 26.313	+0.611
" " " . . .	E.	E_4—F_5	19 36.74	—0.319	—1 34.226	+0.613
β Geminorum . . .	"	B_1—F_5	37 11.91	—0.427	0 0.000	—0.473
φ "	"	C_1—E_5	45 22.93	—0.399	—0 0.031	—0.435
ε Draconis L.C. . . .	"	B_1—C_5	47 27.73	—0.395	+1 6.936	+0.577
" " ". . . .	W.	B_1—D_3	7 49 27.95	—0.389	—0 53.228	+0.568

$T = 7^h$ $\theta = -0^s.20$ $\rho = -0^s.03$ $c = +0^s.033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
γ Geminorum . . .	$6^h\,30^m\,30^s.22$	$30^m\;2^s.84$	+$0^s.035$	+$0^s.04$	—$0^s.14$	—$0^s.02$
51 Cephei U. C. . . .	37 31.83	37 35.04	- - - -	+3.39	+3.51	—0.32
ε Canis Majoris . . .	6 53 25.91	53 25.41	—0.038	—0.34	—0.30	—0.25
δ " " . . .	7 3 0.87	3 0.42	—0.037	—0.29	—0.29	—0.20
δ Geminorum . . .	12 11.92	12 11.75	—0.036	+0.01	—0.12	—0.07
τ Draconis L.C. . . .	18 3.41	18 2.16	- - - -	—1.04	—0.79	—0.45
β Geminorum . . .	37 11.44	37 11.41	+0.038	+0.23	—0.10	+0.13
φ "	45 22.49	45 22.21	—0.037	—0.02	—0.11	—0.12
ε Draconis L. C. . . .	7 48 35.26	48 34.00	- - - -	—1.04	—0.69	—0.55

$$9\,\Delta\theta - 3.692\,a = +\,0^s.932.$$
$$-\,3.692\,\Delta\theta + 192.501\,a = -\,51.059.$$
$$a = -\,0^s.266,\ \Delta\theta = -\,0^s.006,\ \Delta t = -\,0^s.206.$$

1866, December 16.—Gr., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
o Piscium	W.	B_1—F_5	$1^h\,38^m\,24^s$ 26	+0^s.144	0^m 0^s.000	+0^s.098
β Arietis	"	B_1—F_5	47 19.80	+0.118	0 0.000	+0.096
50 Cassiopeæ U. C. . .	"	B_1—C_5	50 58.54	+0.097	+0 13.440	+0.240
" " " . . .	E.	B_1—D_4	53 6.10	+0 087	—0 53.665	+0.210
α Arietis	"	B_1—F_5	1 59 42.86	+0.073	0 0.000	+0.057
65 Ceti	"	B_1—F_5	2 5 59.16	+0.069	0 0.000	+0.040
ι Cassiopeæ U. C. . . .	"	E_1—F_5	17 14.38	+0.093	+0 58.363	+0.188
" " . . .	W.	D_3—F_5	2 18 58.85	+0.114	—0 46.353	+0.239

$T = 2^h$ $\theta = -1^s.10$ $\rho = 0^s.000$ $c = +0^s\,033.$

Star.	t	α	Cc	ω_0'	Aa	Δt
o Piscium	$1^h\,38^m\,24^s$.36	$38^m\,23^s$.01	—0^s.034	—0^s.28	—0^s.22	—1^s.17
β Arietis	47 19.90	47 18.62	—0.036	—0.21	—0.17	1.15
50 Cassiopeæ U.C. . .	52 12.43	52 11.89	- - - -	+0.56	+0.43	0 98
α Arietis	1 59 42.92	59 41.74	—0.036	—0.04	—0.15	0.99
65 Ceti	2 5 59.20	5 57.87	—0.034	—0.20	—0 22	1.08
ι Cassiopeæ U.C. . . .	3 18 12.83	18 11.83	- - - -	+0.10	+0 28	—1.28

$$6\,\Delta\theta + 0.124\,a = -0^s.079.$$
$$+\,0.124\,\Delta\theta + 3.652\,a = -1.230.$$
$$a = -0^s.336,\ \Delta\theta = -0^s.006,\ \Delta t = -1^s.106.$$

1866, December 16.—Gr., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
η Tauri	W.	B_1—F_5 [$F_{4\ 5}$ lost]	$3^h\ 39^m\ 34^s.05$	$+0^s.077$	$+0^m\ 3^s.273$	$+0^s.062$
ζ Persei	"	B_1—D_5	45 31.15	+0.062	+0 17.979	+0.054
ζ Urs. Minoris L.C.	"	D_1—E_5	48 10.05	+0.053	+0 37.410	—0.085
" " " .	E.	E_4—F_5	3 51 1.17	+0 044	—2 13 966	—0.059
γ Tauri	"	B_1—F_5	4 12 16.04	+0.026	0 0 000	+0.009
ε "	"	B_1—F_5	20 53 65	+0.040	0 0.000	+0.022
15 Draconis L. C. .	"	B_1—C_5	27 8.58	+0.063	+1 4.277	—0.041
" " " .	W.	B_1—D_4	4 28 59.92	+0.066	—0 46.970	—0.045

$T = 4^h$ $\theta = -1^s.10$ $\rho = 0^s.000$ $c = +0^s.033.$

Star.	t	a	Cc	ω_0'	Aa	Δt
η Tauri	$3^h\ 39^m\ 37^s.39$	$39^m\ 36^s.18$	$-0^s.036$	$-0^s.14$	$-0^s.15$	$-1^s.09$
ζ Persei	45 49.18	45 48.02	—0.039	—0 10	—0.11	1.09
ζ Ursæ Minoris L. C. .	3 48 47.26	48 44.78	- - - -	—1.38	—1 34	1.14
γ Tauri	4 12 16.05	12 14 81	+0.034	—0 10	—0 19	1.02
ε "	20 53.67	20 52.41	+0 035	—0 13	—0 17	1.05
15 Draconis L.C. . . .	4 48 12.86	28 11.12	- - - -	—0.63	—0 85	—0.88

$$6\ \Delta\theta + 8\ 296\ a = -2^s.485.$$
$$+ 8\ 296\ \Delta\theta + 22\ 690\ a = -7\ 249$$
$$a = -0^s\ 340,\ \Delta\theta + 0^s\ 056,\ \Delta t = -1^s.044.$$

VI.

OBSERVATIONS AT CALAIS.

The Hardy clock was used at this station, and the transit-instrument No. 8, which had been employed with the same reticule at Mobile in 1858, and Eufaula in 1860. The cumbrous structure of the clock gave much trouble to the observers, which was increased by a couple of accidents. Some of the teeth of the escapement were bent, in the transportation or otherwise, and the performance was unsatisfactory. Still the most serious difficulties were obviated by the care and zeal of all the members of the party; and although the time-determinations could not always be all that they desired, and especially those on December 12 seem affected by some unexplained source of error, there is small doubt that had the operations continued for another week these sources of discordance would have been removed. The determinations on different dates are much more accordant than might have been expected under the circumstances, and the probable error of the final result is small.

The thread-intervals are derived from twenty-two complete transits, and the values deduced from these observations have been combined with those found for the same instrument and reticule from transits at Mobile in 1858, and Eufaula in 1860. These are given in the following table, in which the intervals previously found are reduced to the scale corresponding to the Calais focus.

EQUATORIAL THREAD-INTERVALS OF TRANSIT NO. 8.

	Mobile, 1858.	Eufaula, 1860.	Calais, 1866.	Adopted.
B_1	$+37^{s}.925$	$+37^{s}.926$	$+37^{s}.976$	$+37^{s}.942$
B_2	35.194	35.205	35.214	35.204
B_3	32.664	32.665	32.611	32.647
B_4	29.959	29.933	29.986	29.069
B_5	27.214	27.215	27.183	27.204
C_1	21.728	21.742	21.810	21.760
C_2	19.069	19.056	19.047	19.057
C_3	16.286	16.284	16.271	16.280
C_4	13.644	13.619	13.583	13.615
C_5	10.950	10.930	10.948	10.943
D_1	5.546	5.562	5.528	5.545
D_2	+2.737	+2.747	+2.706	+2.130
D_3	—0.065	—0.060	—0.060	—0.062
D_4	2.794	2.796	2.641	2.740
D_5	5.527	5.532	5.555	5.538
E_1	10.922	10.909	10.936	10.922
E_2	13.600	13.594	13.663	13.619
E_3	16.371	16.378	16.376	16.375
E_4	19.032	19.035	19.013	19.027
E_5	21.700	21.686	21.679	21.688
F_1	27.137	27.113	27.115	27.122
F_2	29.871	29.870	29.850	29.864
F_3	32.591	32.612	32.626	32.610
F_4	35.305	35.315	35.321	35.314
F_5	—37.999	—38.014	—38.038	—38.017

The correction for inequality of pivots, as deduced from the Calais observations, is $+0^s.022$; the pivot at the perforated end of the axis being the smaller. The mean of the results from five previous campaigns having been found to be $+0^s.027$, and no individual determination differing from this amount by so much as $0^s.002$, the value $+0^s.025$ has been employed in the reductions.

The observations here given were made by Mr. Boutelle on December 12, 13, 14, 15, and by Mr. Chandler December 11, 16, and 18. The correction for personal equation will be applied when deducing the resultant longitudes, and is not needed here, since no group contains observations by both gentlemen. It will be seen that the transit of only a single star could be obtained before or after exchanges on the 16th, one of these being moreover a circumpolar, and that the obstacles in the way of good determinations of time were quite serious on other nights, when exchanges were made with Newfoundland. On those dates when the Calais sky was clearest, the weather at Newfoundland seems to have been unfavorable. It is to be regretted that opportunities did not continue for exchange of signals on at least two more dates, as desired by Mr. Boutelle, and the accordance of longitudes resulting from observations obtained under such unfavorable circumstances is in the highest degree honorable to the gentlemen concerned.

1866, December 11.—C., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Pegasi	E.	D_1—F_5 [C_3 D_4 lost]	$23^h\ 0^m\ 56^s.69$	$-0^s.18$	$+0^m\ 0^s.61$	$-0^s.18$
o Cephei U. C. . .	"	E_1—F_5 [F_4 lost]	15 0.19	−0.19	+1 0.47	−0.50
" " . .	W.	E_3—F_5	17 12.56	−0 23	−1 11.53	−0 59
θ Piscium . . .	"	B_1—F_5	24 2.57	−0.25	0 0.00	−0.21
γ Cephei U.C. . .	"	B_1—C_5	34 59.88	−0.25	+1 47.89	−1.01
" ". . .	E.	B_1—C_5	38 33.75	−0.21	−1 47.89	−0.86
Groombr. 4163 U.C.	"	E_1—$_4$	50 21.95	−0.20	+0 53.32	−0.67
" " ".	W.	E_1—F_5	23 52 47.72	−0.24	−1 27.00	−0.80

$T = 0^h$ $\theta = -2^m\ 49^s.00$ $\rho = -0^s.080$ $c = -0^s.090.$

Star.	t	ξ	Cc	ω_0'	Aa	Δt
α Pegasi	$23^h\ 0^m\ 57^s\ 12$	$58^m\ 8^s.02$	$-0^s.09$	$+0^s.53$	$-0^s.15$	$-2^m\ 49^s.12$
o Cephei U.C. . .	16 0.30	13 11.77	- - - -	−0.98	+0.28	48.87
θ Piscium . . .	24 2.36	21 13.13	+0.09	+0.64	−0.18	49.01
γ Cephei U.C. . .	36 45.88	33 57.53	- - - -	−2.32	+0.67	49.04
Groombr. 4163 L.C.	23 51 14.76	48 26.11	- - - -	−1.70	+0.49	−2 49.15

$$5\ \Delta\theta - 3.831\ a = +\ 0^s.920$$
$$-3.831\ \Delta\theta + 9.906\ a = -\ 2.704$$
$$a = -\ 0^s.289,\ \Delta\theta = -\ 0^s.037,\ \Delta t = +\ 2^m\ 49^s.037.$$

1866, December 11.—C., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
ε Bootis	W.	$\left\{\begin{matrix} B_{125}\ C_{135}\ D_{135} \\ E_{135}\ F_{35} \end{matrix}\right\}$	14^h 41^m 57^s.21	—0^s.14	+0^m 2^s.19	—0^s.17
β Urs. Minoris U.C.	"	B_1—C_5	52 19.36	—0.14	+1 32.70	—0.53
" " "	E.	B_1—C_5	14 55 23.67	—0.10	—1 32.70	—0.39
γ^2 Urs. Minoris U.C.	"	E_1—F_5	15 22 22.11	—0.10	+1 20.47	—0.34
" " "	W.	F_2—E_5	25 34.77	—0.14	—1 51.71	—0.46
α Coronæ	"	$B_1\ C_{13}\ D_5$	31 32.30	—0.13	+0 19.80	—0.16
α Serpentis . . .	"	E_1—F_5	15 40 57.10	—0.12	—0 24.63	—0.12

$T = 15^h$ $\theta = -\,2^m\ 50^s.00$ $\rho = -\,0^s.062$ $c = -\,0^s.090.$

Star.	t	α	Cc	ω_0'	Aa	Δt
ε Bootis	14^h 41^m 59^s.23	39^m 9^s.12	+0^s.10	—0^s.03	—0^s.10	—2^m 49^s.93
β Ursæ Minoris U.C. .	14 53 51.06	51 1.57	- - - -	+0.51	+0.54	50.03
γ^2 " " " . .	15 23 42.45	20 52.50	- - - -	+0.08	+0.43	50.35
α Coronæ	31 51.94	29 1.70	+0.10	—0.11	—0.10	50.01
α Serpentis	15 40 32.35	37 41.60	+0.09	—0.62	—0.18	—2 50.44

$$5\,\Delta\theta - 2.054\,a = -\,0^s.170.$$
$$-\,2.054\,\Delta\theta + 6.363\,a = -\,1.511.$$
$$a = -\,0^s.287,\ \Delta\theta = -\,0^s.151,\ \Delta t = -\,2^m\ 50^s.151.$$

1866, December 12.—B., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
β Arietis	W.	B_1—F_5	1^h 50^m 10^s.06	—0^s.18	0^m 0^s.00	—0^s.19
α "	"	B_1—F_5	2 2 33.07	—0.19	0 0.00	—0.21
β Urs. Minoris L.C.	E.	C_1—E_5	2 53 52.03	—0.20	+0 0.01	+0.43
ζ Arietis	"	B_1—F_2	3 10 12.67	—0.19	—0 5.14	—0.21
α Persei	"	B_1—F_5	3 17 42.95	—0.19	0 0.00	—0.31
α Camelop. U. C. .	"	B_1—F_5 [E_5F_1 lost]	4 43 50.03	—0.21	—0 5.24	—0.52
ι Aurigæ	"	D_1—D_5	4 51 11 76	—0.21	—0 0.02	—0.26

$T = 3^h$ $\theta = -\,2^m\ 50^s.50$ $\rho = -\,0^s.065$ $c = -\,0^s.080.$

Star.	t	α	Cc	ω_0'	Aa	Δt
β Arietis	1^h 50^m 9^s.87	47^m 18^s.66	+0^s.08	—0^s.71	—0^s.02	—2^m 51^s.19
α "	2 2 32.86	59 41.77	+0.08	—0.57	—0.02	51.05
β Ursæ Minoris U.C. .	2 53 52.47	51 1.64	+0.30	+0.04	—0.14	50.40
ζ Arietis	3 10 7.32	7 16.77	—0.08	—0.12	—0.02	50.60
α Persei	3 17 42.64	14 52.37	—0.12	+0.13	+0.01	50.38
α Camelop. U. C. . .	4 43 44.27	40 54.09	—0.20	+0.17	+0.04	50.37
ι Aurigæ	4 51 11.48	48 21.59	—0.09	+0.58	—0.01	—2 49.91

$$7\,\Delta\theta + 3.853\,a = -\,0^s\ 560$$
$$+\,3.853\,\Delta\theta + 12.217\,a = -\,.0757$$
$$a = -\,0^s.044,\ \Delta\theta = -\,0^s.056,\ \Delta t = -\,2^m\ 50^s.556.$$

1866, December 12.—B., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Canis Minoris . . .	W.	B_1—F_5	$7^h\,35^m\,12^s.03$	—0^s.34	$0^m\,0^s$.00	—0^s.28
β Geminorum	E.	B_1—F_5 [F_2 lost]	40 4 24	—0.28	—0 1.41	—0.32
ε Draconis L.C. . . .	"	B_1—F_5	7 51 24.32	—0.28	0 0.00	+0.39

$T = 7^h$ $\theta = -2^m\,51^s.00$ $\rho = -0^s.065$ $c = -0^s.080.$

Star.	t	α	Cc	ω_0'	Aa	Δt
α Canis Minoris .	$7^h\,35^m\,11^s$.75	$32^m\,21^s$.32	+0^s.08	—0.^{s}68	—0^s.06	—$2^m 50^s$.26
β Geminorum . .	40 2.51	37 11.35	—0.09	—0.21	—0.03	51.18
ε Draconis L. C. .	7 51 24.71	48 34.05	+0.23	+0.62	—0.26	—2 50.12

$$3\,\Delta\theta + 3.608\,a = +\,1^s.090$$
$$+\,3.608\,\Delta\theta + 7.484\,a = +\,1.002$$
$$a = -\,0^s.097,\ \Delta\theta = +\,0^s.480,\ \Delta t = -\,2^m\,50^s.520.$$

1866, December 13.—B., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
65 ξ^1 Ceti	W.	D_1—F_5	$2^h\,8^m\,50^s$.32	—0^s.02	$0^m\,0^s$.00	—0^s.04
ι Cassiopeæ U.C. . . .	"	B_1—F_5	21 5.36	—0.02	0 0.00	—0.09
5 Ursæ Minoris L. C. .	"	E_1—F_5	28 51.50	—0.01	+1 43.15	+0.08
" " " " . .	E.	E_1—F_5	33 18.41	+0.03	—1 43.15	—0.01
γ Ceti.	"	B_1—F_5	39 17.87	+0.03	0 0.00	0.00
α "	"	B_1—E_5	2 58 21.10	+0.06	—0 8.16	+0.02

$T = 3^h$ $\theta = -2^m\,52^s.80$ $\rho = -0^s.074$ $c = -0^s.060.$

Star.	t	α	Cc	ω_0'	Aa	Δt
65 ξ^1 Ceti	$2^h\,8^m\,50^s$.28	$5^m\,57^s$.89	+0^s.06	—0^s.40	+0^s.35	—$2^m\,52^s$.75
ι Cassiopeæ U.C. .	21 5.27	18 11.91	+0.15	—0.47	—0.54	52.73
5 Ursæ Minoris L.C.	30 34.99	27 44.36	- - - -	+2.13	+2.08	52.75
γ Ceti	39 17.87	36 25 48	—0.06	+0.33	+0.39	52.86
α ".	2 28 12.96	55 20.63	—0.06	+0.41	+0.39	—2 52.78

$$5\,\Delta\theta + 4.612\,a = +\,2^s.800.$$
$$+\,4.612\,\Delta\theta + 15.082\,a = +\,8.840.$$
$$a = +\,0^s.578,\ \Delta\theta = +\,0^s.027,\ \Delta t = -\,2^m\,52^s.773.$$

1866, December 14.—B., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
β Arietis . .	W.	B_1—F_5	$1^h 50^m 12^s.44$	$+0^s.13$	0^m $0^s.00$	$+0^s.11$
α “ . .	“	B_1—F_5 [C_4 lost]	2 2 36.31	+0.14	—0 0.62	+0.12
65 ξ¹ Ceti . .	“	B_1—D_3	8 32.30	+0.14	+0 19.65	+0.09
ι Cassiopeæ U.C.	“	B_1—F_5	21 5.66	+0.15	0 0.00	+0.31
γ Ceti . . .	E.	B_1—C_3 E_4 F_5 [F_2 lost]	39 22.72	+0.21	—0 3.31	+0.13
α “ . . .	“	B_1—F_5	2 58 14.52	+0.17	0 0.00	+0.11
α Persei . . .	“	B_1—F_5	3 17 46.04	+0.14	0 0.00	+0.19

$T = 3^h$. $\theta = -2^m 54^s.00$. $\rho = -0^s.081$. $c = -0^s.660$.

Star.	t	α	Cc	ω_0'	Aa	Δt
β Arietis	$1^h 50^m 12^s.55$	$47^m 18^s.64$	$+0^s.06$	$+0^s 05$	$-0^s.04$	$-1^m 53^s.91$
α “	2 2 35.81	59 41.76	+0.06	—0.07	—0.04	54.03
65 ξ¹ Ceti . . .	8 52.04	5 57 88	+0.06	—0.17	—0.06	54.11
ι Cassiopeæ U.C. .	21 5.97	18 11.89	+0.15	+0.02	+0.09	54.07
γ Ceti.	39 19.54	36 25.47	—0.06	—0.16	—0.06	54.10
α “	2 58 14.63	55 20.63	—0.06	—0.06	—0.06	54.00
α Persei	3 17 46.23	14 52.36	—0.09	+0.06	+0.01	—2 53.95

$$7\,\Delta\theta + 1.767\,a = -0^s.330.$$
$$+1.767\,\Delta\theta + 2.531\,a = -0.282.$$
$$a = -0^s.095,\ \Delta\theta = -0^s.023,\ \Delta t = -2^m 54^s.023.$$

1866, December 14.—B., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
μ Geminorum . .	E.	B_1—$_5$ F_2—$_5$	$6^h 17^m 54^s.26$	$+0^s.10$	-0^m $3^s.27$	$+0^s.08$
γ “ . . .	W.	B_1—F_1 [B_5—C_2lost]	32 52.26	+0.04	+0 4.92	+0.02
ε Canis Majoris .	“	D_3—E_5	6 56 32.48	+0.04	—0 12.83	—0.01
δ “ “ . .	“	B_5—E_4	7 5 51.31	+0.04	+0 3.63	—0.01
δ Geminorum . .	“	B_1—$_5$ $C_{1\,4\,5}$ $D_{1\,4}$ F_1—$_5$	7 15 2.51	+0.04	+0 3.61	+0.02

$T = 7^h$ $\theta = -2^m 54^s.30$ $\rho = -0^s.081$ $c = -0^s.060$.

Star.	t	α	Cc	ω_0'	Aa	Δt
μ Geminorum . . .	6^h $17^m 51^s.07$	$14^m 56^s.07$	$-0^s.06$	rejected	- - - -	- - - - - -
γ “ . . .	32 57.20	30 2.84	+0 06	$-0^s.04$	$+0^s.03$	$-2^m 54^s 37$
ε Canis Majoris . .	6 56 19.64	53 25.41	+0.07	+0 14	+0.07	54.23
δ “ “ . . .	7 5 54.93	3 0.42	+0.07	—0.13	+0.07	54.50
δ Geminorum . . .	7 15 6.14	12 11.75	+0.06	—0.01	+0.03	—2 54.34

$$4\,\Delta\theta + 3.075\,a = -0^s.040$$
$$+3.075\,\Delta\theta + 2.747\,a = -0.007$$
$$a = +0^s.063,\ \Delta\theta = -0^s.058,\ \Delta t = -2^m 54^s.358$$

1866, December 15.—B., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Arietis	W.	$B_3\ C_3\ D_3\ E_3\ F_3$	$2^h\ 2^m\ 37^s.56$	$+0^s.26$	$-0^m\ 0^s.03$	$+0^s.24$
ι Cassiopeæ U. C. .	"	B_1—F_5	21 7.40	+0.19	0 0.00	+0.40
5 Urs. Minoris L.C.	E.	C_3—F_5	31 29.68	+0.23	—0 47.75	—0.45
γ Ceti	"	B_1—E_5	39 21.63	+0.24	0 0.00	+0.16
α "	"	{B_1—F_5 [$C_{1\,2\,3}$ $D_1\ E_1$ lost]}	2 58 14.22	+0.25	+0 2.59	+0.17
48 Cephei U. C. . .	"	B_1—F_5 [D_3 lost]	3 6 34.46	+0.27	—0 0.01	+0.96
α Persei	W.	B_1—F_5	17 48.93	+0.25	0 0.00	+0.36
γ^2 Urs. Minoris U. C.	"	$B_{1\,2}\ C_1$—F_1	23 57.72	+0.26	—0 8.41	+0.34
δ Persei	"	B_1—F_5	36 25.82	+0.26	0 0.00	+0.36
η Tauri	E.	B_1—F_5	3 42 32.30	+0.30	0 0.00	+0.28

$T = 3^h \qquad \theta = -2^m\ 56^s.20 \qquad \rho = 0^s.087 \qquad c = -0^s.060.$

Star.	t	α	Cc	ω_0'	Aa	Δt
α Arietis	$2^h\ 2^m\ 37^s.77$	$59^m\ 41^s.75$	$+0^s.06$	$+0^s.15$	$-0^s.06$	$-2^m\ 56^s.00$
ι Cassiopeæ U.C. .	21 7.80	18 11.86	+0.15	+0.35	+0.12	55.98
5 Urs. Minoris L.C. .	30 41.48	27 44.46	+0.25	—0.61	—0.48	56.33
γ Ceti	39 21.79	36 25.47	—0.06	—0.24	—0.09	56.35
α "	2 58 16.98	55 20.63	—0.06	—0.21	—0.09	56.32
48 Cephei U. C. . .	3 6 35.41	3 39.64	—0.27	+0.17	+0.32	56 35
α Persei.	17 49.29	14 52.36	+0.09	rejected	- - - -	- - - - - -
γ^2 Urs. Minoris L.C. .	23 48.97	20 52.65	—0.20	—0.29	—0.39	56.10
δ Persei	36 26.18	33 29.75	+0.09	—0.11	+0.01	56.32
η Tauri	3 42 32.58	39 36.18	—0.06	—0.20	—0.05	—2 56.35

$$9\,\Delta\theta + 5.275\,a = -0^s.990$$
$$+5.275\,\Delta\theta + 29.338\,a = -4.092$$
$$a = -0^s.134, \quad \Delta\theta = -0^s.032, \quad \Delta t = -2^m\ 56^s.232.$$

1866, December 16.—C., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
o Cephei U. C. . .	E.	B_5—$C_2\ D_2$—E_1	$23^h\ 16^m\ 26^s.26$	$+0^s.15$	$-0^m\ 16^s.74$	$+0^s.32$
ι Aurigæ	"	B_1—F_5	4 51 19.92	+0.11	0 0.00	+0.10

$T = 3^h \qquad \theta = -2^m\ 58^s.40 \qquad \rho = -0^s.087 \qquad c = -0^s.060.$

Star.	t	α	Cc	ω_0'	Aa	Δt
o Cephei U. C. . .	$23^h\ 16^m\ 9^s.84$	$13^m\ 11^s.53$	$-0^s.16$	$-0^s.39$	$-0^s.39$	$-2^m\ 58^s.40$
ι Aurigæ	4 51 20.02	48 21.63	—0.07	+0.10	+0.10	—2 58.40

$$2\,\Delta\theta - 0.730\,a = -0^s.290$$
$$-0.730\,\Delta\theta + 1.031\,a = +0.408$$
$$a = +0^s.395, \quad \Delta\theta = -0^s.001, \quad \Delta t = +2^m\ 58^s.401.$$

1866, December 18.—C., Obs.

Star.	Lamp.	Threads.	M	b_0	R	Bb_0+k
α Camelop. U.C. . . .	E.	$\{B_1$—F_5 [C_{345} D_2 lost]$\}$	$4^h\,43^m\,51^s.78$	$+0^s.04$	$+0^m\,5^s.12$	$+0^s.05$
ι Aurigæ	"	B_1—F_5	51 24.16	+0.06	0 0.00	+0.05
ε Ursæ Minoris L.C.	"	B_5—C_3	4 59 28.97	+0.07	+3 1.47	—0.21
" " "	W.	B_1—C_5	5 5 30.99	+0.04	—3 1.47	—0.03
α Aurigæ	"	D_1—F_5	10 19.96	+0.05	—0 23.42	+0.05
β Tauri	"	B_1—C_5 [C_1 lost]	20 39.22	+0.05	+0 18.11	+0.03
δ Orionis	"	B_1—F_5	28 16.37	+0.05	0 0.00	+0.02
ε Orionis	"	B_1—F_5 [E_5 lost]	32 30.73	+0.05	+0 0.90	+0.01
ψ′ Draconis L. C. .	"	E_1—F_5	45 54.84	+0.05	+1 20.07	—0.03
" " " . .	E.	E_2—F_5	48 40.23	+0.09	—1 24.99	—0.09
α Arionis	"	B_1—F_3	5 51 1.82	+0.09	0 0.00	+0.05

$T = 5^h$ $\theta = -3^m\,3^s.00$ $\rho = -0^s.088$ $c = -0^s.050.$

Star.	t	α	Cc	ω_0'	Aa	Δt
α Camelop. L. C. . .	$4^h\,43^m\,56^s.95$	$40^m\,54^s.12$	$-0^s.12$	$+0^s.03$	$-0^s.52$	$-3^m\,2^s.45$
ι Aurigæ	4 51 24.21	48 21.64	—0.06	+0.36	+0.15	2.79
ε Ursæ Minoris L.C.	5 2 39.86	59 31.22	- - - -	+4.36	+3.50	2.14
α Aurigæ	9 56.59	6 53.93	+0.07	+0.42	—0.01	2.57
β Tauri	20 57.36	17 54.56	+0.06	+0.19	+0.19	3.00
δ Orionis	28 16.39	25 13.98	+0.05	+0.68	+0.42	2.74
ε "	32 31.64	29 29.13	+0.05	+0.58	+0.43	2.85
ψ′ Draconis . . .	47 15.01	44 14.01	- - - -	+2.07	+1.73	2.66
α Orionis	5 51 1.87	47 59.54	—0.05	+0.70	+0.37	—3 2.67

$$9\,\Delta\theta + 10.537\,a = +\ 9^s.390$$
$$+\,10.537\,\Delta\theta + 49.521\,a = +\,33.065$$
$$a = +\,0^s.594,\ \Delta\theta = +\,0^s.348,\ \Delta t = -\,3^m\,2^s.562.$$

VII.

LONGITUDE SIGNALS BETWEEN FOILHOMMERUM AND HEART'S CONTENT.

The method of giving and receiving the signals for longitude, between Foilhommerum and Heart's Content, was that prescribed in the programme which I had prepared before leaving home. Three series, of two sets each, were exchanged on every occasion; each set consisting of ten signals alternately positive and negative, at intervals of about five seconds, except that the fifth and eighth were preceded by pauses of ten seconds, which was also the interval between the two sets. The purpose of this arrangement was to discover whether the velocity of transmission was perceptibly affected by a longer time being allowed for the cable to recover its electrical equilibrium, and also to facilitate the identification of the individual signals. Some slight convenience in the practical details also arose from the circumstance that each set occupied one minute, and that each series consisted of ten positive and ten negative signals. Those signals were considered positive by which the platinum was put in connection with the cable and the zincode with the ground.

In receiving the signals, the observer (Mr. Dean at Newfoundland, and myself at Valencia) watched the deflections of the light-spot, while his thumb rested on the button of a delicately adjusted break-circuit key, which was pressed at the instant in which the deflection was perceived. This instant was thus recorded upon the chronograph, after a certain amount of delay, which we will call the personal error of noting, and which depended upon a considerable number of influences to be discussed hereafter. The keys by which the signals were transmitted were made by the American Telegraph Company, under the supervision of Mr. Dean, and are constructed according to the arrangement devised by Prof. Thomson for the Atlantic Telegraph, in such a manner that pressure upon one button produces a positive, and upon the other a negative signal, while no current flows at other times. To this arrangement an additional contrivance was applied by which the local circuit to the chronograph passed through the same key, and was interrupted by pressure upon either button, so that every signal transmitted through the cable was recorded upon the chronograph at the station whence it was sent.

It is thus manifest that the times of sending the signals were accurately recorded, while the times of receiving signals were recorded after an interval of time dependent on the personal error of noting, and inseparable from the time of transmission through the cable, except by some independent means of measurement. If this interval were the same for both observers, it would be eliminated entirely from the longitude and merged with the time of transmission. Otherwise it would affect the resultant longitude by one-half the difference between the personal errors of noting for the two observers. Happily it proved to be very nearly the same for Mr. Dean and myself, and also measurable; so that it has been possible to eliminate its influence from the measure of velocity, as well as from the longitude.

If now we denote the clock-times at Valencia and Newfoundland by T and T' respectively, the corrections for reducing these to the true sidereal time by Δt and $\Delta t'$, the time required for transmission of the galvanic signals by x, and the longitude by λ; and if furthermore we distinguish those quantities which pertain to Valencia signals by a subjacent 1, and similarly those belonging to Newfoundland signals by the subjacent figure 2, it is manifest that, if we include in x the personal error of noting signals, then

the signals given and recorded at Valencia at the time T_1 will be registered upon the Newfoundland record at $T_1' = T_1 + \Delta t_1 - \Delta t_1' - \lambda + x_1$

and the signals given and recorded at Newfoundland at T_2 will be registered upon the Valencia record at $T_2 = T_2' + \Delta t_2' - \Delta t_2 + \lambda + x_2$

Thus the comparison of the records of Valencia signals, at the two stations, gives

$$T_1 - T_1' = \Delta t_1' - \Delta t_1 + \lambda - x_1$$

while the comparison of the records of Newfoundland signals gives

$$T_2 - T_2' = \Delta t_2' - \Delta t_2 + \lambda + x_2$$

and consequently

$$2\lambda = (T_2 - T_2') + (T_1 - T_1') + (\Delta t_2 - \Delta t_2') + (\Delta t_1 - \Delta t_1') + (x_1 - x_2)$$

$$x_1 + x_2 = (T_2 - T_2') - (T_1 - T_1') + (\Delta t_2 - \Delta t_2') - (\Delta t_1 - \Delta t_1')$$

If we assume the personal error of noting to be the same for the two observers, and the signals to travel with equal velocity in the two directions, the term $x_1 - x_2$ will disappear from the first equation, while the second will give a measure of the sum of the transmission-times and the personal errors of noting.

From the time-determinations in Chapters IV and V we may obtain the clock-corrections as follows, for the periods in which longitude-signals were exchanged. They are first given for those epochs for which they were determined, and the interpolated values follow for intervals of five minutes during the period of the exchanges.

On November 5, a double weight is assigned to the first time-determination, on account of the much smaller value of the azimuth error; this having been largely changed by an accident (due to no carelessness of the observer) which interrupted the first series of observations.

CLOCK-CORRECTIONS AT EACH STATION.

Valencia Clock Corrections.			Newfoundland Clock Corrections.		
	Sid. time $=T.$	Δt		Sid. time $=T'.$	$\Delta t'$
1866					
October 25,	$19^h.8$	$—8^s.447$	October 25,	$21^h.0$	$+4^s.714$
				0.0	+4.745
27,	1.7	—8.420			
			October 28,	22.0	+5.640
28,	21.0	—8.812		1.0	+5.713
30,	22.0	—9.266	November 5,	23.0	+8.326
				2.0	+8.332
November 5,	23.0	—13.034			
	"	.058	November 6,	21.0	+7.973
				23.0	+7.967
6,	23.0	—13.236			
	3.0	364	November 9,	21.0	+7.810
				1.0	+7.813
9,	20.0	—15.977			
	4.0	—16.608			
October 25,	$1^h\ 50^m$	$—8^s.442$		$23^h\ 0^m$	+4.735
	1 55	.441		23 5	.736
	2 0	.441		23 10	.737
	2 5	.441		23 15	.738
October 28,	2 35	—8.864		23 40	+5.681
	2 40	.865		23 45	.683
	2 45	.865		23 50	.685
	2 50	.866		26 55	.687
	2 55	.867		0 0	.689
November 5,	3 30	—13.078		0 40	+8.329
	3 35	.079		0 45	.329
	3 40	.079		0 50	.329
	3 45	.080		0 55	.329
	3 50	.080		1 0	.329
November 6,	1 10	—13.305		22 15	+7.967
	15	.308		22 20	.967
	20	.311		22 25	.966
	25	.313		22 30	.966
November 9,	3 0	—16.529		0 10	+7.812
	5	.535		0 15	.812
	10	.542		0 20	.812
	15	.548		0 25	.813
	20	.555		0 80	.813

We are thus enabled to construct the following table, in which the times given are the means of the clock-times for each set, to the nearest minute, and the results for positive and negative signals are exhibited separately as well as together.

Trans-Atlantic Longitude and Transmission-Time.

1866, October 25.

		Series I.		Series II.		Series III.	
Valencia signals.	T_1	$1^h 49^m 01^s$	$1^h 50^m 7^s$	$1^h 55^m 27^s$	$1^h 56^m 32^s$	$2^h 1^m 48^s$	$2^h 2^m 53^s$
	T_1'	22 56 52	22 57 58	23 3 18	23 4 23	23 9 40	23 10 45
	pcs.	2 52 9.02	2 52 8.99	2 52 9.03	2 52 9.05	2 52 9.08	2 52 9.09
	neg	8.90	9.05	8 95	9.06	9.13	9.10
	all.	8.96	9.02	8.99	9.05	9.11	9.10
	$\Delta t_1 - \Delta t_1'$	—13.176	—13.176	—13.177	—13.177	—13.178	—13.178
Newfoundland sigs.	T_2	1 52 9	1 53 15	1 58 41	1 59 6	2 5 11	2 6 17
	T_2'	23 0 0	23 1 5	23 6 30	23 7 36	23 13 1	23 14 6
	pos.	2 52 10 26	2 52 10.25	2 52 10.25	2 52 10.27	2 52 10.26	2 52 10.29
	neg.	10.26	10.26	10.29	10.28	10.25	10.32
	all.	10.26	10.26	10.27	10.28	10.25	10.30
	$\Delta t_2 - \Delta t_2'$	—13.176	—13.176	—13.177	—13.177	—13.178	—13.178
	Corr.	—26.352	—26.352	—26.354	—26.354	—26.356	—26.356
Sum of intervals.	pos.	5 44 19.28	5 44 19.24	5 44 19.28	5 44 19.32	5 44 19.34	5 44 19.38
	neg.	19.16	19.31	19.24	19.34	19.38	19.42
	all.	19.22	19.28	19.26	19.33	19.36	19.40
	pos.	0.62	0.63	0.61	0.61	0.59	0.60
x	neg.	0.68	0.60	0.67	0.61	0.56	0.61
	all.	0.65	0.62	0.64	0.61	0.57	0.60
	λ	$2^h 51^m 56^s.449$.		$2^h 51^m 56^s.470$.		$2^h 51^m 56^s.512$.	

1866, October 28.

Valencia signals.	T_1	$2^h 33^m 30^s$	$2^h 34^m 35^s$	$2^h 39^m 35^s$	$2^h 40^m 40^s$	$2^h 52^m 37^s$	$2^h 53^m 42^s$
	T_1'	23 41 20	23 42 25	23 47 25	23 48 30	0 0 27	0 1 32
	pos.	2 52 10.34	2 52 10.36	2 52 10.40	2 52 10.39	2 52 10.43	2 52 10.42
	neg.	10.39	10.36	10.40	10.41	10.42	10.42
	all.	10.37	10.36	10.40	10.40	10.42	10.42
	$\Delta t_1 - \Delta t_1'$	—14.546	—14.547	—14.549	—14.550	—14.556	—14.556
Newfoundland sigs.	T_2	2 36 37	2 37 43	2 42 38	2 43 43	2 56 40	2 56 45
	T_2'	23 44 25	23 45 31	23 50 26	23 51 31	0 3 28	0 4 33
	pos.	2 52 11.78	2 52 11.79	2 52 11.65	2 52 11.67	2 52 11.68	2 52 11.66
	neg.	11.69	11.68	11.64	11.72	11.57	11.69
	all.	11.73	11 74	11.64	11.69	11.62	11.67
	$\Delta t_2 - \Delta t_2'$	—14.548	—14.548	—14.551	—14.551	—14.557	—14.558
	Corr.	—29.094	—29.095	—29.100	—29.101	—29.113	—29.114
Sum of intervals.	pos.	5 44 22.12	5 44 22.15	5 44 22.05	5 44 22.06	5 44 22.11	5 44 22.08
	neg.	22.08	22.04	22.04	22.13	21.97	22.11
	all.	22.10	22.10	22.04	22.09	22.04	22.09
	pos.	0.72	0.72	0.62	0.64	0.62	0.62
x	neg.	0.65	0.66	0.62	0.66	0.58	0.64
	all.	0.68	0.69	0.62	0.65	0.60	0.63
	λ	$2^h 51^m 56^s.502$.		$2^h 51^m 56^s.482$.		$2^h 51^m 56^s.476$.	

1866, November 5.

		Series I.		Series II.		Series III.	
Valencia signals.	T_1	$3^h 32^m 35^s$	$3^h 33^m 41^s$	$3^h 39^m 22^s$	$3^h 40^m 27^s$	$3^h 46^m 0^s$	$3^h 47^m 0^s$
	T_1'	0 40 18	0 41 23	0 47 5	0 48 10	0 53 42	0 54 42
	pos.	2 52 17.25	2 52 17.30	2 52 17.32	2 52 17.31	2 52 17.25	2 52 17.27
	neg.	17.25	17.29	17.30	17.31	17.26	17.25
	all.	17.25	17.30	17.31	17.31	17.26	17.26
	$\Delta t_1 - \Delta t_1'$	—21.407	—21.407	—21.408	—21.408	—21.409	—21.409
Newfoundland sigs.	T_2	3 35 45	3 36 50	3 42 46	3 43 51	3 49 19	3 50 24
	T_2'	0 43 27	0 44 32	0 50 28	0 51 33	0 57 1	0 58 6
	pos.	2 52 18.42	2 52 18.47	2 52 18.44	2 52 18.47	2 52 18.46	2 52 18.47
	neg.	18.43	18.48	18.43	18.55	18.46	18.47
	all.	18.42	18.47	18.43	18.51	18.46	18.47
	$\Delta t_2 - \Delta t_2'$	—21.408	—21.408	—21.408	—21.408	—21.409	—21.409
Sum of intervals.	Corr.	—42.815	—42.815	—42.816	—42.816	—42.818	—42.818
	pos.	5 44 35.67	5 44 35.77	5 44 35.76	5 44 35.78	5 44 35.71	5 44 35.74
	neg.	35.68	35.77	35.73	35.86	35.72	35.72
	all.	35.67	35.77	35.74	35.82	35.72	35.73
x	pos.	0.57	0.58	0.56	0.58	0.60	0.60
	neg.	0.59	0.60	0.56	0.62	0.60	0.61
	all.	0 58	0.59	0.56	0.60	0.60	0.60
	λ	$2^h 51^m 56^s.428.$		$2^h 51^m 56^s.482.$		$2^h 51^m 56^s.454.$	

1866, November 6.

Valencia signals.	T_1	$1^h 9^m 10^s$	$1^h 10^m 15^s$			$1^h 21^m 20^s$	$1^h 22^m 17^s$
	T_1'	22 16 53	22 17 58			22 29 3	22 30 0
	pos	2 52 17.19	2 52 17.20			2 52 17.18	2 52 17.20
	neg.	17.22	17.18			17.30	17.18
	all.	17.20	17.19			17.24	17.19
	$\Delta t_1 - \Delta t_1'$	—21.272	—21.272			—21.277	—21.278
Newfoundland sigs.	T_2	1 12 25	1 13 30			1 24 2	1 25 32
	T_2'	22 20 6	22 21 11			22 32 86	22 33 14
	pos.	2 52 18.32	2 52 18.31			2 52 18.25	2 52 18.33
	neg.	18.30	18.33			18.29	18.33
	all.	18.31	18.32			18.27	18.33
	$\Delta t_2 - \Delta t_2'$	—21.273	—21.274			—21.279	—21.279
Sum of intervals.	Corr.	—42.545	—42.546			—42.556	—42.557
	pos.	5 44 35.51	5 44 35.51			5 44 35.43	5 44 35.53
	neg.	35 52	35.51			35.59	35.51
	all.	35.51	35.51			35.51	35.52
x	pos.	0.56	0.55			0.54	0.56
	neg.	0.54	0.57			0.50	0.58
	all.	0.55	0.56			0.52	0.57
	λ	$2^h 51^m 56^s.482.$				$2^h 51^m 56^s.480.$	

1866, November 9.

		Series I.		Series II.		Series III.	
Valencia signals.	T_1	$3^h\ 0^m\ 0^s$	$3^h\ 1^m\ 6^s$	$3^h 10^m 12^s$	$3^h 11^m 17^s$	$3^h 16^m 23^s$	$3^h 17^m 28^s$
	T_1'	0 7 40	0 8 45	0 17 52	0 18 56.	0 24 3	0 25 8
	pos.	2 52 20.25	2 52 20.27	2 52 20.30	2 52 20.26	2 52 20.27	2 52 20.29
	neg.	20.27	20.30	20.28	20.26	20.29	20.26
	all:	20.26	20.28	20.29	20.26	20.28	20.28
	$\Delta t_1 — \Delta t_1'$	—24.341	—24.342	—24.354	—24.355	—24.363	—24.364
Newfoundland sigs.	T_2'	3 3 6	3 4 11	3 13 13	3 14 18	3 19 44	3 20 50
	T_2	0 10 44	0 11 49	0 20 51	0 21 56	0 27 25	0 28 28
	pos.	2 52 21.32	2 52 21.34	2 52 21.34	2 52 21.39	2 52 21.35	2 52 21.41
	neg.	21.34	21.33	21.36	21.37	21.37	21.36
	all.	21.33	21.33	21.35	21.38	21.36	21.39
	$\Delta t_2 — \Delta t_2'$	—24.345	—24.346	—24.358	—24.360	—24.367	—24.369
Sum of intervals.	Corr.	—48.686	—48.688	—48.712	—48.715	—48.730	—48.733
	pos.	5 44 41.57	5 44 41.61	5 44 41.64	5 44 41.65	5 44 41.62	5 44 41.70
	neg.	41.61	41.63	41.64	41.63	41.66	41.62
	all.	41.59	41.62	41.64	41.64	41.64	41.66
x	pos.	0.53	0.53	0.52	0.57	0.54	0.56
	neg.	0.53	0.51	0.54	0.55	0.54	0.55
	all.	0.53	0.52	0.53	0.56	0.54	0.56
	λ	$2^h\ 51^m\ 56^s.459.$		$2^h\ 51^m\ 56^s.463.$		$2^h\ 51^m\ 56^s.459.$	

It is manifest that $\Delta t — \Delta t'$ was in no instance variable during the telegraphic exchanges, so that no correction is needed for the deduced values of x on account of difference of clock-rates; and there is every reason to believe, both from theoretical considerations and from special experiment, that the velocity is the same for eastward and for westward signals, and that the resultant λ is consequently subject to no correction depending upon the clocks.

The resultant values of the longitude are thus found to be

1866, October	25,	$2^h\ 51^m\ 56^s.477$
	28,	56.487
November	5,	56.455
	6,	56.481
	9,	56.460

subject, however, in every case to a correction for personal equation in determining the time.

The mean interval between the moments of giving the signals and of their record upon the chronograph sheet is similarly found to have been

October	25,	$0^s.62$ ±	$0^s.008$
	28,	0.64	.010
November	5,	0.59	.004
	6,	0.55	.007
	9,	0.54	.005

in which the quantities appended are the probable errors of the respective determinations as deduced from the total results of the several sets, there being six sets for each determination except that of November 6.

On the 25th October the cable of 1865 was employed, one-half the circuit being formed by the earth; a battery of ten cells was used at each station, and "condensers" were interpolated between the battery and the cable. On the 28th October the connections were the same, in every respect, as on the 25th; but on the three other days the two cables were joined so as to form a complete metallic circuit, the number of elements employed being—

November 5,	3	at Valencia,	3	at Newfoundland.
6,	3	"	10	"
9,	4	"	10	"

VIII.

LONGITUDE SIGNALS BETWEEN HEART'S CONTENT AND CALAIS.

Clock-signals were exchanged between these two stations on four nights, upon only two of which the clock-errors at Calais could be determined either immediately before, or soon after, the exchange, one of these two nights being the same on which the clock occasioned so much trouble. It is a source of regret also that the signals were not exchanged according to the rule laid down in the programme, which prescribed that the Calais clock should be put into the circuit several times, for not more than half a minute at each time, while the time-scale was graduated for both chronographs by the Heart's Content clock only. In this way it would not have been difficult to obtain both records on the sheets at both stations with the ordinary connections, and without the necessity of continual adjustments of the relay magnets, and the results would have been more satisfactory in other respects.

On the 11th and 12th December, only the first and last signals of the Heart's Content clock in each minute can be deciphered, but these are legible by reason of the omission of the second-marks corresponding to the beginning of the minute. For the other two nights this difficulty does not exist. The means of the records are appended for the two stations separately. Upon the first two dates the individual measures from the Calais registers, although numbering but two in each minute, were derived from consecutive minutes.

NEWFOUNDLAND SIGNALS.

Date.	No.	H. C. clock-time.	Calais clock-time.
1866, December 11.	10	6^h 46^m $0^s.0$	5^h 53^m $13^s.912$
	10	7 8 0.0	6 15 13.908
December 12.	10	6 21 0.0	5 28 14.828
	16	7 29 30.0	6 36 44.813
	12	7 57 30.0	7 4 44.838
December 14.	38	5 43 40.0	4 50 56.462
	40	44 20.0	51 36.461
	39	45 0.0	52 16.453
	39	45 40.0	52 56.451
	40	5 46 20.0	4 53 36.455

Date.	No.	H. C. clock-time.			Calais clock-time.		
1866, December 14.	39	5^{h}	47^{m}	$0^{s}.0$	4^{h}	54^{m}	$16^{s}.450$
	59	5	47	50.0	4	55	6.446
	56	5	54	17.0	5	1	33.457
	58		55	25.0		2	41.454
	54		56	23.0		3	39.451
	57	5	57	45.0	5	5	1.444
	38	6	5	4.0	5	12	20.459
	56		5	54.0		13	10.445
	55		6	54.0		14	10.440
	59		7	54.0		15	10.463
	59		8	54.0		16	10.464
	59	6	9	44.0	5	17	0.457
December 16.	59	2	26	20.0	1	33	39.714
	59		27	20.0		34	39.709
	59		28	20.0		35	39.711
	52	2	29	20.0	1	36	39.734
	59	2	37	4.0	1	44	23.689
	58		38	3.0		45	22.691
	59		39	4.0		46	23.701
	47	2	40	0.0	1	47	19.700
	53	2	48	22.0	1	55	41.704
	56		49	23.0		56	42.707
	56		50	23.0		57	42.709
	57	2	51	23.0	1	58	42.719

CALAIS SIGNALS.

Date.	No.	Calais clock-time.			H. C. clock-time.		
1866, December 11.	59	5^{h}	43^{m}	$26^{s}.0$	6^{h}	36^{m}	$12^{s}.598$
	59		44	26.0		37	12.594
	58		45	25.0		38	11.594
	56		46	25.0		39	11.578
	59	5	47	26.0	6	40	12.562
	58	5	59	15.0	6	52	1.586
	80	6	0	26.0		53	12.578
December 12.	56	5	32	25.0	6	25	10.797
	50		33	23.0		26	8.793
	56		34	25.0		27	10.803
	61	5	35	30.0		28	15.818
	55	6	28	5.0	7	20	50.783
	56		29	5.0		21	50.786
	58		30	5.0		22	50.773
	59		31	7.0		23	52.761
	60	6	32	7.0	7	24	52.770
December 14.	59	4	56	36.0	5	49	20.113
	59		57	36.0		50	20.103
	59		58	36.0		51	20.102
	58		59	36.0		52	20.102
	57	5	0	36.0		53	20.099

Date.	No.	Calais clock-time.			H. C. clock-time.		
1866, December 14.	57	5^h	6^m	$50^s.0$	5^h	59^m	$34^s.096$
	57		7	50.0	6	0	34.092
	41		8	48.0		1	32.092
	18	5	9	46.0	6	2	30.091
	36	5	18	10 0	6	10	54.086
	62	5	21	6.0	6	13	50.143
	34	5	22	31.0	6	15	15.168
December 16.	56	1	38	32.0	2	31	12.901
	39		39	28.0		32	8.926
	59		40	32.0		33	12.902
	59		41	32.0		34	12.905
	59	1	42	32.0	2	35	12.897
	42	1	49	33.0	2	42	13.832
	55		50	34.0		43	14.843
	55		51	34.0		44	14.869
	59		52	34 0		45	14.877
	58	1	53	34.0	2	46	14.881
	57	2	0	39.0	2	53	19.839
	47		1	35.0		54	15.843
	56		2	39.0		55	19.830
	52	2	3	38.0	2	56	18.847

From the reductions of Chapters V and VI we may deduce the following determinations of the clock-corrections at the two stations:—

1866.	Heart's Content clock-corrections.		Calais clock-corrections.	
	Sid. clock time, T'	$\Delta t'$	Sid. clock time, T''	$\Delta t''$
December 11	$6^h 35^m$	$+2^s.080$	$5^h 40^m$	$—2^m$ $49^s.457$
	40	.079	45	.463
	45	.078	50	.469
	50	.077	55	.475
	55	.075	6 0	.482
	7 0	.074	5	.488
	5	.073	10	.494
	7 10	+2.072	6 15	—2 49.501
December 12	6 20	+1.538	5 25	—2 50.535
	25	.536	30	.534
	6 30	.535	5 35	.533
	7 20	.518	6 25	.526
	25	.516	30	.525
	30	.515	35	.524
	7 55	.505	7 0	.520
	8 0	+1.504	7 5	—2 50.519
December 14	5 40	—0.149	4 50	—2 54.204
	45	.152	55	.197
	50	156	5 0	.190
	55	.160	5	.183
	6 0	.163	10	.176
	5	.167	15	.169
	10	.170	20	.162
	6 15	—0.174	5 25	—2 54.155

	Heart's Content clock-corrections.		Calais clock-corrections.	
	T'	$\Delta t'$	T''	$\Delta t''$
December 16.	$2^h\ 25^m$	$-1^s.092$	$1^h 30$	$-2\ 58.266$
	30	.090	35	.274
	35	.087	40	.281
	40	.085	45	.288
	45	.082	50	.295
	50	.080	1 55	.303
	2 55	.077	2 0	.311
	3 0	$-$ .075	2 5	$-2\ 58.318$

We have thus from the Heart's Content signals, recorded at Calais—

Date.	T'	No. signals.	Difference of clocks.	$\Delta t'-\Delta t'$	$\lambda-x'$
1866, December 11.	$6^h 46^m\ 0^s$	10	$0^h 52^m 46^s.09$	$+2^m 51^s.55$	$0^h 55^m 37^s.64$
	7 8 0	10	46.09	51.57	37.66
December 12.	6 21 0	10	0 52 45.17	+2 52.07	0 55 37.24
	7 29 30	16	45.19	52.04	37.23
	7 57 30	12	45.16	52.02	37.18
December 14.	5 45 40	294	0 52 43 56	+2 54.04	0 55 37.59
	5 56 0	225	43.55	54.02	37.57
	6 7 30	326	43.55	54.00	37.55
December 16.	2 27 50	229	0 52 40.28	+2 57.18	0 55 37 46
	2 38 30	223	40.30	57.20	37.50
	2 50 0	222	40.29	57.22	37.51

and from the Calais signals, recorded at Heart's Content—

Date.	T'	No. signals.	Difference of clocks.	$\Delta t'-\Delta t''$	$\lambda-x$
1866, December 11.	$6^h 38^m 12^s$	291	$0^h 52^m 46^s.59$	$+2^m 51^s.54$	$0^h 55^m 38^s.13$
	6 52 36	138	46.58	+2 51.55	38.13
December 12.	6 26 40	223	0 52 45.80	+2 52.07	0 55 37.87
	7 22 50	288	45.78	+2 52.04	37.82
December 14.	5 51 20	292	0 52 44.10	+2 54.03	0 55 38.13
	6 0 40	177	44.09	54.01	38.10
	6 10 54	36	44.09	53.99	38.08
	6 14 25	96	44.16	+2 53.98	38.14
December 16.	2 33 12	272	0 52 40.91	+2 57.19	0 55 38.10
	2 44 15	269	40.86	57.21	38.07
	2 55 30	212	40.84	+2 57.23	38.07

From these we find the several values of the longitude and time of transmission—

1866.	λ	x
December 11.	$0^h\ 55^m\ 37^s.89$	$0^s.24$
12.	37.53	0.31
14.	37.84	0.27
16.	37.78	0.28

the longitude results requiring, however, a correction for personal equation.

IX.

PERSONAL ERROR IN NOTING SIGNALS.

Since the signals sent through the telegraphic cable were recorded upon the chronograph automatically at the transmitting station, but at the receiving station through the mediation of an observer, who noted the deflection of the light-spot from the galvanometer by sending a second telegraphic signal to his own chronograph, it will be seen that the interval x, which elapses between the giving of a signal at one station and its chronographic record at the other, may be conveniently divided into four different parts, viz., the time requisite

1. For the signal to arrive at the other station;
2. For the magnet of the galvanometer to be moved through an arc sufficient to be readily perceived;
3. For the observer to take cognizance of the deflection, and give his signal upon the break-circuit key;
4. For this observation-signal to be recorded upon the chronograph.

Each of these four parts comprises the time, appreciable or otherwise, consumed in more than one distinct process; yet this division suffices for all our purposes. If these several intervals be practically equal at the two stations, they become absolutely eliminated in our determination of the longitude. If they be unequal, the resultant longitude will require an increase by one-half the excess of their sum for westward signals. In either case, only their total sum at the two stations is determined by the operations for longitude.

If we assume that the time lost upon the chronograph-circuit is the same at each station, the last of the above-mentioned intervals becomes eliminated by the comparison of the two records. The second and third depend upon the galvanometer and observer at the receiving station, and are not easily to be separated from each other in any determination of their amount; but if their sum can be measured, this, subtracted from our quantity x, will afford a trustworthy determination of the velocity with which the signals are actually transmitted through the telegraphic circuit.

This sum of the delays dependent on the galvanometer and the observer, I have called "the personal error of noting;" and the attempts to measure its amount have been so successful, and have manifested such an unexpected constancy in its value for different persons, at different times, and at both stations, that the results obtained for the velocity of transmission of our signals seem entitled to a high degree of confidence.

By observing a series of signals similar to those exchanged for longitude, and so arranged that both the original signal and the observation of the consequent deflection shall be recorded on the same chronograph, the desired measure may be obtained. Experiment showed at once that the interval thus determined was altogether too large for any inconvenience to arise from the use of a single recording pen. The obstacle first encountered arose from the circumstance that the minimum battery force requisite for the electro-magnet of the chronograph pen was about seventy-five times greater than the maximum which could be safely employed for the galvanometer signals. To obviate this difficulty, a battery of two Minotti cells being employed, the circuit was divided at the galvanometer into two branches—one, of fine German silver wire, passing to the galvanometer and thence again to the main circuit, while the other branch was made to pass through the break-circuit key by means of which the deflections were noted. The resistances of these two branches were so adjusted that they were in the ratio of 1 to 100, by which device each signal at the observatory was sharply indicated on the galvanometer, without too great violence; and by a slight adjustment of the movable permanent magnets, it was always possible to render these deflections similar in amount to those received from Newfoundland. It was, of course, necessary to include the clock in the galvanic circuit, in order to obtain a time-scale; but the interruption and restoration of the circuit at each oscillation of the pendulum caused a vibration in the galvanometer needle, which was not quieted for more than half a second, and then only to be renewed immediately. To render all the circumstances of the experiment as similar to those of the longitude-signals as the nature of the case permitted, as well as to avoid any tendency to mechanical rhythm in the act of noting the signals (a source of inaccuracy which every observer by the chronographic method must have recognized whenever the beats of his clock have been audible or visible during the process of observation), it was necessary to dispense with the clock while the measures were actually in process.

The observations were therefore arranged as follows:—After the clock had been included in the circuit for some minutes, recording its beats upon the chronograph in the observatory, and manifesting them likewise upon the galvanometer in the telegraph office, the assistant in the observatory excluded the clock from the circuit by means of a plug-switch, thus stopping all record of time upon the chronograph sheet, although the pen continued to trace a straight line, and stopping likewise the pulsations of the galvanometer needle, by which indication the observer was warned that the signals were about to begin. He then gave a set of ten signals on one of the observing keys, at the same intervals, roughly, as those exchanged for longitude—namely, four sharp, quick taps upon the key, about five seconds apart; then, after ten seconds, three more; and, after another ten seconds, yet three more. At the close of this set of signals, he restored the clock to the circuit by removing the plug from the switch, and the graduation of the time-scale recommenced as before after an intermission of scarcely a minute; so that the times of each signal could be read off by means of the second-marks of the preceding and following minutes with an accuracy scarcely, if at all, inferior to that attainable when the time-record is simultaneously in progress. The chronographic records of the signals thus given are about $0^s.04$ long.

The observer is meanwhile at the galvanometer in the other building, out of sight and hearing of the assistant, and notes the moments of deflection of the light-spot by a tap upon the break-circuit key which he holds in his hand, taking care to conform in all respects to his habitudes while observing longitude-signals. The intervals between the chronographic records of the original signals and his observations of the same, then furnish a measure of the "personal error of noting" as already defined; and show the lapse of time corresponding to the sum of all the various delays of which our x is composed, except the actual time of transmission through the cable; unless the adjustments of the two chronographic or local circuits are so diverse that the loss of time which they entail cannot be regarded as equal for the two instruments. This is not the case, since repeated examination has shown that the difference is not measurable. The exclusive employment of signals given by interrupting the galvanic circuit, and of a pen which is not removed from the paper during the whole period, renders the measurement of armature-time very easy, and eliminates it from ordinary observations.

On the 2d November I made five such determinations of my personal error of noting, each one based upon one series of signals, and with the following results. The errors appended are the mean errors of the mean, not the so-called probable errors, which would be but two-thirds as large.

$0^{s}.277 \pm 0^{s}.013$
$0.256 \pm .012$
$0.230 \pm .011$
$0.248 \pm .014$
0.262 ± 0.018

These give the final value . . . 0.253 ± 0.006

A series by Mr. Mosman gave 0.275 ± 0.014

and one by Mr. George, of the telegraphic staff, who had had no previous experience in observing, gave . . . 0.296 ± 0.017

On the 7th November, five determinations gave for my own error—

$0^{s}.292 \pm 0^{s}.010$
0.300 ± 0.013
0.288 ± 0.006
0.285 ± 0.007
0.291 ± 0.010

the mean value being . . . . . 0.289 ± 0.005

Mr. Mosman's error from four determinations being—

0.322 ± 0.027
0.296 ± 0.031
0.303 ± 0.016
0.297 ± 0.013

and Mr. George's . . . . 0.309 ± 0.022

The galvanometer was evidently somewhat less sensitively adjusted than on the previous occasion, as was indeed known independently of the signals, since it had been undergoing some repairs; yet the average excess was but three and a half hundredths of a second.

The Kessels clock, at Heart's Content, was provided with two signal-giving attachments, one being the ordinary arrangement for breaking circuit at the moment when the pendulum-rod is vertical, and an additional tilt-hammer being available for interrupting the circuit at the instant of extreme elongation on alternate seconds. Mr. Dean availed himself of this means for measuring the personal error of noting signals, by connecting each tilt-hammer with a separate circuit. One of these passed through the normal signal-apparatus of the clock, the Morse register, the signal-key, and the galvanometer; the other through the subsidary tilt-hammer, the observing key, and the chronograph. The original signals were thus recorded on the chronograph sheets by means of a clock-scale graduated to two seconds, while the observations of the same were registered upon the Morse fillet; and a slight change made in the connections at the close of the experiments sufficed to put the records of both tilt-hammers upon the chronograph, and thus permit an accurate measurement of the interval between the two systems of clock-signals. In the first-named circuit a battery of two carbon cells was employed, resistance-coils being interposed to reduce the deflections of the galvanometer to the magnitude of those obtained through the cable; and the chronograph magnet proved sufficiently sensitive to record these.

On November 10, five series of measures gave for his personal error—

$0^{s}.22 \pm 0^{s}.020$
$0.28 \pm .019$
$0.24 \pm .010$
$0.24 \pm .025$
$0.22 \pm .008$
or from all . . . . 0.236 ± 0.009

On the 12th November, again, his observations of twelve sets of signals give, after deducting $0^{s}.48$ from each to correct for the difference of the two time-scales—

$0^{s}.224 \pm 0^{s}.017$
$.244 \pm .020$
$.193 \pm .014$
$.181 \pm .014$
$.170 \pm .017$
0.239 ± 0.016

$0^{s}.148 \pm 0^{s}.010$
$.195 \pm .009$
$.208 \pm .016$
$.271 \pm .012$
$.239 \pm .022$
0.209 ± 0.013

or from all . . . . $0^{s}.192 \pm 0^{s}.009$

The marked inferiority of these values to those found for three observers, on two different occasions at Valencia, excited my suspicions, and on inquiry of Mr. Dean it proved that his observations had been made in the same room in which Mr. Goodfellow had given the signals, and where the click of the key was distinctly audible, so that the observation was not purely dependent upon the deflection of the needle, but was possibly influenced by the sense of hearing.

Mr. Dean therefore repeated his observations under circumstances precluding the possibility of his personal error being affected by any extraneous influence of this kind. This was done on November 17, and ten series of signals (one of the original eleven being discarded for manifest irregularity) afford the following results, in which the difference of time-scales is included:—

$0^{s}.803 \pm 0^{s}.027$
$.834 \quad .014$
$.831 \quad .020$
$.820 \quad .017$
$0.848 \quad 0.021$

$0^{s}.832 \pm 0^{s}.020$
$.795 \quad .018$
$.857 \quad .026$
$.870 \quad .027$
$0.864 \quad 0.026$

the definite value from the ten series being

$0^{s}.830 \pm 0^{s}.008$

For the difference of the time-scales 52 comparisons, during one minute preceding the observations, give $0^s.491$, and 60 comparisons immediately afterwards give $0^s.499$. Adopting $0^s.495$, therefore, as the most probable value, and deducting this from the final value $0^s.830$, we have $0^s.335$ as Mr. Dean's personal error in noting the signals.

The difference between this error and that found for my own observations at Valencia is small, and is probably owing to the galvanometer rather than the observer; the apparatus at Heart's Content being known to be somewhat less sensitive than that at Foilhommerum. The constancy of the error is also here strongly manifest; and the illustration of the unrecognized but marked effect of the sound of the tap, upon observations supposed to be of the visible deflection only, is instructive.

It may not be inappropriate to mention in this connection that a very marked effect upon the observation of transits of stars is likely to be produced when the chronograph is in the same apartment, so that the regular beats of the magnet are audible. When the intervals between the transit-threads are approximately multiples of half a second, the tendency is very great so to tap upon the observing key as to produce a rhythmical beat in the armature; and when the interval differs from the multiple of a second, the occurrence of that magnet-beat which records an even second often precipitates the tap of the observer, whose nerves are in keen tension awaiting the instant of bisection. Only a strong effort of will can obviate these perturbing influences—which are akin to those exhibited in the measurements just described.

The personal error of noting being then assumed as $0^s.271$ at Valencia, and $0^s.335$ at Newfoundland, the sum of these quantities, or $0^s.606$, is to be deducted from our value of $x_1 + x_2$ to obtain the true time of transmission; and half their difference, or $0^s.032$, is to be deducted from the longitude after all other corrections are applied. This correction will be taken into account, in fixing the value to be adopted.

It may be added that the indications are strong that a considerable portion of this "personal error of noting" is not strictly a personal phenomenon, but that it is due to the consumption of a very appreciable interval of time in overcoming the inertia of the needle and in moving the needle through an arc sufficient to attract attention. Indeed it is my conviction that not less that the tenth of a second is thus lost.

An automatic apparatus might be arranged, all other means failing, for recording the signals received, by adjustment of delicate silver wires on each side of the galvanometer needle, in such a position, and so connected with the battery, that they would be brought in contact whenever the deflection of the needle reached a certain angle, and the signal be thus recorded upon the chronograph. This would definitely decide the question; but, for obvious reasons, no such experiment was undertaken at Valencia. My immediate object was thoroughly attained by the satisfactory results of these measurements of the sum of all delays not due to time consumed in the actual transit of the signals across the Atlantic.

X.

PERSONAL EQUATION IN DETERMINING TIME.

In the telegraphic operations of the Coast Survey, the unvarying rule has been that the personal equation be eliminated as far as possible by an interchange of position of the two observers, and also measured at least once during the progress of each longitude-campaign, by observations specially instituted for that purpose. These determinations are made with the same instruments used for the other work, the two observers sitting side by side, and observing alternate tallies of five threads each. A pair of stars thus gives a measure of personal equation unaffected by any small error in the adopted values of the thread-intervals; since the same person who observes the first, third, and fifth tallies for the first star, observes the second and fourth tallies for the second star.

The advantages and defects of this method are evident to the astronomer at once. For the end to which it is ordinarily applied, it is especially adapted. Since the longitudes depend on transit-signals for zenithal stars, the observations for personal equation are made by the use of stars of the same class, and care is moreover taken that the magnitudes of stars employed for the two purposes shall not differ essentially from one another. On the other hand, it cannot be denied that a certain amount of nervous excitement is likely to accompany observations thus made, since the observer has usually but a short time available after bringing his eye to the telescope, before the first transit occurs.

Furthermore, the eye-piece has to be moved, to bring the new tally into the middle of the field, and the position of the body is frequently somewhat constrained in consequence of the close proximity of the two observers. The careful and long-continued study of these observations of personal differences for a considerable number of observers, during a period of about eighteen years, has thoroughly convinced me, as often stated on other occasions, that the personal equation varies decidedly with the magnitude, and very greatly with the declination of the star.

Three elements seem especially to enter into the magnitude of the personal differences in right-ascension: 1, the perceptions of the observer, which are affected by the magnitude of the star, and possibly to some extent by the rapidity of its apparent motion; 2, the habitudes of the observer, as determining the moment at which he endeavors to give his signal upon the telegraphic key; and 3, the construction and adjustment of this key itself, which affect, to a certain extent, the interval between the intention to give the signal and the complete execution of this intention. The unrecognized interval, which intervenes between the perception by sight and the performance of the consequent endeavor to press the button of the observing key, may be regarded as merged with the second of the influences above named. It forms a large portion of the theoretical personal equation, but a much smaller part of its practical amount, which is very dependent upon less subtle causes of delay.

The first of these elements of personal equation explains the difference which certainly exists in its value for the same observer, when different instruments are employed for its measurement; the magnifying power, and the amount of light, each appearing to exert a distinct effect.

The second is a subject of considerable interest; and extended series of comparisons between the observations of the same persons, using eye-pieces of different magnifying power with the same instrument, and using instruments of different aperture with similar reticules and eye-pieces, could not fail to afford much information. It had long been my desire to carry out this investigation, toward which, indeed, a considerable amount of materials has been collected, but for the present, at least, no facilities are within my reach. It is certain that persons of the most delicate nervous organizations are not generally those who observe a transit earliest; nor does the reverse hold true. And it would seem that an influence is here involved, which does not exist in the method of observation by eye and ear; viz., an (generally unconscious) effort of judgment, by which many, if not most, observers give their signal-tap, not at the instant when the star is seen upon the thread, but at such a previous moment that the signal may in their estimation take effect at the instant which it is desired to record, after the lapse of an interval of volition and an interval of muscular contraction. It is readily seen that if an observer succeed in attaining this end for both equatorial and circumpolar stars, it can only be by a very accurate estimate of the apparent rate of motion of the star, and that a change of eye-piece for the same star will produce an effect analogous to a change of declination in the star observed. The true method to be aimed at, in chronographic observation, clearly is to give the signal at that instant when the star is actually seen to be bisected. Then, however large the personal difference from other observers, the personal equation becomes constant, unaffected by many extraneous influences, which cannot otherwise fail to exert a perturbing influence. Still, the attainment of this end is by no means entirely within the observer's control, but must, under any ordinary circumstances, vary with the organization and training of the individual. The strictly psychophysical part of the personal equation, is, as I have already remarked, merged with such other parts as depend upon the observer's habitude. Yet it is clear that all these portions are in general not constant, but vary to a great extent with the position of the star, and probably with other external circumstances. It is probably in this element, also, that the well-known variation takes place according to the condition of the observer.

The third element, the key used, is generally of more importance in those chronographs on which the signals are given by the closing, or making, of a circuit, than on our own, all of which are arranged for break-circuit signals, inasmuch as in the former case it is usually needful for the contact-piece to be moved through an appreciable space before the signal is given, while in the last-named arrangement the first motion of the contact-piece breaks the galvanic circuit, and records itself upon the chronograph. But if the spring, which maintains the contact when the button is not pressed, be stronger than usual, or not nicely adjusted, there is danger that an observer accustomed to the use of a more delicate key, upon which a touch suffices to produce an interruption of the circuit, may either fail to record his signals at all, or in default of this may consume an appreciable time in exerting sufficient muscular force to produce a galvanic circuit. For the sharpest observation a delicate adjustment is requisite; yet this very delicacy of touch, which requires ordinarily no muscular effort, becomes a source of inaccuracy when the habitude of observation thus acquired is applied to a coarsely-adjusted key. From this extreme case downward, every degree of gradation may exist, and this crude source of discordance between individuals may acquire great importance, under some circumstances, when the same key is employed by different observers; since the most delicate adjustment tolerable for one person, may and often does require too strong a pressure for another's observations to be at all satisfactory.

These various considerations are here presented in some detail, inasmuch as they have proved particularly important in this investigation; in which the question of personal equation has been the most embarrassing, and in which all the considerations here presented are to be carefully weighed.

It will readily be seen that the measurements of personal difference by the ordinary method, properly and successfully used in connection with the determinations of longitude by star-signals, are inapplicable, in great measure, to determinations, like the present one, by comparison of clocks. For the clock-corrections at the two stations, upon the correctness and congruity of which the resultant longitude is dependent, are determined by the combination of transits of high and low, zenithal and equatorial stars. And the personal difference of observers for the aggregate of such observations upon stars not the same, is a quantity entirely different from that which would be deduced from, and applicable to, stars of any one particular class. Indeed, when transits of stars at declinations beyond the limit proper for chronographic determinations are combined with the time-stars in the neighborhood of the zenith or equator, the two values of the personal difference are scarcely comparable. In a word, the values applicable to the method of star-signals are inapplicable to the method of clock-comparisons, and their employment may result in not the removal, but the introduction, of error. For time-determinations in general, there are two modes in which the personal equation may be measured or eliminated. One is an interchange of stations by the observers; the other is the systematic determination of time by the two observers independently, using the same instrument and clock, and a well-determined series of stars carefully reduced to the same equinoctial points. These methods give, not the personal difference strictly speaking, but the mean value of the personal differences for such stars as are habitually employed for determining time; and either of them thoroughly applied would remove all effect of personal equation from the longitude as measured by clock comparisons. The last-named method is, as is well known, exclusively employed at Greenwich, and with excellent results.

Of course neither of these methods was available for the trans-Atlantic longitude. The remoteness of the stations from each other, and their difficulty of access precluded any undertaking of the kind, except at an inadmissible outlay of time and money. It was therefore arranged that a thorough series of comparisons between all the observers should take place at the earliest possible time after their return to the United States, and the corrections to be adopted thus determined. The misapprehension by which the intended elimination of the personal equation of the observers at Newfoundland failed of accomplishment is attended by a minimum of embarrassment, since the equation between Messrs. Dean and Goodfellow has varied between very narrow limits, on the two sides of nothing, for a number of years.

It was found impracticable to make the arrangements for the series of personal comparisons, without fitting up a small building specially for the purpose, which could not be accomplished till the middle of April, on account of the snow and various delays. On the 9th of April the comparisons commenced, and were continued on every occasion that the extremely unfavorable weather permitted, until sixteen comparisons had been made between eight pairs of observers; four of the six observers comparing each with three others, and two of them each with two others. It was provided that a single comparison should depend upon not less than ten pairs of stars, ten transits over twenty-five threads being thus observed by each person, and that no person should take part in more than one comparison on the same night, lest the results be affected by his fatigue.

The results of these comparisons, together with their mean errors (stars between 25° and 50° being almost exclusively used), are as follows:—

Gould—Dean	=	$+0^{s}.427$	±	$0^{s}.034$	April 13
		+ 0.380	±	0·026	18
Gould—Mosman	=	+ 0.472	±	0.028	May 23
		+ 0.459	±	0.070	28
Gould—Chandler	=	+ 0.190		0.037	June 1
		+ 0.202		0.033	19
Dean—Goodfellow	=	— 0.013		0.023	April 9
		— 0.008		0.024	11
Dean—Mosman	=	+ 0.109	±	0.014	19
		+ 0.094		0.024	23
Boutelle—Goodfellow	=	— 0.134		0.029	19
		— 0.146		0.029	23
Boutelle—Chandler	=	— 0.147		0.028	11
Goodfellow—Chandler	=	— 0.021		0.032	13
		— 0.072	±	0.026	April 18

Farther comparisons between Messrs. Boutelle, Mosman and Chandler, were contemplated, but were prevented by duties which called two of these gentlemen away, before farther observations could be obtained. One comparison between Mr. Chandler and myself was rejected for manifest error, on a night when the stars were only visible between rapidly flying clouds.

Assigning to these several determinations their appropriate weights and equating, we arrive at the following values—

Gould—Dean = $+ 0^{s}.303$
Gould—Mosman = + 0.454
Gould—Chandler = + 0.216
Dean—Goodfellow = — 0.029
Dean—Mosman = + 0.121

Boutelle—Goodfellow = — $0^s.132$
Boutelle—Chandler = — 0.223
Goodfellow—Chandler = — 0.090

or reducing to Mr. Goodfellow, as the standard of comparison,

Goodfellow—Gould = — $0^s.304$
Goodfellow—Mosman = + 0.150
Goodfellow—Dean = + 0.029
Goodfellow—Chandler = — 0.090
Goodfellow—Boutelle = + 0.132

In considering these quantities, the attention is at once attracted by the unusual magnitude of some of them, by the excessive tardiness of my own signals as compared with those of the other five observers, and by the fact that the personal differences in ordinary time-determinations had not been comparable with those here deduced. For example, although my own observations have usually been somewhat later than those of the many others with whom I have measured personal equations on past occasions, there is no room for the hypothesis that my difference from Mr. Mosman can have reached the enormous value of nearly half a second for chronographic observations. Indeed, a very thorough study of our observations at Valencia established the fact, that it must certainly have been less than $0^s.05$ upon those occasions when observations were made by both of us during the same night.

A similar inference is deducible from a comparison of the longitude-results themselves. Thus, the time being determined by myself alone for the first series of exchanges, the resultant value for the longitude between Foilhommerum and Heart's Content is $56^s.477$; for the second series, where the clock-correction is derived from interpolation between one determination by myself alone, and one made by Mr. Mosman and myself jointly, the deduced value is 56.487; while the mean of the other three series, all which depend upon time determined by Mr. Mosman alone, gives 56.465, and one of these three gives 56.481. Since the observer at Newfoundland was the same for all five series, it is very evident that no decided personal difference existed between Mr. Mosman and myself. That it could have amounted to one-tenth part of the value deduced on the 23d and 28th of May at Cambridge, is totally out of the question.

So too with Mr. Chandler's comparisons, which indicate for him a habit of observing nearly a quarter of a second later than Mr. Mosman, although more than two-tenths of a second earlier than myself. Until he went to Calais, he had observed exclusively with the same signal-key which I have employed at Cambridge; and at Calais his key was similarly adjusted. And during a very considerable series of observations with a large transit-instrument during the last two years, in which Mr. Chandler took part, I had convinced myself that so large a difference as one tenth of a second between our observations was out of the question. Yet in the present comparisons my observations were recorded later than his, by more than two-tenths of a second.

The difference between Messrs. Chandler and Boutelle seems, from examination of the Calais record, likewise to have been by no means so large as these special observations would indicate. A series of similar observations with the large transit instrument of the Coast Survey on four nights immediately after the close of the comparisons just described—using delicately adjusted keys, to which both of us were accustomed—gave as the difference between Mr. Chandler and myself

$$\text{Gould—Chandler} = -0^s.021,$$

instead of + 0.216 as above; while the difference between Mr. Boutelle and myself, as measured in past years, has rarely attained the limit of $0^s.2$.

The comparisons between Messrs. Dean and Mosman seem to have been similarly, although not equally affected by the same cause; and I have thus been led to the conviction that but little, if any, weight ought to be assigned to these determinations of personal equation, as regards their application to the clock-errors, from which the longitude must be deduced. If farther argument were needed, it would only be necessary to apply to the series of preliminary results already deduced in Chapters VII. and VIII., the values of personal difference here obtained. The accordance, now so satisfactory, would be entirely destroyed; and the probable error of the result increased more than tenfold, for each of the two longitudes.

The difference here found between Messrs. Dean and Goodfellow is the only satisfactory one. These gentlemen have been accustomed to observe in connection with one another for ten or twelve years; and a very extensive series of measurements, both by observations specially made for the purpose, and by the comparison of longitude-results deduced from their observations before and after exchanging stations, shows that their personal difference has usually scarcely exceeded the limits of probable error, while it has varied in sign, as already stated.

A satisfactory explanation of the phenomenon is, I think, to be found in the break-circuit keys employed, of which the springs were so strong as to prompt a memorandum on each date when I observed, to the effect that my observations were embarrassed by the strong tension of the keys, which were those used at Newfoundland. Many of my observations were lost in this way at the commencement of the work, and my first night's comparisons proved futile for this reason; inasmuch as the greater proportion of my signal-taps were found not to have been recorded at all upon the chronograph, which was in another building, some twenty-five rods distant. My pressure upon the button had not been forcible enough to break the contact. Mr. Boutelle also complained of the stiffness of the observing key, and caused a note to this effect to be entered upon the journal of the observations for personal equation.

Under these embarrassing circumstances only two courses seem to be available. A repetition of the comparisons, using more delicate signal-keys, would have been highly desirable, and was earnestly hoped for; but, apart from the other serious obstacles, the assignment of the various observers to other duties, some of them at very remote stations, precluded all possibility of this solution of the difficulty. We may however totally discard all consideration of the personal equation, except the value between Dean and Goodfellow, which latter may be regarded as so small and well established as to reduce nearly to a minimum the effects of the misapprehension by which the time-determinations, at Calais, for the two steps in the longitude, were made by different persons; or, on the other hand, we may fix upon approximate values, by considering the tolerably accordant determinations made at other times, and comparing likewise the transit-observations made by different persons at the same station, during the present longitude-operations.

The latter course seems preferable, and all the more allowable, inasmuch as those values which careful, independent scrutiny has rendered the most probable are all of them small, yet most of them distinctly indicated. And I propose to adopt, as not altogether empirical, although obtained by an exercise of judgment quite as much as of computation, values for the personal equations, deduced from other sources than the special comparisons here described. It so happened that the algebraic signs of the numerical values thus employed are the same as by the special comparisons, although the magnitudes of these values are very much diminished.

I cannot but believe that an explanation is here presented of the very perplexing phenomenon, so often, and indeed so generally, encountered in the discussion of personal equations, that the values, as found from the comparison of two observers directly, differ so widely from the results obtained when a third observer is employed as an intermediate standard. Different individuals are affected, by any unusual circumstances attending their observations, in degrees differing with their nervous organizations.

Thus, in the present case, Mr. Mosman's observations were probably affected but slightly by the stiffness of the key-spring, which apparently affected those of Messrs. Boutelle and Chandler and myself to so great an extent.

The following values have been adopted, as seeming most truly to represent the personal equations between the different observers, while engaged in the regular observations of the campaign:—

Gould—Mosman = + $0^s.02$
Dean—Mosman = + 0.11
Goodfellow—Dean = + 0.02
Boutelle—Goodfellow = — 0.14
Boutelle—Chandler = — 0.04

While adopting these values, I am far from believing that they are the same for stars in different declinations, or even for stars of different magnitudes. But they do seem to represent, with some approximation to the truth, the average differences between the several observers in determining time.

XI.

FINAL RESULTS FOR LONGITUDE.

1. *Foilhommerum and Heart's Content.*

The longitude deduced from the signals of Oct. 25 depends upon time-observations at Valencia by myself, and may therefore be combined with those of the last three nights on which Mr. Mosman determined the time, by subtracting the adopted personal equation, Gould—Mosman = + $0^s.020$. But the longitude of Oct. 23 depends upon the transit-observations of Oct. 28 and 30, on the latter of which dates three of the nine stars were determined by Mr. Mosman. Applying to the observed times of these three stars the correction $+ 0^s.020$, and repeating the solution for two unknown quantities, we shall find the azimuth correction A to be changed by $+ 0^s.011$, and the clock-correction Δt by $- 0^s.009$. This increases the interpolated values for the Valencia clock-corrections during the period of the telegraphic exchanges by only $0^s.001$, making the resultant longitude larger by this amount, and the subtraction of $0^s.020$ from the result refers the whole series to the observations of Mosman at Valencia, and Dean at Newfoundland, as follows:—

1866. Oct.	25	$2^h\ 51^m\ 56^s.457$
	28	.468
Nov.	5	.455
	6	.481
	9	.460

The sum of the squares of the deviations of the several values from their mean is thus slightly reduced. An equal weight seems fairly attributable to all the determinations, excepting the first, in which there is a regular increase in the values deduced from the successive sets, which possibly indicates a variability in the clock-rate. This, together with the want of experience necessarily attendant upon the first trial, leads me to assign to it but half the weight given to the other four, and we thus attain the mean value of the longitude.

$$\lambda = 2^h\ 51^m\ 56.465$$

which, corrected for the personal equation in determining time Dean—Mosman $= + 0^s.11$, and for that of noting signals Dean—Gould $= + 0^s.03$, becomes

$$\lambda = 2^h\ 51^m\ 56.54.$$

2. *Heart's Content and Calais.*

The time-observations from which the longitude between Heart's Content and Calais is deduced were made by Mr. Boutelle for the second and third series of exchanges, and by Mr. Chandler for the first and fourth. The resultant values on the 11th and 16th December require, therefore, the subtraction of the correction, Boutelle—Chandler $= - 0^s.04$; after which the several determinations may be combined, to obtain the value which would have been found, had all the Calais observations been made by Mr. Boutelle alone.

The result of the exchanges, Dec. 12, is very far from trustworthy, as a glance at the computation of the time will show. During the three hours which were requisite for obtaining the transits of seven stars at Calais, the clock lost $1^s.28$, although it had gained $0^s.4$ during the eleven hours preceding, and gained again during the two hours following. Some serious disturbance to the clock evidently occurred about this time. The unfavorable weather prevented Mr. Boutelle from detecting it, in spite of his best endeavors; but the fact is not surprising in a clock so old, and so ill adapted for transportation. It would seem as though the fault were in the compensation; but examination has shown the teeth of the seconds-wheel to have been in bad order, so that a "jump may have occurred during the course of the observations, without detection at the time, or recognition in the transit-observations themselves." At any rate the result obtained from the exchanges of Dec. 12 seemed entitled to small reliance, before its large discordance from the other values was manifest.

Reducing all the values to Mr. Boutelle, and rejecting that of December 12 from the mean, we thus obtain:—

December 11,	$0^h\ 55^m\ 37^s.93$
12,	[37.53]
14,	37.84
16,	37.82
Mean,	0 55 37.86

which diminished by $0^s.14$ to correct for the personal equation between Messrs. Boutelle and Goodfellow, becomes—

$$\lambda = 0^h\ 55^m\ 37^s.72.$$

3. *Greenwich and Foilhommerum.*

It has been already stated that the Astronomer Royal cordially acceded to my request that he would take measures for the determination of the longitude between Greenwich and our station at Foilhommerum. This request was made with diffidence, since Mr. Airy had already determined the longitude of two other points in Valencia with all possible care,—Feagh Main, the highest point on the island, having been measured chronometrically in 1844, and Knightstown telegraphically in 1862,—so that the establishment of our station at Foilhommerum implied the determination of an additional arc in order to connect it with Greenwich, whereas we had hoped to adopt the old station of the Astronomer Royal at Knightstown, six miles to the eastward.

The arrangements for the telegraphic interchange of signals with Greenwich were made by Mr. Airy, and the reductions were executed under his direction at the Royal Observatory; our own share in the work being limited to the operations at Foilhommerum. Exchanges were attempted on ten nights between the 3d and 15th November, but were successful only on the 5th, 13th, and 14th. On the last occasion the weather precluded us from obtaining any observations for time, so that the result depends upon two nights' exchanges. These proved, however, very accordant.

The clock at each terminus was made to record itself upon the chronograph at the other for half an hour, and the construction of the chronographic and signal-giving apparatus at Greenwich required our clock-signals to be given by closing an open circuit, not by interrupting a closed one, and the Greenwich signals to be received in a similar way. To meet this need, the relay-magnet was modified, while receiving signals, by transferring the conducting-stop of the armature to the rear, so that the currents arriving at each second should interrupt the local circuit of the chronograph-magnet like our own clock-signals. And in sending our signals to Greenwich the connections of the main and local circuits with the relay-magnet thus modified were respectively reversed, so that an interruption of the local circuit by our own clock produced a closure of the main circuit, which transmitted a current to Greenwich. Thus no loss of time was entailed in receiving signals;

but, in sending them, an armature-time intervened between the actual clock-signal and its transmission to Greenwich. This was reduced to a minimum by strong tension of the spring, and two series of experiments were made to measure the amount of the delay.

For this purpose, the relay-magnet being retained in the chronograph-circuit in the same manner as during the transmission of signals to Greenwich, the two terminals of the instrument (which are in permanent connection with the armature and its conducting stop, and which, during the sending of signals, are connected with the two wires of the main line) were also brought into communication with the chronograph-circuit on the two sides of the recording magnet. The effect of this arrangement was, that when the clock-signal, which is of course recorded upon the chronograph, released the armature of the relay-magnet by interrupting the galvanic circuit, this armature on its arrival at the outer stop completed a metallic connection by which the chronograph was excluded from the circuit. This was recorded upon the chronograph, like a second interruption, which continued until the tension of the spring was overcome by the re-established current. In this manner two signals were given in each second; the first by the clock directly, the second by the relay after the lapse of the interval required for the armature to reach the outer stop. Then, if the chronograph-magnet be adjusted with all possible delicacy, the length of the record of the total interruption must be increased by the full amount of the delay in question. Series of observations were made for the investigation of this point on the 4th and 14th of November, and indicate a delay of $0^s.02$ in the communication of signals, being equivalent to a retardation of the clock by this amount in the currents sent, though not in their record; and implying a diminution both of the longitude and of the transmission time by $0^s.01$.

The longitude as deduced from the two nights' exchanges is:—

	λ	x	Number of signals. Greenwich.	 Valencia.
1866, November 5,	$0^h\ 41^m\ 33^s.305$	$0^s.115$	66	210
13,	33.280	0.110	80	70
the mean being,	0 41 33.29			

The Greenwich observations were made by different persons on different nights, but were all reduced to Mr. Dunkin in the usual manner.

The line of telegraph passed through Killarney and Mallow to Dublin, thence to Wexford, St. David's, Cardiff, London, and Greenwich. Its total length must have been very nearly 600 miles (966 kilometers), exclusive of the submarine cable between Ireland and Wales, which is about one-tenth part as long. The length of the cable across the straits of Valencia is about three-quarters of a mile.

Referring the longitude of Valencia to Feagh Main, as the fundamental point adopted for the great European Arc of Parallel, by means of geodetic reduction of the telegraphic stations, Mr. Airy finds for the longitude of this point west of Greenwich—

1. By the great chronometric expedition of 1844, the transit instrument being placed in the station of the trigonometrical survey . . . . $0^h\ 41^m\ 23^s.23$
2. By the telegraphic communication of 1862, the time instrument being placed at Knightstown,
   Greenwich to Knightstown . . $0^h\ 41^m\ 9^s.81$
   Reduction to Feagh Main . . + 13.56
   0 41 23.37
3. By this telegraphic communication in 1866, the transit-instrument being placed at Foilhommerum,
   Greenwich to Foilhommerum . . $0^h\ 41^m\ 33^s.29$
   Reduction to Feagh Main . . — 10.10
   0 41 23.19

From which he adopts
Feagh Main west of Greenwich 0 41 23.29

The variation of these measures may be accounted for in great degree by the local deviations of the direction of gravity in this hilly region, and their consequent effect upon the geodetic reductions.

4. *Final Inferences.*

The combination of the three longitudes thus determined, gives—

Greenwich—Foilhommerum,	$0^h\ 41^m\ 33^s.29$
Foilhommerum—Heart's Content,	2 51 56.54
Heart's Content—Calais,	0 55 37.72
Greenwich—Calais,	4 29 7.55

The Valencia observations having been made by, or referred to, Mr. Mosman throughout the whole period, his personal equation is eliminated; the equation between Messrs. Goodfellow and Dean, always small, may be regarded as trustworthy, and by a happy coincidence the personal equations of Mr. Boutelle on the west, and of Mr. Mosman on the east, seem to be almost identical, so that even a total disregard of this quantity would have resulted very nearly in its perfect elimination, the oceanic arc being diminished and the land arc increased, each by about $0^s.14$.

The only probable influence of personal equation in the entire longitude-measurement, comprising, as it does, three-sixteenths of the whole circumference, lies in the difference between the observations of Messrs. Dunkin and Boutelle.

The longitude of Calais, as heretofore telegraphically determined, is as follows:—

Calais—Bangor,	$0^h\ 6^m\ 0^s.31$
Bangor—Cambridge,	0 9 22.99
Cambridge—New York,	0 11 26.07
New York—Washington,	0 12 15.47
Calais—Washington,	0 39 4.84

whence we have

Greenwich—Washington, $5^h\ 8^m\ 12^s.39$

The Seaton Station being $12^s.44$, and the dome of the Capitol $10^s.17$, east of the

Naval Observatory, to the centre of the dome of which the preceding value refers, we have as their longitudes from Greenwich—

Seaton Station,	$5^h\ 7^m 59^s.97$
Capitol,	5 8 2.22

XII.

TRANSMISSION-TIME OF THE SIGNALS.

We have seen in Chapter VII how an interchange of signals gives the numerical measure of the time consumed in their transmission and registration, upon comparison of the records at the two stations. Representing the clock-time and its needful correction by T and Δt, denoting the signals from Valencia and from Newfoundland by the subjacent figures 1 and 2 respectively, and distinguishing by an accent those quantities which depend upon the Newfoundland clock, we have (since the Valencia signals preceded)—

$$x_1 + x_2 = (T_2 - T_1) - (T_2' - T_1') + (\Delta t_2 - \Delta t_1) - (\Delta t_2' - \Delta t_1')$$

or, in words: the sum of the transmission-times for westward and eastward signals, each increased by the error incurred in the process of recording, is equal to the excess of the recorded interval upon the chronograph at the station whence the first signal was given, increased by the excess in the loss of time by the clock at that station during the interval.

In our experiments the interval in question rarely amounted to so much as 160 seconds, and the clock-rates were small. The correction due to difference of rates appears never to have surpassed the thousandth of a second; and, since it is certainly a quantity of the second order in comparison with the variation in personal error, we may disregard it, and consider the quantity x_1+x_2 as the excess, in the record upon the eastern chronograph, of the interval between the westward and eastward signals. Or, otherwise stated, it is the excess, for eastward signals above westward ones, of the difference of time recorded upon the two chronographs.

Half of this excess would measure the time required for the transmission and record of a signal, assuming the velocity to be the same in each direction, could we assume the personal error in noting to be equal for the two observers. This we have in Chapter IX found not to be the case, but happily we have trustworthy values of the absolute amount of the error for each observer. Deducting the sum of the two errors from the quantity x_1+x_2, we have determinations of the actual time consumed in one westward and one eastward transmission; or, if we assume the velocity in each direction to be the same, we have the measure of twice the time required for the transmission of a signal through the length of the telegraphic cable.

The transmission-time as determined for the dates of the several longitude-determinations has been deduced in Chapter VII, subject to a correction for the mean personal error in noting signals, which correction we have in Chapter IX found to be $0^s.303$. Applying this to the results obtained, we have the following values for the mean time of transmission of signals, upon the five nights when the longitude was determined:—

1866, October	25,	$0^{s}.314$	Cable of 1865, with earth and condenser.
	28,	.343	" " " " " "
November	5,	.280	Both cables, no earth.
	6,	.248	" " " "
	9,	0.240	" " " "

The battery-strength on these nights was as follows:—

October	25,	10	cells at Valencia,	10	cells at Newfoundland.
	28,	10	" " "	10	" " "
November	5,	3	" " "	3	" " "
	6,	3	" " "	10	" " "
	9,	4	" " "	10	" " "

It was my intention that the battery employed at Newfoundland should in every case be of equal strength with that used at Valencia; but, through misapprehension on the part of the observer at Heart's Content, this was not the case on either of the last two of the five nights of our longitude-exchanges. Yet from the results just given, the inferences seem warrantable, 1st, that the velocity of transmission is greater when the circuit is direct and consists of a good metallic conductor exclusively, than when the signals are given by induction, although the earth may be at the other electrode; and 2d, that an increase of intensity in the electromotive force is attended by an increase in the velocity of propagation of the signal.

From the beginning it was part of my design to arrange and make a system of experiments for obtaining general answers, so far as might be possible, to sundry interesting questions to which previous investigations had afforded no satisfactory replies. Among these were—

1. The character of the agency which gives the telegraphic signal upon the closing or interruption of the galvanic circuit, and the route by which its transmission is effected.

2. The influence exerted upon the conductor by using the earth as part of the circuit, or by placing the complete circuit in electrical communication with the earth.

3. The extent to which the velocity of propagation of the signals is dependent upon the intensity of the electromotive force and upon the resistance of the conductor.

4. The equality or difference in speed of the signals from the positive and from the negative electrode, when the other is connected with the earth; as also the relative velocity of signals given by completing and by interrupting the circuit.

Of course it was not to be expected that satisfactory information could be obtained, or crucial experiments devised regarding all these points; but these were the guiding ideas in providing for the additional experiments, which were carried out with the friendly aid of the gentlemen of the telegraphic staff on the 1st, 10th, and 16th of November.

The length of the cable of 1865 is 1896.5 nautical or 2186 statute miles, and that of the cable of 1866 is 1851.6 nautical or 2134 statute miles. Expressed in metric units, the cable of 1865 is 3518 kilometers, and that of 1866 is 3435 kilometers long.

In each cable the conductor is formed by six copper wires twisted around a seventh one. It has a diameter of 0.147 inch or 3.7 millimeters; and weighs 300 pounds to the nautical mile, or 73.476 grams to the meter. The copper was guaranteed by the manufacturers to have a chemical purity of 85 per cent., and its specific conducting power (that of pure copper being 100) was found by test to be 93.1 for the cable of 1865, and 94.6 for that of 1866. Its specific gravity as determined by Mr. Willoughby Smith was 8.90.

The electrical tests of the cables, after they were laid and in complete working order, had been made by Mr. Latimer Clark, a short time previous. They gave the following values, expressed in terms of the standard units,[1] adopted by the British Association for the Advancement of Science, and which promise to become generally accepted, as a peculiarly convenient system of electrical measurement.

The cable of 1865 gave[2] a resistance of 4.01 ohms to the knot; the "insulation," or resistance of the coating, being 2945 megohms to the knot, and the electrostatic capacity 0.3535 farad to the knot, or about one farad to each 3¼ statute miles.

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[1] This excellent system of measures is derived from the absolute electrodynamic units of Weber, by multiplying them by such powers of 10 as shall refer them to a convenient scale.

The unit of force f is that force which, acting during 1 mean second upon a mass weighing 1 gram, would impress upon it a velocity of 1 meter in 1 second. It differs from the meter-gram, which is the force requisite for lifting a gram through a meter in a second, and is 9.80868 f.

The unit of current c is that current which acting through 1 meter, at 1 meter distance exerts the force f upon a similar current. It decomposes about 92 milligrams of water in each cell in a second, consuming about one-third of a gram of zinc.

The unit of resistance r is the resistance of the conductor which transmits the current c in 1 second.

The unit of electromotive force e is the tension which maintains the current c with the resistance r.

The unit of quantity q is that amount of electricity which flows in the current c during 1 second.

These measures, 'absolute' in so far as they depend only upon the gram, the meter, and the second, are referred to convenient scales in the British Association's system; the measures adopted being named in honor of eminent discoverers in electrical science, in accordance with a suggestion of Mr. Clark.

The measure of electromotive force is $10^5 f$, or one hundred thousand times the absolute unit.

This has about 0.927 the tension of a Daniell's cell, and is called a *volt.*

The measure of resistance is $10^7 r$, or ten million times the absolute unit.

This is about 1.0456 times the unit adopted by Siemens, and is called an *ohm.*

The measure of quantity is $10^{-8} q$, or the hundred millionth part of the absolute unit.

This is called a *farad.*

Consequently, with a tension of one volt, and a resistance of one million ohms, the quantity of electricity would be one farad in each second.

Moreover, since the volt-farad is $10^{-3} f. q$, we have 1000 volt-farads = the absolute unit of work; or 9808.08 volt-farads per second = the meter-gram.

One million of ohms is conveniently designated as a *megohm;* and one million of farads as a *megafarad.*

[2] In the manufactory, the resistances found in each knot, at the temperature 75° Fahr. were 4.27 and 4.20 ohms, for the two cables respectively; and the respective insulating capacity of the coverings, 349 and 342 millions of ohms to the knot. These data show an increase of conducting power by 6 per cent. for the cable of 1855, and 8 per cent. for that of 1866; while the insulation had been increased in the ratios of 8.44 and 7.13. Hence, we may roughly infer the average temperature of the cables to be not far from 5° Centigrade in their ocean bed.

The cable of 1866 showed for each knot a resistance of 3.89 ohms, and an insulation of 2437 megohms; the electrostatic capacity being essentially the same as in the other.

Thus we have in the cable of 1865, as the total resistance to conduction, about 7650 ohms; as the total resistance of the insulator 1 505 000 ohms; as the total electrostatic capacity about 670.4 farads. In the cable of 1866 the total resistance is about 7270 ohms; the total insulation 1 316 000 ohms; the total electrostatic capacity 654.5 farads.

The battery employed by the telegraph company was composed of what are known as Minotti's cells; these being a modified form of Daniell's, in which the zinc rests upon a column of wet saw-dust at the bottom of which is a layer of sulphate of copper, and a copper disk being at the base of all. My friend Mr. M. G. Farmer, to whom I applied for information, found by experiment the electromotive force of one of these cells to vary from 0.75 to 0.95 volt, averaging 0.84; while the average of four Daniell's cells of ordinary construction gave 0.923 volt. Hence he estimates that, after the full strength of the current is developed, one cell should give, upon one cable with earth-connection, about 110 farads in a second.

The experiments made for measuring the velocity of signals it will be well first to describe in their regular order.

On the night of November 1, the first essays were made, after the use of an electro magnet had proved hopeless; but owing to numerous difficulties incident to a first trial, only a few signals were exchanged. These were made by employing a battery of 20 cells at Valencia, having its positive electrode to the cable of 1866, while the two cables were connected at Newfoundland without battery, and the signals thence were given by alternately breaking and closing the circuit. In the first set no communication was made with earth; 18 signals from Valencia, and 7 from Newfoundland being recorded at both stations. In the second the zincode of the battery was connected with the ground as well as with the cable; and of the signals thus given, 13 from Valencia and 3 only from Newfoundland were thus recorded.

On November 10, the first two series of experiments were successfully made, as previously arranged in the programme, excepting that during the second series the Newfoundland battery remained without change, Valencia using 4 cells, and Newfoundland 20. On November 16 the last two series were carried out, with 4 cells at each station.

On the 16th, an independent series of experiments was also instituted by causing the cables to be connected without battery at Newfoundland, while signals were given and observed at Valencia, with resistances of various amounts introduced in the circuit, and with variations in the battery power.

The first question to be investigated is, whether the positive and negative signals were transmitted with the same velocity. For deciding this, no knowledge of the actual time of transmission is requisite, but a simple comparison of the records of the same signals at the two stations will afford an answer. This comparison gives us the interval $T—T'$ (the difference of the time indicated at the same moment by the two clocks) diminished by the time of transmission in the case of signals given from Valencia, and increased by this amount for signals from Newfoundland. This interval is a measure of the longitude, uncorrected for clock-errors or for transmission-time; but for our present purpose its absolute magnitude is unimportant, since our inquiry is answered by comparing the results deduced from positive and from negative signals with each other. Any excess of the time consumed in the passage of either class of signals should manifest itself by a superior value in the measures of the temporary clock-difference derived from that class, when the signals are sent westwardly. For eastward signals the reverse holds.

It had been intended, as will be seen from the original programme, to measure the velocity of signals while the batteries at both ends were included in the circuit, as well as when only one was employed; but since the construction of the signal-keys rendered this arrangement difficult, and inconvenient in many respects, the plan was not carried out. In all cases the battery at the receiving station was cut off from the circuit. Consequently all our experiments may, so far as regards the point now in question, be arranged in four classes, according to the character of the ground-connection. When, as in the last three of these classes, both cables were included in the circuit, those signals are called positive which put the copper of the Valencia battery to the cable of 1865, or the copper of the Newfoundland battery to the cable of 1866.

A. Cable of 1865, only, using condensers.

	From Positive Signals.		From Negative Signals.		No. cells.	Excess for positive.
	No.	Mean interval.	No.	Mean interval.		
Valencia signals.						
October 25, Longit.	30	$2^h\ 52^m\ 9^s.041$	28	$2^h\ 52^m\ 9^s.041$	10	$0^s.000$
28, "	29	10.107	30	10.120	10	—0.013
Newfoundland signals.						
October 25, Longit.	30	10.277	29	10.293	10	—0.016
28, "	28	11.110	27	11.096	10	+0.014

B. Both cables; middle of battery to ground.

	From Positive Signals.		From Negative Signals.		No. cells.	Excess for positive.
	No.	Mean interval.	No.	Mean interval.		
Valencia signals.						
November 10, I. 1,	8	$2^h\ 52^m\ 20^s.862$	9	$2^h\ 52^m\ 20^s.844$	4	$+0^s.018$
10, II. 1,	8	20.887	9	20.864	4	+0.023
16, IV. 1,	8	21.179	10	21.163	4	+0.016
Newfoundland signals.						
16, III. 1,	8	22.234	8	22.262	4	+0.028

C. Both cables; zincode to ground.

	From Positive Signals.		From Negative Signals.		No. cells.	Excess for positive.
	No.	Mean interval.	No.	Mean interval.		
Valencia signals.						
November 1, I. 2,	9	$2^h\ 52^m\ 14^s.119$	9	$2^h\ 52^m\ 14^s.124$	20	$—0^s.005$
10, I. 2,	9	20.692	10	20.869	4	—0.177
10, II. 2,	7	20.693	9	20.850	4	—0.157
Newfoundland signals.						
16, III. 2,	9	22.290	10	22.315	4	+0.025

D. No ground-connection whatever.

		From Positive Signals.		From Negative Signals.		No. cells.	Excess for positive.
		No.	Mean interval.	No.	Mean interval.		
Valencia signals.							
November 1,	I. 3,	9	$2^h\ 52^m\ 14^s.112$	9	$2^h\ 52^m\ 14^s.122$	20	$-0^s.010$
5,	Longit.	29	17.294	29	17.294	3	0.000
6,	"	18	17.203	16	17.214	3	—0.011
9,	"	30	20.292	28	20.290	4	+0.002
10,	I. 3,	10	20.748	10	20.790	4	—0.042
10,	II. 3,	9	20.752	10	20.821	4	—0.069
16,	IV. 3,	9	21.157	10	21.161	4	—0.004
Newfoundland signals.							
November 5,	Longit.	30	18.465	28	18.482	3	—0.017
6,	"	20	18.302	20	18.312	10	—0.010
9,	"	30	21.369	30	21 365	10	+0.004
10,	II. 1,	10	21.902	10	21.915	20	+0.013
10,	II. 2,	10	21.926	10	21.939	20	+0.014
10,	II. 3,	10	21.922	10	21.918	20	—0.004
16,	III. 3,	10	22.285	10	21.277	4	—0.008
16,	IV. 3,	9	22.287	10	21.266	4	—0.021

Our mean values have here been recorded to thousandths of a second—a degree of precision which is of course only nominal, since the accuracy attainable by the mode of observation employed would scarcely warrant any reliance even upon the second decimal for the mean of a number of observations much larger than ten. Yet, if this be borne in mind, no error can result from the employment of three decimals; while, on the other hand, this affords a reciprocal control in the figures.

It is manifest that if we disregard the signals given from Valencia while the zincode was connected with the ground on the 10th November, all the differences are of an order of magnitude which justifies the assumption, already probable from theoretical considerations, that the positive and negative signals travel with equal velocity under the same circumstances. This assumption I will therefore make, postponing any remarks concerning the discordance manifested on the 10th November.

The speed of the two kinds of signals being thus taken as the same under similar circumstances, the time required for their transmission is easily deduced, being one-half the difference between the measures of longitude as derived from the records at the respective stations. The weak point in our determination is, of course, the absence of any automatic record of signals received; but the considerations already presented in the chapter on Personal Error in Noting Signals afford ground for confidence that the uncertainty here introduced is comparatively small, and that the aggregate personal error of the two observers is very close to $0^s.606$. This value is adopted in the present investigation, and all the measurements hereinafter recorded, with which this personal error is merged, have been corrected by deducting this quantity.

Then for a circuit formed by both cables, without earth-connection, we have the following determinations of the sum of the transmission-times for eastward and westward signals, derived from the last three series of longitude-determinations, and from the second and fourth series of special experiments.

B. MIDDLE OF BATTERY TO GROUND.

1866.	Positive signals. No.	Positive signals. $x_2 + x_2$	Negative signals. No.	Negative signals. $x_1 + x_2$	Mean. $x_1 + x_2$	No. of cells. Val.	No. of cells. Newf.
II. 1. Nov. 10.	5	$0^s.396$	5	$0^s.432$	$0^s.414$	4	20
	5	0.422	5	0.458	0.440		
	10	0.409	10	0.445	0.427		
IV. 1. Nov. 16.	...	.....	5	0.524	.....	4	4
	...	.....	4	0.558	.....		
			9	0.541			

C. ZINC TO GROUND.

II. 2. Nov. 10.	4	0.553	4	0.502	0.528	4	20
	3	0.719	5	0.468	0.562		
	7	0.624	9	0.483	0.545		
IV. 2. Nov. 16.	...	.....	5	0.550	.....	4	4
	...	.....	5	0.486	....		
			10	0.518			

D. NO GROUND CONNECTION.

Longit. Nov. 5.	10	0.562	10	0.617	0.590	3	3
	10	.532	10	.578	.555		
	9	.570	9	.612	.591		
	29	0.555	29	0.602	0.579		
Longit. Nov. 6.	10	0.513	9	0.518	0.515	3	10
	8	.494	7	.458	.476		
	18	0.504	16	0.488	0.496		
Longit. Nov. 9.	10	0.464	10	0.446	0.455	4	10
	10	.472	10	.508	.490		
	10	.500	10	.489	.494		
	30	0.479	30	0.481	0.480		
II. 3. Nov. 10.	5	0.572	5	0.482	0.532	4	20
	3	.577	4	.506	.536		
	8	0.574	9	0.494	0.534		
IV. 3. Nov. 16.	4	0.554	5	0.540	0.547	4	4
	5	.494	5	.458	.476		
	9	0.524	10	0.499	0.511		

And for a single cable (that of 1865) which went to earth at one end, while at the other the electrical equilibrium was disturbed only by means of a condenser through which the battery acted inductively, so that no real charge entered or left the cable at the signal station, we have from ten cells at each station—

A. Induced current.

	Positive signals.		Negative signals.		Mean.
1866.	No.	$x_1 + x_2$	No.	$x_1 + x_2$	$x_1 + x_2$
Oct. 25.	10	$0^s.648$	8	$0^s.659$	$0^s.653$
	10	.617	10	.675	.646
	10	.594	10	.577	.584
	30	0.620	28	0.635	0.627
Oct. 28.	9	0.794	9	0.707	0.750
	9	.691	10	.667	.679
	10	.637	9	.627	.632
	28	0.705	28	0.667	0.686

Let us now consider the experiments made without any earth-connection whatever, and first those of November 5 and 16, on which occasions the battery-power at the two stations was the same. Each station sent signals with a battery of 3 Minotti's cells on the 5th, and 4 on the 16th, receiving them with its battery disconnected. The circumstances at the two stations were as nearly identical as possible, and the mean interval consumed in the transmission of the signals appears to have been $0^s.29$ on the former, and $0^s.26$ on the latter occasion.

With a battery of 3 Minotti's cells, each possessing a tension of 0.84 of a volt, and incapable of generating more than 110 farads to the second when circuit was made through earth and one cable only, the maximum permanent current would not exceed 168 farads in the joined cables, and to develop nine-tenths of this current more than 1¼ second would be needed. With 3 Daniell's cells the maximum current would not exceed 185 farads. Assuredly we cannot suppose that in the lapse of three-tenths of a second, when not more than one-seventh of this current had been developed at the farther station, this battery could have charged the two joined cables, each of which possessed an electrostatic capacity of more than 650 farads. Hence the impulse upon which the transmission of the signal depends must have been propagated along the conductor by some other means than by charging its successive parts electrically; *i. e.*, fully, and in the ordinary sense of this expression. The 30 farads, more or less, which could have been generated before the signal arrived at the distant extremity of the cables, would have been consumed in charging the first six or seven hundredths of the conductor.

During my stay in Valencia, messages were effectively and distinctly transmitted in each direction by the use of an electromotor formed by a small percussion-cap containing moistened sand, upon which rested a particle of zinc. The current here evolved could scarcely have amounted to more than six or seven farads, so that nearly two minutes would have been requisite for charging one cable; yet the transmission-time was certainly small, although it was not definitely measured.

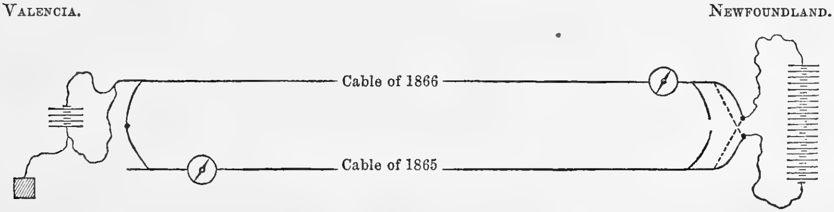
The experiments without earth-connection on November 6 and 9, differed from those of the 5th and 6th, only in that the Newfoundland battery consisted of ten cells instead of the same number as was employed at Valencia. The mean times of transmission were respectively $0^s.25$ and $0^s.24$, indicating an increase of speed with the increase of electromotive power. And, so far as the experiments on these four days are concerned, we might infer that on the complete metallic circuit formed by the two cables, the time for transmitting the signals through about 3475 kilometers, or 2160 statute miles, was not far from $0^{s}.29$ for a battery of 3 cells, $0^{s}.26$ for one of 4 cells, and $0^{s}.215$ for one of 10 cells.

On the other hand, the average transmission-time for signals sent by a current induced in a single cable, by means of a "condenser" with a battery of 10 cells, was $0^{s}.31$ on the 25th, and $0^{s}.34$ on the 28th October; the mean interval for these two days being $0^{s}.328$. Each of the condensers used possessed an electrostatic capacity of about 20 farads; so that with a tension of 10 cells, or 8.4 volts, their capacity would be not far from 168 farads, or equal to that of about 590 miles [945 kilometers] of cable—in other words, a little more than one-quarter of the capacity of one whole cable.

The value of those experiments in which the batteries were connected with the earth is seriously impaired by the series of mistakes made at Newfoundland on the 10th November. On that day 20 cells were used instead of 4, and the prescribed connection of the battery with the ground was forgotten, so that both the electromotive and the electrostatic relations became too complicated for any safe inferences as to the results. But apart from these, some other grave error appears to have been committed, by which we are apparently led to the singular result that the average time consumed in the transmission of signals was $0^{s}.31$ for the positive, and only $0^{s}.24$ for the negative signals; although the only difference between these classes consisted in an interchange of electrodes relatively to the two cables, and although the transmission-time for the two cables is shown by all our other experiments to be practically equal. The sole reason which I can discover for any difference between these two kinds of signals seems inadequate to explain the phenomenon, yet it ought not to be overlooked. It is this:—

The construction of the signal-keys was such that, in the only manner in which it was safe to use them for these experiments, the battery-circuits remained connected with the cables at the receiving station. The cables were connected with each other without the battery, and the battery was short-circuited independently of them; still, a metallic connection did exist between the telegraphic circuit which was formed by the two cables together with their transatlantic battery, on the one hand, and the temporarily disused (and also closed) local circuit, on the other. So long as there is no earth-connection in this local circuit, its effect may fairly be left out of all consideration; but whenever any such connection is introduced, the case is changed.

In the experiments of Nov. 10, the zinc of the 4-cell battery at Valencia was provided with an earth-connection, while the 20-cell battery at Newfoundland was insulated. And, since the galvanometer at each terminus was situated upon that cable to which the platinode was applied for those signals which we term positive, some difference must have existed in the action of the two classes of signals from Newfoundland upon the Valencia galvanometer. For the Newfoundland signals would exert a tension on the cable of 1866, which on reaching Valencia might act for an instant inductively upon the local circuit, before the dynamic equilibrium of the main circuit should be established by means of the opposite tension upon the other cable, and the signal thus exhibited upon the Valencia galvanometer. Obviously, when the ground-connection was made with the zinc of the Valencia battery, this disturbing action would be the greatest for those signals of which the tension would thus be for a moment partially neutralized; namely, for the positive signals.

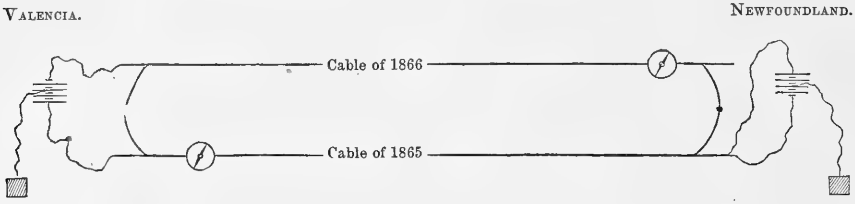


No other explanation than this has suggested itself; and though, as already stated, this scarcely appears adequate, it would yet derive some color from the absence of any analogous differences for the two classes of signals in the first experiment of the same day, in which the ground-connection was made to the middle of each battery. On the other hand, a similar though inferior difference does exhibit itself in the third experiment, where no earth-contact was made; and it seems safer to assume some additional and yet undiscovered mistake in the arrangement of the connections, and therefore to discard the observations of November 10 altogether, than to attempt to draw any inferences from them. These would contradict the experiments upon other days, when the connections were managed somewhat more effectively, although not without mistakes in the Newfoundland batteries on both the 6th and 9th of November.

On November 16th all the arrangements seem to have been correctly made, each battery consisting of 4 cells, and the earth-connections at both stations being made with the zincodes in the second experiment, and with the middle of the batteries in the third.

In the former case, all the positive signals found earth at the other extremity of their respective cables without affecting the second cable at all, and therefore without manifesting themselves upon the galvanometer at the distant station; while negative signals, which differed from the positive ones only by the interchange of the cables used for the respective electrodes, were of course received and recorded. Thus we have on this occasion only the "negative" signals; *i. e.*, those in which the platinodes went to the cable of 1866 at Valencia, and to that of 1865 at Newfoundland.

In the latter case the effect of the arrangement would be to substitute two circuits (each consisting of one cable with two cells at each extremity and earth-connections), for the one circuit, formed by a cable with four cells at the signal-giving station and with earth-connections; were it not that a very small portion of each of the two first-named circuits is common to the two, being formed by the piece of metal which unites the short-circuit of the local battery with the connected or "looped" cables. This will be readily seen from the diagram, which represents a positive signal from Valencia. Both sets of signals from Valencia were received at Newfoundland; but, contrary to my expectations, only two of the ten positive signals from Newfoundland were perceptible upon the Valencia galvanometer, and these were but weakly indicated, the needle being much agitated.



The results of the recorded signals give 0s.26 as the transmission-time through one cable with earth-return, when the ground-connection was made with the zinc, and 0s.27 when it was made with the middle of the battery; the former corresponding to the use of four cells, at one station only, and the latter to two cells at each station.

Passing next to the consideration of the velocity of signals given by closing and interrupting the circuit, which for convenience we will call "make-circuit" and "break-circuit" signals, we have some data for the investigation from the first and third series of experiments. For the first series the battery was at Valencia, and the signals from Newfoundland were necessarily given by making and breaking the circuit for the battery at the other station, or, in the language of telegraphers, sending against the current. For the third series, the inverse was the case, and the Valencia signals were sent by means of the current from Newfoundland. In both instances the signals from the battery-station were given in the usual way by the alternation of opposite currents. That such an arrangement was ill adapted for any important electrical investigation is palpable; but such few experiments as were made were of course entirely subordinate to the object of our expedition, and were, as will be seen from the programme, very roughly indicated in advance. The totally different character of the methods and appliances from those which had come within the previous experience of our longitude-parties, as well as the very different nomenclature, rendered telegraphic instructions difficult, ambiguous, and, as the event proved, often ineffective. The circumstances under which our few simple trials were made were embarrassing, in spite of the cordial interest and friendly aid of the telegraphic staffs on both sides of the ocean. The cables were in continual requisition for commercial purposes, although all facilities were accorded which I could conscientiously ask. It nevertheless appeared desirable to make such few essays at measuring the time of transmission as opportunity conveniently allowed, in the hope that something of interest might prove deducible. And it will be perceived that our own experience could not be rendered available at the time, inasmuch as all inferences must be derived from the measurement and collation of chronographic records, which could only be brought into juxtaposition by some 3000 miles of transportation.

Our data, thus obtained, for the relative velocity of the make-circuit and break-circuit signals, lead to the singular inference that the latter travelled most rapidly in the case of Newfoundland signals with the Valencia battery, while for the Valencia signals with the Newfoundland battery precisely the reverse was the case. For this I have no explanation to suggest. It has been impossible for me to shake off a suspicion that the same error in the connections on November 10, which occasioned the discordances heretofore mentioned, may have also acted to produce the discrepancies here manifested; but I will confine myself to a statement of the results, and leave any possible reconciliation of discrepancies for the future.

There are two ways in which the comparative velocity of these two sorts of signals may be examined. One is by comparing the values of the approximate longitude, as given by the make-circuits and break-circuits respectively, for which purpose all corrections for clock-error, &c. may be disregarded, since they affect both sets of signals alike. The other is by deducing the sum of the transmission-times for each kind of signals taken together with the signals sent in the opposite direction. This latter method permits the employment of a much larger number of observations, and by use of the value of the transmission-time for the positive and negative signals, as previously deduced, it allows a tolerably approximate determination of the actual time for the signals in question. The former gives only the difference between the intervals consumed by the two classes respectively, but it affords measures of this difference free from the influence of extraneous sources of error. I will state the results obtained by each of these methods.

Beginning with the first named, it will readily be perceived that an excess in the approximate longitude, as deduced from make-circuit signals indicates an inferior velocity for these, when they are sent from Newfoundland eastward, but a superior velocity when they are sent from Valencia westward. Yet such an excess is manifested in both cases, as will be seen from the appended table.

SERIES I.—SIGNALS FROM NEWFOUNDLAND; BATTERY AT VALENCIA.

Exp't.	Date.	Earth-connection.	Make-circuit signals.		Break-circuit signals.		Excess for make-circuits.	No. of cells.
			No.	Mean interval.	No.	Mean interval.		
I. 3	Nov. 1	None	2	$2^h\ 52^m\ 15^s.515$	4	$2^h\ 52^m\ 15^s.335$	$+0^s.180$	20
I. 1	10	Middle	3	22.293	4	21.997	+0.296	4
I. 2	10	Zinc	9	22.293	10	22.040	+0.253	4
I. 3	10	None	10	22.091	10	21.965	+0.126	4

SERIES III.—SIGNALS FROM VALENCIA; BATTERY AT NEWFOUNDLAND.

III. 1	Nov. 16	Middle	9	$20^s.950$	10	$20^s.798$	$—0^s.152$	4
III. 2	16	Zinc	10	21.002	10	20.880	—0.122	4
III. 3	16	None	10	21.082	10	21.030	—0.152	4

The results by the second method of inquiry may be obtained by assuming the transmission-time for signals from Valencia, November 1, to have been $0^s.214$, and that for signals from Valencia, November 10, and from Newfoundland, November 16, to have been $0^s.264$; Thus we have:—

SERIES I.—NEWFOUNDLAND SIGNALS, VALENCIA BATTERY.

Exp't.	Date.	Earth-connection.	Transmission-time. Make-circuits.	Break-circuit.	Excess for make-circuits.
I. 2	Nov. 1	Zinc	$0^{s}.65$	0^{s} 39	$+0^{s}.26$
I. 3	“ “	None	0.80	0.61	+0.19
I. 1	Nov. 10	Middle	0.54	0.22	+0.32
I. 2	“ “	Zinc	0.72	0.30	+0.42
I. 3	“ “	None	0.47	0.31	+0.16

SERIES III.—VALENCIA SIGNALS, NEWFOUNDLAND BATTERY.

Exp't.	Date.	Earth-connection.	Make-circuits.	Break-circuit.	Excess for make-circuits.
III 1	Nov. 16	Middle	$0^{s}.44$	$0^{s}.64$	$-0^{s}.20$
III. 2	“ “	Zinc	0.43	0.56	—0.13
III. 3	“ “	None	0.36	0.34	+0.02

These values are rudely confirmatory of those deduced by the first method. They show at any rate a difference in velocity for the two kinds of signals, which becomes very large when the tension at any part of the circuit is disturbed by an earth-connection. And they also indicate that a full charge or discharge of the cable is not requisite for a make-circuit or break-circuit signal.

In the experience of the Coast Survey since 1851, the break-circuit signals, which have exclusively been employed for longitude-determinations, have varied comparatively little in their velocity. This question has been investigated in every instance; and, in many cases, large changes have been made in the battery-power and in the connections, for the purpose of observing the effect upon the transmission-time. I have no access to the records of these experiments at present; but the results have in general shown, that with a well insulated line of uncoated iron wire, of the size ordinarily employed[1] (the earth itself forming half the circuit), the time required for the signals to reach their destination is not far from $0^{s}.07$ for each thousand miles, or, roughly, that their velocity is 22,000 kilometers to the second. The necessary interpolation of repeaters between Heart's Content and Calais precludes any determination of the velocity of the electrical action; but the average interval of time consumed in the passage of a signal between these two stations was $0^{s}.277$, the distance being 1090 miles, and four repeaters being interposed.

During the intervals between the signals, the electrical condition of the cable was undisturbed, and no extraneous influence prevented its return to a state of equilibrium. The signals were a quarter of a second long, as nearly as might be, and intervals of five or of ten seconds elapsed between the successive signals, each pair of "sets" having fourteen intervals of 5^{s} each, and five intervals of 10^{s}. Upon no one of the five longitude-nights was there any direct connection between the cable and the earth. The two extremities of the cable were connected with condensers on the 25th and 28th October, and all signals on those occasions were therefore given by induction only; while on the 5th, 6th, and 9th November, a complete circuit was formed by the two cables, and the battery at the receiving-station was short-circuited. On these last two nights the two cables were not con-

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[1] That called in commerce No. 9, weighing about 320 pounds to the mile, or 78.4 grams to the meter.

nected at the sending station during the intervals between the signals, but the battery was short-circuited there also. Thus the cables were always resuming their equilibrium between the signals, during each of the five nights when the exchanges for longitude were made; there being upon the first two nights only one length of cable used, but upon the last three a double length, through which the adjustment of the perturbation was to be effected.

I will give the results for these five nights in the same form in which they were first presented; viz., the mean difference between the records of the same signals upon the two registers, this being the resultant value of the longitude, uncorrected for clock-errors or for transmission-time. The 2h. 52m., which are common to all, can be here omitted, only the seconds and fractions of a second being needful for our purpose, and the signals are assorted according to the length of the interval which immediately preceded. On each date three series, of 20 signals each, were sent from each station, but not all were received. The average number upon which the several values for each day actually depend, is 16 positive and 22 negative, after the five-second intervals, and 6 positive and 5 negative, after the ten-second intervals.

UNCORRECTED VALUES OF LONGITUDE.

ASSORTED BY LENGTH OF INTERVAL PRECEDING THE SIGNAL.

Date and signal-station.		No. cells.	5^{s} interval.		10^{s} interval.		All.	
			Pos.	Neg.	Pos.	Neg.	5^{s}	10^{s}
Oct. 25.	Val.	10	9^{s}.075	9^{s}.060	9^{s}.033	8^{s} 975	9^{s}.068	0^{s}.092
	Newf.	10	10.235	10.265	10.308	10 332	10.250	10.320
Oct. 28.	Val.	10	10.406	10.388	10.376	10.445	10.397	10.401
	Newf.	10	11.678	11.677	11.710	11.742	11.373	11.723
Nov. 5.	Val.	3	17.313	17.287	17.272	17.243	17.299	17.261
	Newf.	10	18.446	18.467	18.481	18.482	18.457	18.480
Nov. 6.	Val.	4	17.214	17.220	17.224	17.185	17.217	17.211
	Newf.	10	18.285	18.298	18.335	18.372	18.292	18.350
Nov. 9.	Val.	4	20.288	20.281	20.251	20.267	20.284	20.257
	Newf.	10	21.370	21.350	21.344	21.373	21.359	21.357

Hence we may infer the sum of the transmission-times in the two directions to have been

Date.	5^{s}	10^{s}	Excess for 10^{s} interval.		
			Val.	Newf.	Mean.
Oct. 25	0^{s}.576	0^{s}.622	—0^{s}.024	+0^{s}.070	+0^{s}.046
28	0.670	0.716	—0.004	+0.050	+0.046
Nov. 5	0.552	0.613	+0.038	+0.023	+0.061
6	0.469	0.532	+0.006	+0.058	+0.064
9	0.469	0.493	+0.027	—0.003	+0.024

Taking next the results afforded by the experiments of November 10 and 16, we find the mean difference between the records of the same signal at the two stations (omitting the 2h 52m as before), to be:—

Exper't and signal station.	No. of cells.	Earth-connection.	5^s interval.		10^s interval.		All.	
			Pos.	Neg.	Pos.	Neg.	5^s	10^s
I. 1. Val.	4	Middle	20^s.874	20^s.894	20^s.840	20^s.815	20^s.886	20^s.830
I. 2. "	4	Zinc	20.698	20.876	20.680	20.840	20.800	20.744
I. 3. "	4	None	20.790	20.792	20.677	20.780	20.791	20.718
II. 1. Val.	4	Middle	20.893	20.869	20.876	20.845	20.879	20.863
Newf.	20	None	20.898	21.921	21.903	21.890	21.911	21.898
II. 2. Val.	4	Zinc	20.692	20.870	20.690	20.780	20.792	20.735
Newf.	20	None	21.918	21.940	21.937	21.935	21.931	21.936
II. 3. Val.	4	"	20.758	20.827	20.760	20.800	20.798	20.780
Newf.	20	"	21.897	21.909	21.960	21.955	21.904	21.958
III. 1. Newf.	4	Middle	22.232	22.262	22.260	- - - -	22.251	- - - -
III. 2. "	4	Zinc	22.307	22.301	22.247	22.345	22.304	22.306
III. 3. "	4	None	22.290	22.270	22.263	22.300	22.279	22.278
IV. 1. Val.	4	Middle	21.192	21.150	21.157	21.215	21.166	21.180
Newf.	4	"	- - - -	22.316	- - - -	22.285	22.316	22.285
IV. 2. Val.	4	Zinc	- - - -	21.195	- - - -	21.180	- - - -	- - - -
Newf.	4	"	- - - -	22.315	- - - -	22.300	- - - -	- - - -
IV. 3. Val.	4	None	21.188	21.164	21.133	21.150	21 174	21.140
Newf.	4	"	22.270	22.259	22.317	22.295	22.271	22.308

whence we find the sum of the transmission-times, in the two directions in the experiments when batteries are used at each station, to have been

Exper't.	5^s	10^s	Excess for 10^s interval.		
			Val.	Newf.	Sum.
II. 1	0^s.426	0^s.429	+0^s.016	—0^s.013	+0^s.003
II. 2	.533	.595	+0.057	+0.005	+0.062
II. 3	.500	.572	+0.018	+0.054	+0.072
IV. 1	.544	.499	—0.014	—0.031	—0.045
IV. 2	.544	.514	+0.015	—0.015	0.000
IV. 3	0.491	0.562	+0.034	+0.037	+0.071

The mistakes, heretofore mentioned, at Heart's Content in the number of cells and in the connections on the 10th November, put it out of our power to make any definite inferences from the first two experiments of Series II; and the number of signals after intervals of 10^s, in the first two experiments of Series IV, was so small as to forbid much reliance upon their mean. But the evidence here also indicates that a longer time was consumed in the transmission of signals after the longer interval.

Finally, the first and third series of experiments (in which a battery was employed at one station only) give the following results for the relative speed of the make-circuit and break-circuit signals, four cells being used in every instance.

Nov. 10. Signals from Newfoundland; Battery at Valencia.

Exper't.	Earth connection.	5^s interval.		10^s interval.		Excess of time for make-circuits.		
		Makes.	Breaks.	Makes.	Breaks.	5^s	10^s	Diff.
I. 1 . .	Middle	$22^s.293$	$22^s.000$	- - - -	- - - -	$+0^s$ 293	- - - -	- - - -
I. 2 . .	Zinc	22.260	22.056	$22^s.360$	$21^s.975$	+0.204	$+0^s.385$	$+0^s.181$
I. 3 . .	None	22.107	21.979	22.063	21.910	+0.128	+0.163	+0.025
Nov. 16. Signals from Valencia; Battery at Newfoundland.								
III. 1 . .	Middle	20.920	20.796	21.010	20.935	—0.124	—0.075	+0.049
III. 2 . .	Zinc	21.045	20.876	20.977	20.895	—0.169	—0.082	+0.087
III. 3 . .	None	21.067	21.030	21.120	21.030	—0.037	—0.090	+0.053

It is thus manifest that in general a longer time was required for the transmission of signals after an interval of ten seconds, than after an interval of five seconds. In those cases where no earth-connection existed, and the signals were alternately positive and negative, the cable was meanwhile assuming its electrical equilibrium, so that a positive signal was transmitted more rapidly through the conductor when it was affected with a larger amount of negative electricity, and a negative signal more rapidly through a conductor containing more positive electricity. This affords new testimony to the erroneous character of the supposition that the conductor must be charged through any portion of its length, in order to transmit a signal beyond this portion.

As showing the continued existence of currents (doubtless engaged in establishing equilibrium) during the intervals between the signals, it may be of interest to mention that on one occasion when the two cables had been joined at Heart's Content without battery, and while the Valencia battery had been temporarily disconnected, signals from Newfoundland were distinctly received. They were weak, and the deflections of the needle were scarcely one-fifth as large as usual, yet they were none the less distinct, and a complete set of signals, ten in number, at proper intervals and preceded by a "rattle," was recognized at Valencia. No other record of them was made, than the fact of their transmission by alternation of the make-circuit and break-circuit signals, although no battery had been connected with the cable for several minutes.

On the 16th of November I made a series of experiments at Valencia, for the purpose of ascertaining the effect of changes in the electromotive force upon the speed of the signals, and whether these signals could, by the interpolation of any resistance between them and the galvanometer, be made to traverse the double length of the cable before reaching the galvanometer at the same station.

The results of these experiments may be very briefly stated, after mentioning some details regarding the signal-key or commutator. The construction of this key was such, that very little time was lost in pressing down either button, the interval being as nearly as I could estimate, about one-seventieth of a second, or approximately $0^s.015$. All signals by which currents were sent were given in this way, but the break-circuit signals were given by removing the thumb from the button, which was then lifted by the tension of the spring. This tension being less than the muscular force of the thumb when the button was pressed down, a longer time was consumed in traversing the distance between the stops; and, for this, repeated measurements give $0^{s}.035$ as a near approximation to the average interval. Now since, as already related, the ordinary signals record themselves upon the chronograph when the arm carrying the button leaves one stop, but are not really given until it reaches the other, all the recorded intervals between the instants of giving and receiving make-circuit signals will be too large by about $0^{s}.015$; while for break-circuit signals the reverse obtains, and the recorded interval will be too small by about $0^{s}.035$. Consequently, in comparisons between break-circuit signals and others, a correction must be applied, varying with the temporary adjustment of the signal-key, but amounting on the average at Valencia to not far from $0^{s}.05$. The importance of this correction will be recognized on inspection of the results of the first four experiments of the following series. It has, nevertheless, not been applied to any of our results, inasmuch as during the exchanges between Valencia and Newfoundland, no measurements or estimates were made to determine this pass-time for the Newfoundland key. It must, of course, be taken into account in any attempts to draw inferences regarding the relative velocity of break-circuit signals.

The signals in these experiments were given by Mr. Mosman, and recorded by myself, using the circuit formed by the two cables without any other connections than the same key, galvanometer, and battery at Valencia, which had been employed for the other work of the expedition. Care was of course taken that the signals should be neither seen nor heard by myself, except as indicated by the deflections of the galvanometer-needle.

Exp. I. 4 cells. Circuit made and broken. Key between zincode and galvanometer.

	No.	Mean interval.
Make-circuits	11	$0^{s}.257$
Break-circuits	11	0.229

Exp. II. 4 cells. The same, with 126 ohms resistance between key and galvanometer.

Make-circuits	10	0.279
Break-circuits	9	0.227

Exp. III. 4 cells. Key and galvanometer upon opposite sides of the battery.

Make-circuits	13	0.278
Break-circuits	14	0.225

Exp. IV. 4 cells. The same, with 126 ohms resistance between key and cable.

Make-circuits	11	0.287
Break-circuits	11	0.220

Exp. V. 1 cell. Positive and negative signals.

Positive.		Negative.		Both.	
No.	Mean.	No.	Mean.	No.	Mean.
2	$0^{s}.240$	8	$0^{s}.292$	10	$0^{s}.282$

Here the moments for the positive signals were only recognized with difficulty, 8 out of 10 being lost. The battery-power was insufficient to move the needle promptly, with the existing adjustment of its damping-magnet. The difference in this respect between the two classes of signals was very marked, although they alternated at the prescribed intervals of 5 and 10 seconds.

			Positive.		Negative.		Both.	
			No.	Mean.	No.	Mean.	No.	Mean.
Exp. VI.	2 cells.	Positive and negative signals.	10	$0^s.249$	9	$0^s.242$	19	$0^s.246$
Exp. VII.	4 cells.	The same.	8	0.268	10	0.290	18	0.279
Exp. VIII.	10 cells.	The same.	10	0.270	10	0.245	20	0.258
Exp. IX.	10 cells.	Resistance of 25 ohms interposed between key and galvanometer.	10	0.254	10	0.258	20	0 256
Exp. X.	10 cells.	Resistance increased to 251 ohms.	9	0.287	10	0.289	19	0.288
Exp. XI.	10 cells.	Resistance increased to 2513 ohms.	10	0.305	9	0.286	19	0.296
Exp. XII.	10 cells.	Resistance increased to 25130 ohms.	11	0.288	10	0.299	21	0.293

From these experiments it may fairly be concluded:—

1. That there was no real difference in the interval for the make-circuit and the break-circuit signals. The mean from the first four experiments gives, after application of the corrections for pass-time of the key, an interval $0^s.261$ for the make-circuits, and $0^s.260$ for the break-circuits.

2. That the relative positions of key, galvanometer, and battery exerted no perceptible influence upon the result, when a battery of 4 cells was employed. The mean intervals from the first two, and from the second two experiments, are $0^s.258$ and $0^s.262$ respectively.

3. That no appreciable effect was produced by the interpolation of 126 ohms' resistance. The mean intervals with and without this resistance, were $0^s.258$ and $0^s.263$.

4. That no marked diminution of the interval was produced by an increase of the battery from 2 to 10 cells. The results with 1 cell, although untrustworthy, indicate a somewhat less interval. The others vary by less than their probable errors, yet the interval was certainly not greater with 2 cells than with 10.

5. From the last three experiments it would appear that the interval was slightly longer after resistances above 250 ohms had been introduced. Yet it was no longer in the 12th experiment, when the resistance between the key and the galvanometer was more than two-thirds greater than the whole resistance of the two joined cables, than in the 11th when it was only one-sixth as great as that of the two cables.

6. We have every reason for believing that in all these twelve experiments, the measures of the intervals were merely determinations of my own personal equation in noting signals, which, as has been shown in Chapter IX, had been found by special investigation to be about $0^s.275$. The variations from this value amount in but few cases to more than ± $0^s.03$, which we have seen to be the normal range.

7. These experiments are entirely confirmatory of what would have been anticipated from theory, viz., that a signal given by closing a galvanic circuit is transmitted in both directions simultaneously, and with equal velocity under similar

circumstances; so that under no ordinarily practicable circumstances could a signal from either station fail to traverse both parts of the circuit at that station before passing on to the other.

Since the investigation[1] in 1850 to which I have alluded, the progress of science has thrown light upon many points which then were subjects of doubt or of individual opinion. The condition of an open galvanic circuit is now almost universally conceded not to be essentially different from that of an interrupted conductor to an electrical machine. The velocity of a current is also known to be dependent upon its quantity, and therefore generally upon its intensity, as well as upon the resistance of the conductor. But it appears questionable whether the law is so simple as has been supposed by some, who have regarded the velocity as inversely proportional to the capacity of the conductor multiplied by its resistance, and therefore, in a homogeneous conductor, to the square of its length. For the problem, as it now presents itself, does not pertain so much to the time for transmission of a given signal, as to the time for its transmission with a certain force, depending on the sensitiveness of the receiving apparatus; since the electrical impulse or disturbance consists of a continuous series of molecular influences which propagate themselves in every possible direction according to the inverse ratio of their several resistances. And the form of the conductor, as well as other conditions, may essentially modify the time requisite for the attainment of the prescribed force at the other extremity of the line. A current may thus be temporarily established in part of an open circuit, continuing until the battery and conductors have attained an electrostatic equilibrium. The time required for attaining this equilibrium depends of course simply on the capacity and form of the conductors, and on the energy of the battery; but the first electrical impulse may reach the most remote point of the circuit before a portion nearest the battery has received its full charge. Similarly, in a closed circuit, the distant extremity of the line may well be supposed to perceive some slight electrical disturbance from a signal, before its full force is manifested at intermediate points; so that a signal might be received with a delicate galvanometer at the farther extremity, before it could be recognized upon an electromagnet at half the distance. And this, too, apart from any consideration of increasing intensity in the electromotor.

The circuit formed by the two cables might, although broken at Valencia, thus serve to establish what would practically be a momentary current at Newfoundland when the battery at that station was introduced, deflecting the galvanometer there for an instant; and the change of statical condition in the cables at Valencia would thereupon be manifest to the electroscope. But the closure of circuit at Valencia would be accompanied by instantaneous deflection of the galvanometer, with corresponding insensibility of the electroscope. Thus a signal given by closing or interrupting an insulated circuit at any point is instantaneously transmitted from that point in both directions, and at full speed; but the interval before it attains its total force at any other point, must depend upon the character of the intervening conductor.

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[1] Proc. Amer. Assoc. Adv. Sci., 1850, p. 71; Am. Jour. Sci. XI, 67, 154.

The question as to the route by which signals are transmitted, when part of the circuit is formed by the earth, is thus disposed of; and the position maintained in the memoir above cited seems entirely corroborated, although it loses its theoretical significance. Prof. Kuhn, in his learned and valuable *Handbuch der Elektricitätslehre*,[1] while doing the fullest justice to the former investigation in other respects, takes exception to the propriety of my inferences regarding this question, but careful reconsideration has failed to convince me of any flaw in the argument, such as it is, notwithstanding my distrust of any reasoning from which so eminent a physicist would dissent.

Our experiments with the cables are inadequate for any decided deductions regarding the relative velocity when the earth forms a part of the circuit, but it may be well to examine for a moment what they appear to indicate.

The transmission-time for the several signals in our exchanges of November 10 and 16 may be approximately determined by a method different from those which we have thus far employed. Since the experiments occupied but a comparatively short time on each of these days, we may suppose the clock-errors to have remained constant during each series. Then, from those experiments in which no earth-connection was made, we may deduce the constant difference of the two clock-times; and a comparison of this quantity with the difference of clock-times as deducible from any set of signals will afford a near approximation to the actual time of their transmission.

Thus we have from II. 3 and IV. 3, supposing the speed the same in each direction—

Date.	Signals.	Diff. of records.	Error of noting.	True interval.	Diff. of clocks.
November 10.	Valencia,	$2^h\ 52^m\ 20^s.790$	$+0^s.331$	$21^s.121$	$2^h\ 52^m\ 21^s.382$
	Newfoundland,	21.917	—0.275	21.642	
November 16.	Valencia,	21.184	+0.331	21.515	2 52 21.753
	Newfoundland,	22.236	—0.275	21.991	

and adopting these values of the difference of clocks, we obtain as the transmission-times—

Experiment.	Signals.	Pos. & neg.	Make-circuit.	Break-circuit.
I. 1.	Valencia,	$0^s.202$		
	Newfoundland,	- - - -	$0^s.633$	$0^s.343$
I. 2.	Valencia	0.271		
	Newfoundland,	- - - -	0.636	0.383
I. 3.	Valencia,	0.301		
	Newfoundland,	- - - -	0.434	0.308
II. 1.	Valencia,	0.181		
	Newfoundland,	0.308		
II. 2.	Valencia,	0.279		
	Newfoundland,	0.288		
II. 3.	Valencia, Newfoundland,	0.260		

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[1] Allgemeine Encyklopädie der Physik. Bd. XX, p. 494, Leipzig, 1866.

III. 1.	Valencia,	- - - -	0.472	0.624
	Newfoundland,	0.267		
III. 2.	Valencia,	- - - -	0.420	0.592
	Newfoundland,	0.284		
III. 3.	Valencia,	- - - -	0.340	0.392
	Newfoundland,	0.252		
IV. 1.	Valencia,	0.264		
	Newfoundland,	0.332		
IV. 2.	Valencia,	0.224		
	Newfoundland,	0.262		
IV. 3.	Valencia, Newfoundland,	0.238		

The experiments IV. 2 and IV. 3 differ only in that the return-circuit is formed by the earth in the former case, and by the second cable in the latter. The transmission-time appears in both instances to be $0^{s}.24$. For the Newfoundland signals in Experiments II. 2, and II. 3, the same difference exists, and the transmission-time appears to be $0^{s}.28$ in the former, and $0^{s}.26$ in the latter case. It would seem therefore that the velocity was but little, if any, affected by this great change in the character of the circuit, with a battery of 4 cells.

In the first and third series, the signals from one station were given by breaking and making circuit, but from the other in the ordinary way by alternate currents, so that the 2d and 3d experiments of each series differed from one another by the tension of the zincodes having been destroyed in the former by an earth-connection, leaving the tension to reach the cables from the platinodes only. The results give

	Val. I.	Newf. III.	Mean.
Experiment 2,	$0^{s}.271$	$0^{s}.284$	$0^{s}.278$
Experiment 3,	0.301	0.252	0.276

or an average transmission-time of $0^{s}.28$ in each case, using 4 cells.

In the first experiment of Series I and III, one half the circuit was formed by the earth, while the cables had 2 cells at each end. In the second experiment of Series IV, the earth formed one half the circuit, and the cables had 4 cells at the sending station. The results give:—

	Val.	Newf.	Mean.
I. 1, III. 1,	$0^{s}.202$	$0^{s}.267$	$0^{s}.234$
IV. 2,	0.224	0.262	0.243

The Valencia signals of Series I were made November 10; all the others were on November 16, without other difference of circumstances than those in the connections as described. No difference in the velocity appears to have been produced by the changed arrangement of the 4 cells which constituted the battery.

It is not without hesitation that I present the facts and inferences of this chapter. For I am not unaware of the careful and thorough quantitative investigations of Thomson, Jenkin, and others, and should of course shrink from publishing these relatively crude and very incomplete results, were it to be supposed that I regarded them as comparable with those obtained by those distinguished electricians. But the opportunity of adding some few facts to those heretofore established seemed worth improving, although obtained with no special apparatus, and entirely collateral and subordinate to the astronomical purposes of the expedition. And furthermore, the question has an especial interest for me, as having been among the first to demonstrate and measure nearly twenty years ago the transmission-time of the galvanic signals, which had previously been assumed to be instantaneous. The duration of our signal-currents was intended to be uniformly one-quarter of a second, but depended upon the skill and care of the observer, no automatic signal-giver having been employed. Every electrician knows how greatly the strength of the current is augmented by an increase of its duration from $0^s.2$ to $0^s.3$; yet the duration of the signals varied frequently through a larger range than this. Still the actual length of each signal is recorded upon the chronograph-register, and its average did not vary much from the prescribed duration of $0^s.25$.

It appears manifest that not an electrical charge or discharge, but simply an electrical disturbance, is requisite for transmitting a signal; that an inductive impulse, sufficient to deflect the galvanometers employed, was transmitted through one cable, having at each end a condenser with 10 cells, in somewhat less than the third of a second, five seconds after the transmission of an impulse of the opposite sort; that with a circuit formed by the two cables, a smaller electromotive force sufficed to transmit the signals with yet greater rapidity; that the signals travelled more rapidly through a cable which had not recovered its electrical equilibrium after a current of the opposite character; and that the speed of the signals is modified by the earth-connections, more readily than by changes[1] in the battery-power. And the very marked differences, found in the rates of transmission, between signals given by completing an interrupted circuit and those given by interrupting a closed circuit, may perhaps lead to investigations which will afford an explanation.

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[1] Jenkin (Phil. Trans. CLII, 982) arrived at the conclusion that the electromotive force of the battery has no appreciable effect on the velocity with which the current is transmitted. But he would doubtless consider that some qualifications to the general statement should be taken for granted.

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THE

INDIANS OF CAPE FLATTERY,

AT THE ENTRANCE TO THE STRAIT OF FUCA,
WASHINGTON TERRITORY.

BY

JAMES G. SWAN.

[ACCEPTED FOR PUBLICATION, JUNE 1868.]

COMMISSION

TO WHICH THIS PAPER HAS BEEN REFERRED.

GEORGE GIBBS.
JEFFRIES WYMAN.

JOSEPH HENRY,
Secretary S. I.

COLLINS, PRINTER,
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ADVERTISEMENT.

THE following memoir on the Makah Indians was prepared at the request of the Smithsonian Institution by Mr. James G. Swan, who, for several years, resided among them in the capacity of teacher and dispenser of medicines under the Government of the United States. Mr. Swan had previously become well acquainted with the Indian tribes of the Pacific, and had published a small work detailing his adventures among them. In 1855 he accompanied the late Maj. Gen. Stevens, then Governor of Washington Territory, while making treaties with the Makahs and other tribes, and was subsequently appointed to the position above mentioned.

For the information of those not acquainted with the relation of the United States to the Indian tribes it may be remarked that where lands occupied by them are required for settlement, or where their proximity to the whites is found inexpedient, it has been the practice to extinguish their possessory rights by treaty, paying them generally in annuities of money or goods, and setting apart a portion of land, sometimes within their original territory, in other cases at a distance, for their exclusive occupation, upon which no white settlers are allowed to intrude. These tracts are known as reservations, and are under charge of government "agents," often assisted by teachers, mechanics, &c.

In the absence of Mr. Swan, the editorial supervision of the work was committed to Mr. George Gibbs, who has added a few notes.

JOSEPH HENRY,
Secretary S. I.

SMITHSONIAN INSTITUTION,
1869.

PREFATORY NOTE.

The philological family, to which the Makahs belong, is that known on old maps as the "Wakash Nation," a name given by Captain Cook from the word of greeting used by the Indians of King George's, or Nootka Sound, where he first met them. For the purpose of classification it may be convenient to preserve the name of Nootka, which has been usually recognized, as that of the language in general, although it originally sprung from an equally trivial source. It is to be observed that there are no *nations* in our sense of the word among these Indians, but those speaking even the same dialect of a common language are often broken up into separate bands under different chiefs, and their various appellations belong only to localities. Occasionally a chief, more powerful and sagacious than the rest, will bring several of these under his control, but his power is after all limited, and dies with him.

The territory occupied by this Nootka family is not as yet clearly defined on the north. Generally speaking, it embraces, besides that of the Makahs, on the south side of the Strait of Fuca, described by Mr. Swan in the following paper, Vancouver Island, with the exception of a small part of its northeastern border, occupied by intrusive bands of the Hailtsa, and the southwestern portion extending from Sooke Harbor to above Komooks in the Gulf of Georgia, which is held by tribes of the Shehwapmukh or Sélish family. It also covers part of the adjacent continent on the Gulf of Georgia and Johnston's Straits, being thus enclosed by Sélish tribes on the south and east and by those of the Hailtsa on the north. The Kwilléyutes on the coast of Washington Territory, south of the Makahs, are a remote branch of the Sélish, and the Clallams lying east along the southern shore of Fuca Strait are another tribe of that family, closely connected with the Sooke and Songhus Indians of the southeastern end of Vancouver Island.

GEORGE GIBBS.

Washington, January, 1870.

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THE INDIANS OF CAPE FLATTERY,

AT THE

ENTRANCE TO THE STRAIT OF FUCA, WASHINGTON TERRITORY.

The tribe of Indians who inhabit the region about Cape Flattery is known among the whites and the Indians who reside further eastward, on the Straits of Fuca, as the Makah, or more properly speaking, Mak-kah, the word being strongly accented on both syllables. They are also called by the tribes on the western coast of Vancouver Island, "Klas-set," and by those tribes residing between the Columbia river and Cape Flattery, "Kwe-nĕt-sat'h." The tribal name among themselves is "Kwe-nĕt-che-chat." All these different names have the same meaning, and signify "the people who live on a point of land projecting into the sea," or, as we term it, the "Cape People." There are other tribes who reside on promontories, but the Makahs appear to be the only one who are particularly called "Cape Indians."

GEOGRAPHICAL POSITION.—At the time of making the treaty between the United States and the Makah Indians in 1855, known as the treaty of Neeah Bay, which was effected by Governor Isaac I. Stevens, of Washington Territory, who was also Superintendent of Indian Affairs, the tribe claimed as their land, all that portion of the extreme northwest part of Washington Territory lying between Flattery Rocks on the Pacific coast, fifteen miles south from Cape Flattery, and the Hoko river, about the same distance eastward from the cape on the Strait of Fuca. They also claimed Tatooche Island, which lies at the southern side of the entrance to the Strait, and separated from the main land of the cape by a channel half a mile wide.

This tract of country was ceded to the United States, except a portion of the extreme point of the cape, from Neeah Bay to the Wäatch creek on the Pacific, both points being nearly equally distant from Tatooche Island, say six miles each way. The reserved portion, as can be readily seen, by reference to the maps of the United States Coast Survey, is separated from the main body of the peninsula by a tract of swamp and meadow land, partially covered with a dense forest, and partially open marsh, extending from Neeah Bay to the Pacific, a distance of about four miles. The general appearance of this low land, and the abrupt and almost precipitous hills which border it on both sides through its entire length, show almost conclusively, that at a not very remote period, the waters of the Pacific joined those of Neeah Bay, leaving that portion of the cape which is included within the boundaries named by the treaty, an island. This hypothesis is supported by a tradition of the natives to that effect, which will be noticed in another portion of this paper. Even at the present time, the waters of Wäatch creek at very high tides, flow, by one of its branches, within a few rods of the waters of Neeah Bay. The whole of this region is of a mountainous character, and is the termination of the Olympic range, which has its highest peak far in the interior, near Hood's canal. From the snow-covered mountains in the rear of Dungeness, the range gradually becomes depressed, till at Cape Flattery it assumes the character of hills, five or six hundred feet in height. These hills are composed of conglomerate, clay-stone, tertiary sandstones, and occasional boulders of granite. Small veins of bituminous coal have been found on the cape, but as yet nothing of practical value. With but very few intervals, the whole of this portion of Washington Territory is covered with an almost impenetrable forest, which at Cape Flattery is composed of spruce and hemlock, and a dense undergrowth of crab apple, alder, elder, gualtheria, raspberry, wild currant, and rose bushes. The only land belonging to the Makahs, suitable for cultivation, is at Tsuess, where an open prairie of sandy loam affords material for farming; another open spot is on a hill at Flattery rocks, where the Indians cultivate some potatoes; and several acres at Neeah Bay have been cleared from the forest at great expense and labor, for the use of the Reservation officers and employés, who are stationed at that point. The Wäatch marsh is fit for a stock range only during the summer, and its best portions could not be cultivated save by extensively draining the land, and preparing it for the plough. The soil at Neeah Bay consists of a stiff clay loam and ridges of rich black earth, formed by the decomposition of the animal and vegetable matter thrown out by the Indians, and accumulated for centuries. The humidity of the climate is extreme, consequently the cereals do not ripen, nor has it been found possible to cure hay. Very excellent potatoes, however, are raised, and the soil and climate are well adapted to the growth, in perfection, of root vegetables of various kinds. The animals most common are elk, deer, black bears, wolves, beaver, otter, raccoons, skunks, minks, squirrels, etc. But these are found in limited numbers, although they abound in the interior. They are not much sought after by the Indians, who devote their attention more particularly to marine animals, such as fur and hair seal, porpoises, whales, and fish of various kinds, which are plentiful and form the principal part of their food.

CENSUS OF THE TRIBE.—During the month of October, 1861, I took a census of the Makah tribe, under the direction of the United States Indian Agent. This service was performed by visiting every lodge in the different villages, at a time when the whole tribe were in winter quarters. The villages at that time were Bäada and Neeah, at Neeah Bay; and Wäatch, Tsuess and Hosett, on the Pacific coast. There were six hundred and fifty-four souls, all told; viz., men, 205; women, 224; boys, 93; girls, 93; infants, 39. Again, in October, 1863, I took another census of the tribe for the Indian Department. The village of Bäada had then been removed within the limits of the Reserve, and joined with Neeah village. This census showed a table of 202 men, 232 women, 111 boys, 95 girls, and 23 infants, a total of six hundred and sixty-three. It appears from the above, that from 1861 to 1863, there had been but little change in the whole number, the births and deaths being nearly equal. While other tribes have been decreasing since 1852 (at which time the smallpox swept off a large number of them), this one seems to have been spared. The fact may be accounted for, in great measure, by their distance from the white settlements, and the small quantity of alcoholic poison which finds its way among them. But morally they are not at all in advance of their neighbors, and if the means of procuring whiskey were as readily at hand, they would soon become as degraded, and their numbers be as rapidly reduced, as the Chinook, Chihalis, Cowlitz, Clallam, Chemakum and other tribes of Washington Territory.

PHYSICAL CONSTITUTION.—The Makahs are of medium stature, averaging about five feet four inches; a few men of the tribe may be found who measure six feet, but only three or four of that height were noticed. Their limbs are commonly well proportioned, with a good development of muscle. Some are symmetrically formed, and of unusual strength. Although to a superficial observer they present much similarity of appearance, yet a further acquaintance, and closer examination, show that there is in reality a marked diversity. Some have black hair; very dark brown eyes, almost black; high cheek-bones, and dark copper-colored skin; others have reddish hair, and a few, particularly among the children, light flaxen locks, light brown eyes, and fair skin, many of them almost white—a fact perhaps attributable to an admixture of white blood of Spanish and Russian stock.[1]

The custom of flattening the forehead, as observed among the Chinook, Chihalis, and other tribes south of Cape Flattery, does not appear to be in general use among the Makahs. This practice is not common among the Clyoquot and Nootkans (Tokwaht) to the north, and as the Makahs have intermarried with the tribes both north and south, we find it confined principally to those families who are related to the Kwinaiults, Chihalis, and Clallams. It is not uncommon to see children, belonging to the same parents, some of whom have their heads as nature made them, while others are deformed by compressing them in infancy. I am not prepared to state positively what mental effect is produced by this compression of the skull, but from my own experience among the children there seems to be but little difference in their capacity for acquiring information, or in their desire for instruction; the most proficient, however, appear to be those with naturally formed heads. It would require an extended and close observation for a series of years, marking the growth of these children to mature age, and noting the various peculiarities of a number selected for the purpose, before any reliable results could be had on which to found a correct judgment.

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[1] In Holmberg's Work will be found an account of the wreck of a Russian ship, the survivors of whose crew lived several years among the Makahs. As late as 1854, I saw their descendants, who bore in their features unmistakable evidence of their origin. (G. G.)

These Indians are not remarkable for the special perfection of any of their organs, as that of sight, or hearing, or smelling; or for any corporeal faculties, as speed in running, agility in climbing, or of diving and remaining long under water. I have seen them occasionally run foot-races on the beach, climb poles set up for the purpose, and swim and dive in the bay, but they do not excel in any of these athletic exercises. They do excel, however, in the management of canoes, and are more venturesome, hardy, and ardent in their pursuit of whales, and in going long distances from the land for fish, than any of the neighboring tribes. They are, in fact, to the Indian population what the inhabitants of Nantucket are to the people of the Atlantic coast, being the most expert and successful in the whale fishery of all the coast tribes.

They do not appear to be a very long-lived people. At the present time (1864) there is but one old man who was alive at the time the Spaniards attempted to make a settlement at Neeah Bay in 1792. He could remember the circumstance well a few years since, but is now in his dotage. He was then a small boy, and if we assume that he was but five years old, it would make him now seventy-seven years of age. I have inquired of a number of men whose appearance indicated advanced age, and with the exception above named, have found no one who personally recollected the visit of the Spaniards, although all remembered hearing their fathers mention it. Threescore years may be safely set down as the limit of life among those who escape the casualties incident to their savage condition; and, I think, from my observations among them, that an Indian at sixty years is as old as a white man at eighty. The average longevity is of course far below this standard, but I have no data that would warrant a positive statement of what that actually is; it could only be ascertained by an accurate record of births and deaths during a series of years.

DWELLINGS.—The houses of the Makahs are built of boards and planks, split from the cedar. These are principally made by the Indians of Vancouver Island, and procured by barter with them. There is very little cedar about Cape Flattery, and such as is found is small and of inferior quality. Drift logs, however, are frequently thrown on the shores by the high tides of winter, and whenever any such are saved they are either split into boards or made into canoes. The process of making the boards is very primitive. A number of long narrow wedges are cut from the yew, which is selected for its hardness; little rings of withes, made like a sail-maker's "grummet," are fastened on the head of the wedge to keep it from splitting under the blows of the stone hammer. These hammers are shaped like a pestle, and made from the hardest stone that can be found. They are very neatly formed, but the process is tedious and laborious. A description will be found under *Arts and Manufactures.* The Indian first strips the bark from the log, and cuts off the end as squarely as he can; he next cuts transversely through the top of the log, as far from the end as the required length of the plank, and as deep as the required thickness. A horizontal cut is then made across the end of the log with the axe, and into this are inserted the wedges, about three inches apart. These are struck successively with the stone hammer till the split is effected; more wedges are then inserted in the longitudinal split on each side of the board, and all being regularly driven in, the board comes off very straight. The first piece being rounded on the top, is a mere slab. The process is repeated until the log is entirely split up. The widest and best boards are from the centre, and are highly prized. I have measured some of them which were over five feet in width. The choicest are reserved for use in the interior of the lodge, or to paint their rude devices upon.

When a sufficient number of boards is procured, they next proceed to the erection of the house. The roofs of all these houses are nearly flat, the least possible inclination being given them that will allow the water to pass off freely. They are intended to accommodate several families, and are of various dimensions; some of them being sixty feet long by thirty wide, and from ten to fifteen feet high. To support the weight of these flat roofs it is necessary to have large timbers. These are usually hewn down evenly, and are set up, either parallel with the length of the house (in which case only one great timber extends along it), or else across the width, when three or four are used. A space of the required size having been cleared of stones and rubbish, and properly levelled, stout posts, notched on the top, are securely inserted perpendicularly into the ground. The friends and neighbors join to assist. Then all unite at one end of the beam and raise it as high as they can at one lift, when it is blocked up. Stout poles, with their ends lashed together crosswise, are now inserted under the beam, and while some hoist it, others are lifting at the poles, till finally, after excessive labor and waste of strength, the end of the timber is raised and placed on the top of the notched post; the other end of the beam is then raised, supporting posts are placed under the centre, and the first portion of the building is finished. Whenever one of these large beams is to be lifted, or when any work requiring the united exertions of several is to be done, it is usual for some one, generally an old man, to give the word. He may be seen at such times seated a little distance off, with a stick in his hand, with which to strike a blow on a board as a signal. When all is ready, he calls out "*Shaugh shogh*," which they all repeat, and at the word "*Shogh*" he gives a blow with his stick and all lift together. The expression is equivalent to "Now then, hoist!" or if to move a canoe, "Now then, haul!"

Other posts are next set in the ground, which serve to form the frame for the sides and ends. Smaller timbers are fixed on these posts parallel with the large one, then poles are placed at right angles across the whole, and on these are lastly laid the roof boards, which are made slightly concave on one side and convex on the other, and are set alternately, overlapping like tiles. The sides and ends are now to be built up with boards. First, double rows of poles are set up perpendicularly all around the house, at distances of four or five feet from each other, the rows themselves being about four inches apart. A board is then placed between these rows of poles, with one of its edges resting on the ground. Withes made from twisted cedar twigs are passed round the poles, and on these withes another board is laid, with its lower edge overlapping the one beneath; this process is repeated till the sides and ends are complete. Moss and dry sea-weed are then stuffed into all the seams, and the house is considered habitable.

The bed places are next to the walls of the house, and raised about eighteen inches from the ground; on them are laid Clallam mats, which, being made of bulrushes and flags, are better adapted for sleeping upon than the cedar bark mats of their own manufacture. These mats are rolled up at one end of the bed so as to form a pillow, and on them the Indian lies down, with generally no other covering than the blanket he has worn through the day. Sometimes a thickness of eight or ten mats is used, but commonly from three to five. They make a very healthy and easy couch by themselves, but some of the more luxurious add a sack full of feathers. These bed places are arranged all around the sides and ends of the lodges, and are separated from each other by the boxes containing the family wealth, consisting of blankets, beads, and clothing, which are piled up at the head and feet. Directly in front of them is a lower platform, usually three inches from the ground. On this, other mats are laid, and here the family and visitors sit and eat or talk as the case may be. The fire is in front of it, and a chain depending from a beam overhead, serves to hang the pots or kettles on, while cooking. Over the beds are stowed the provisions belonging to the family, packed away in baskets, while above the fire are hung such fish or other food as they may be desirous of drying in the smoke.

The dwellings of the Makahs are not removed except for some emergency. They are collected in villages, each containing from eight to fifteen houses. The principal one is situated at Neeah, to which locality that formerly at Bäada, on the eastern point of the bay, has been removed, and the two thus combined comprise fifteen dwellings and two hundred and forty-one inhabitants. The other villages are Wäatch, on the Pacific coast, at the mouth of Wäatch creek, four miles from Neeah, consisting of nine dwellings and one hundred and twenty-six residents; Tsuess, four miles south from Wäatch, containing eight houses and ninety-nine residents, and Hosett, at Flattery Rocks, consisting of fifteen houses and one hundred and eighty-eight persons. The above constitute the winter residences of the tribe. Early in the spring they remove to their summer quarters, which are the villages of Kiddekubbut, three miles from Neeah; Tatooche Island, and Ahchawat, between Tatooche Island and Wäatch. At these three spots are houses, similar to those in the other villages, which are left standing when the tribe goes into winter quarters. Occasionally, when an Indian has not sufficient boards for both, he will remove the roof-boards to whichever house he is occupying. To do so, they place two canoes abreast and lay the boards across the top. Each house is generally owned by one individual, and the families who occupy it with him are his relatives or friends, who are accommodated free of rent. They usually, however, make presents of food, or render assistance in various ways when required; but they are not obliged to do either unless they wish. The houses are all placed fronting the beach, and usually have but one door. Some, however, have a small opening in the rear, through which wood and water are brought in. They have no buildings set apart for public purposes, but when an unusually large gathering takes place, they proceed to the largest lodge, which is always thrown open for the accommodation of the tribe.

The reason why the roofs of the houses are so different from those of the Chihalis and Chinooks, at the Columbia river, is that they are used to dry fish upon. Now, the Chinooks and Chihalis, as well as all the tribes on the sound and coast, store great quantities of fish for their winter's use; but the fish they dry are salmon, which require to be cured in the smoke and protected from the sun and rain. Consequently, the tribes above mentioned use pitched roofs, or roofs much more elevated than those of the Makahs. But the staple of the Makahs is halibut, which, to be properly cured, is cut into thin slices and dried, if possible, in the open air without smoke; the best portions being those that have kept white and free from any color. As the climate is very humid, it is rare that a season is propitious for the curing their fish; so they have their roofs as flat as possible, and during fair weather, in the fishing season, not only are these covered with the slices of fish, but quantities are hung on horizontal poles fastened across the ends of the uprights that form the side fastenings to the houses. The appearance of one of the lodges on a fine day in summer when plenty of fish are drying is that of a laundry with clothes out bleaching. When the weather threatens to be rainy, the occupants proceed to the roof, and by removing several boards, they can stow away their provender in a very few minutes, and again replace it in the open air on the return of fair weather.

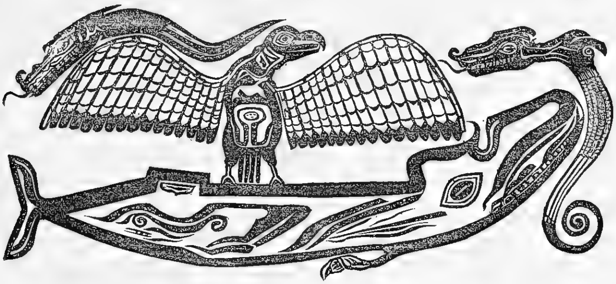
The interior of a lodge often presents a curious domestic scene. In one corner may be seen a mother rocking her child to sleep, securely lashed in its cradle, which is suspended by strings to the top of a pliant pole, that moves with every motion of her hand. If the mother is engaged in making baskets or mats, she transfers the string from her hand to her great toe, and moving her foot, produces the required motion, not unlike that of a modern baby jumper. In the centre a chain hangs from the roof, supporting over the fire the kettle in which is the food for her husband, while a boy, having cooked his own meal, is taking it alone. In another part of the house, separated from this apartment by a board set up on edge to serve as a partition, is another family, the father holding an infant in his arms, while another child is playing with kittens; the child's mother seated on the bed, wrapped in her blanket, and a group of friends in the centre cooking their supper.

Picture Writing.—In almost every lodge may be seen large boards or planks of cedar carefully smoothed and painted with rude designs of various kinds. With one exception, however, I have found nothing of a legendary or historic character, their drawings being mostly representations of the private totem or tamanous of individuals, and consisting of devices rarely understood by their owners and never by any one else. The exception referred to is a representation of the thunder-bird (T'hlu-klūts), the whale (chet-up-ūk), and the fabulous animal supposed by the natives to cause lightning (Ha-hék-to-ak). This painting is on a large board in the lodge of one of the chiefs of Neeah Bay, and was executed by a Clyoquot Indian named "Chá-tik," a word signifying painter or artist. A painting is termed Cha-tái-ūks, and writing Chá-tātl.

The coast Indians, as well as those I have conversed with, living on Puget Sound, believe that thunder is caused by an immense bird whose size darkens the heavens, and the rushing of whose wings produces peals of thunder. The Makahs, however, have a superstition which invests the thunder-bird with a twofold character. This mythological being is supposed by them to be a gigantic Indian, named, in the various dialects of the coast tribes, Ka-kaitch, T'hlu-klūts, and Tu-tūtsh, the latter being the Nootkan name. This giant lives on the highest mountains, and his food consists of whales. When he is in want of food, he puts on a garment consisting of a bird's head, a pair of immense wings, and a feather covering for his body; around his waist he ties the Ha-hēk-to-ak, or lightning fish, which bears some faint resemblance to the sea horse (*hippocampus*). This animal has a head as sharp as a knife, and a red tongue which makes the fire. The T'hlu-klūts having arrayed himself, spreads his wings and sails over the ocean till he sees a whale. This he kills by darting the Ha-hék-to-ak down into its body, which he then seizes in his powerful claws and carries away into the mountains to eat at his leisure. Sometimes the Ha-hék-to-ak strikes a tree with his sharp head, splitting and tearing it in pieces, or again, but very rarely, strikes a man and kills him. Whenever lightning strikes the land or a tree, the Indians hunt very diligently with the hope of finding some portion of the Ha-hék-to-ak, for the possession of any part of this marvellous animal endows its owner with great powers, and even a piece of its bone, which is supposed by the Indians to be bright red, will make a man expert in killing whales, or excel in any kind of work. Those Indians, however, who pretend to possess these fabulous relics carefully conceal them from sight, for they are considered as great "medicines," and not to be seen except by the possessor. A tale was related to me, and religiously believed by them, respecting the possession of a quill of the thunder bird by a Kwinaiult Indian, now living, named Neshwāts. He was hunting on a mountain near Kwinaiult, and saw a thunder bird light on a rock. Creeping up softly, he succeeded in securing a buckskin thong to one of its wing feathers, fastening the other end at the same time to a stump. When the T'hlu-klūts flew off, the feather was drawn from the wing and kept by the Indian. The length of this enormous feather is forty fathoms. Neshwāts is very careful that no person shall see this rare specimen, but his tale is believed, particularly as he is very expert in killing sea otter, which abound on that part of the coast.

I saw an instance of their credulity on an occasion of a display of fireworks at Port Townsend a few summers since. A number of the rockets on bursting displayed fiery serpents. The Indians believed they were Ha-hék-to-ak, and for a long time made application to the gentlemen who gave the display, for pieces of the animal, for which they offered fabulous prices. So firm is their belief in this imaginary animal, that one chief assured me if I could procure him a backbone he would give two hundred dollars for it. One of the principal residences of the T'hlu-klūts is on a mountain back of Clyoquot, on Vancouver Island. There is a lake situated in the vicinity, and around its borders the Indians say are quantities of old bones of whales. These, they think, were carried there by the T'hlu-klūts, but they are very old, and it must have been many years ago. I have not seen these bones, but have heard of them from various Indians who allege that they have seen them. If they really do exist as stated, they are undoubtedly the fossil remains that have been deposited there at a time when that portion of the continent was submerged, and respecting which there is a tradition still among them. The painting above described, although done by an Indian, does not fully represent the idea of the Makahs respecting the T'hlu-klūts. But, having by me a copy of Kitto's Cyclopædia of Biblical Literature, I showed some of the chiefs the cut of the Babylonian cherubim, which came very near their idea of its real form. It was perfect, they said, with the exception of not having the Ha-hék-to-ak around its waist, and of having feet instead of bird's claws, which they think are necessary to grasp whales. But when I informed them that there were no whales in Babylon, they were fully persuaded that the identity was the same, claws being given to the T'hlu-klūts who live near water, and feet to those living in the interior. Of their religious belief in this thunder-bird, I shall make further mention in their ta-ma-na-was ceremonies. In the design the T'hlu-klūts is represented as holding a whale in its talons, and the accompanying figures are the Ha-hék-to-ak. These animals the bird is supposed to collect from the ocean, and keep concealed in its feathers.

Fig. 1.



Thunder-bird of the Makahs.

Among the most remarkable specimens of their painting which I have seen, was a design on the conical hats worn during rain, and another on a board in a chief's lodge, afterwards placed at the base of a monument erected over his body. The circular design for the hat was said to represent a pair of eyes, a nose, and mouth. The other was a rude one, in which eyes are very conspicuous. The form of these designs is a distinctive feature in Indian painting, but I never could learn that they attached any more meaning to them than we do to the designs on a shawl border, or the combinations of a calico pattern artist.[1]

I have painted various devices for these Indians, and have decorated their ta-ma-na-was masks; and in every instance I was simply required to paint something the Indians had never seen before. One Indian selected from a pictorial newspaper a cut of a Chinese dragon, and another chose a double-headed eagle, from a picture of an Austrian coat-of-arms. Both these I grouped with drawings of crabs, faces of men, and various devices, endeavoring to make the whole look like Indian work; and I was very successful in giving the most entire satisfaction, so much so that they bestowed upon me the name of Chā-tic, intimating that I was as great an

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[1] The constant recurrence of certain conventional figures in the ornamentation of all the tribes from Cape Flattery to Sitka would seem to indicate a symbolical meaning, now lost. Examples may be found in the Clyoquot paddle; in the trencher and dish; and two of the masks, *post.* (G. G.)

artist as the Chā-tic of Clyoquot. In the masks I painted, I simply endeavored to form as hideous a mixture of colors as I could conceive, and in this I again gave satisfaction.

I have noticed in Indian paintings executed by the northern tribes, particularly the Chimsyan, Haida, and others north of Vancouver Island, a very great resemblance in style to that adopted by the coast Indians. Whether or not these tribes have any legend connected with their pictures I have no means of ascertaining. There are, however, but very few persons among the coast Indians who are recognized as painters, and those that I have met with, either could not or would not give me any explanation. My object in painting for them was to find out if they really had any historical or mythological ideas which they wished to have represented, and I have invariably inquired on every occasion; but I never could get any other information than that they wished me to paint something the other Indians could not understand. I am satisfied, so far as this tribe is concerned, that, with the exception of the thunder-bird drawing, all their pictures and drawings are nothing more than fancy work, or an attempt to copy some of the designs of the more northern tribes; and as they have always evinced a readiness to explain to me whatever had significance, I have no alternative but to believe them when they say that they attach no particular meaning to their paintings.

Social Life.—The Makahs, in common with all the coast tribes, hold slaves. These were formerly procured by making captives of the children or adults of any other tribes with whom they might be at variance. But latterly, since the advent of the whites, they have obtained their slaves mostly by purchase from their neighbors on Vancouver Island, or those further up the Strait of Fuca. Children seem in all cases to be preferred, because they are cheaper, and are less likely to escape than adults. The price varies, according to age, from fifty to one hundred blankets. These slaves are for the most part well treated, and, but for the fact that they can be bought and sold, appear to be on terms of equality with their owners, although there are instances where they have received rather harsh usage. In case one is killed by his master, which occasionally happens, no notice is taken of the occurrence by the rest of the tribe. Many of the men who were born of slave parents, and have resided all their lives with the tribe, have purchased their freedom; while others, who were bought, when children, from other tribes, have regained their liberty as soon as they have grown up, by making their escape. In fact the only slaves who are sure to remain are those who are born in the tribe; all others will run away whenever a safe opportunity presents to enable them to get back to their relatives. In former times, it is said, the slaves were treated very harshly, and their lives were of no more value than those of dogs. On the death of a chief, his favorite slaves were killed and buried with him, but latterly, this custom seems to have been abandoned, and their present condition is a mild kind of servitude. The treaty between the United States and the Makahs makes it obligatory on this tribe to free their slaves, and although this provision has not thus far been enforced, it has had the effect of securing to the latter better treatment than they formerly had. Instances are not rare where a master has married his slave woman, and a mistress has taken her slave man as her husband. The children of such connections are considered half slave, and although some of the more intelligent have acquired wealth and influence among the tribe, yet the fact that the father or mother was a slave is considered as a stigma, which is not removed for several generations. Their status, as compared with the African slavery of the Southern States, is rather that of bond servants; they are the hewers of wood and drawers of water. They appear to have no task-work assigned them, but pursue the same avocations as their owners; the men assisting in the fisheries, and the women in manufacturing mats and baskets, and other indoor work, or in preparing and curing fish. Formerly, it was considered degrading for a chief, or the owner of slaves, to perform any labor except hunting, fishing, or killing whales; proficiency in any of these exercises was a consideration that enabled the most expert to aspire to the honor of being a chief or head man; but since the tribe has been under the charge of an agent of the Government, and it is seen that no distinction is made between bond or free, but that both are treated alike, the old prejudice against labor is wearing away, and men and women, with the exception of a few among the old chiefs, are willing to engage side by side in such work as requires to be done for the agency. And it is to be hoped that, in a few years, under the judicious plan of the treaty, slavery will be gradually abolished, or exist only in a still milder form. The division of labor between husband and wife, or between the males and females, is, that the men do all the hunting and fishing, and cut the firewood. The women dress and cure the fish or game, bring wood and water, and carry all burdens of whatever nature that require transportation. They also attend to the household duties of preparing and cooking food; but the men wash and mend their own clothes, and in many instances make them. This custom is not confined to the slaves, but is practised by all. The women also provide a portion of the food, such as berries and various edible roots, and, to a limited extent, cultivate potatoes. The fact that they assist in procuring food, appears to secure for them better treatment by the men, than is usual among the buffalo-hunting tribes east of the Rocky Mountains. The husband, however, claims the privilege of correcting the wife, and some of them receive very severe beatings; but, on the other hand, they have the privilege of leaving their husbands, which they do for a slight cause. The marriage tie is but a slender bond, which is easily sundered, although it requires much negotiation when first contracted. Among the common people it is simply a purchase, payment being made in blankets, canoes, and guns, or such other commodities as may be agreed upon; but where the girl is the daughter or relative of a chief, a variety of ceremonies takes place. One of these, which I have witnessed, displayed a canoe borne on the shoulders of eight men, and containing three persons, one in the bow of the craft in the act of throwing a whaling harpoon at the door of a lodge; one in the centre about to cast a seal-skin buoy, which was attached to the harpoon; and one in the stern with a paddle as if steering. The ceremonies in this instance represented the manner of taking a whale.

The procession formed on the beach a short distance from the lodge, and in front of it an Indian, dressed in a blanket which concealed his head, crept on all fours, occasionally raising his body to imitate a whale when blowing. At intervals the Indian in the canoe would throw the harpoon as if to strike, taking studious care, however, not to hit him; then the same evolutions were performed as is customary in the whale fishery. A party of friends followed the canoe, who sang to the accompaniment of drums and rattles. The burthen of their song was, that they had come to purchase a wife for one of their number, and recounted his merits and the number of blankets he would pay. When they reached the lodge the representative of the whale moved to one side, while the man in the canoe threw his harpoon with such force as to split the door, which was a single plank, in halves. The door, however, was kept barred, and the party, after piling a great number of blankets and a couple of guns against it, rested awhile, hoping to be admitted. After another chant, and the adding of a few more blankets to the heap, another harpoon was thrown against the door; but to no purpose, the damsel was obdurate, and the price not sufficient to satisfy her parents. This operation may be said to be symbolical of Cupid's dart on a large scale. The party effected nothing, and returned home. A few weeks later another lover, who was acceptable to the girl, came from Nittinat on Vancouver Island, with a great number of friends in five large canoes. These approached the shore, side by side, very slowly, the Indians in them standing up, singing and brandishing their paddles; they stopped just outside the surf, and one of the men delivered a speech, stating what they had come for and what they would pay. Then they all landed, and, having hauled their canoes on the beach, formed a blanket procession. First came a ta-má-na-was or medicine man, dressed up with a gaudy display of finery, with his face painted red, and a bunch of eagle's feathers in his hair, a large wooden rattle in one hand and a bunch of scallop shells in the other, with which he kept time to a song. Next him was a man with a blanket over one shoulder, and holding one corner of another blanket, which was stretched out by an Indian who walked behind him holding the other corner, and also the corner of a third blanket, which was in like manner held by a third Indian behind. In this manner eighty-four blankets were brought by the procession, single file, and deposited one after the other at the door of the lodge, which in this instance was open, showing that the suitor was favorably received; but the eighty-four blankets were not enough, so the procession returned to the canoes and brought eighty-four more blankets in the same manner. These were all piled up outside the lodge; but the parents were in no haste, their daughter was too valuable, and the lover must wait. This he did for a week with all his friends. Every day a speech was made, and every night songs and dances were performed. At length the parents yielded, and the maiden was carried off in triumph, very much to her own satisfaction as well as that of her lover. The blankets, guns, and other articles used in the purchase, are not usually retained by the parents or relatives of the bride, but are returned to the bridegroom, who takes them home with his new wife and distributes them to the friends of both. In short, what is said to be paid for a wife, is simply the amount which the bridegroom will give away to the assembled friends.

A girl is considered marriageable as soon as she arrives at puberty. On the appearance of the menstrual discharge she is immediately secluded, by being placed behind a screen of mats or boards in a corner of the lodge. A number of little girls are in attendance day and night for a week or ten days, who keep up a constant singing. They relieve each other as they get tired; but the girl is never left alone, nor do the songs cease except at slight intervals. At the expiration of this first period, the girl is taken out to be washed. The little girls form a procession, at the head of which she walks, with her face concealed in her blanket, the children singing as loud as they can scream. Arrived at the brook she is required to sit naked in the cold water half an hour, and is then taken back to the lodge. She is bathed in this manner three times a day for a fortnight, and her hair tied up in two bunches, one on each side of her head, which are wound round with cloth, strips of leather, beads, brass buttons, and other trinkets. The only dress worn is a cincture of fringed bark about the waist, reaching to the knee, and a blanket. At the expiration of a month the ordinary dress is resumed, and a head-dress of the shells of the dentalium put on. This is the distinctive mark of all young girls until they are married. After this first period they are not compelled to live apart on the monthly return, nor are they required to be secluded after giving birth to a child. Love matches are frequently made, and whenever the parents are opposed the young couple will hide themselves in the woods for a day or two, and on their return the matter is amicably arranged.

Marriages usually take place at an early period. The men take for wives either the women of their own or the neighboring tribes; but they are prohibited from marrying any of their own connections, unless the consanguinity is very remote. I do not know of an instance nearer than a fourth cousin. I knew of one young man who was in love with his own cousin, and the Indians spoke of it to me in terms of contempt; they said he wanted to marry his sister, and it was not permitted. Polygamy is practised among the Makahs, but is not general. None of them, however, have more than two wives, and these are on terms of perfect equality. If one thinks herself ill treated, she will leave and get another husband, in which event she will take her children with her. If the wife dies, the father takes the children; but while the mother lives and they need her care, she invariably takes them with her to her new abode. The facility with which the wives can leave their husbands and take others, gives rise to great confusion, particularly to the mind of a stranger seeking information relative to their domestic affairs. Chastity among the females is a thing much talked of, but it appears to be more honored in the breach than the observance, and, although they are not so grossly licentious as the Clallams and other tribes on the Sound, yet the men have great occasion for jealousy.

The festivals are but few, and are confined to the ta-má-na-was ceremonies, which usually take place during the winter months; to certain "medicine" performances, which will be alluded to hereafter, both of these closing with feasting and dancing, and the pot-lat-ches, or distributions of presents, which are made at all seasons of the year. The ta-má-na-was is allied to a religious ceremony, and will be treated of under that head. The pot-lat-ches occur whenever an Indian has acquired enough property in blankets, beads, guns, brass kettles, tin pans, and other objects of Indian wealth, to make a present to a large number of the tribe; for the more an Indian can give away, the greater his standing with the others, and the better his chance of attaining tc the dignity of a chief among his people.

Whenever it is the intention of an individual to make such a distribution of his property, a number of his friends are called in solemn council; an inventory of the articles is made, and the amount each one is to receive is decided upon. The names of the persons who are to be thus favored are then announced in the following manner: One of the party, seated on the ground with a board before him and a stick in his hand, acts as a herald. The person about to give the presents then announces a name, which, if satisfactory to the assembled friends, is repeated, whereupon the herald strikes a blow on the board with his stick, and calls the name in a loud voice; this is repeated until all the names are called to whom presents are to be given, and the articles each is to receive decided upon. Messengers are then sent to invite the guests. If the party is to be a large one, there will be from fifteen to twenty messengers who go in a body, with painted faces, and sprigs of evergreen in their hair. They enter the lodges with songs, and one of their number announces the intended feast and calls aloud the names of all who are invited. On the set day these assemble at the lodge of the Indian who gives the entertainment, and, after much feasting, singing, dancing, and masquerade performance, which sometimes lasts several days, the articles are distributed. The blankets are displayed on poles, or cords stretched across the lodge for the purpose, and all the other articles are placed so as to be seen by the assembled guests, who are seated at one end of the lodge opposite the goods. The herald, after making a speech, extolling the great liberality of the donor, strikes the board with his stick, and calls a name; thereupon an attendant takes the intended present and deposits it in front of the person who is to receive it, where it remains till all are served. Then a song is sung, a dance performed, and the party retire.

Sometimes these parties are composed of children. The parents of a boy or girl who are ambitious for the child, give presents to the children of the tribe. Invitations are sent to the parents, and the names of those children who are to receive the offerings are given. The entertainments are similar to those in the case of adults, except that the performers are children, who dance and sing and go through a variety of plays. The dancing is certainly not graceful; it consists in a clumsy sort of jump, with about as much ease and agility as a person would display while attempting to dance in a sack. The children have a variety of plays, some of which resemble those of white children, and were undoubtedly learned by observation of the customs of those they have seen at Victoria and other places on the Strait and Sound. For instance, peg-tops, which they call ba-bet'hl-ká-di, and battledore and shuttlecock, which is termed kla-há-tla (kla-hāk, shuttlecock; kó-ko-wi, battledore). They also make little wagons, using for wheels sections of kelp stems, cut transversely and about an inch thick. These stems are cylindrical and hollow, and the little wheels answer exceedingly well for their miniature carts. They are quite as expert as most white children in the manufacture of miniature ships and schooners; some of which are very creditable pieces of work. But their chief pleasure is to get into a little canoe, just large enough to float them, and paddle about in the surf. It is this early and constant practice in the management of a canoe and the use of the paddle, that makes them so exceedingly expert when they become of maturer years. Another pastime of the boys is to imitate the killing of a whale. One will select a kelp stem of the largest size, and trail it along the beach. The other boys, armed with miniature harpoons with wooden buoys attached, follow after, and dart their harpoons into the kelp, until it is full or split, when they get another, and keep up the game with eagerness for hours. Another sport is to set a pole upright in the sand and climb to the top, which they do readily by tying a piece of rope so as to form a loop, which is passed once around the pole, forming stirrups for the feet. As they climb, the rope is slipped up by the feet, but becomes fast on pressing the weight upon it; this affords a foothold, till the hands are raised for a fresh grasp of the pole, when the feet are again lifted, and thus alternately by hands and feet, they rapidly ascend to the top. The use of the bow and arrow is early learned by the boys, and is a favorite source of amusement. A description of them will be found under *Arts and Manufactures.* The amusements of the girls consist in dressing up clam shells with strips of rags, and setting them in rows in the sand to resemble children. They are also very fond of dolls, and appear much pleased with any toys such as white children use. They are early taught to make little baskets and mats, and their simple sports are varied by excursions into the woods after berries, or among the rocks, at low tide, in search of shell fish. Like the boys, they are accustomed from infancy to the use of canoes, and may be seen on any pleasant day throughout the summer, paddling in any pool of water left by the receding tide, or in the little bays formed at the mouths of the brooks by the sand which may have been washed in during high water. During the spring, when the flowers are in bloom and the humming birds are plenty, the boys take a stick smeared with the slime from snails, and place it among a cluster of flowers. This slime is an excellent bird lime, and if a humming bird applies his tongue to it he is glued fast. They will then tie a piece of thread to its feet and holding the other end let the birds fly, their humming being considered quite an amusement. They however are cruel to all animals, and particularly birds, which they torture in every conceivable manner. Among their sports is wrestling, which is common not only with the boys but the men also. The parties are entirely naked, and at a signal advance and seize each other by the hair. Each then strives to throw his antagonist, and the victor is rewarded by the shouts of his friends.

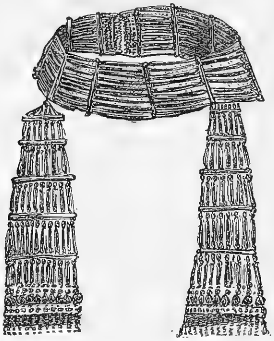
Formerly, deadly combats or duels were often fought. Each fighter being armed with a dagger held in the right hand, grasps firmly with the left the long hair of his antagonist; then holding each other fast, they inflict wounds with their knives till one or both are mortally wounded, or else both are exhausted, when friends interfere and the parties are separated. Some fighting is done with big stones instead of knives, when each tries to beat the other's brains out; but these gladiatorial scenes are of very rare occurrence of late years. The most common practice in vogue at present is shooting each other with guns or pistols.

DRESS.—The usual dress of the men consists of a shirt and blanket; but some, especially the old men, are content with a blanket only. Nearly all of them however have suits of clothes of various kinds, which they have procured from the whites; but these are only worn on occasions of visits to the settlements up the Strait, on the arrival of strangers, or when at work for the white people, and are usually taken off when they return to their lodges. It is not an unusual sight to see an Indian who has been well dressed, even to stockings and shoes or boots, perhaps for several days while with white people, or who may have been at work all day, come out of his lodge at night, or as soon as he leaves work, with nothing on but a blanket. This change from warm clothing to nearly none at all causes colds and coughs to be prevalent among them. During rainy weather they wear, in addition to the blanket, a conical hat woven from spruce roots, so compact as to exclude water, and a bear skin thrown over the shoulders. They are not particular in the arrangement of their dress, even when they have clothes to put on, and may occasionally be seen parading with a cap on the head, boots on the feet, and the body only covered with a blanket.

Fig. 2.

Makah Indian with his wet-weather fishing dress, blanket, bear skin, and hat.

Fig. 3.



Head dress and pendant of dentalium.

Before blankets of wool were procured from the whites, their dress was composed of robes made of skins or blankets woven from dogs' hair or from the prepared bark of the pine which is found on Vancouver Island. Very comfortable blankets were also made from the down of birds woven on strings to form the warp. These garments are still occasionally worn, and a description of their manufacture may be found under the proper head.

The dress of the women usually consists of a shirt or long chemise reaching from the neck to the feet; some have in addition, a skirt of calico like a petticoat tied around the waist, or petticoats made of blankets or coarse baize. Formerly their entire dress was merely a blanket and a cincture of fringed bark, reaching from the waist to the knees. This is called wad-dish, a name they apply to their petticoats of all kinds. Some of the women, particularly the younger ones, have of late years dressed themselves in calico gowns, which are always of an antique pattern and open in front instead of the back. Occasionally a squaw who has been to Victoria and seen the fashions of white women will array herself in hoops, but these articles, so necessary to the dress of civilized females, together with bonnets, are not at all becoming to a squaw, and it is doubtful whether the fashion will ever obtain among these natives. A Makah belle is considered in full dress with a clean chemise; a calico or woollen skirt; a plaid shawl of bright colors thrown over her shoulders; six or seven pounds of glass beads of various colors and sizes on strings about her neck; several yards of beads wound around her ankles; a dozen or more bracelets of brass wire around each wrist; a piece of shell pendent from her nose; ear ornaments composed of the shells of the dentalium, beads and strips of leather, forming a plait three or four inches wide and two feet long; and her face and the parting of the hair painted with grease and vermilion. The effect of this combination of colors and materials is quite picturesque, which is perhaps the only praise that it merits.

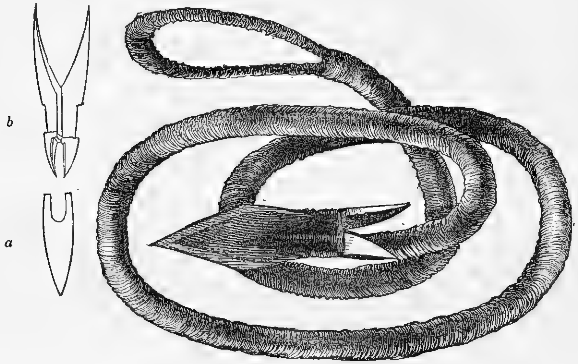
Both sexes have their noses pierced, and usually, although not constantly, suspended from them a small piece of the *haliotis* shell (the "abalone" of the Californians), obtained from Vancouver Island, particularly on the eastern side in the Cowitchin district, where specimens of a large size are found. Some wear pieces of this shell two or three inches square as ear ornaments. The men wear their hair long, but on whaling excursions they tie it up in a club knot behind the head. They frequently decorate themselves by winding wreaths of evergreens around the knob, or stick in a sprig of spruce with a feather. At times they vary this head-dress by substituting a wreath of sea-weed, or a bunch of cedar bark bound around the head like a turban. They paint their faces either black or red, as fancy may suggest, or in stripes of various colors. I have never been able to discover any particular signification for this practice, although I have frequently inquired. Some have told me the red paint was to keep the sun from burning their faces; others paint themselves black, either to show that they have stout and courageous hearts, or because they feel depressed; and others again because they happen to be in the humor of so doing. The method of painting is first to rub the face well with deer's tallow, upon which they apply the dry vermilion or red ochre if these colors are desired. If they wish to produce black, pulverized charcoal is first mixed with bear's grease or deer's fat, and rubbed between the hands, and then applied to the face. The other colors are put on dry. The mode of coloring the face in stripes is to dip a thin slip of wood in the dry paint and lay it carefully on the face, producing a red mark the width of the stick; narrow marks or lines are made with the edge of the stick. The lines thus drawn are more uniform and more clearly defined than if laid on with a brush, and are done quite rapidly. During the berry season the children paint or stain their faces with the juice. A coarse quality of red ochre is often used for painting their faces, and also the inside of canoes. This pigment is made by the Kwilléyute Indians, who reside thirty miles south from Cape Flattery. It is found in the form of a yellowish clay or ochre, which oozes in a semi-fluid state from the banks of the river at certain places. This is collected, squeezed into balls the size of a hen's egg, and then wrapped in rags and baked in the hot ashes till it acquires the desired hue. If heated too much the color becomes a dark brown, and is not so highly prized. When used it is pulverized and mixed with oil, for painting canoes, or applied dry to the face like vermilion, although some blend it first with grease and rub it between the palms of the hands before applying it. Another paint is made from hemlock bark found on decayed roots, or in the forks of old roots that have been long under ground. This is dried at the fire, and, to be used, is rubbed on a stone with spittle and then applied to the face. They all prefer vermilion, however, when they can get it, nor are they averse to using blue or yellow when they can procure those colors dry, which they occasionally do from the whites. During the grand ta-má-na-was or duk-wal-ly performances the face is painted black, and a wreath of cedar bark dyed red is worn around the head. During the tsi-āk or medicine ta-má-na-was the face is painted red, and the wreath is of undyed bark. This bark, which is prepared by beating it fine, is termed he-sé-yu. The name of the bark which has been dried but not broken is pīt-sōp. The war paint is generally black, although some use red; but the braves use black invariably. The hair is twisted in a knot behind, and green twigs tied up with it. The tattooing consists of marks on the arms or legs, and does not seem to amount to much. It is done by drawing a threaded needle under the skin, the thread having previously been colored with charcoal and water. Some prick in the color with a number of needles tied together, as sailors tattoo themselves. Many of these marks are merely straight lines, others show a rude attempt to represent an animal, and letters of the alphabet are sometimes seen tattooed on the arms, the characters being copied from any old newspaper they may get hold of. They seem to attach no definite meaning to this tattooing, and most of it is done while they are children. Many have no marks at all on their persons, while others have a few on the wrists and hands, and some on the ankles; but there is nothing in their tattooing which is in any way distinctive of tribe.

Some of the tribes on the northwest part of Vancouver Island have the custom of wearing disks of wood or ivory in the under lip, and I have seen it asserted that it is the custom of all the tribes from the Columbia River north. This however is not the fact with any of the coast tribes as far as I have seen, which is from the Columbia River to Nootka. The practice of flattening the heads of infants, although, as I have said, not universal among the Makahs, is performed in a manner similar to that of the Chinooks and other tribes in the vicinity of the Columbia River. As soon as a child is born it is washed with warm urine, and then smeared with whale oil and placed in a cradle made of bark, woven basket fashion; or of wood, either cedar or alder, hollowed out for the purpose. Into the cradle a quantity of finely separated cedar bark of the softest texture is first thrown. At the foot is a board raised at an angle of about 25°, which serves to keep the child's feet elevated; or, when the cradle is raised to allow the child to nurse, to form a support for the body, or a sort of seat. This is also covered with bark, he-sé-yu. A pillow is formed of the same material, just high enough to keep the head in its natural position, with the spinal column neither elevated nor depressed. First the child is laid on its back, its legs properly extended, its arms put close to its sides, and a covering either of bark or cloth laid over it; and then, commencing at the feet, the whole body is firmly laced up so that it has no chance to move in the least. When the body is well secured a padding of he-sé-yu is placed on the child's forehead, over which is laid bark of a somewhat stiffer texture, and the head is firmly lashed down to the sides of the cradle; thus the infant remains, seldom taken out more than once a day while it is very young, and then only to wash it and dry its bedding. The male children have a small opening left in the covering, through which the penis protrudes to enable them to void their urine. The same style of cradle appears to be used whether it is intended to compress the skull or not, and that deformity is accomplished by simply drawing the strings of the head-pad tightly and keeping up the pressure for a long time. Children are usually kept in these cradles till they are a year old, but as their growth advances they are not tied up quite so long as for the first few months. The mother, in washing her child, seldom takes the trouble to heat water; she simply fills her mouth with the water, and when she thinks it warm enough spirts it on the child and rubs it with her hand. If the child is very dirty, and they generally get thoroughly grimed up with soot and grease, a wash of stale urine is used, which effectually removes the oil and dirt, but does not impart a fragrant odor. This species of alkali as a substitute for soap is the general accompaniment of the morning toilet of both males and females. They wash as soon as they get up, and may be seen any morning proceeding to the brook with their urinals in their hands. In the winter months, in stormy weather, when they have been confined to the house, or after they have been curing fish or trying out oil, they get exceedingly dirty, and then they go through a process of scouring themselves with a wisp of grass or cedar leaves and sand and urine; after which they give themselves a rinse in fresh water and come out as red as boiled lobsters. Although, in respect of bathing, they may be said to be comparatively cleanly, yet they are not so particular about washing their clothes, which they wear till they are positively filthy before they will take the trouble to cleanse them; and as their washing is done in cold water, with but little if any soap, their clothes have always a dingy appearance. There are exceptions, however, to this, both among the males and females, particularly the younger ones, who, since the advent of the whites, seem more desirous of having clean apparel than their elders, who retain all their old savage customs.

Food, and Method of Procuring It.—The principal subsistence of the Makahs is drawn from the ocean, and is formed of nearly all its products, the most important of which are the whale and halibut. Of the former there are several varieties which are taken at different seasons of the year. Some are killed by the Indians; others, including the right whale, drift ashore, having been killed either by whalemen, sword fish, or other casualties. The various species of whales are: The sperm whale, kōts-ké, which is very rarely seen; right whale, yakh′-yo-bad-di; black fish, klas-ko-kop-ph; fin-back, kaú-wid; sulphur bottom, kwa-kwau-yak′-t'hle; California gray, che-che-wid, or chet′-a-pūk; killer, se-hwau. The generic name of whales is chet′-a-pūk. The California gray is the kind usually taken by the Indians, the others being but rarely attacked.

Their method of whaling, being both novel and interesting, will require a minute description—not only the implements used, but the mode of attack, and the final disposition of the whale, being entirely different from the practice of our own whalemen. The harpoon consists of a barbed head, to which is attached a rope or lanyard, always of the same length, about five fathoms or thirty feet. This lanyard is made of whale's sinews twisted into a rope about an inch and a half in circumference, and covered with twine wound around it very tightly, called by sailors "serving." The rope is exceedingly strong and very pliable.

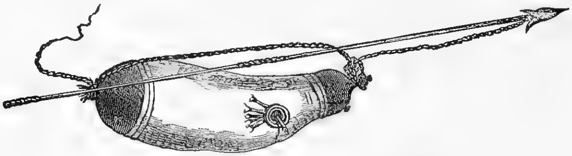
Fig. 4.



Harpoon point (kwe-kāhptl) and line. *a.* Blade. *b.* Barbs.

The harpoon-head is a flat piece of iron or copper, usually a saw-blade or a piece of sheet copper, to which a couple of barbs made of elk's or deer's horn are secured, and the whole covered with a coating of spruce gum. The staff is made of yew in two pieces, which are joined in the middle by a very neat scarph, firmly secured by a narrow strip of bark wound around it very tightly. I do not know why these staves or handles are not made of one piece; it may be that the yew does not grow sufficiently straight to afford the required length; but I have never seen a staff that was not constructed as here described. The length is eighteen feet; thickest in the centre, where it is joined together, and tapering thence to both ends. To be used, the staff is inserted into the barbed head, and the end of the lanyard made fast to a buoy, which is simply a seal-skin taken from the animal whole, the hair being left inwards. The apertures of the head, feet, and tail are tied up air-tight, and the skin inflated like a bladder.

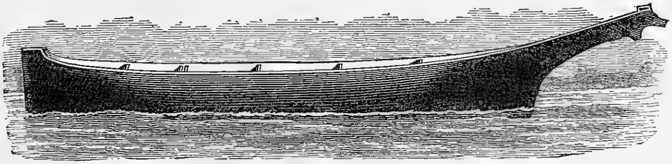
Fig. 5.



Seal skin buoy (Do-ko-kup-tl).

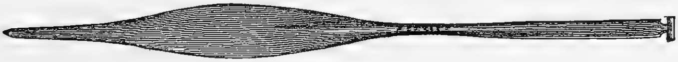
When the harpoon is driven into a whale the barb and buoy remain fastened to him, but the staff comes out, and is taken into the canoe. The harpoon which is thrown into the head of the whale has but one buoy attached; but those thrown into the body have as many as can be conveniently tied on; and, when a number of canoes join in the attack, it is not unusual for from thirty to forty of these buoys to be made fast to the whale, which, of course, cannot sink, and is easily despatched by their spears and lances. The buoys are fastened together by means of a stout line made of spruce roots, first slightly roasted in hot ashes, then split with knives into fine fibres, and finally twisted into ropes, which are very strong and durable. These ropes are also used for towing the dead whale to the shore. The harpoon-head is called kwe-kaptl; the barbs, tsa-kwat; the blade, k'ūt-só-wit; the lanyard attached to the head, klūks-ko; the loop at the end of the lanyard, kle-tait-lĭsh; the staff of the harpoon, du-pói-ak; the buoy, dōpt-kó-kuptl, and the buoy-rope, tsis-ka-pūb.

Fig 6.



Whaling canoe.

Fig. 7.

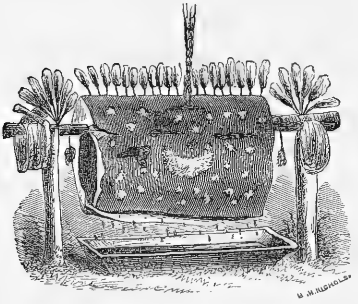


Whaling paddle.

A whaling canoe invariably carries eight men: one in the bow, who is the harpooner, one in the stern to steer, and six to paddle. The canoe is divided by sticks, which serve as stretchers or thwarts, into six spaces, named as follows: the bow, he-tuk-wad; the space immediately behind, ka-kai-woks; centre of canoe, cha-t'hluk-dōs; next space, he-stuk′-stas; stern, kli-chá. This canoe is called pa-dau-t'hl. A canoe that carries six persons, or one of medium size, is called bo-kwis′-tat; a smaller size, a-tlis-tat; and very small ones for fishing, te-ka-aú-da.

When whales are in sight, and one or more canoes have put off in pursuit, it is usual for some one to be on the look-out from a high position, so that in case a whale is struck, a signal can be given and other canoes go to assist. When the whale is dead, it is towed ashore to the most convenient spot, if possible to one of the villages, and hauled as high on the beach as it can be floated. As soon as the tide recedes, all hands swarm around the carcass with their knives, and in a very short time the blubber is stripped off in blocks about two feet square. The portion of blubber forming a saddle, taken from between the head and dorsal fin, is esteemed the most choice, and is always the property of the person who first strikes the whale. The other portions are distributed according to rule, each man knowing what he is to receive. The saddle is termed u-butsk. It is placed across a pole supported by two stout posts. At each end of the pole are hung the harpoons and lines with which the whale was killed. Next to the blubber at each end are the whale's eyes; eagle's feathers are stuck in a row along the top, a bunch of feathers at each end, and the whole covered over with spots and patches of down. Underneath the blubber is a trough to catch the oil which drips out. The u-butsk remains in a conspicuous part of the lodge until it is considered ripe enough to eat, when a feast is held, and the whole devoured or carried off by the guests, who are at liberty to carry away what they cannot eat. After the blubber is removed into the lodge the black skin is first taken off, and either eaten raw or else boiled. It looks like India rubber; but though very repulsive to the eye it is by no means unpalatable, and is usually given to the children, who are very fond of it, and manage to besmear their faces with the grease till they are in a filthy condition.

Fig. 8.



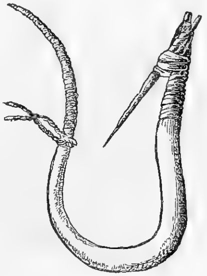
Saddle of whale's blubber.

The blubber, after being skinned, is cut into strips and boiled, to get out the oil that can be extracted by that process; this oil is carefully skimmed from the pots with clam shells. The blubber is then hung in the smoke to dry, and when cured, looks very much like citron. It is somewhat tougher than pork, but sweet (if the whale has been recently killed), and has none of that nauseous taste which the whites attribute to it. When cooked, it is common to boil the strips about twenty minutes; but it is often eaten cold and as an accompaniment to dried halibut.

From information I obtained, I infer that formerly the Indians were more successful in killing whales than they have been of late years. Whether the whales were more numerous, or that the Indians, being now able to procure other food from the whites, have become indifferent to the pursuit, I cannot say; but I have not noticed any marked activity among them, and when they do go out they rarely take a prize. They are more successful in their whaling in some seasons than in others, and whenever a surplus of oil or blubber is on hand, it is exchanged or traded with Indians of other tribes, who appear quite as fond of the luxury as the Makahs. The oil sold by these whalers to the white traders is dogfish oil, which is not eaten by this tribe, although the Clyoquot and Nootkan Indians use it with their food. There is no portion of a whale, except the vertebræ and offal, which is useless to the Indians. The blubber and flesh serve for food; the sinews are prepared and made into ropes, cords, and bowstrings; and the stomach and intestines are carefully sorted and inflated, and when dried are used to hold oil. Whale oil serves the same purpose with these Indians that butter does with civilized people; they dip their dried halibut into it while eating, and use it with bread, potatoes, and various kinds of berries. When fresh, it is by no means unpalatable; and it is only after being badly boiled, or by long exposure, that it becomes rancid, and as offensive to a white man's palate as the common lamp oil of the shops.

The product of the ocean next in importance for food is the halibut. These are taken in the waters of the strait in certain localities, but as the depth of water at the mouth of the strait is very great, the Indians prefer to fish on a bank or shoal some fifteen or twenty miles west from Tatooche light. The depth on the banks varies from twenty to thirty fathoms. The lines used in the halibut fishing are usually made of the stems of the gigantic kelp (*fucus gigantea*), and the hooks of splints of hemlock. A line attached to one of the arms of the hook holds it in a vertical position, as shown in Fig. 9. The bait used is the cuttlefish or squid (*octopus tuberculatus*), which is plentiful and is taken by the natives by means of barbed sticks, which they thrust under the rocks at low water, to draw the animal out and kill it by transfixing it with the stick. A portion of the squid is firmly attached to the hook, which is sunk by means of a stone to the bottom, the sinker keeping the hook nearly in a stationary position. To the upper portion of the line it is usual to attach bladders, which serve as buoys, and several are set at one time. When the fish is hooked, it pulls the bladder, but cannot draw it under water. The Indian, seeing the signal, paddles out; hauls up the line; knocks the fish on the head with a club; re-adjusts his bait; casts it overboard; and proceeds to the next bladder he sees giving token of a fish. When a number of Indians are together in a large canoe, and the fish bite readily, it is usual to fish from the canoe without using the buoy. This hook is called che-būd, and the club, sometimes fancifully carved, is called ti-ne-t'hl.

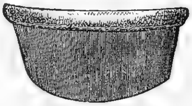
Fig. 9.



Halibut hook.

When the fish are brought home, they are first landed on the beach, where the women wash and wipe them with a wisp of grass or fern. The entrails are taken out and thrown away, and the rest of the fish carried into the houses. The heads are taken off first to be dried separately, and the body of the fish is sliced by means of a knife of peculiar construction, somewhat resembling a common chopping knife, called kó-che-tin (Fig. 10). The skin is first carefully removed, and the flesh then sliced as thin as possible to facilitate the drying; and when perfectly cured, the pieces are wrapped in the skin, carefully packed in baskets, and placed in a dry place. The heads, the back bones, to which some flesh adheres, and the tails, are all dried and packed away separately from the body pieces. When eaten, the skin, to which the principal portion of the fat or oil of the fish adheres, is simply warmed, or toasted over the coals, till it acquires crispness. The heads, tails, and back bones are boiled. The dried strips from the body are eaten without further cooking, being simply broken into small pieces, dipped in whale oil, and so chewed and swallowed. It requires a peculiar twist of the fingers and some practice to dip a piece of dry halibut into a bowl of oil and convey it to the mouth without letting the oil drop off, but the Indians, old and young, are very expert, and scarcely ever drop any between the mouth and the bowl. In former times, dried halibut was to these Indians in lieu of bread; oil in place of butter, and blubber instead of beef or pork. When potatoes were introduced, they formed a valuable addition to their food, and since the white men have become more numerous, the Indians

Fig. 10.



Halibut chopper.

have accustomed themselves to other articles of diet; flour, hard bread, rice, and beans are always acceptable to them; they are also very fond of molasses and sugar, and are willing at all times to barter their furs, oil, or fish for these commodities.

Next to the halibut are the salmon and codfish, and a species of fish called the "cultus" or bastard cod. These, however, are usually eaten fresh, except in seasons of great plenty, when the salmon is dried in the smoke. They are all taken with the hook, and the salmon fishing is most excellent sport. The bait used is herring, and unless these are plenty, they will not try to catch salmon, although the waters may be alive with them. A more extended notice of these fish and of several other varieties used for food, will be found in another portion of this paper.

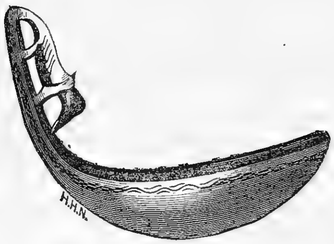
The squid, which is used for bait in the halibut fishery, is also eaten. When first taken from the water it is a slimy jelly-like substance, of rather disgusting appearance, but when boiled it becomes firm and as white as the flesh of a lobster, which it somewhat resembles in taste, but is much tougher to masticate. I have found it, chopped with lettuce, an excellent ingredient in salad. The *onychoteuthis* is also found, but it is never eaten. Skates are abundant, but as they usually make their appearance during the halibut season, they are seldom used, although the Indians like them very well; but they seem to prefer halibut. Three varieties of *echinus* are found here, and are eaten in great quantities; they are either caught by spearing them at low tide, or are taken in a very simple manner by means of a piece of kelp. To effect this a stem of the kelp is sunk to the bottom, having a line and buoy attached. The echini go on it to feed, and after the kelp has remained several hours, it is gently drawn into a canoe and the creature picked off. The Indians collect them in this manner in great numbers during the spring months. Although a variety of bivalves is found, they do not abound as they do in the bays further up the Strait, and do not form a common article of nutriment, except that mussels of the finest description cover the rocks about Cape Flattery and Tatooche Island, and are eaten whenever the Indian appetite craves them, or when the breakers of the Pacific are sufficiently quiet to permit a search. These are either boiled or roasted in the ashes, and are very delicious cooked by either method. Barnacles, crabs, sea slugs, periwinkles, limpets, &c. furnish occasional repasts. Scallops, which are found in the bays of Fuca Strait, are excluded from their list of food. They are considered as having some peculiar powers belonging to them, and in consequence their shells are made use of as rattles to be used in their ceremonials. Oysters were formerly found in Neeah Bay, but have been destroyed by some cause of late years; the only evidence of their former existence being the shells which are thrown ashore by the waves. They are found in the various bays and inlets of Vancouver Island, but the Indians do not eat them. In fact there are but few of the animal products of the ocean but are considered edible, and serve to diversify the food. Of land animals they eat the flesh of the elk, deer, and bear; but, although these abound a short distance in the interior, the Indians very seldom hunt for them, and when they kill any, as they occasionally do, they are always ready to sell the flesh to the white residents in the bay, seeming to care more for the skin than the carcass. Smaller animals, such as raccoons, squirrels, and rabbits, are seldom if ever eaten by them, and are killed only for the sake of the skin. Of birds, however, they are very fond, particularly the sea fowl, which are most plentiful at times, and are taken in great numbers on foggy nights, by means of spears. A fire of pitch-wood is built on a platform at one end of the canoe, and by the glare of its light, which seems to blind or attract the birds, the Indian is enabled to get into the midst of a flock, and spear them at his leisure. On the return of a canoe from one of these nocturnal excursions, particularly in the fall, it is not unusual to find in it a collection of pelicans, loons, cormorants, ducks of various kinds, grebes, and divers of various sorts. These, after being picked, and very superficially cleaned, are thrown promiscuously into a kettle, boiled and served up as a feast.

The roots used for food are potatoes, which are raised in limited quantities; Kammas (*Scilla Fraseri*), which is procured from the tribes south (Kwilléyute and Kwinaiūlts), and some from the Vancouver Island Indians; tubers of the equisetum; fern roots, and those of some species of meadow grass and water plants; the roots of several kinds of sea-weed, particularly eel grass, are also used. These and the equisetum root are eaten raw; the others are all cooked. In the spring the young sprouts of the salmon berry (*Rubus spectabilis*) and thumb berry (*Rubus odoratus*) are consumed in great quantities. They are very tender, have a slightly acid and astringent taste, and appear to serve as alteratives to the system, which has become loaded with humors from the winter's diet of dried fish and oil. The sprouts are sometimes cooked by being tied in bundles and steamed over hot stones. After the season of sprouts is over the berries commence. The salmon berry comes first and is ripe in June; it is followed by the other summer berries till autumn, when the sallal and cranberry appear and continue till November. It is customary, when an Indian has a surplus of food of any kind, to invite a number of friends and neighbors to share it, and as they seem very fond of these social gatherings, scarcely a day passes but some one will give a feast, sometimes to a few, or it may be to a great number of persons. It is this fondness for feasts which makes them so improvident, for when they have anything they never seem satisfied until it is all eaten up. If one man is more fortunate than his neighbors in procuring a supply, instead of preserving it for his own wants and those of his family, he must give a feast, and while his supplies last the others are content to live on his hospitality; when that is exhausted they will seek food for themselves.

The articles used for culinary purposes are, for the most part, pots, kettles, and pans, principally procured from the whites, at the trading post of the Hudson's Bay Company at Victoria. The ancient method of steaming or boiling is occasionally resorted to, particularly in cooking quantities of meat, fish, or roots, for a feast. Large bowls shaped like troughs, cut from alder logs, are partially filled with red hot stones, on which a few fern leaves or sea-weed are laid; then the food, whether fish or potatoes, or kammas, is placed on this, a bucket of water is thrown into the trough, and the whole quickly covered with mats and blankets and left to steam till the contents are cooked. When larger quantities of food are to be prepared, the same process is employed, with the exception that, instead of using wooden troughs, a shallow pit is made in the ground. Potatoes and fish take only half an hour's cooking; but some of the roots, particularly the kammas, require a constant heat for nearly two days.

Their method of serving up food is very primitive, and the same forms are observed by all. When a feast is to consist of a variety of dishes, such for instance as hard bread, potatoes, blubber, fish, &c., they proceed in this manner: after the guests are assembled, the women begin to knead flour, and prepare it in cakes to bake in the ashes, the men meanwhile heating stones red hot. When these are ready, they are transferred by means of tongs made of a split stick, to large wooden troughs, and potatoes laid on top of them. Some water is then thrown on the heap, and the whole quickly covered with mats and old blankets to retain the steam. The potatoes having been covered up, the cakes are next placed in the hot ashes to bake. The guests meanwhile are served with dried halibut and oil; each has his allowance set before him, and what he cannot eat he is expected to carry away. Dry fish and oil constitute the first course, and by the time that is finished the potatoes are steamed, and the bread is baked. The potatoes are served first, and are eaten with oil, the custom being to peel off the skins with the fingers, dip the potato in oil and bite off a piece, repeating the dipping at each mouthful. The potatoes disposed of, the bread is next served; or, if they have hard bread, that is offered instead of fresh. Molasses is preferred with the bread, but if they have none, oil is used instead. If any more provision is to be served, it is brought in courses, and at the end of each course each guest wipes his mouth and fingers with a wisp of bark, puts whatever may be left into his basket, and looks out for the next course. The host is offended if his guests do not partake of everything that is set before them, and if strangers are among the visitors, it is not uncommon for four or five such feasts to be given in the course of a single day or evening, each arranged and conducted as described. I have attended several entertainments in visiting the different villages of the tribes. On one occasion, when an unusual display of hospitality was expected, one of the Indians who accompanied me remarked that I had better not eat too much at any one lodge, lest I should be sick, and not be able to feast at all of them, as I was expected to do. I asked him how

Fig. 11.



Ladle of "big horn."

Fig. 12.

Spoon of *aploceras* horn.

he managed to eat such enormous quantities, for his appetite appeared insatiable. He replied, that when he had eaten too much he made it a practice, before going into the next lodge, to thrust his fingers down his throat, which enabled him to throw off the load from his stomach, and prepare to do justice to the coming feast. An Indian who can perform this feat dexterously, so as to eat heartily at every house, is looked upon as a most welcome guest, who does justice to the hospitality of his host. Sometimes the feast is confined to boiled rice and molasses, of which they are very fond. This is served out in tin pans or wooden platters, and eaten with spoons made of horn, procured from the northern tribes, and said to be the horn of the mountain sheep.[1] If horn spoons are not at hand, they improvise an excellent substitute which is simply a clam shell, and with one of large size an Indian will swallow quite as much rice and molasses as by any other known method.

Fig. 13.

Wooden ladle.

After eating, they sometimes, but not always, indulge in a whiff of tobacco; but smoking is not a universal practice among them, and is rather as a stimulant than a mere luxury; the pipe is more agreeable to them in their canoes, when tired with fishing or paddling; then the Indian likes to take out his little pouch of smoking materials, and draw a few whiffs. The article generally used is the dried leaves of the *Arctost uva-ursi* mixed with a little tobacco; they also use, when they have no *uva-ursi*, either the dried leaves of the sallal *Gaultheria shallon*, or dried alder bark. Smoking, however, is practised even less than among some of the tribes east of the Rocky Mountains, and there are no ceremonials connected with its use. Occasionally an Indian will swallow a quantity of the smoke, which, being retained a few seconds in the lungs or stomach, produces a species of stupefaction, lasting from five to ten minutes and then passing off. The calumet, or pipe of peace, with its gayly decorated stem, is quite unknown among these Indians. They are content with anything in the shape of a pipe, and seem to prefer a clay bowl, to which they affix a stem made of a dried branch of the *Rubus spectabilis*. They simply scrape off the bark and take out the pith, and the stem is finished. The smoking occupies but a few minutes of the time devoted to a meal; when they have finished, each guest gathers what provision he may have left, and all proceed to the next lodge, where another feast has been prepared; and when all is over, they return home with their gleanings.

OTTER, FISH, SEALS, &c., TAKEN BY THE MAKAHS.—Besides those already named, other varieties are taken, some of which are not used for food. As several have

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[1] The ladles are made of wood, or of the horns of the "big-horn," *Ovis montana;* the spoons of those of the mountain goat, *Aploceras americana.*—G. G.

not been described in any work of reference I have seen, I shall have to describe them simply by their common and Indian names. The cottoids are very plenty and of several varieties, all of which are eaten. The largest, which is called tsá-daitch, measures twenty-seven inches in length. It is an uncouth, repulsive-looking fish, dark greenish-brown, the body larger in proportion to the head than other sculpins; but it is of good flavor, either boiled or fried. One specimen weighed ten pounds. The buffalo sculpin, kāb′-bis and other small varieties, are quite common, and are usually taken with spears. The kla-hap-pāk resembles the "grouper" of San Francisco. Its color is red; the scales large and coarse; the meat white, and in large flakes. It is excellent, either fried, boiled, or baked. The whites call it "rock cod," but it is not of the cod species, although the flavor and appearance of the flesh, when cooked, resemble that. The tsa-bá-hwa is much like the rock-cod of Massachusetts. It is variously marked, but the general color is olive-green on the back, shaded down to a yellow belly, and covered with reddish or brown spots or freckles; some are of a sepia-brown, with blue spots. It is a nice pan fish when fresh, but soon gets soft. Its flesh varies in color with the locality where it is taken, and the difference of food, and may be found with shades ranging from a pure white to a greenish-blue—the latter color being very disagreeable to most of the white men, who regard it as produced by a poisonous agency. I have eaten freely of this fish, and found that the color of the flesh made no difference either in flavor or quality. It can be taken by the hook while trolling for salmon, but is usually caught near the rocks with small hooks and lines. The cul-tus or "bastard cod," as it is termed by the whites, which abounds, and is taken at all seasons of the year, forms an important article for fresh consumption. This fish, in general appearance, somewhat resembles the true cod, but differs from it in many material respects. The dorsal fins are double, and extend from the head to the tail. These, as well as all the other fins, are thick, gelatinous, and palatable. This also differs from the common cod, in wanting the barbel under the lower jaw, which is longer than the upper, and in having both upper and lower jaws armed with strong teeth. The liver contains no oil, but the flesh has a portion of fat mixed through it. It is most excellent food, and especially when cooked, closely resembles the true cod. Exceedingly voracious also, in taking it the Indians use no hook; they simply secure a small fish, usually a perch or sculpin, to the line, and when the cod closes its jaws upon the bait, it holds with bull-dog tenacity, and is hauled into the canoe and knocked on the head. The Indian name for it is tūsh-kaú. A fish closely resembling this, and perhaps of the same species, is sold in the San Francisco market under the name of cod. At certain seasons, particularly during the spring, it is found around the rocks and in coves of shallow water, and is then easily speared. The Indians seldom dry it, preferring to boil and eat it fresh. The true cod, ká-dátl, is taken in limited quantities. In some seasons it is more plentiful than at others. It is caught on banks and shoals, in from thirty to forty fathoms of water. This fish abounds in the more northern waters of the Pacific coast; but the extreme depth and swift currents of Fuca Strait make it difficult to fish for them there, except at those times during the summer months, when it approaches near the shore. Another fish, termed by the Indians be-shó-we, or black cod, although not a codfish, has not been described in any work that I have seen. It is a deep water fish, being caught in eighty fathoms. I have never been able to get one perfect. They are rarely taken, and those that I have seen had been split for curing. The color of the skin is black, and the flesh white and fat like mackerel. I have eaten some broiled, and the flavor was like that of halibut fins, extremely rich and fat. The weight varies from four to twelve pounds.

The dogfish (yá-cha) *Acanthias suckleyi*, is taken in great quantities for the sake of the oil contained in the liver, which forms the principal article of traffic between these Indians and the whites. Although this fish is plentiful on the coast south of Cape Flattery, I have never known the Indians there to make a business of fishing for them. Even at Kwilléyute, where I saw great quantities of dogfish in the summer of 1861, the Indians of that tribe and locality did not know how to extract the oil, and we had to send a Makah Indian, who was on board the vessel, ashore to show them how to try out the livers of a lot of fish we had caught.

The Indians on Vancouver Island, on the contrary, make a lucrative business of extracting the oil, and sell large quantities to the Makahs in exchange for whale oil, which they eat. The Clyoquots and Nootkans eat dogfish oil, but prefer whale oil when they can obtain it. The method of extracting as practised by the Makahs is to collect the livers, which are put into a tub and kept until a considerable quantity has accumulated. They are then put into iron pots, and set to simmer near the fire; or else hot stones are placed among them and they are cooked by the heat until all the oil is extracted, which is then carefully skimmed off and stored in receptacles, made of the paunches and intestines of whales, fish, or seals. In the fall of the year the flesh of the dogfish contains a considerable proportion of oil, which at other times it does not appear to possess; this is extracted in the following manner: When the livers are taken out, the head and back bone are also removed, and the rest of the body, being first slightly dried in the smoke, is steamed on hot stones till it is thoroughly cooked. It is then put into little baskets, made for the purpose, of soft cedar bark, and rolled and squeezed till all the liquid is extracted. This in color resembles dirty milk. It is boiled and allowed to cool and settle, and the oil is then skimmed off. After the oil is extracted, the flesh is washed in fresh water and again squeezed in the baskets, and in this state it is eaten by the Indians when other food is scarce. But dogfish is seldom tasted by the Makahs, and never until the oil has been thoroughly removed. The oil has a nauseous taste, and is not relished by these Indians, who are epicures in their way, and prefer the oil of whales and seals. The quality of dogfish oil for burning is very good, quite superior to whale oil. In astral lamps it burns with a clear, strong flame, and, when properly refined, is second only to sperm oil. Dr. Suckley states that while he was on service as surgeon at the U. S. military station at Fort Steilacoom, he used dogfish oil with great success in pulmonary affections, and considered it, when fresh, equal to cod-liver oil. A very large species of shark, known among whalemen as "bone shark," is occasionally killed by the Makahs, and its liver yields great quantities of oil. I saw one in October, 1862, killed in Neeah Bay, twenty-six feet long, and its liver yielded nearly seven barrels of oil, or over two hundred gallons. These sharks are very abundant during the summer and fall, but the Indians rarely attack them except when they come in shore to feed, which they do at certain times. They are easily seen by the long dorsal fin projecting above the water, and, as they appear to be quite sluggish in their movements, are readily killed with harpoons or lances. The flesh is never eaten.

A fish of the *Anarrhichthys* tribe is frequently killed during the summer months at low tide among the rocks. This is called the "doctor fish" by the Indians, and is never eaten except by some medicine-man who wishes to increase his skill in pharmacy.

Of the porpoise family there are three varieties in the waters of Fuca Strait. The large black kind called by the Makahs a-ikh-pet'hl; white fin porpoise, called kwak-watl, and the "puffing pig," tsailt'h-ko. These are killed with harpoons of a smaller size than those used for whales, and are highly esteemed as food.

Seals also abound. The sea-lion, the largest variety, is called á-ka-wad-dish; the fur-seal, kāt-hla-dōs, and the hair-seal, kās-chó-we. The skin of the hair-seal is always taken off whole, and, after the head and feet have been removed and the orifices firmly secured, it is blown full of air and dried with the hair side in. This is the buoy used for the whale fishery, and is usually painted on the outside with rude devices in red vermilion or ochre. The skins of the fur-seal are sold to the whites. The sea otter, tí-juk, is very rarely found around the cape, but is plentiful further down the coast in the vicinity of Point Grenville. During the summer of 1864 the fur-seals were more numerous in Fuca Strait than they had been for many years, and great numbers were taken by the Indians. Sometimes they kill seals with spears; but the common mode is to shoot them with guns. The flesh of all the species is eaten. There are several deep caverns in the cliffs at Cape Flattery in which the seals congregate during the breeding season. At such times the Indians go in with a torch and club, and kill numbers by knocking them on the head.

The ease with which these Indians can obtain their subsistence from the ocean makes them improvident in laying in supplies for winter use, except of halibut; for, on any day in the year when the weather will permit, they can procure, in a few hours, provisions enough to last them for several days.

TRADE.—The Makahs, from their peculiar locality, have been for many years the medium of conducting the traffic between the Columbia River and Coast tribes south of Cape Flattery, and the Indians north as far as Nootka. They are emphatically a trading, as well as a producing people; and in these respects are far superior to the Clallams and other tribes on Fuca Strait and Puget Sound. Before the white men came to this part of the country, and when the Indian population on the Pacific coast had not been reduced in numbers as it has been of late years, they traded largely with the Chinooks at the mouth of the Columbia, making excursions as far as the Kwinaiūlt tribe at Point Grenville, where they met the Chinook traders; and some of the more venturesome would even continue on to the Columbia, passing through the Chihalis country at Gray's Harbor and Shoalwater Bay. The Chinooks and Chihalis would in like manner come north as far as Cape Flattery; and these trading excursions were kept up pretty regularly, with only the interruption of occasional feuds and rivalries between the different tribes, when the intercourse would be suspended, or carried on by means of intermediate bands; for instance, the Chinooks would venture up as far as Chihalis, or perhaps Kwinaiūlt; they would go as far as the Kwilléyute, and these last in turn to Cape Flattery. After a while peace would be restored, and the long voyages again resumed. The Makahs took down canoes, oil, dried halibut, and hai-kwa, or dentalium shells. The large canoes were almost invariably made on Vancouver Island; for, although craft of this model are called "Chinook" canoes, very few in reality, except small ones, were made at Chinook, the cedar there not being of suitable size or quality for the largest sizes, and the best trees being found on the Island. The Makahs in return received sea-otter skins from Kwinaiūlt; vermilion or cinnabar from the Chinooks, which they in turn had procured from the more southern tribes of Oregon; and such articles of Indian value as might be manufactured or produced by the tribes living south of the cape. Their trade with the northern Indians was for dentalium, dried cedar bark for making mats, canoes, and dried salmon; paying for the same with dried halibut, blubber, and whale oil. Slaves also constituted an important article of traffic; they were purchased by the Makahs from the Vancouver Island Indians, and sold to the coast Indians south.

The northern Indians did not formerly, nor do they now, care to go further south on their trading excursions than Cape Flattery; and the Columbia River and other coast tribes seem to have extended their excursions no further north than that point. Isolated excursions are attributed to certain chiefs. Comcomly, for instance, the celebrated Chinook chief, would occasionally go north as far as Nootka; while Maquinna, Klállakum, and Tatooshátticus, of the Clyoquots, made visits to Chinook; but, as a general practice, the Makahs at Cape Flattery conducted the trade from north to south. In those early days, when so many more Indians were in every tribe than at present, and when they were so often at variance with each other, it is not probable that the trade conducted by the coast tribes was of any great value. But when the white traders began to settle at the mouth of the Columbia, the desire to obtain their goods, which had been awakened by the early fur traders at Nootka, caused a more active traffic to spring up, the Makahs wishing to get from Chinook the blankets, beads, brass kettles, and other commodities obtained at the trading post at Astoria. The entire supply was drawn from that settlement, until the Hudson's Bay Company established a trading post at Victoria, and, as trade could be conducted so much more readily at that place than at Astoria, the coast traffic was nearly stopped, or confined to the summer excursions of those Indians who had intermarried with the Kwinaiūlts or Chihalis. The coast trade south at present is confined to the exchange of a few canoes for the sea-otter skins of the Kwinaiūlts, but the amount is very small. Their trade with the Vancouver Island Indians is to exchange whale oil and dried halibut, for dog-fish oil, which is procured in large quantities by the Nittinat and Clyoquot tribes. The dog-fish oil is sold by the Makahs to the white traders. Formerly it went to those who traded with them at Neeah Bay; but of late years the greater portion is carried either to Victoria, or else to the different lumber mills on the Sound, where it finds a ready sale at prices averaging about fifty cents per gallon. They also trade off considerable quantities of dried halibut and whale oil to the Clallams and the Victoria Indians—receiving in return from these Indians blankets, guns, beads, &c., and from the whites either blankets, flour, hard bread, rice, and molasses, or money, which they usually expend before their return, in the purchase of those articles either at Victoria or at the villages on the Sound.

Blankets are the principal item of wealth, and the value of anything is fixed by the number of blankets it is worth. In the early days of the Hudson's Bay Company, and until within the past ten years, a blanket was considered equal in trade to five dollars; but since so many different traders have settled on the Sound, with such a variety of qualities and prices, the Indian in naming the number of blankets he expects to receive (as for a canoe), will state what kind he demands. Thus, if the price is to be twenty blankets, he will say, "how many large blue ones," which are the most costly, "how many red, and how many white ones?" and the purchaser must be acquainted with the value of the several kinds before he can tell what the canoe will really cost. Also in their trades among themselves they will pay for a slave, for instance, from one to two hundred blankets, but the number of each quality is always stated. They are very shrewd in their bargains, and from their long intercourse with the white traders are as well informed of the money-value of every commodity they wish to purchase, as most white people are.

I have no trustworthy statistics from which to derive information respecting the amount of their yearly barter; for, as I before remarked, only a portion of their oil is sold to the traders in the bay, the remainder being carried to Victoria, or the saw-mills; nor have I any means of ascertaining the value of the oil and dried fish they trade to other Indians I think, however, I am not far from the truth when I assert that their yearly produce of oil of all kinds will amount, on an average, to five thousand gallons. I have seen it stated in some reports of the Indian Department that the Makahs sold to the whites annually about sixteen thousand gallons of oil. They may possibly have done so in former years, but since my residence among them, I doubt if their sales have ever reached that amount. They, nevertheless, produce more than any other tribe I know of in the Territory, not of oil alone, but of the various products of the ocean; and were they a little more industrious, and more capable of realizing the advantage of taking care of their earnings, they would not only be a self-supporting tribe, completely independent of any assistance from the Government, but might actually become a wealthy community in the sense in which we employ the term. But they are, like all Indians, careless, indolent, and improvident, seeking only to obtain a temporary supply of food, or to get oil enough to purchase a superfluity of blankets, hard bread, rice, and molasses; and then have a big feast and give everything away. By judicious management on the part of the Government and its agents, these Indians might easily be taught to improve their fisheries of all kinds, so as to reap more lucrative returns; but as far as the Makahs are concerned, there are two very serious obstacles which will forever prevent them from being an agricultural people; and these two obstacles are soil and climate.

I have already shown that the whole of the reservation is a rocky, mountainous, forest-covered region, with no arable land except the low swamp and marsh, extending from Neeah Bay to Wäatch, and a small prairie at Tsuess. And not only are these lands too wet for the cultivation of anything but roots, but the climate is so exceedingly humid that cereals will not ripen. The only sure, repaying crop is potatoes. But Indians cannot live on potatoes alone, any more than the white men; they require animal food, and prefer the products of the ocean to the farina of the land. It will take many years, and cost the Government large sums of money to induce these savages to abandon their old habits of life and acquire new ones. In fact, these Coast Indians are an anomaly in their general style of living, as compared with the tribes of the plains, and as such, I think they should be encouraged in their fisheries, and taught to prepare fish for sale, to make barrels to hold their stock and oil, and helped, by means of the white men's experience, to take more whales and fish than they do now.

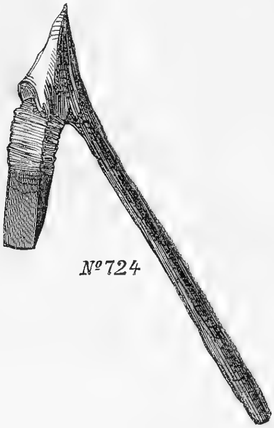
There is one article, and but one that I know of, which I think might be cultivated with profit, and that is the osier willow. If anything will grow in this wet climate, it appears to me it must be this, and, as these people are very expert in making baskets, they could easily be taught to manufacture an article from osiers suitable for our markets, or to prepare the osiers alone for sale to basket-makers. Agricultural labor is very odious to them all; still, a few will work, but they must be paid for everything they do. They are so accustomed to trade with white people and to receive gifts, that they will neither perform labor, however trivial, nor part with the least article of property, without exacting payment. They carried this practice so far as to demand compensation for allowing their children to attend the reservation school. They know the use and value of money, and are generally willing to do anything required of them if they can look for tangible results that will be of advantage to themselves. But they are profoundly indifferent to the benefits of education, and cannot be made to believe that clearing land, making roads, or draining swamps is of any use. When the season for planting arrives they are willing to put a few potatoes into the ground, because their experience has taught them that they can reasonably expect a harvest. But potatoes are esteemed by them rather as a luxury than as ordinary food, and, when they know how easily they can draw their subsistence from the ocean, and how much labor is required to till the earth, they prefer to continue in their old course, and let the white man's agriculture alone.

There are other articles of traffic, such as miniature canoes, baskets, mats, berries, &c.; but the principal source of wealth is oil and dried fish; the rest is only sold as the chance presents, on the arrival of strangers in the bay, or when they make their excursions up the Strait to the white settlements.

TOOLS.—The Makahs display considerable ingenuity in the manufacture of the knives, tools, and weapons they use, and are quite expert in forging a piece of iron with no greater heat than that of their ordinary fire, with a large stone for an anvil and a smaller one for a hammer. Their knives, which are employed either as weapons of defence or for cutting blubber or sticks, are made of rasps and files, which they procure at the saw-mills after they have been used in sharpening the mill-saws; or, not uncommonly, they purchase new ones of the traders in Victoria. They are first rudely fashioned with the stone hammer into the required shape, brought to an edge by means of files, and finely sharpened on stones; they are always two-edged, so as to be used as daggers. The handles are of bone riveted, and sometimes ornamented with inserted strips of brass or copper. As they are experienced in the use of heat, they are able to temper these knives very well. The chisels are made of rasps, or of any kind of steel that can be obtained. Sometimes they take an old axe, and, after excessive labor, succeed in filing it in two, so as to make as it were two narrow axes; these are then heated and forged into the required shape, and handles attached similar to that shown in Fig. 16. They are not all carved alike, but the mode of fastening the iron to the handle is the same. The instrument for boring holes in the canoes to receive nails or wooden pegs is simply an iron or steel wire flattened at the point and sharpened; this wire or gimlet is inserted into the end of a long stick which serves as a handle; and the manner of using it is to place the point of iron on the spot where a hole is required, and then roll the stick briskly between the palms of the hands.

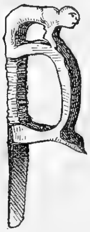
Knives somewhat resembling a round-pointed cobbler's knife are also used, the end being bent into a hook. This tool is used in carving, or for work where a gouge would be required, the workman invariably drawing the knife toward instead of thrusting it from him. All the native tools are made to operate on this principle. Cutting with a knife of any kind, or with a chisel, is done by working toward instead of from the person, and it is only when they get hold of an old plane that they work as white men do. They also make knife-blades from half an inch to two inches long, which are inserted into wooden handles, and used either for whittling or for scarifying their bodies during their medicine or ta-ma-na-was performances. Some of them have managed to procure hammers and cold chisels from the various wrecks that have been thrown on the coast from time to time; and the wreck of the steamer Southerner, in 1855, about 30 miles south of Cape Flattery, afforded a rich harvest of old iron and copper, as well as engineer's tools,

Fig. 15.



Stone adze.

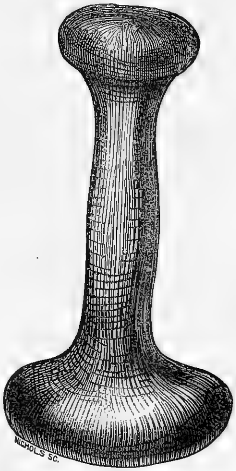
Fig. 16.



Chisel.

which have been extensively distributed and used among the coast tribes of the vicinity. Those who have been so fortunate as to obtain iron hammers use them in preference to those made of stone; but they generally use a smooth stone like a cobbler's lap-stone for an anvil. The common hammer is simply a paving stone. They, however, make hammers, or, more properly speaking, pestles, with which to drive their wooden wedges in splitting fire wood or making boards. These pestles are shaped like that shown in Fig. 17. They are made of the hardest jade that can be procured, and are wrought into shape by the slow drudgery of striking them with a smaller fragment, which knocks off a little bit at each blow. Months are consumed in the process, and it is one of their superstitions that from first to last no woman must touch the materials, nor the work be done except at night, when the maker can toil in solitude unnoticed by others. If a woman should handle the pestle, it would break; or if other persons should look on while the work was in progress the stone would split or clip off. The night is preferred, because they imagine the stone is softer then than during the day. Any one can form an idea of the nature of this manufacture and its tedious labor by taking two nodules of flint or a couple of paving stones and attempting to reduce one of them to a required shape by striking them together. Yet these Indians not only fashion their hammers in this manner, but they make very nice jobs, and some that I have seen had quite a smooth surface with a degree of polish. They are valued, according to the hardness of the stone, at from one to three blankets.

Fig. 17.

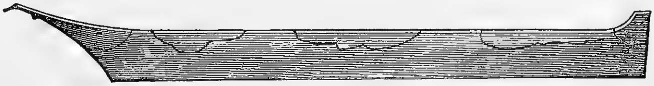


Stone hammer.

A canoe-maker's stock of tools is quite small, consisting only of an axe, a stone hammer, some wooden wedges, a chisel, a knife, and a gimlet. Those who are so fortunate as to possess a saw will use it occasionally; but the common method of cutting off a piece of wood or a board is with the axe or chisel. And yet with these simple and primitive tools they contrive to do all the carpenter work required.

The principal articles manufactured by the Makahs are canoes and whaling implements, conical hats, bark mats, fishing lines, fish-hooks, knives and daggers, bows and arrows, dog's hair blankets, feather capes, and various other articles which will hereafter be named and described. As I before remarked, the largest and best canoes are made by the Clyoquots and Nittinats on Vancouver Island; the cedar there being of a quality greatly superior to that found on or near Cape Flattery. Canoes of the medium and small sizes are made by the Makahs from cedar procured a short distance up the Strait or on the Tsuess River. After the tree is cut down and the bark stripped, the log is cut at the length required for the canoes, and the upper portion removed by splitting it off with wedges, until the greatest width is attained. The two ends are then rough-hewed to a tapering form and a portion of the inside dug out. The log is next turned over and properly shaped for a bottom, then turned back and more chopped from the inside, until enough has been removed from both inside and out to permit it to be easily handled, when it is slid into the water and taken to the lodge of the maker, where he finishes it at his leisure. In some cases they finish a canoe in the woods, but generally it is brought home as soon as they can haul it to the stream. Before the introduction of iron tools, the making of a canoe was a work of much difficulty. Their hatchets were made of stone, and their chisels of mussel shells ground to a sharp edge by rubbing them on a piece of sandstone. It required much time and extreme labor to cut down a large cedar, and it was only the chiefs who had a number of slaves at their disposal who attempted such large operations. Their method was to gather round a tree as many as could work, and these chipped away with their stone hatchets till the tree was literally gnawed down, after the fashion of beavers. Then to shape it and hollow it out was also a tedious job, and many a month would intervene between the times of commencing to fell the tree, and finishing the canoe. The implements they use at present are axes to do the rough-hewing, and chisels fitted to handles, as shown in Figure 15; these last are used like a cooper's adze, and remove the wood in small chips. The process of finishing is very slow. A white carpenter could smooth off the hull of a canoe with a plane, and do more in two hours than the Indian with his chisel can do in a week. The outside, when it is completed, serves as a guide for finishing the inside, the workman gauging the requisite thickness by placing one hand on the outside and the other on the inside and passing them over the work. He is guided in modelling by the eye, seldom if ever using a measure of any kind; and some are so expert in this that they make lines as true as the most skilful mechanic can. If the tree is not sufficiently thick to give the required width, they spring the top of the sides apart, in the middle of the canoes, by steaming the wood. The inside is filled with water which is heated by means of red hot stones, and a slow fire is made on the outside by rows of bark laid on the ground, a short distance off, but near enough to warm the cedar without burning it. This renders the wood very flexible in a short time, so that the sides can be opened from six to twelve inches. The canoe is now strengthened, and kept in form by sticks or stretchers, similar to a boat's thwarts. The ends of these stretchers are fastened with withes made from tapering cedar limbs, twisted, and used instead of cords, and the water is then emptied out; this process is not often employed, however, the log being usually sufficiently wide in the first instance. As the projections for the head and stern pieces cannot be cut from the log, they are carved from separate pieces and fastened on by means of withes and wooden pegs. A very neat and peculiar scarph is used in joining these pieces to the body of the canoe, and the parts are fitted together in a simple and effectual manner. First the scarph is made on the canoe; this is rubbed over with grease and charcoal; next the piece to be fitted is hewn as nearly like the scarph as the eye can guide, and applied to the part which has the grease on it. It is then removed, and the inequalities being at once discovered and chipped off with the chisel, the process is repeated until the whole of the scarph or the piece to be fitted is uniformly marked with the blackened grease. The joints are by this method perfectly matched, and so neat as to be water tight without any calking. The head and stern pieces being fastened on, the whole of the inside is then chipped over again, and the smaller and more indistinct the chisel marks are, the better the workmanship is considered. Until very recently it was the custom to ornament all canoes, except the small ones, with rows of the pearly valve of a species of sea-snail. These shells are procured in large quantities at Nittinat and Clyoquot, and formerly were in great demand as an article of traffic. They are inserted in the inside of the edge of the canoe by driving them into holes bored to receive them. But at present they are not much used by the Makahs, for the reason, I presume, that they are continually trading off their canoes, and find they bring quite as good a price without these ornaments as with them. I have noticed, however, among some of the Clallams, who are apt to keep a canoe much longer than the Makahs, that the shell ornaments are still used. When the canoe is finished it is painted inside with a mixture of oil and red ochre. Sometimes charcoal and oil are rubbed on the outside, but more commonly it is simply charred by means of long fagots of cedar splints, set on fire at one end like a torch, and held against the side of the canoe. The surface is then rubbed smooth with a wisp of grass or a branch of cedar twigs. When the bottom of the canoe gets foul from long use, it is dried and charred by the same process.

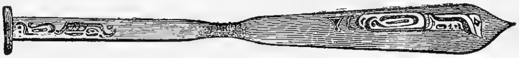
Fig. 18.



Canoe showing method of scarphing.

The small canoes sold to the white people as curiosities are made from alder; they vary in size, from two to three feet in length; but they are not good models of the great canoes, the head and stern pieces being too large in proportion to the whole, and generally the breadth is too great. Still they afford an idea of the general form. These miniature boats are usually painted in a fanciful style according to the taste of the maker. Some have in them grotesquely carved figures resembling men in various attitudes, but these do not really represent anything that may be recognized as a custom peculiar to canoe service. I have seen one with the effigy of a man on horseback standing in it, a sight that of course was never seen. Not only are there no horses at Cape Flattery, but it is quite impossible for a man on horseback to get into, and stand in, one of these canoes. I have seen others with figures of owls, eagles, and bears in them. The Indians assured me they were merely fancy work, and I mention the fact lest any one seeing these rude carvings elsewhere, might be led to suppose that they were seriously designed to represent

Fig. 19.



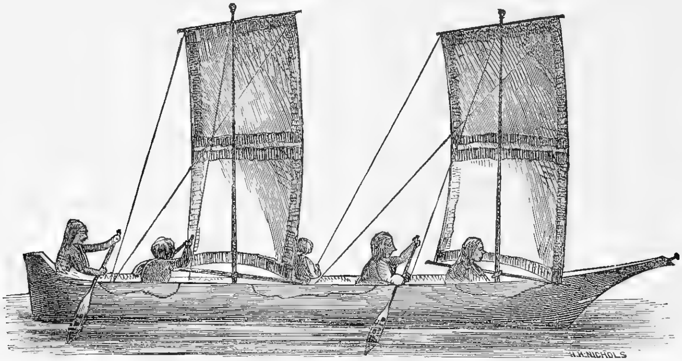
Clyoquot paddle.

certain customs of the tribe. Neither the paintings nor carvings on these miniature canoes have any symbolical value or other significance attached to them. All the large canoes, in fact all except the miniature ones, are invariably painted red inside, and charred or painted black outside.

The paddles are made of yew, and are usually procured by barter with the Clyoquot Indians. The blade is broad like an oar blade, and the end rounded in an oval or lanceolate form. The handle is a separate piece fitted transversely with the length of the paddle, and sufficiently long to afford a good hold for the hand. These paddles when new are blackened by slightly charring them in the fire, and then rubbed smooth and slightly polished.

The sails were formerly made of mats of cedar bark, which are still used by some of the Clyoquots, although most of the tribes in the vicinity now use cotton. The usual form is square, with sticks at the top and bottom like a vessel's yards; a line passes through a hole in the top of the mast, rigged from the lower stick, and the sail is easily and quickly hoisted or lowered. When taken in it is rolled round the lower yard, and can be enlarged to its full size or reduced to adjust it to the force of the wind. Some Indians have adopted sprit-sails, but they are not in general use, nor are they as safe or convenient for the canoe as the square sail.

Fig. 20.



Canoe under sail.

In cruising on the Strait they usually keep well in shore, unless they intend to cross to the opposite side; and, if the canoe is large and heavily laden, they always anchor at night, and for this purpose use a large stone tied to a stout line. Sometimes they moor for the night by tying the canoe to the kelp. When the craft is not heavily burdened it is invariably hauled on the beach whenever the object is to encamp. If the wind is fair, or they have white men on board, they will travel all night, but on their trading excursions they usually encamp, which causes much delay in a journey. I have been seven days in the winter season making the passage between Neeah Bay and Port Townsend, about one hundred miles, and in the summer have made the same trip in but little over twenty-four hours. The average passage, however, is about three days for the distance named, which includes camping two nights.

Whaling and Fishing Gear.—This is a most interesting and important portion of the manufacture of the Makahs, and consists of harpoons, ropes, lines, buoys, fish-hooks, spears, &c.

The harpoon has been partly described before. Its head is made of sheet copper or sheet iron, cut as shown in Fig. 4, *a*. The barbs are of elk or deer horn, and shaped as shown in Fig. 4, *b*. These are fixed on each side of the blade or point, fitted tightly, and kept in place by cords or strips of bark. The whole is then covered with spruce gum, which is obtained by setting a fat pitch-knot by the fire, and catching the melted pitch in a shell placed beneath. It is then kneaded till it acquires the consistency of soft cobbler's wax, and is applied and distributed with the fingers. The whole blade and a portion of the barbs are covered with this pitch, which when cool is hard and smooth, and forms a tapering wedge-shaped spear-head. The pitch is then scraped from the edge of the blade, which is ground very sharp. The lanyard attached to the spear-head is made of the sinews of the whale, twisted into a rope and covered with twine. It is made fast to the head by unlaying the strands, fitting them around the barbs, and winding the cord and bark over them while fastening the barbs on. The fisherman is careful to have the lanyard securely fastened to the barbs, for on it depends the hold of the buoy on the whale. The blades, not being so securely fastened, frequently get loose after being imbedded in a whale for a long time, although some that were shown to me have been used for years.

This species of harpoon would scarcely be strong enough to bear the strain of a whale boat towing by it, as is the practice with our whalemen; but as they have only to bear the tension of the buoyancy of the float which is attached to the lanyard, they answer the double purpose of impeding the progress of the whale, so as to enable the Indian to kill it, and also of keeping the body from sinking after it is dead. The staff of the harpoon I have already described.

The method of making ropes and cords from sinews of the whale is as follows: The sinews, after being well dried, are separated into small fibres, and when ready for twisting resemble finely dressed flax. The threads are spun by twisting them between the palm of the hand and the naked thigh, and, as they are twisted, they are rolled up into balls. When unrolled for use they are twisted in the same manner by rolling them on the thigh. The strands are prepared from fine or coarse fibres, as the size of the cord or rope may require. Twine too is made by the process just described; but ropes are first made into strands, and these strands are twisted by hand and laid together with much hard work, which might be avoided by the use of the most primitive machinery of our rope factories. But the Makahs use nothing but their hands, and, although the work is slow and hard, yet they manufacture as handsome ropes as any of the "hand-laid" articles of the whites.

Ropes of greater size, such as are required for towing whales, are made of the tapering limbs of the cedar, first twisted like withes; and from the long fibrous roots of the spruce. These are first cut in lengths of three or four feet, and then subjected to a process of roasting or steaming in the ashes, which renders them extremely tough and pliable and easy to split. They are reduced to fine strands or threads with knives, and are then twisted and laid in ropes by the same process as that described for making the rope of sinews. Those that are attached to the buoys have one end very neatly tapered down, as shown in Fig. 4. This is to enable the whalemen to tie the rope with facility, and to pass it readily through the loop in the end of the harpoon lanyard. In making ropes, it is customary for quite a number of persons to assist. They are invited by the man who wishes to get ready his whaling gear, and each prepares a portion of the roots or sinews, so as to have as much as may be required at once. The next operation is to twist the fibres into threads. Another party, perhaps the same individuals, will meet on another day and work till the strands are completed. Then there may be a resting spell, probably because the provisions are exhausted and more must be obtained. The operation is often interrupted, and resumed at intervals, consequently much time is consumed in completing the work, a rope of thirty fathoms occupying frequently a whole winter in its manufacture.

Fishing lines, as already described, are made of the kelp stem. This is collected by means of two sticks joined like the letter V. At the bottom a stone is secured as a sinker; five or six inches above the stone a knife-blade is fastened between the two sticks, and a line is then fastened to the upper ends. This instrument is slipped over the bulb of kelp and lowered to the bottom, and a slight pull severs the stem close to the ground. They usually prefer the kelp growing in ten or twelve fathoms of water; most of the stems, however, that they procure rarely exceed ten fathoms in length, and many are not over five. The lower portion of the kelp stem is solid and cylindrical, and about a fourth of an inch in diameter. It retains this size for five or six fathoms, and then increases very gradually to the surface of the water, where it terminates in a globular head from four to six inches in diameter, from which float long streamer-like leaves. For more than half its length the stem is hollow, but this section is not taken for lines. The bulbs are frequently used to hold bait, or as water-bottles for fishermen. When a sufficient number of stems have been cut they are placed in fresh water—a running brook being always preferred—where they remain for five or six days, or until they become bleached nearly white. They are then partially dried in the smoke, and knotted together at the ends, and further dried in the sun, after being stretched to their full length, and to their utmost tension. This process reduces the size to that of a cod-line. They require several days' exposure to the sun and air before they are sufficiently cured. They are taken in every night while curing, and are coiled up very neatly each time. When perfectly dry they are brittle, and break easily, but, when wet, they are exceedingly strong, fully equal to the best of hemp cod-lines. The usual length is from eighty to one hundred fathoms, although it is seldom that fishing is attempted at that depth, except for the "*be-shó-we*" or black cod; and the probable reason for their being so long is to guard against accidents by which a portion of the line may be lost. When fishing in shoal water, it is usual to untie a portion of the line at the required depth, and lay the remainder on one side, so as not to endanger its being entangled by the fish that may be caught.

Lines for small fish are made from kelp stems of the first year's growth, which are about as large as pipe-stems, with heads perfectly round and of the size of billiard balls. I supposed from the dissimilarity in the appearance of the kelp that it was a different variety, till the Indians assured me that it was all the same, but that it did not attain its full growth the first year. I have had no means of making observations to satisfy myself on this point; but as they make so much use of kelp, and seem to know so much about it, I am inclined to think they must be correct.

The halibut hook (Fig. 9) is a peculiarly shaped instrument, and is made of splints from hemlock knots bent in a form somewhat resembling an ox bow. These knots remain perfectly sound long after the body of the tree has decayed, and are exceedingly tough. They are selected in preference to those of spruce because there is no pitch in them to offend the fish, which will not bite at a hook that smells of resin. The knots are first split into small pieces, and after being shaped with a knife, are inserted into a hollow piece of the stem of the kelp and roasted or steamed in the hot ashes until they are pliable; they are then bent into the required form, and tied until they are cold, when they retain the shape given them. A barb made of a piece of bone is firmly lashed on the lower side of the hook with slips of spruce cut thin like a ribbon, or with strips of bark of the wild cherry. The upper arm of the hook is slightly curved outward, and wound around with bark to keep it from splitting. A thread made of whale sinews is usually fastened to the hook for the purpose of tying on the bait, and another of the same material loosely twisted, serves to fasten the hook to the kelp line. As the halibut's mouth is vertical, instead of horizontal like that of most other fish, it readily takes the hook, the upper portion of which passes outside and over the corner of the mouth, and acts as a sort of spring to fasten the barb into the fish's jaw. The Indians prefer this kind of hook for halibut fishing, although they can readily procure metal ones from the white traders. Smaller hooks for codfish are made of a single straight piece of wood from four to six inches long, with a bone barb lashed on in a manner similar to the barb of the halibut hook.

Fig. 21.

Codfish hook. No. 2629.

For very small fish, like perch or rock fish, they simply fasten a small piece of bone to a line of sinews. The bone is made sharp as a needle at both ends, and is tied in the middle. Many of the old men will not use any other than native made hooks and lines; while a few are very glad to obtain fish hooks and lines from the whites. In every canoe is a club for killing fish, which is usually nothing more than a billet of wood roughly fashioned, though sometimes rudely carved, as seen in

Figs. 22, 23. This club is about a foot long, and is commonly made of yew, and its use is to stun the fish by striking it on the head before the hook is removed from the mouth. Another instrument used in fishing is called the kák-te-wahd′-de (Fig. 24). This is formed of two slender slips of cedar something in the shape of feathers. What would be the quill part is fastened to a bit of wood with a stone in it, to keep the instrument in an upright position. It is used for attracting fish when they do not bite readily. The Indian takes his fishing spear, thrusts the kák-te-wahd-de to the bottom, and when he releases it, its buoyancy brings it to the surface, while the wooden blades or feathers create a rotary or gyratory motion which attracts the fish.

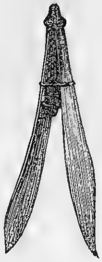
Fig. 22.

Fish club.

Fig. 23.

Fish club.

Fig. 24.



Boxes, Baskets, Mats, &c.—Vessels for carrying water, and large boxes for containing blankets or clothing, are made in the following manner: a board as wide as the box is intended to be high, is carefully smoothed with a chisel, then marked off into four divisions, and at each of the marks cut nearly in two. The wood is then wet with warm water, and gently bent around until the corners are fully formed. Thus three corners of the box are made, and the remaining one formed by the meeting of the two ends of the board, is fastened by wooden pegs. The bottom is then tightly fitted in by pins, and the box is made. The water box or bucket consists of one of these, and the chest is simply two large boxes, one shutting down over the other. These boxes are manufactured principally by the Clyoquot Indians, very few being made by the Makahs, on account of the scarcity of good cedar. They procure these by barter, and every lodge has a greater or less number of them according to the wealth of the occupants. Many have trunks purchased from the whites, either of Chinese or American manufacture, but although they can readily supply themselves at cheap rates with these as well as with water pails, they prefer those used by their ancestors. Wooden bowls and dishes are usually manufactured from alder (Figs. 25 to 28). Some are of an oblong

Fig. 25. No. 2566.

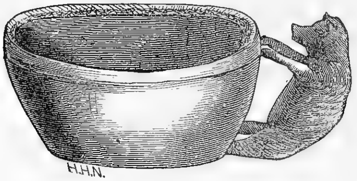
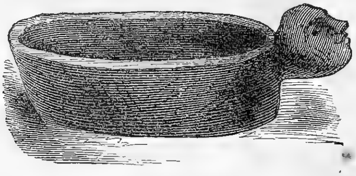


Fig. 26.

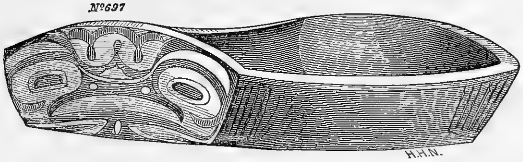


shape and used as chopping trays (Figs. 27 and 28). The wood of the alder, when freshly cut, is soft and white and easily worked, but a short exposure to the air hardens and turns it to a red color. The bark chewed and spit into a dish forms a bright red dye pigment of a permanent color, which is used for dyeing cedar bark or grass. I have tried to extract this color by other means, but find that no process produces so good a dye as chewing. Alcohol gives an orange color, and boiling water, dark brown or black. I think, however, if it were macerated or ground in warm water, with, perhaps, the addition of certain salts, a very useful dye might be obtained.

Fig. 27. No. 1137.

Wooden trencher.

Fig. 28.



Wooden bowls and dishes.

Bowls are sometimes made of knots taken from decayed logs of maple or fir, as represented in Figs. 29 and 30.

Fig. 29.

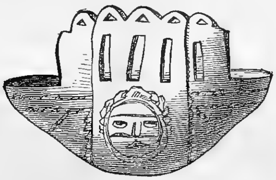
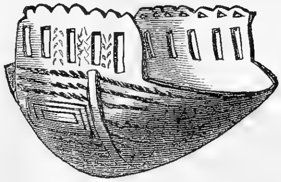


Fig. 30.



Wooden bowls of maple or fir knots.

Feather and Dog's-hair Blankets.—Blankets are not only made of feathers, or rather down, and of dog's hair, but also of cedar bark. The method of manufacturing the first named is to select a bird that has plenty of down, and, first picking out all the feathers carefully, to skin it, and then dry the skin with the down on. When a sufficient number have been prepared they are slightly moistened, then cut into narrow strips, each one of which is twisted around a thread, leaving the down outside, which thus forms a round cord of down resembling a lady's fur boa. This is woven with twine and forms a compact, light, and very warm blanket. The hair blankets are made from the woolly covering of a species of dog of a yellowish-white color, which, after having been sheared off, is packed away with dry pulverized pipe clay, for the purpose of extracting the oil or grease. When a sufficient quantity has been obtained, and has remained long enough in the pipe clay, it is carefully picked over by hand, and beaten with a stick to knock out the dirt. It is then twisted on strong threads, and finally woven into a thick, strong, and heavy blanket. The pipe clay[1] is procured at Kwillĕyute. The weaving process does not clean out all this substance, since its presence can be readily noticed at any time by shaking or beating the blanket. Bark blankets and capes are made from the inner bark of the cedar, dried and beaten into a fine mass of fibres, which are then spun into threads, and woven into the required forms, the edges of which are trimmed with fur. Very nice ones are also made by the Clyoquot Indians from the inner bark of the white pine, which is whiter and softer than cedar bark.

Gambling Implements.—Of these one form consists of disks made from the wood of a hazel which grows at Cape Flattery and vicinity. The shrub is from ten to fifteen feet high, and with limbs from two to three inches in diameter. The name in Makah is hul-li-á-ko-bupt, the disks hul-liák, and the game la-hul-lum. The game is common among all the Indians of this territory, and is called in the jargon la-hull. The disks are circular like checkers, about two inches in diameter, and the fourth of an inch thick; and are usually smoothed off and polished with care. They are first cut off transversely from the end of a stick which has been selected and properly prepared, then smoothed and polished, and marked on the outer edge with the color that designates their value. They are used in sets of ten, one of which is entirely black on the outer edge, another entirely white, and the rest of all degrees from black to white. Two persons play at the game, each having a mat before him, with the end next his opponent slightly raised, so that the disks cannot roll out of reach. Each player has ten disks which he covers with a quantity of the finely-beaten bark, and then separates the heap into two equal parts, shifting them rapidly on the mat from hand to hand. The opposing player guesses which heap contains the white or black, and on making his selection the disks are rolled down the mat, when each piece is separately seen. If he has guessed right, he wins; if not, he loses. Another game consists in passing a stick rapidly from hand to hand, and the object is to guess in which hand it may be. A third game, played by females, is with marked beaver teeth, which are thrown like dice. Four teeth are used; one side of each has marks, and the other is plain. If all four marked sides come up, or all four plain sides, the throw forms a double; if two marked and two plain ones come up, it is a single; uneven numbers lose. Both males and females are passionately fond of these games, and continue them for days, or until one or the other loses all that can be staked.

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[1] Diatomaceous earth. (G. G.)

Mats, Baskets, Ornaments, &c.—Mats constitute one of the principal manufactures of the females during the winter months. With the Makahs, cedar bark is the only material used. Other tribes, who can obtain bulrushes and flags, make their mats of these plants, which, however, do not grow in the vicinity of Cape Flattery. Cedar bark, which constitutes an important item in their domestic economy, is prepared by first removing the outer bark from young trees, then peeling the inner bark off in long strips, which are dried in the sun, folded in a compact form, and used as articles of trade or barter. When wanted for use, if for making mats, the strips are split into strands varying from an eighth to a quarter of an inch in width, and as thick as stout wrapping-paper. These are then neatly woven together, so as to form a mat six feet long by three wide. Formerly mats were used as canoe sails, but at present they are employed for wrapping up blankets, for protecting the cargoes in canoes, and for sale to the whites, who use them as lining of rooms, or as floor coverings. Baskets for various uses are also made of this bark; but, as it is not very strong, those used for carrying burdens are made from spruce roots.

The bark is reduced to fine fibres by being broken across the edge of a paddle, and, when perfectly prepared in this way, is put to a variety of uses. It serves to make the beds of infants, for gun-wadding, as a substitute for towels, and for gambling in the game of la-hull. It is often dyed red with alder bark, and worn like a turban around the head during tamánawas performances. In the mat manufacture some is dyed black by soaking it in mud, and woven in as a sort of ornament around the edge, or as the dividing line across the centre. The Kwillé-yute tribe manufacture very neat mats of a species of coarse grass, and excellent baskets from ash, which grows upon the banks of the river. These are common among the Makahs, being received in the way of trade.

Fig. 31.

Conical hat.

Conical-shaped hats are made of spruce roots split into fine fibres, and plaited so as to be impervious to water. They are very ingeniously manufactured, and it requires some skill and experience to make one nicely. These hats are painted with rude devices on the outside, the colors being a black ground with red figures. The black is produced by grinding a piece of bituminous coal with salmon eggs, which have been chewed and spit on a stone; the red, by a mixture of vermilion and chewed salmon eggs. These eggs, after having been first dried, form a glutinous substance when chewed, which easily mixes with the colors, and forms a paint that dries readily and is very durable. The designs are drawn with brushes made of sticks, with the ends chewed. Some Indians, however, use brushes or pencils of human hair for these designs as well as those on the miniature canoes; but the most common brush is simply a stick. The process, with these rude implements, is very slow.

Beside the conical hats worn by themselves, they have also, of late years, manufactured hats which they sell to the white men. These are shaped like the common straw hat, and are made of spruce roots, and, although rather heavy, are strong and durable. Some have designs of various kinds woven in them, while others are plain, the color being of a buff, somewhat resembling the Mexican wool hats. This color cannot be removed by bleaching, attempts for this purpose having been made in San Francisco and Victoria; but the experiment proved a failure. The color, however, is no objection, and is indeed rather preferred; the hats being more generally purchased as curiosities than as articles for wear. Within a few years past they have taken a fancy to cover with basket-work any bottles or vials they can obtain, and, as they do this sort of work very well, they find ready sale for it among the seekers after Indian curiosities.

During rainy weather they make use of capes worn over the shoulders while in the canoes. These are woven whole, with a single opening in the centre for the head to pass through, something like a *poncho*. They come down from the neck to the elbow, and are usually trimmed with fur around the edges. Some are woven from cedar bark, and others from strips of cloth or old blankets. They are warm, and impervious to water, and when an Indian has on one of these and his conical hat, his head and shoulders are well protected from wet. The rest of his body he seems to care little about, and he paddles round in his canoe with bare legs and arms, seemingly as indifferent to the rain or the water as a seal or an otter.

Fig. 32.

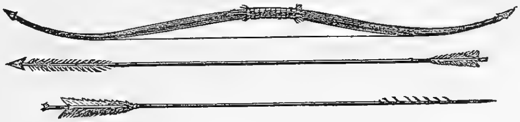
Bark basket.

The baskets made by the Makahs are classed according to the material of which they are formed, and the uses to which they are put. The large ones, made of bark, which are used for holding dried fish, or blankets, are called klap-páirk. Carrying-baskets, worn on the back, with a strap around the forehead, are made of spruce roots or cedar twigs. They are woven quite open, and much larger at the top than at the bottom, the form tapering down in something of a wedge-shape. This enables them to carry loads with greater ease, as the weight is kept well up on the shoulders. These baskets are called bo-hé-vi. Small baskets are made of bark and grass, dyed of various colors. Some are woven with designs intended to represent birds or animals; others in simple checks of various patterns. Other small ones are of bark, and a species of eel grass that bleaches of a beautiful white. These small baskets are called pé-ko. The various colors are produced thus: black, by immersing the material in the salt-water mud, where it remains several weeks, usually during the summer months; a place being selected where the mud is rich with marine algæ, and emits a fetid smell, the sulphuretted hydrogen undoubtedly being the agent that imparts the color to the vegetable fibres of the bark or grass; red is procured from the alder bark by the process already described; yellow from the bark of the root of the Oregon grape (*Berberis*), which is boiled, and the grass immersed in it. Bark is not dyed yellow, that color only being imparted to beach grass, which is used for weaving into baskets, and around the edges of some kinds of mats as an ornament. Grass in its natural state, by contrast with the other colors, appears white; but a pure white is obtained from the eel grass, or sea weed, which is procured in the bay, and bleached in the sun.

Their ornaments consist mainly of the head and ear decorations worn by young girls, and of pieces of variegated shell inserted in their noses and ears. The first are made of the *Dentalium*, which is procured by barter with the Nootkan and other Indians of Vancouver Island. The shape of these ornaments is shown in Fig. 3, the shells being run on strings separated by pieces of leather, and so arranged as to form a fillet to surround the head. The shells, in the ear ornaments, generally have their tapering or small end up. These last are usually finished off with a quantity of glass beads of various sizes, shapes, and colors. They are not, however, attached to the head ornament, as shown in the drawing, unless they are very heavy; but usually tied to the ear, which is pierced all round the edge with holes, into which the strings are inserted. When the ornaments are laid aside, these holes in the ear usually have a piece of twine tied in them, and sometimes brass buttons are attached to the twine. This head ornament is very pretty, and when a squaw is in full dress she has quite a picturesque appearance. The shell ornaments for the nose are made of the *Haliotis*, which is procured on Vancouver Island. The largest specimens I have seen came from the Cowitchan district, on the eastern side; smaller ones are found at Clyoquot and Nootka. The pieces worn in the nose are of various shapes, circular, oval, or triangular, and hang pendent by means of a string; others are cut in the form of rings, with a small opening on one side, so they can be inserted or removed at pleasure; the size varies from a dime to a quarter of a dollar. Some of the ear ornaments, however, and particularly those worn by children, are much larger—not unfrequently two inches square. These are fastened to the rim of the ear by strings; they are not very attractive ornaments, as they serve to give the wearer a very savage appearance. Bracelets are made of brass wire, bent to the form of the wrist; some are rudely ornamented by notches filed in them, but most of them are plain. Finger rings are manufactured out of silver coin by first beating it flat, and then cutting it into strips, which are bent into a circular form and smoothed. The ends are not joined together, probably from the fact that they do not understand the art of brazing; although among the Haida and Chimsyan tribes the art of working in precious metals has attained a considerable degree of perfection.

Bows and Arrows, Fish, and Bird-spears.—The bow is usually made from yew, and bent in the form shown in Fig. 33; but many are straight, simply acquiring a curved form when bent for use. Those that are made with care have usually a lock of hair fastened to the middle by means of a strip of bark wound around it. The string is made of whale sinews or seal gut, and is very strong. Inferior bows are made of a species of dog-wood which grows around Neeah Bay. This wood is white and tough, and also makes excellent hoops for barrels. The bow is used

Fig. 33.



principally by the boys, who are not very dexterous in its use, but manage to kill birds and other small game; as a weapon of defence it is scarcely ever used, fire-arms entirely superseding it, most, if not all, of the men having guns. The arrows are made of cedar split into the required size and finished with a knife. It is usual when making arrows to be seated holding one end of the stick with the toes of the left foot, and the other end in the left hand, and to use the knife by drawing it towards the person. The arrow-heads are of various patterns; some are made of a piece of iron wire, which is usually obtained from the rim of some old tin pan or kettle; this is flattened at the point, sharpened, and a barb filed on one side, and driven into the end of the shaft; a strip of bark is wound around it to keep the wood from splitting. Some are made of bone with jagged edges, like barbs; others of two pieces of wood or bone so attached as to form a very acute angle to the shaft; others again are regularly shaped, double-barbed, and with triangular heads of iron or copper, of very neat workmanship. All the arrows are winged or tipped with feathers to give them a steady flight through the air. They are all buoyant, so as to be readily recovered after having been shot at waterfowl, for the aim while shooting from a canoe can no more be relied on than in throwing a stone. Frequently five or six arrows will be shot at a duck before it is hit, and they will often miss it altogether.

The bird spears are made of three or four prongs of different lengths, jagged, and barbed, and fastened to a pole or staff ten or twelve feet long, with a place at the upper end for the hand to press against. This spear is used at night, when the natives go in a canoe with fire to attract the birds. The prongs are made either of wood or bone. Fish spears have longer poles, and barbs of iron or bone, and are used for spearing fish, echini, and crabs. The manufacture of implements is practised by all; some, however, producing neater articles, are more employed in this way. The manufacture of whaling implements, particularly the staff of the harpoon and the harpoon head, is confined to individuals who dispose of them to the others. This is also the case with rope making; although all understand the process, some are peculiarly expert, and generally do the most of the work. Canoe making is another branch that is confined to certain persons who have more skill than others in forming the model and in finishing the work. Although they do not seem to have regular trades in these manufactures, yet the most expert principally confine themselves to certain branches. Some are quite skilful in working iron and copper, others in carving, or in painting; while others, again, are more expert in catching fish or killing whales.

Fig. 34.

Bird spear.

Although clay is found at Neeah Bay, the Indians do not know how to manufacture earthen or pottery ware. Their ancient utensils for boiling were simply wooden troughs, and the method of cooking in them being by hot stones, with which they could boil or steam whatever they desired to prepare. These troughs are used by many at the present day, and are preferred for cooking fish and potatoes to boiling in kettles; particularly on occasions of feasting, where a large quantity of food is to be prepared; but for ordinary purposes pots and kettles are used. Iron pots and brass kettles, with a goodly display of tin pans, are to be found in every lodge, all of which are purchased from the white traders.[1]

SONGS.—The songs of the Makahs are in great variety, and vary from that of the mother lulling her infant to sleep, to barbarous war cries and horribly discordant "medicine" refrains. Some of the tunes are sung in chorus, and many of the airs of the children do not sound badly when heard in the distance. They are good imitators, and readily learn the songs of the white men, particularly the popular negro melodies. Some of their best tunes are a mixture of our popular airs with notes of their own, and of these they sing several bars, and while one is expecting to hear them finish as they began, they will suddenly change into a barbarous discord. Their songs at ceremonials consist of a recitative and chorus, in which it would be difficult for any one to represent in musical characters the wild, savage sounds to which they gave utterance.

Some of the tribes sing the songs that have been composed by other tribes, and as they cannot always pronounce the words accurately, a person is liable to be misled as to the meaning. I was present, with several other white persons, at the opening ceremonies of the Clallams, at Port Townsend, a few years since. The chorus was a repetition of the words (as we all understood them) "a new-kushu ah yah yah." Kushu in the jargon means hog, and we supposed they were referring to that animal. The words, however, which they did pronounce were "wah-noo-koo-choo ah yah yah," but they said they did not know their meaning, they were "tamánawas." I subsequently ascertained that the song originated with the Clyoquots, and by them it is pronounced "wă-nă-kā-chee-ah yă yăh," and signifies a disposition to break things, or to kill their friends; and is in evidence of a bold and fearless spirit. Sometimes the young men assemble in the evening and sing some simple air in chorus, the words being generally improvised. They keep time with a drum or tambourine, which is simply a skin stretched tightly on a hoop. These songs sound very well, and are melodious when compared to some of their other chants. Many, both males and females, have good voices, and could be taught to sing, but their own native songs have nothing to recommend them to civilized ears. The words used are very few, seldom extending beyond those of a single sentence, and generally not more than one or two, which are repeated and sung by the hour. Sometimes they take the name of an individual, and repeat this over and over. A single instance will suffice as an illustration: There was a young Nittinat Indian, by the name of Bah-die, who was quite a favorite with the Makah boys. Some prank that he played caused his name to be frequently mentioned, and finally some one sang it to a tune with a rousing chorus. All the words used were "ah Bah-die," and this would be roared through all the changes in the gamut. This was a popular and favorite tune till Bah-die died, and then it was dropped, as they would not mention his name after he was dead.

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[1] Arrow and spear-heads of stone seem not to have been used by the tribes in this part of the coast. Basket work and wood take the place of pottery, the manufacture of which article, however, again prevails among some of the tribes of Alaska.—G. G.

Method of Warfare.—The causes of feuds and hostilities between the coast tribes are usually of a trivial nature, generally originating in a theft, either of canoes, slaves, or blankets, or sometimes a dispute about a barter; but as these difficulties, no matter how they originate, are never confined to the principals, but are taken up by friends and relatives on both sides, reprisals are made on any one who may chance to fall in the way. For instance, a Makah visiting a neighboring tribe may perhaps steal something. He will not be pursued and the property taken away, but an opportunity will be embraced at some other time to steal from any Makah who may visit the same tribe. He in return may possibly kill some one, and then the whole tribe is held responsible. Sometimes several years may intervene between the commission of the first offence and the breaking out of hostilities; but every offence is remembered, and if not settled in an amicable manner, is avenged sooner or later. Since I have been among the Makahs, I have known but one war expedition, and a description of that will illustrate their general system of warfare.

An Indian belonging to the Makah tribe had a difficulty with an Elwha Indian belonging to a band of Clallams, who reside at the mouth of the Elwha River, emptying into the Strait of Fuca, near Port Angeles. The difficulty was about a squaw, and the ill-feeling had lasted for a year or two when the Elwha waylaid the Makah, and shot him. As the murdered man was a chief, the whole tribe were determined to avenge the murder; but first they referred the affair to the agents of the Indian Department, who promised that the murderer should be arrested and hung; nothing, however, was done about it, and at last the tribe, getting tired of waiting the action of the white men, concluded to settle the affair in their own way. After several meetings had been held, and the matter decided upon, they prepared themselves for war. The plan of approach to the Elwha village was first drawn on the sand, and the method of attack decided on. They then prepared great torches of dried pitch-wood made into fagots, and tied on the ends of poles. These were to set the houses of the Elwhas on fire. Knives were also sharpened, bows and arrows prepared, bullets cast, and guns cleaned. The largest canoes were put in war trim to convey the party, were blackened by burning fagots of cedar splints passed along under the bottom, freshly painted red in the inside, and decorated with branches of spruce limbs tied to the head and stern. There were twelve of these canoes, containing in all about eighty men, dressed with their blankets girt tight about the waist, in such a manner as to leave both arms free. Their faces were painted black, and their hair tied up in a club-knot behind, and bound round with sprigs of evergreen. They assembled on the beach previous to starting, where speeches were made and war dances performed; they then embarked precipitately and set off at the full speed of their boats up the Strait for Elwha village. As soon as they had gone, the women and children assembled on the roofs of the lodges and commenced a dismal chant, which they continued for a couple of hours, accompanying their music with beating the roof boards with sticks to mark the time. Each day, during the absence of the men, the women went through this performance at sunrise and sunset. On the third day the party returned, bringing with them the heads of two Elwhas they had killed. They came with songs of victory, with shouts, and firing volleys of musketry. When they had landed on the beach, they formed a circle, and having placed the two heads on the sand in the centre, they danced and howled around them like fiends. Speeches were then made, another volley fired, and the heads taken from village to village, at each of which the same scenes were repeated, until they finally arrived at Tsuess, the residence of the chief of the expedition, where they were stuck on two poles, and remained several months, presenting a weather-beaten and very ghastly appearance. From the parade the Indians made on starting, and after their return, one would be led to suppose that they had boldly attacked their enemies and burned their village; but such was not the fact. They crept along the coast, and after they had reached a point a few miles from Elwha, they hid themselves and sent a canoe to reconnoitre. This party discovered a couple of Elwhas fishing, and getting between them and the shore, killed them, cut off their heads, and returned to the main body, who, considering the murder of the chief fully avenged, returned without making any further demonstrations. Formerly, however, these battles were very sanguinary, numbers being killed on both sides and prisoners taken, who were invariably made slaves; but of late years they have confined themselves to occasional murders only, fearing lest any more extensive warfare would call down upon them the vengeance of the whites. They do not appear to have practised scalping, their custom being to cut off the heads of their enemies, which they bring home as trophies.

Since the system of reservations has been established, with officials residing upon them, there have been no attempts made by the Makahs to go on these war parties; but they refer all their grievances instead to their agent; they have, however, been threatened with an attack from some of the Vancouver Island Indians, and during the time the apprehension lasted they put themselves in a state of defence by erecting stockades of poles and brush about their houses, which they pierced with loopholes, and by keeping a constant watch night and day. Formerly they had stockade forts at Tatoosh Island, and on one of the rocky islets composing Flattery Rocks, where on an attack by their enemies, or during any alarm, they retired as to strongholds, in which they could easily defend themselves. These forts have been done away with for several years, and the only one that I know of at present, between the Columbia River and Cape Flattery, is at Kwilléyute. A precipitous rock, several hundred feet high, situated at the mouth of that river, is still fortified, and to all Indian attack is perfectly impregnable. I visited this rock a few years since, and found it several acres in extent on the surface, and with quite a growth of large spruce trees upon it, which are used both for firewood and for defence. There is but one path by which the summit can be gained, and to defend this they roll great logs to the brink of the descent, whence they can be easily thrown down on any force attacking them. As the approach is steep and slippery, nothing could prevent a log from sweeping down as many as might be in its path. The only way they could be subdued would be by siege and starvation; but that species of warfare does not seem to be practised among the coast tribes, their plan being to go in a body in their canoes, surprise their enemies, and return as soon as possible whether successful or not.

It has been customary to kill the men who fall into their hands, and to make slaves of the women and children; but very few if any slaves have been gained by the Makahs in this manner for several years past; all they have acquired being by purchase. They never bury their enemies slain in battle, as they have a superstition that the bodies would come to life again, and attack them; so they leave them exposed to the wolves; but the heads are stuck on poles, in order to be readily seen at all times. Thus, if the enemy should recover the bodies of his slain, and bury them, it would not matter so long as the heads were drying in the air. The two heads of the Elwhas that I have mentioned had remained on poles for several months, when the relatives requested permission to purchase them of the old chief who had them in charge, and offered ten blankets apiece; but the old savage refused the offer with the greatest disgust, and being fearful that I might possibly get hold of them for specimens, he hid them away in the woods, and I saw them no more. This chief, whose name was Kobétsi, or Kabátsat, was a powerful man, possessed of great strength and personal bravery. He was celebrated for his prowess in killing whales, and that, together with his being an hereditary chief, had given him the pre-eminence on all war parties. The other chief who headed the expedition was also a celebrated whale-killer named Häahtse, or Sowsom.

Government.—Formerly the tribe had chiefs and head men whose word was law. The strongest man, who had the most friends or relatives, was the head chief, but of late years there has been no head. In every village there are several who claim a descent from chiefs of note, and call themselves chiefs and owners of the land, but their claims are seldom recognized, excepting that they are considered as belonging to the aristocracy, and are superior to the mis-che-mas or common people, or the kōt-hlo or slaves. They are listened to in counsel, and always invited to feasts; are sure of a share of all presents, and of their proportion of any whales that are killed; but no one takes precedence of the rest, although many, if not all, would be very glad to be considered as the head chief provided the rest would consent. The eldest son of a chief succeeds to the title and property of the father, and in case of several children, of whom only one is a boy, he takes the property whether he is the eldest or youngest child. In case of a chief who died leaving one child, a son, the widow took for a second husband the brother of the one who died. By the last one she had a girl, and the father told me that his property too would descend to his brother's son, and not to the girl who was his own and only child. In the event of his having a son, the bulk of the property would still go to the nephew, whom he considered as his eldest son. The dignity of chief or head man can be attained by any one who possesses personal prowess, and who may be fortunate enough to accumulate property. An instance of this kind is in the case of Sekówt'hl, the head chief of the tribe, who was appointed such by Governor Stevens at the time of making the treaty. Sekówt'hl's mother was a slave, and his father a common person, but he was very brave and very successful in killing whales, and having accumulated much wealth in blankets, canoes, and slaves, was enabled to marry the daughter of a chief, by whom he had a son, who is also celebrated for his strength and bravery, and his success in the whale fishery, and is now considered as one of the principal chiefs of the village at Flattery Rocks, where both father and son reside.

In the government of the tribe at present, all matters of importance are submitted to a council, which is held whenever any one gives a feast, or during the time of the ceremonials of the tamánawas. The old men on these occasions generally do all the talking, although women are permitted to speak on matters where they are concerned. I have known of but two or three instances where they have inflicted punishment, and on those occasions their mode was a pretty rough one. The first case was that of a man who was noted for his quarrelsome disposition; always in trouble, and always finding fault. Having become offended with his squaw, he turned her off and took another, a practice which is very common, both men and women leaving their partners on the most trivial occasions. Some time afterward the squaw got another husband, at which the first one was very indignant; and after much wordy warfare finally stabbed the new husband in the back. This was considered a gross outrage by the rest of the tribe; not the stabbing, but doing it without sufficient cause. The head men deliberated, and at last gathering together a band of friends, they proceeded to the village where the culprit resided, and after first securing him, they pulled out his hair and scarified the top of his head. The women finished the scene by pouring salt water on him, and rubbing his head with sand. One of the performers in this strange mode of punishment told me that the man felt very much ashamed, and would probably hereafter be more civil in his speech, and try and improve his fractious temper, a result very likely to be attained, as they promised upon a repetition of any more acts of violence to treat him to another and a severer dose. I have observed that he has been remarkably quiet in his deportment ever since. The other instances were for offences committed during the tamánawas ceremonies, and the punishment consisted in having sharp skewers of bone thrust through the fleshy part of the arms between the elbows and shoulders. After they had thus remained a short time, they were pulled out, and stuck in the bark head band, where they were obliged to be worn during the remainder of the ceremonies. In some instances they close the mouth by thrusting these skewers through the lips. This punishment is inflicted on those who laugh at or ridicule the ceremonials. In cases of theft, adultery, or murder, an opportunity is always offered to compromise the affair by restitution of the stolen property; and by the payment of a certain amount of blankets, guns, or canoes for the other offences; the amount of such payment being decided by the friends of the plaintiff in the case. If no such compromise is made, the aggrieved party will take his revenge either on the person who has committed the offence, or on any of his relatives; this revenge will be satisfied by breaking up a valuable canoe, taking forcible possession of any blankets or guns that may be had; or, if the offence consists in murder, by shooting or stabbing the offender or his nearest relative.

With the exceptions I have already noticed, there have been no instances, during my residence, of the tribe, or a number of them, being concerned in the punishment of offenders. All other cases that have come under my observation have been settled by individuals after their own fashion. In one instance a sort of bloodless duel was fought between two men, one of whom had stolen the other one's squaw. They were both slaves, and had the will to kill each other with knives, but the presence of the white men prevented resort to such extreme measures, and they were obliged to content themselves with seizing each other by the hair, and scuffling for a fall. After they had pulled one another about till they were tired, the victor, who in this instance was the man to whom the squaw really belonged, was considered entitled to her by the voice of the collected crowd. The affair was then considered satisfactorily settled. Others have been more serious. One young chief who had a grudge of long standing against another of equal rank, satisfied himself by shooting a brother of his adversary with a pistol, inflicting a serious though not a mortal wound. This affair, which caused much excitement, was finally compromised by the payment of certain articles. A common and favorite means of revenge consists in defacing or destroying canoes, and in other wanton acts of malice which would disgrace school boys; but as a general thing they have very few quarrels among themselves, compared with the breaches of the peace which so frequently occur in white settlements containing an equal number of individuals. This fact can be attributed to their freedom from the use of intoxicating liquor, which has been entirely prohibited on the reservation by the exertions of the agent. When, in former times, they had access to liquor, they were quite as quarrelsome as any other savages. Whenever a slave commits an offence, the owner administers punishment according to his own fancy, without consulting with others, or being held responsible for his acts. Two instances came within my knowledge where the slaves were killed. In one of these a slave went to Kwilléyute and murdered a man and woman, and on his return home was shot by his master. Peace was thus preserved between the two tribes, the murderer being rightly punished. In the other, a woman used abusive language toward her master, which he bore for a long time, till, finally, becoming exasperated, he struck her a blow on the head with a club, which stunned, but did not quite kill her. She remained in that state all night, and toward morning partially recovered; but the owner's wrath was not appeased, and he killed her with his knife. No notice was taken of this affair by the tribe. The owner, however, for this and several other crimes, was taken to Fort Steilacoom, and imprisoned for several months by order of the Indian agent. The Indians say, that formerly when slaves were more numerous, and more easily obtained, they were oftener punished. Instances are related in which an offender has been bound hand and foot, placed in a canoe and set adrift, while a strong east wind was blowing, which would carry him out to sea, and insure a miserable death by starvation. Others have been hung, and others tortured; but they are getting more moderate of late years, and extreme measures are seldom resorted to. The presence of white men has exerted a salutary influence in this respect, and the fear of being held responsible renders them more gentle in their deportment to their slaves.

The authority of the chief is respected relative to anything cast ashore by the tide, whether drift lumber, dead whales, or wrecks. Formerly, when each village contained but one head chief, he claimed and owned all the land between certain points, and everything cast ashore became his by right of seigniorage, and of this he could make distribution among his friends as he saw fit. The chief, for instance, who owned the land around Neeah Bay, was named Deeaht or Deeah, who, with his brother Obiee, claimed all the shore to the Hoko River, a distance of about eight miles. Deeaht died without issue, and his brother Obiee or Odiee succeeded to his property, and his descendants still claim this right of seigniorage. The same custom prevails not only in all the villages of this tribe, but with every tribe on the coast; and as it is the custom, and agreed to by all, there is no dispute relative to any property acquired by jetsam. This right is not insisted on at present, except when a whale is cast ashore, or in case of wrecked property. Drift lumber, particularly mill logs, are so frequently brought down the straits, and cast ashore about the Cape, that any one who finds them has only to cut a notch in them with his axe, and his right is respected. The chief who receives any wrecked property invariably pays the finder something, or makes him a present of some kind. The chiefs also claimed the right to make prisoners of all who were cast ashore by shipwreck, whether Indians or white men; and, unless they could ransom themselves, they were detained as slaves. Hence we can readily account for, the avidity with which they possessed themselves of the persons and property of shipwrecked mariners who have from time to time been cast upon their shores. They looked upon everything thrown up by the waves as theirs, and it is but very recently that they have been led to respect the rights of white men, and to account to their agent for any wrecked materials coming into their possession. They still demand payment for anything they save, and, on the principle of salvage, such demands are just; but these claims are now arbitrated by the agent, instead of being left to the savages, as has always been the case heretofore.

History, Traditions, Etc.—The history of this tribe, as far as their knowledge extends, is a confused mass of fables, legends, myths, and allegories. Nothing that they can state prior to the existence of a few generations back is clear or wholly to be relied upon. There are a few prominent events that have been remembered as having occurred; but the detail is confused, and it is very rare that two Indians tell the same story alike, unless it may be some wild and improbable legend, like the fairy tales related in nurseries, which are remembered in after life. A notable instance of this unreliability is in their version of the account of the Spanish settlement attempted at Neeah Bay by Lieut. Quimper, in 1792, by order of the commandant of the Spanish forces at Nootka. All they really know about it, is that they have been told by their fathers that the Spaniards were here, and they can point out the locality where yet may be found pieces of tile used by the Spaniards in building. But although that occurrence was only seventy-three years ago, there is but one man living in the tribe who remembers the circumstances, and he is in his dotage. Almost every Indian I have questioned upon the subject gives a different version of the detail. Now, as they cannot relate correctly matters given in our history, and of a comparatively recent date, but little dependence can be placed upon the tales of their origin, which are interesting only for their fabulous and superstitious nature. In the matter of the Spaniards, I have been told by one that they built a brick house with a shingle roof, and surrounded it with palisades. Another stated that the house was of wood, with a brick chimney; another that they built no house at all, but simply landed some bricks and other materials; and, before they could build the house, were driven away by the Indians. More recent events, such as the murder of the crews of the ship Boston, in 1803, and of the Tonquin, in 1811, and the captivity of Jewett among the Nootkans, they remember hearing about, and relate with tolerable accuracy. As events recede in years, however, they become obscured with legends and fables, so that the truth is exceedingly difficult to discover.

The legend respecting their own origin is, that they were created on the Cape. First, animals were produced, and from the union of some of these with a star which fell from heaven, came the first men, and from them sprang all the race of Nittinats, Clyoquots, and Makahs. Indians were also created on Vancouver Island at the same time. They claim for themselves and the Nittinats a greater antiquity than the Clyoquots or Nootkans, so-called, which were originally a mere band of the Nittinat tribe. The name Nootka, which was given by the first discoverers to the band of Indians called Mowitchat, or, as the Makahs pronounce it, Bo-wat-chat, has been most singularly accepted by all the authors; and not only is the tribe or band, and the Sound they live near, called Nootka, and the treaty of 1790, between Great Britain and Spain, relative to its possession, called the Nootka convention, but recent ethnologists class all these tribes as belonging to the Nootkan family. Had Captains Cook and Vancouver, and the early Spanish explorers made Neeah Bay their head quarters, there is no reason to doubt that the Makahs, or Classets, as they were called, would have been considered the parent stock, and the other coast tribes classed as of the Makah family. My own impression is that the Nittinats were originally the principal and most powerful tribe; and that the Clyoquot, Nootka, Ahosett, and other bands on the southwest portion of Vancouver Island, as well as the Makahs at Cape Flattery, were bands or offshoots from that tribe. We have seen that the name "Nootka" is not the name of any tribe on the northwest coast, but one given in mistake by the whites, and since adhered to. Still, it may perhaps be as well to class all these tribes as the Nootkan family, since that name has come into such general use; though there is no evidence that the tribe called Nootkas were the parent stock, nor can any proof of ancestry be obtained from any of the tribes, of which each claims an antiquity as great as the others.

There is, however, a marked similarity among all the coast tribes from the Columbia River to Nootka. But, farther north, the Haida, Stikine, Chimsyan, and other tribes are very different in appearance. This great dissimilarity can be noticed by the most casual observer in the streets of Victoria at any time. All these different tribes resort there for purposes of trade; and the northern Indians —for so those three are termed—can at a glance be distinguished from the Nootka family, or from the Flatheads. The northern Indians, so-called, are much taller, more robust, and with features more like the Tartar hordes of the Siberian coast. The women are much larger, better shaped, and with lighter complexions than the Flatheads, among which may be classed—of those who frequent Victoria, and with whom a comparison may be formed—the Cowitchins, Songish, Clallams, and the various tribes on Puget Sound, who all resemble the coast tribes in general appearance, manners, and customs. A northern Indian can as readily be distinguished and marked, among a crowd of Flatheads, as a Chinaman among white men. That the northern tribes have originated from wandering hordes from the Asiatic side of the Pacific, coming by way of the Aleutian Islands and Behring Strait, is in my opinion the most probable hypothesis, for there is as strong a resemblance to each other among all the Indians north of Vancouver Island, as far as Sitka, as there is among the so-called Nootkan family. Whether the Flatheads originally travelled by the same route, cannot be shown, either by their own traditions, or any other evidence that I have been able to get, during a very careful investigation among them, and the truth respecting their origin, if ever found, must be by evidence derived from other sources. The only tradition that I have heard respecting any migratory movement among the Makahs, is relative to a deluge or flood which occurred many years ago, but seems to have been local, and to have had no connection with the Noachic deluge which they know nothing about, as a casual visitor might suppose they did, on hearing them relate the story of their flood. This I give as stated to me by an intelligent chief; and the statement was repeated on different occasions by several others, with a slight variation in detail.

"A long time ago," said my informant, "but not at a very remote period, the water of the Pacific flowed through what is now the swamp and prairie between Wäatch village and Neeah Bay, making an island of Cape Flattery. The water suddenly receded, leaving Neeah Bay perfectly dry. It was four days reaching its lowest ebb, and then rose again without any waves or breakers, till it had submerged the Cape, and in fact the whole country, excepting the tops of the mountains at Clyoquot. The water on its rise became very warm, and as it came up to the houses, those who had canoes put their effects into them, and floated off with the current, which set very strongly to the north. Some drifted one way, some another; and when the waters assumed their accustomed level, a portion of the tribe found themselves beyond Nootka, where their descendants now reside, and are known by the same name as the Makahs in Classet, or Kwenaitchechat. Many canoes came down in the trees and were destroyed, and numerous lives were lost. The water was four days regaining its accustomed level."

The same tradition was related to me by the Kwilléyutes, who stated that a portion of that tribe made their way to the region in the vicinity of Port Townsend, where their descendants are known as the Chemakum tribe. I have also received the same tradition from the Chemakum Indians, who claim to have originally sprung from the Kwilléyutes. There is no doubt in my mind of the truth of this tradition. The Wäatch prairie shows conclusively that the water of the Pacific once flowed through it; and on cutting through the turf at any place between Neeah Bay and Wäatch, the whole substratum is found to be pure beach sand. In some places the turf is not more than a foot thick; at others the alluvial deposit is two or three feet.

As this portion of the country shows conclusive evidence of volcanic action, there is every reason to believe that there was a gradual depression and subsequent upheaval of the earth's crust, which made the waters rise and recede as the Indians stated. Fossil remains of whales are said by the Indians to be found around a lake near Clyoquot, which were possibly deposited at the time of this flood. I have not seen these remains, but I have been told of their existence by so many different Indians who professed to have seen them, that I think the story probably correct. The Indians do not think they got there by means of the flood, but that, as before stated, they are the remains of the feasts of the T'hlukloots, or thunder bird, who carried the whales there in his claws, and devoured them at his leisure. With the single exception of this legend of the flood, I have never learned from them that they have any tradition respecting the tribe coming to or going from the place where they now reside, and this is the only one which they relate of ancient times that is corroborated by geological or other evidence.[1]

The only genealogical record that has been related to me is one commencing twelve generations ago, beginning with Deeaht and his brother Obiee, or Odiee. This was told me by an old chief, named Kolchote, or Kalchote, who died two years ago. He was a very intelligent Indian, and held high rank among his people. According to his account he was a direct descendant, on his mother's side, from Odiee Deeaht (or, as it is sometimes pronounced, Deeahks, or Deeah, and by the Nittinats and Clyoquots Neeah), was the principal chief, and owned the land and resided at Neeah Bay, where Neeah village now stands. The bay takes its name from the village, and the village from its being the residence of, and owned by Deeah, who, dying without issue, was succeeded by his brother Odiee. His descendants were in the following order: Kat'hl-che-da, Wa-wa-tsoo-pa, Wat-lai-waih-kose, Kla-che-tis-sub, How-é-sub, Ko-shah-sit, Tai-is-sub, Kloo-kwá-kay, Yáh-hie, and Kow-é-das. The daughter of Kow-é-das was the mother of Kalchote. Thus from Obiee to Kalchote are twelve generations. Some of the other Indians, who claim a descent on the male side, have told me that this story of Kalchote is incorrect, and that Neeah Bay was not named from Deeaht; but as they could assign no reason for the word, except that it was in use many years ago, I am inclined to think his version correct, particularly as he gave it to me just before his death, and it was interpreted to me on two different days by two different Indians, and was told me as an evidence that his only child, a daughter, was of high rank, and was to have his property, which he wished me to see distributed according to directions given at the time.[2]

The legend about Deeaht, and his tragical end, is as follows: The Nittinats came over with a mighty host and attacked the Makahs, driving them away from all their villages, and forcing them to retire to their strongholds at Flattery Rocks. Deeaht, who was a young man, very brave and influential, ventured back alone and built a house near the brook at Neeah village. He was shortly joined by his brother Obiee, and soon had a large number of friends and retainers around him. The Hosett Indians at Flattery Rocks, becoming jealous of his prosperity, came up and attacked him; but he defeated them and drove them back, discomfiting them so badly that they were glad to sue for peace, which he granted on condition of receiving for a wife the daughter of a chief residing at Hosett village. This

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[1] Traditions of a deluge are also universal among the Flathead tribes, each claiming to have its particular Ararat.—G. G.

[2] The earlier names in this genealogy are probably of mythical personages.—G. G.

chief had a boy and girl who were twins, and could scarcely be told apart; so they dressed the boy in his sister's clothes, and delivered him to Deeaht; but as soon as it became night the young savage, who had concealed a knife in his dress, cut Deeaht's throat, and then made his escape to Hosett. Odiee then succeeded his brother, and is the ancestor of a great portion of the Makahs who reside at Neeah Bay.

In one of the lodges at Neeah Bay are three carved figures, on whose heads rests the huge beam that supports the roof; of these one is intended to represent Deeahks, or Deeaht. Another figure, in the centre, is named Klessakady, and is symbolical of sunrise. His head is surmounted with a crescent-shaped cap, and between his feet is a head representing night. The beam above is marked with circular holes, to represent stars, and, according to Kalchote, the old chief, who placed it there, it may be said to show the manner in which the sun, when rising, thrusts the stars away with his head and tramples the night under his feet. A figure at the remote end of the lodge is named Billaksakut'hl, and represents a fabled giant of antiquity, who could spread his feet apart, leaving a space between his legs wide enough to pass the largest canoes through. These are the only carvings of any note in the village, but as to their significance, as stated to me by Kalchote, there is good reason to doubt its correctness. I recently asked the Indian who carved them, whose name is Dick, what *he* intended to represent? He said he had no other idea than to cut some posts to look like men, and that so far as the head between the feet of Klessakady was concerned, it simply meant nothing; but there happened to be a big knot in the wood, which made it difficult to carve, so he made a head of it; and after it was done, Kalchote painted it and set it up in his lodge with the other two, and gave them names, and invented the allegory himself. He explained himself further by remarking that he would carve me a figure if I would like, and that I could make any meaning to it I chose. Although Kalchote undoubtedly associated in his mind the allegories which he related to me with the images, the other Indians ridicule the idea, and say they are only Dick's work, which he did, with no particular object in view.

Each village has its own local traditions and genealogies, and each claims to have had, at former times, great men, who were head chiefs of the tribe. But it would appear that really each village was a community by itself, and they were often engaged in feuds among themselves; nor is this feeling wholly extinct; they speak of each other as they do of other tribes, and it is only on questions affecting the whole that they admit themselves to be all one. It is a common practice with all the chiefs of these tribes, Makahs, Nittinats, Clyoquots, Nootkans, etc., to claim great possessions, particularly when relating their tales to white men. Thus, if one's father or mother, or even the grandparents, belonged to another tribe, it is customary to claim the land of that tribe as theirs. For instance, one, whose mother was a Nittinat, will say: "That is my land at Nittinat." The chief of the Clyoquots, named Cédakanim, who frequently comes to Neeah Bay, told me that Cape Flattery was his land, because his mother was a Makah. His wife, who was the daughter of a Makah chief formerly residing at Neeah Bay, lays claim, in behalf of her son, to the land around the bay, as a portion of his grandfather's estate. Such claims, however, are ignored by the Makahs, or looked upon as merely complimentary titles. It was thus that the great chiefs of the Nootkans and Clyoquots made the early discoverers believe that they owned all the land south of Nootka and about Cape Flattery; and undoubtedly it was with this impression that Meares named the island at the entrance of the strait Tatoosh, supposing it to belong to Tatooshatticus, one of the Clyoquot or Nootkan chiefs. The Indian name of the island and village is Chahdi, and it is either called by that name, or Opa-jek-ta, meaning island—in the same manner as we would say, "We will go to Tatoosh," or "We will go to the island."

Taken in connection with the allegory of the thunder bird, Tatoosh or Tootootsh, which is the Clyoquot name of the thunder bird, seems singularly appropriate. The roaring of the waves reverberating in the caverns of the island, reminding them of thunder, and the bright flashes from the thunder cloud of the Ha-hék-to-ak—the producer of fire. But however amusing such an application of the name might appear, it has no foundation in reality, as the Indians do not, nor have they ever called the island by any other name than Chahdi. It is worthy of remark at this place that Maquinna or Maquilla, the great Nootkan chief mentioned by Vancouver, Meares, and others, is claimed by Cedakanim to have been a Clyoquot; while Kwistoh, a very intelligent chief among the Nittinats, has assured me that he was a Nittinat, who resided at Mowatchat, or Nootka. It is from conversation with these chiefs, as well as the Makahs, that I have formed the opinion that the Nittinat tribe was in reality the parent stock, and that the Indians of the south-western portion of Vancouver Island, and at Cape Flattery, should be termed the Nittinat family, instead of the Nootkan or Clyoquot. I have not been able to prepare vocabularies of all these tribes, but their language, so far as I can judge from hearing them speak, is sufficiently alike to be recognized, and to leave no doubt that it was originally the same in all.

The changes that have been introduced among the Makahs by intercourse with the whites, can be summed up in a few words. Formerly they were clothed in robes of furs or skins, or with blankets made from cedar bark, dog's-hair, or bird skins; their weapons consisted of bows and arrows, spears, and stone-knives, and hatchets. Their food was the product of the ocean, the roots and berries indigenous to the Cape, and such wild animals and birds as they could destroy. Their trade was confined to barter among themselves, or the tribes of the coast. They were almost constantly at variance with other tribes, and lived in a state of fear and apprehension. They were cruel, ferocious, and treacherous, particularly to any so unfortunate as to be thrown among them, either by the fortunes of war, or otherwise. With the advent of white men blankets were substituted for their robes of skins and bark, and calico used for the simple cincture of bark worn about the loins; guns and knives were substituted for bows and spears; and potatoes, flour, bread, with other articles of food, replaced in a measure their fish, game, and roots. They acquired the knowledge of trade, and learned the value of money; but farther than this their progress has been slow. They have learned enough during their intercourse with the whites to make them careful about committing hostilities, knowing that the good-will of the white men, and the benefits of their trade, were means of enriching themselves and procuring many comforts; but their savage natures have never changed; they are as wild and treacherous as ever; and, but for the fear of punishment and the love of gain, would exterminate every settler that attempted to make his residence among them. Frequently, since the establishment of the reservation, they have made threats of hostilities; but the councils of those who desired to acquire property or hoped for favors have prevailed, and they have contented themselves with simple threats. Improvement in their customs, and habits, must be gradual, and the work of time and patient perseverance on the part of those delegated by the Government to reside among them and look after their welfare. They have steadily opposed everything that has been done or attempted for their benefit, and even now, though they see that the promises made to them by their agent have been, in great part, realized, they are totally indifferent as to whether anything more is to be done, and in no case volunteer a helping hand. Their ancient history is wrapped in an impenetrable obscurity—that of a more recent date I have endeavored to exhibit; their future can be read in the annals of the New England emigrants. The steady wave setting to our western shores will have its due effect upon the Indian races, and in the lapse of another century the places that now know them will know them no more.

MYTHOLOGY.—The Makahs believe in a Supreme Being, who is termed by them Cha-batt-a Ha-tartstl, or Ha-tartstl Cha-batt-a, the Great Chief who resides above. The name of this Great Chief, or Divine Being, is never given, although they have a name; but they must not speak it to any except those who have been initiated into their secret rites and ceremonies. They have no outward forms of religion, but each one addresses the Supreme Being by himself, and generally retires to the depth of the woods, or some cave, for the purpose. Intermediate spirits, or familiars, are supposed to guard the destinies of individuals, and to manifest themselves at certain times by visions, signs, and dreams. These are called in the jargon Tamánawas, and the receiving of a revelation is termed "seeing the Tamánawas."[1] I never with certainty have known an Indian to address himself to the Supreme Being until recently, while in a canoe with a chief named Klaplanhie, or Captain John. He was taken with a violent fit of sneezing, and as soon as he recovered he repeated aloud several short sentences, accompanying each with a blowing noise from his mouth. I asked him what he was saying? He replied that he was asking the Ha-tartstl Cha-batt-a not to kill him by sneezing, but to let him live longer. I have on other occasions, however, noticed that the Indians, upon sneezing, repeat a few words, and think it very probable they all do as John said he did—ask the Great Spirit not to kill them. John told me that, if they did not utter this brief petition, the top of their heads would be blown off when they sneezed.[2] The same chief informed me, during a recent conversation

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[1] This word, which in Chinook means the practice of shamanism, in the jargon of the coast embraces everything supernatural.—G. G.

[2] A similar custom existed among the Peruvians, and runs through nearly all modern Europe. For the antiquity and universality of some superstition connected with sneezing, *v.* Encycl. Brit. also Encycl. Metrop., and Rees' Encycl.—G. G.

respecting their religious belief, that they think the sun is the representative of the Great Spirit, and to him they make their secret prayer. He also said that "The Indian Sunday is not one day, like your Sunday, but it is many days. When we want to talk with the Great Chief, we wait till the moon is full, and then go into the mountain, and rub our bodies with cedar twigs, after having first washed them clean. The cedar makes us smell sweet, and that the Great Chief likes. We watch for the sun, and when he first makes his appearance, we ask him to let us live long, to be strong to defend ourselves or attack our enemies, to be successful in our fisheries, or in the pursuit of game; and to give us everything we want. Every night we wash and rub ourselves with cedar, and every morning talk to the Great Chief, or his representative, the sun, whose name is Klé-sea-kark-tl."[1] We continue praying daily for one week, or from full moon to the quarter. The only instruction the children have as to the Supreme Being, or rather the only form of address taught them, is during the same period, when they are waked up at daylight and made to wash themselves before sunrise, and to ask the sun to let them live. Their tamánawas ceremonies are in reference to events they believe to have happened on the earth, and they try to represent them. But the doings of the Great Supreme they do not dare to attempt to represent, and only address him in private and at stated times. Their prayer is simply a selfish petition; they do not ask to be made wiser or better, but simply for long life, and strength, and skill, and cunning, so that they may be able to enrich themselves and obtain an ascendancy over their fellow-men.

At certain periods, generally during the winter months, they have ceremonies, or mystical performances, of which there are three distinct kinds. The Dukwally, or black tamánawas; the Tsiárk, or medicine tamánawas, and the Dōt'hlub. The latter is seldom performed, the great variety of scenes to be enacted requiring a large number of persons, and a much greater expense on the part of the individual who gives them. All these ceremonies are commenced in secret, none but the initiated being allowed to be present; and it is then, if ever, that they make common supplication to the Deity. Although I have never been able to ascertain the real facts in the case, it would seem that they address themselves to some intermediate being. Certain other ceremonies are performed in public, and spectators admitted. From those that I have seen, I infer that the Dukwally is a ceremonial to propitiate the T'hlūkloots, or thunder bird, who seems with the Makahs to take precedence over all other mythological beings. Into all these mysteries persons of both sexes, and even children, are initiated; but the initiation does not endow them with medicine or tamánawas qualities until they have gone through the private ordeal, of finding their own tamánawas, or guardian

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[1] Among the western Selish, or Flathead tribes of the Sound, I have not detected any direct worship of the sun, though he forms one of their mythological characters. He is by them represented as the younger brother of the moon. According to Father Mengarini he is, however, the principal object of worship among the Flatheads of the Rocky Mountains, or Selish proper, as well as by the Blackfeet. Among both the tribes mentioned he was supposed to be the creation of a superior being.—G. G.

spirit. At such times they are supposed to receive some manifestation which guides them in their after life. This ceremony is performed as follows: The candidate retires to some place of concealment near the salt water, where he bathes himself, remaining till he is pretty well chilled; then returns to his hiding place, and warms himself by rubbing his body and limbs with bark or cedar twigs, and again returns to the water; keeping up this alternate bathing and friction day and night, without eating, and with no interval of sleep. Both body and mind becoming thus exhausted, he lies down in a sort of trance, during which, in his disordered fancy, he sees visions and receives revelations. What he sees he makes known to no one, but ever after addresses himself in secret to that being that has presented itself to him, whether in form of bird, beast, or fish, though the animal representing this guardian spirit is sometimes indicated by carvings or paintings made by the Indian. Such animals as would be most likely to come around him while thus alone are owls, wolves, minks, and mice, during the night; or eagles, crows, ravens, blue-jays, cranes, elk, deer, or seals, during the day. These are all considered tamánawas animals, some possessing more powerful influence than others; and, as an Indian could scarcely be several days or nights without seeing something of the kind, their ceremonies are generally successful in obtaining a manifestation. They do not imagine, however, that the animal they may see is the Guardian Spirit, but only the form in which he shows himself. Of the above, owls, bears, and wolves seem to be those most generally seen, and heads of these are more frequently carved than any others.

To illustrate their superstitious belief in animals connected with their Guardian Spirit, I will relate an incident told me by Captain John, one of the chiefs. About three years ago he had lost the use of one of his feet, probably from paralysis, but which he attributed to a "skookoom," or evil spirit, entering into it one day while he was bathing. He had been confined to his house for several months, and was reduced to a skeleton. I saw him during this sickness, and thought he could not recover. One pleasant day, however, according to his account, he managed to crawl to a brook near his house, and, while bathing, heard a rustling sound in the air, at which he became frightened, and covered his face with his blanket, whereupon a raven alighted within a few feet of him and uttered a hoarse croak. He then peeped through a corner of his blanket, and saw the raven with its head erect, its feathers bristled, and a great swelling in its throat. After two or three unsuccessful efforts, it finally threw up a piece of bone about three inches long, then uttering another croak it flew away. Remaining quiet a few minutes, till he was satisfied that the raven had gone, he picked up the bone, which he gravely informed me was of the Ha-hék-to-ak. He hid this bone near by, and returned to his lodge, and, after relating the occurrence, was informed by the Indian doctors that it was a medicine sent to him by his tamánawas, and this proved to be true, as he entirely recovered in three days. I knew that this man had recovered very speedily, but do not know the actual cause. He says he shall keep the bone hid till his son is old enough to kill whales, when he will give it to him to take in his canoe, as a powerful medicine to insure success. The tale of the raven alighting near him is not improbable, as ravens as well as crows are very plenty and very tame; nor is it impossible that the raven might have had a bone in its mouth, and finally dropped it; nor is it entirely uncertain that the circumstance so affected his superstitious imagination that it caused a reaction in his system, and promoted his recovery. The same effect might perhaps have been produced by a smart shock from a galvanic battery. It is thus, without doubt, that the persons going through the ordeal of becoming tamánawas, or medicine men, have their minds excited by any animal they may see, or even by the creaking of a limb in the forest, and their imaginations are sufficiently fertile to add to natural causes, fancies that appear to them to be real. If there is anything connected with their ceremonials approaching to our ideas of worship, it must be during the secret portion, from which all except the initiated are rigorously excluded; but I have no evidence that such is the fact, and believe, as the Indians state to me, that the only time they address the Supreme Being is by themselves and in secret.

As their general tamánawas ceremonies are based upon their mythological fables, it will perhaps be well first to relate some of those legends before describing their public performances.

The Makahs believe in a transmigration of souls;[1] that every living thing, even trees, and all sorts of birds and fishes as well as animals, were formerly Indians who for their bad conduct were transformed into the shapes in which they now appear. These ancient Indians, said my informant, were so very bad, that at length two men, brothers of the sun and moon, who are termed Ho-hó-e-ap-béss or the "men who changed things"—came on earth and made the transformations. The seal was a very bad, thieving Indian, for which reason his arms were shortened, and his legs tied so that only his feet could move, and he was cast into the sea and told to catch fish for his food. The mink, Kwahtie, was a great liar, but a very shrewd Indian, full of rascalities which he practised on every one, and many are the tales told of his acts. His mother was the blue-jay, Kwish-kwishee. Once, while Kwahtie was making an arrow, his mother directed him to get some water, but he refused until he should have finished his work. His mother told him to make haste, for she felt that she was turning into a bird. While she was talking she turned into a blue jay and flew into a bush. Kwahtie tried to shoot her, but his arrow passed behind her neck, glancing over the top of her head, ruffling up the feathers, as they have always remained in the head of the blue-jay. Those Indians that were turned into wolves formerly resided at Clallam Bay. One day their chief Chu-chu-huuks-t'hl, came to Kwahtie's house, who pretended to be sick, and invited the wolf to come in and take a nap. This he did, as he was quite tired. When he was fast asleep Kwahtie got up and with a sharp mussel shell cut the wolf's throat and buried him in the sand. Two days after this a deputation of the wolf tribe came to look for their chief. "I have not seen him," said Kwahtie. "I am sick and have not left my house." The wolves retired; and shortly another, and then another deputation came. To all of these he gave the same answer. At last one of the

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[1] The term "transmigration of souls" is not strictly correct. The idea is that the pre-human, or demon race, was transformed into the animals and other objects whose names they bore and still bear. The souls of the present race are not supposed to undergo transmigration.—G. G.

wolves said, "Kwahtie, you tell lies, for I can smell something, and my nose tells me that you have killed our chief." "Well," says Kwahtie, "if you think so, call all your tribe here, and I will work spells, and you can then see whether I have killed him or not." Accordingly they all came. Kwahtie told them to form a circle, leaving an opening on one side, which they did. He then took a bottle or bladder of oil in one hand, and a comb with very long teeth in the other, and commenced a song in which he at first denied all knowledge of the chief, but at length admitted the fact, upon which he started and ran out of the circle, dashing down the bladder of oil which turned into water. He also stuck his comb into the sand, which was immediately changed into the rocks from Clyoquot to Flattery rocks. He then dived into the water and escaped. It was in this manner, said my informant, that Neeah Bay and the Straits were formed; for the land formerly was level and good, till Kwahtie turned it into rocks and water. Kwahtie was a great magician till the Ho-hó-e-ap-béss transformed him. He had the choice offered him of being a bird or a fish, but declined both. He was then told that as he was fond of fish he might live on land and eat what fish he could catch or pick up.

The raven, Klook-shood, was a strong Indian very fond of flesh, a sort of cannibal, as was his wife Cha-ká-do, the crow, and their strong beaks were given them to tear their food, whether fish, flesh, or vegetable, for they had great appetites, and devoured everything they could find. The crane, Kwáh-less, was a great fisherman, always on the rocks, or wading about, with his long fish spear ready to transfix his prey. He constantly wore the tsá-sa-ka-dup, or little circular cape, worn by the Makahs during wet weather while fishing. This was turned into the feathers about his neck, and his fish spear into his long bill. The kingfisher, Chesh-kully, was also a fisherman, but a thief, and had stolen a necklace of the Che-tóh-dook or dentalium shells; these were turned into the ring of white feathers about his neck.

At the time of the transformation of Indians into animals, there was no wood in the land, nothing but grass and sand, so the Ho-hó-e-ap-béss, mindful of the wants of the future inhabitants, prepared for them fuel. To one they said, you are old, and your heart is dry, you will make good kindling wood, for your grease has turned hard and will make pitch (kluk-ait-a-biss), your name is Do-hó-bupt, and you shall be the spruce tree, which when it grows old will always make dry wood. To another, your name is Kla-ká-bupt, and you shall be the hemlock. The Indians will want some harder wood, and therefore Kwahk-sá-bupt, you shall be the alder, and you, Dopt-kó-bupt, shall be the crab apple, and as you have a cross temper you shall bear sour fruit. The Indians will likewise want tough wood to make bows, and wedges with which to split logs; you Kla-haik'-tle-bup are tough and strong, and therefore you shall be the yew tree. They will also require soft lasting wood to make canoes, you Kla-áe-sook shall be the cedar. And thus they give the origin of every tree, shrub, or herb.

The cause of the ebb and flow of the tides is accounted for in this manner. The raven, Klook-shood, not being contented with his one wife, the crow, went up the straits and stole the daughter of Tu-chee, the east wind. Tu-chee, after searching twenty days, found him, and a compromise was effected, by which the raven was to receive some land as a present. At that time the tide did not ebb and flow, so Tu-chee promised he would make the waters retire for twenty days, and during that time Klook-shood might pick up what he could find on the flats to eat. Klook-shood was not satisfied with this, but wanted the land to be made bare as far as the cape. Tu-chee said no, he would only make it dry for a few feet. Klook-shood told him he was a very mean fellow, and that he had better take his daughter back again. At last the matter was settled by Tu-chee agreeing to make the water leave the flats twice every twenty-four hours. This was deemed satisfactory, and thus it was that the ebb and flow of the tide was caused, to enable the ravens and crows to go on the flats and pick up the food left by the water.

The Dukwally and other tamánawas performances are exhibitions intended to represent incidents connected with their mythological legends. There are a great variety, and they seem to take the place, in a measure, of theatrical performances or games during the season of the religious festivals. There are no persons especially set apart as priests for the performance of these ceremonies, although some, who seem more expert than others, are usually hired to give life to the scenes, but these performers are quite as often found among the slaves or common people as among the chiefs, and excepting during the continuance of the festivities are not looked on as of any particular importance. On inquiring the origin of these ceremonies, I was informed that they did not originate with the Indians, but were revelations of the guardian spirits, who made known what they wished to be performed. An Indian, for instance, who has been consulting with his guardian spirit, which is done by going through the washing and fasting process before described, will imagine or think he is called upon to represent the owl; he arranges in his mind the style of dress, the number of performers, the songs and dances or other movements, and having the plan perfected, announces at a tamánawas meeting that he has had a revelation which he will impart to a select few. These are then taught and drilled in strict secrecy, and when they have perfected themselves, will suddenly make their appearance and perform before the astonished tribe. Another Indian gets up the representation of the whale, others do the same of birds, and in fact of everything that they can think of. If any performance is a success, it is repeated, and gradually comes to be looked upon as one of the regular order in the ceremonies; if it does not satisfy the audience, it is laid aside. Thus they have performances that have been handed down from remote ages, while others are of a more recent date. My residence in the school building, but a stone's throw from the houses at Neeah village, gave me an excellent opportunity to see all the performances that the uninitiated are permitted to witness, and to hear all the din of their out-door and in-door operations.

The ceremony of the great Dukwally, or the Thunder bird, originated with the Hesh-kwi-et Indians, a band of Nittinats living near Barclay Sound, Vancouver Island, and is ascribed to the following legend:—

Two men had fallen in love with one woman, and as she would give neither the preference, at last they came to a quarrel. But one of them, who had better sense than the other, said, Don't let us fight about that squaw; I will go out and see the chief of the wolves, and he will tell me what is to be done; but I cannot get to his lodge except by stratagem. Now they know we are at variance, so do you take me by the hair, and drag me over these sharp rocks which are covered with barnacles, and I shall bleed, and I will pretend to be dead, and the wolves will come and carry me away to their house. The other agreed, and dragged him over the rocks till he was lacerated from head to foot, and then left him out of reach of the tide. The wolves came, and supposing him dead, carried him to the lodge of their chief; but when they got ready to eat him, he jumped up and astonished them at his boldness. The chief wolf was so much pleased with his bravery, that he imparted to him all the mysteries of the Thunder bird performance, and on his return home he instructed his friends, and the Dukwally was the result. The laceration of the arms and legs among the Makahs, during the performance to be described, is to represent the laceration of the founder of the ceremony from being dragged over the sharp stones.

A person intending to give one of these performances first gathers together as much property as he can obtain, in blankets, guns, brass kettles, beads, tin pans, and other articles intended as presents for his guests, and procures a sufficient quantity of food, which of late years consists of flour, biscuit, rice, potatoes, molasses, dried fish, and roots. He keeps his intention a secret until he is nearly ready, and then imparts it to a few of his friends, who if need be assist him by adding to his stock of presents or food. The first intimation the village has of the intended ceremonies is on the night previous to the first day's performance. After the community have retired for the night, which is usually between nine and ten o'clock, the performers commence by hooting like owls, howling like wolves, and uttering a sharp whistling sound intended to represent the blowing and whistling of the wind. Guns are then fired, and all the initiated collect in the lodge where the ceremonies are to be performed, and drum with their heels on boxes or boards, producing a sound resembling thunder. The torches of pitch wood are flashed through the roof of the house, and at each flash the thunder rolls, and then the whole assemblage whistles like the wind. As soon as the noise of the performers commences, the uninitiated fly in terror and hide themselves, so great being their superstitious belief in the supernatural powers of the Dukwally, that they have frequently fled to my house for protection, knowing very well that the tamánawas performers would not come near a white man. They then visit every house in the village, and extend an invitation for all to attend the ceremonies. This having been done, the crowd retire to the lodge of ceremonies, where the drumming and singing are kept up till near daylight, when they are quiet for a short time, and at sunrise begin again. The first five days are usually devoted to secret ceremonies, such as initiating candidates, and a variety of performances which consist chiefly in songs and chorus and drumming to imitate thunder. They do this part very well, and their imitation of thunder is quite equal to that produced in the best equipped theatre.

What the ceremony of initiation is I have never learned. That of the Clallams, which I have witnessed, consists in putting the initiates into a mesmeric sleep; but if the Makahs use mesmerism, or any such influence, they do not keep the candidates under it for any great length of time, as I saw them every day during the ceremonies, walking out during the intervals. The first out-door performance usually commences on the fifth day, and this consists of the procession of males and females, with their legs and arms, and sometimes their bodies, scarified with knives, and every wound bleeding freely. The men are entirely naked, but the women have on a short petticoat. I had seen this performance several times, and had always been told by the Indians that the cutting was done by the principal performers, or medicine men, who seized all they could get hold of, and thus lacerated them; but I have since been admitted to a lodge to witness the operation. I expected the performers would be in a half frantic state, cutting and slashing regardless of whom they might wound; I, however, found it otherwise. A bucket of water was placed in the centre of the lodge, and the candidates squatting around it washed their arms and legs. The persons who did the cutting, and who appeared to be any one who had sharp knives, butcher-knives being preferred, grasped them firmly in the right hand with the thumb placed along the blade, so as to leave but an eighth or quarter of an inch of the edge bare; then, taking hold of the arm or leg of the candidate, made gashes five or six inches long transversely, and parallel with the limb, four or five gashes being cut each way. Cuts were thus made on each arm above and below the elbow, on each thigh, and the calves of the legs; some, but not all, were likewise cut on their backs. The wounds were then washed with water to make the blood run freely. The persons operated on did not seem to mind it all, but laughed and chatted with each other until all were ready to go out, and then they set up a dismal howling; but I think the pain they felt could not be very great, for two Indians who went in with me, seeing there were but few in the procession, asked me if I would like to see them join in. I told them I should like very well to see the performance; upon which they deliberately pulled off their blankets and shirts, and continued in conversation with me while their arms and legs were gashed in the same manner. An Indian must be possessed of a much lower degree of nervous organization than a white man to suffer such operations and show no more feeling. Some may think it stoical indifference, but certainly such a scoring of the body would throw a white man into a fever. The same two Indians came to me about an hour after the performance had closed, and although their wounds had bled freely, they assured me they felt no pain. Sometimes, however, the cuts are accidentally made deep, and produce sores. When all was ready the procession left the lodge, and marched in single file down to the beach; their naked bodies streaming with blood presenting a barbarous spectacle. A circle was formed at the water's edge, round which this bloody procession marched slowly, making gesticulations and uttering howling cries.

Five men now came out of the lodge carrying the principal performer. One held him by the hair, and the others by the arms and legs. He too was cut and bleeding profusely. They laid him down on the beach on the wet sand, and left him, while they marched off and visited every lodge in the village, making a circuit in each lodge. At last the man on the beach jumped up, and seizing a club laid about him in a violent manner, hitting everything in his way. He too went the same round as the others, and after every lodge had been visited they all returned to the lodge from which they had issued, and the performances, out-door, were closed for that day. In the meanwhile a deputation of fifteen or twenty men, with faces painted black and sprigs of evergreen in their hair, had been sent to the other villages with invitations for guests to come and receive presents. They went in a body to each lodge, and after a song and a chorus, the spokesman of the party in a loud voice announced the object of their visit, and called the names of the invited persons. Any one has a right to be present at the distribution, but only those specially invited will receive any presents.

Every evening during the ceremonies, excepting those of the first few days, is devoted to masquerade and other amusements, when each lodge is visited and a performance enacted. Some of the masks are frightful objects, as may be seen in Figures 35—41. They are made principally by the Clyoquot and Nittinat Indians, and sold to the Makahs, who paint them to suit their own fancies. They are made of alder, maple, and cottonwood; some are very ingeniously executed,

Fig. 35. No. 2714.

Fig. 36. No. 4119.

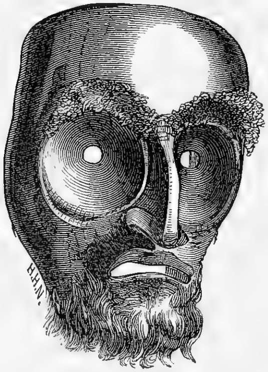


Fig. 37.

Fig 38

having the eyes and lower jaw movable. By means of a string the performer can make the eyes roll about, and the jaws gnash together with a fearful clatter. As these masks are kept strictly concealed until the time of the performances, and as they are generally produced at night, they are viewed with awe by the spectators; and certainly the scene in one of these lodges, dimly lighted by the fires which show the faces of the assembled spectators and illuminate the performers, presents a most weird and savage spectacle when the masked dancers issue forth from behind a screen of mats, and go through their barbarous pantomimes. The Indians themselves, even accustomed as they are to these masks, feel very much afraid of them, and a white man, viewing the scene for the first time, can only liken it to a carnival of demons.

Fig. 39.

Fig. 40.

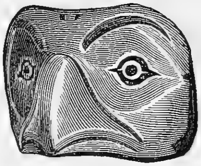
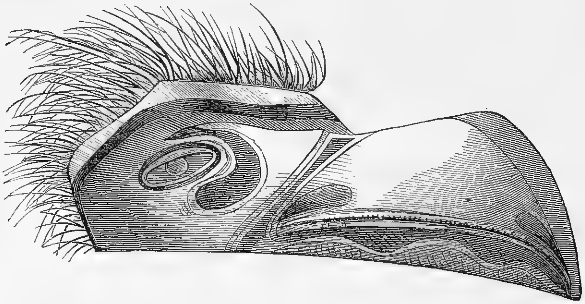


Fig. 41. No. 4117.



Among the masquerade performances that I have seen was a representation of mice. This was performed by a dozen or more young men who were entirely naked. Their bodies, limbs, and faces were painted with stripes of red, blue, and black; red bark wreaths were twisted around their heads, and bows and arrows in their hands. They made a squealing noise, but otherwise they did nothing that reminded me of mice in the least. Another party was composed of naked boys, with bark fringes, like veils, covering their faces, and armed with sticks having needles in one end; they made a buzzing noise, and stuck the needles into any of the spectators who came in their way. This was a representation of hornets. These processions followed each other at an interval of half an hour, and each made a circuit round the lodge, performed some antics, sang some songs, shouted, and left. Another party then came in, composed of men with frightful masks, bear-skins on their backs, and heads covered with down. They had clubs in their hands, and as they danced around a big fire blazing in the centre of the lodge, they struck wildly with them, caring little whom or what they hit. One of their number was naked, with a rope round his waist, a knife in each hand, and making a fearful howling. Two others had hold of the end of the rope as if to keep him from doing any harm. This was the most ferocious exhibition I had seen, and the spectators got out of their reach as far as they could. They did no harm, however, excepting that one with his club knocked a hole through a brass kettle; after which they left and went to the other lodges, when I learned that they smashed boxes and did much mischief. After they had gone the owner examined his kettle, and quaintly remarked that it was worth more to him than the pleasure he had experienced by their visit, and he should look to the man who broke it for remuneration.

On a subsequent evening I was present at another performance. This consisted of dancing, jumping, firing of guns, etc. A large fire was first built in the centre of the lodge, and the performers, with painted faces, and many with masks resembling owls, wolves, and bears, crouched down with their arms clasped about their knees, their blankets trailing on the ground, and fastened around the neck with a single pin. After forming in a circle with their faces towards the fire, they commenced jumping sideways round the blaze, their arms still about their knees. In this manner they whirled around for several minutes, producing a most remarkable appearance. These performers, who were male, were succeeded by some thirty women with blackened faces, their heads covered with down, and a girdle around their blankets drawing them in tight at the waist. These danced around the fire with a shuffling, ungainly gait, singing a song as loud as they could scream, which was accompanied by every one in the lodge, and beating time with sticks on boards placed before them for the purpose. When the dance was over, some five or six men, with wreaths of sea-weed around their heads, blackened faces, and bear-skins over their shoulders, rushed in and fired a volley of musketry through the roof. One of them then made a speech, the purport of which was that the ceremonies had progressed favorably thus far, that their hearts had become strong, and that they felt ready to attack their enemies, or to repel any attack upon themselves. Their guns having in the meanwhile been loaded, another volley was fired and the whole assembly uttered a shout to signify approval. The performances during the daytime consisted of representations on the beach of various kinds. There was one representing a whaling scene. An Indian on all fours, covered with a bear-skin, imitated the motion of a whale while blowing. He was followed by a party of eight men armed with harpoons and lances, and carrying all the implements of whaling. Two boys, naked, with bodies rubbed over with flour, and white cloths around their heads, represented cold weather; others represented cranes, moving slowly at the water's edge, and occasionally dipping their heads down as if seizing a fish. They wore masks resembling a bird's beak, and bunches of eagle's feathers stuck in their hair. During all of these scenes the spectators kept up a continual singing and drumming. Every day during these performances feasts were given at different lodges to those Indians who had come from the other villages, at which great quantities of food were eaten and many cords of wood burned, the giver of the feast being very prodigal of his winter's supply of food and fuel. The latter, however, is procured quite easily from the forest, and only causes a little extra labor to obtain a sufficiency.

The final exhibition of the ceremonies was the T'hlūkloots representation, after which the presents were distributed. From daylight in the morning till about eleven o'clock in the forenoon was occupied by indoor performances, consisting of singing and drumming, and occasional speeches. When these were over, some twenty performers dressed up in masks and feathers, some with naked bodies, others covered with bear skins, and accompanied by the whole assembly, went down on the beach and danced and howled in the most frightful manner. After making as much uproar as they could, they returned to the lodge, and shortly after every one mounted on the roofs of the houses to see the performance of the T'hlūkloots. First, a young girl came out upon the roof of a lodge wearing a mask representing the head of the thunder bird, which was surmounted by a top-knot of cedar bark dyed red and stuck full of white feathers from eagles' tails. Over her shoulders she wore a red blanket covered with a profusion of white buttons, brass thimbles and blue beads; her hair hung down her back covered with white down. The upper half of her face was painted black and the lower red. Another girl with a similar headdress, was naked except a skirt about her hips. Her arms and legs had rings of blue beads, and she wore bracelets of brass wire around her wrists; her face being painted like the other. A smaller girl had a black mask to resemble the ha-hék-to-ak. The masks did not cover the face, but were on the forehead, from which they projected like horns. The last girl's face was also painted black and red. From her ears hung large ornaments made of the haikwa or dentalium, and blue and red beads, and around her neck was an immense necklace of blue beads. Her skirt was also covered with strings of beads, giving her quite a picturesque appearance. A little boy with a black mask and head-band of red bark, the ends of which hung down over his shoulders, and eagles' feathers in a top-knot, was the remaining performer. They moved around in a slow and stately manner, occasionally spreading out their arms to represent flying and uttering a sound to imitate thunder, but which resembled the noise made by the nighthawk when swooping for its prey, the spectators meanwhile beating drums, pounding the roofs with sticks, and rattling with shells. This show lasted half an hour, when all again went into the lodge to witness the distribution of presents and the grand finale. The company all being arranged, the performers at one end of the lodge and the women, children, and spectators at the other, they commenced by putting out the fires and removing the brands and cinders. A quantity of feathers were strewed over the ground floor of the lodge, and a dance and song commenced, every one joining in the latter, each seeming to try to make as much noise as possible. A large box, suspended by a rope from the roof, served as a bass drum, and other drums were improvised from the brass and sheet-iron kettles and tin pans belonging to the domestic furniture of the house, while those who had no kettles, pans, or boxes, banged with their clubs on the roof and sides of the house till the noise was almost deafening. In this uproar there was a pause, then the din commenced anew. This time the dancers brought out blankets, and with them beat the feathers on the floor till the whole air was filled with down, like flakes of snow during a heavy winter's storm. Another lull succeeded, then another dance, and another shaking up of feathers, till I was half choked with dust and down. Next the presents were distributed, consisting of blankets, guns, shirts, beads, and a variety of trinkets, and the whole affair wound up with a feast.

This was the Dukwally or "black tamânawas" ceremony. It is exhibited every winter, sometimes at only one village and sometimes at all.

The other performance is termed Tsiahk, and is a medicine performance, quite as interesting, but not as savage in its detail. It is only occasionally performed, when some person, either a chief or a member of his family, is sick. The Makahs believe in the existence of a supernatural being, who is represented to be an Indian of a dwarfish size, with long hair of a yellowish color flowing down his back and covering his shoulders. From his head grow four perpendicular horns, two at the temple and two back of the ears. When people are sick of any chronic complaint and much debilitated, they imagine they see this being in the night, who promises relief if the ceremonies he prescribes are well performed. The principal performer is a doctor, whose duties are to manipulate the patient, who is first initiated by secret rites into the mysteries of the ceremony. What these secret rites consist of I have not ascertained, but there is a continual singing and drumming during the day and evening for three days before spectators are admitted. From the haggard and feeble appearance of some patients I have seen, I judge the ordeal must have been severe. The peculiarity of this ceremony consists in the dress worn alike by patients, novitiates, and performers. Both men and women assist, but the proportion of females is greater than of males. Fig. 42 shows a back view of a female performer in full dress; on her head is worn a sort of coronet made of bark, surmounted by four upright bunches or little pillars, made of bark wound round with the same material, and, sometimes threads from red blankets to give a variety of color. From the top of each of the four pillars, which represent the horns of the tsiahk, are bunches of eagles' quills, which have been notched, and one side of the feather edge stripped off. In front is a band, which is variously decorated, according to the taste of the wearer, with beads, brass buttons, or any trinkets they may have. From each side of this band project bunches of quills similar to those on the top of the head. The long hair of the Tsiahk is represented by a heavy and thick fringe of bark, which covers the back and shoulders to the elbow. Necklaces composed of a great many strings of beads of all sizes and colors, and strung in various forms, are also worn, and serve to add to the effect of the costume. The paint for the face is red for the forehead and for the lower part, from the root of the nose to the ears; the portion between the forehead and the lower part is black with two or three red marks on each cheek. The dress of the novitiate females is similar, with the exception of there being no feathers or ornaments on the bark headdress, and with the addition of black or blue stripes on the red paint covering the forehead and lower portion of the face. The headdress of the men (Fig. 43) consists of a circular band of bark and colored worsted, from the back part of which are two bunches of bark, like horses' tails. Two upright sticks are fastened to the band behind the ears, and on top of these sticks are two white feathers tipped with red; the quill portion is inserted into a piece of elder stick with the pith extracted, and then put on the band sticks. These sockets give the feathers the charm of vibrating as the wearer moves his head; when dancing or moving in procession the hands are raised as high as the face, and the fingers spread out.

Fig. 42.

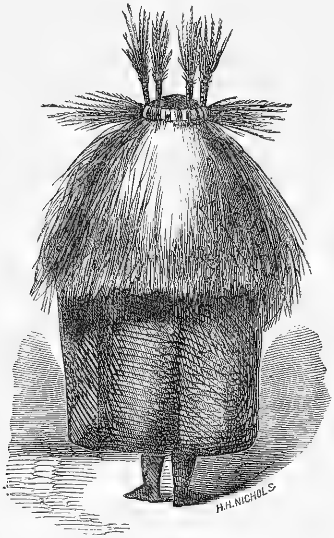


Fig. 43.

The doctor or principal performer has on his head a dress of plain bark similar to the female novitiate. He is naked except a piece of blanket about his loins, and his body is covered with stripes of red paint. The out-door performance consists of a procession which moves from the lodge to the beach; the principal actor or conductor being at the head, followed by all the males in single file, the last one being the doctor. Immediately behind the doctor the patient follows, supported on each side by a female assistant. The females close up the procession. All parties, male and female, have their hands raised as high as their faces, and the motion of the procession is a sort of shuffling dance. They move in a circle which gradually closes around the patient, who, with the novitiate, is left seated on the ground in the centre; songs with choruses by the whole of the spectators, drumming, shaking rattles, and firing of guns wind up the performance, and all retire to the lodge, where dancing and singing are kept up for several days. Finally, presents are distributed, a feast is held, and the friends retire. The patient and novitiates are obliged to wear their dress for one month. It consists of the bark headdress, having, instead of feathers, two thin strips of wood, feather-shaped, but differently painted. Those of the patient are red at each end and white in the centre, with narrow transverse bars of blue. Those of the novitiate have blue ends and the centre unpainted. The patient's face is painted red, with perpendicular marks of blue on the forehead and the lower part of the face. The noviciate's forehead and lower portion of face is painted with alternate stripes of red and blue, the remainder of the face blue; the head band is also wound with blue yarn and yellow bark. The head-band of the patient is wound with red. The tails of bark of both headdresses are dyed red. The patient carries in his hand a staff which can be used as a support while walking; this has red bark tied at each end and around the middle.

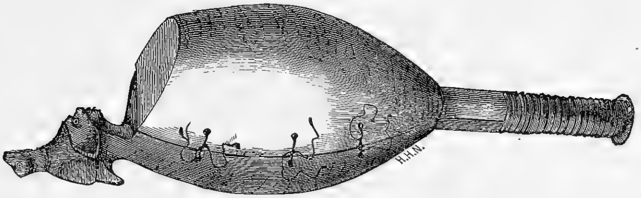
The Dukwally and Tsiahk are the performances more frequently exhibited among the Makahs than any others, although they have several different ones. The ancient tamánawas is termed Do-t'hlub or Do-t'hlum, and was formerly the favorite one. But after they had learned the T'hūlkloots or Thunder Bird, they laid aside the Do-t'hlub, as its performance, from the great number of ceremonies, was attended with too much trouble and expense. The origin of the Do-t'hlub was, as stated to me by the Indians, in this manner: many years ago, an Indian while fishing in deep water for codfish, hauled up on his hook an immense haliotis shell. He had scarcely got it into his canoe when he fell into a trance which lasted a few minutes, and on his recovery he commenced paddling home, but before reaching land he had several of these trances, and on reaching the shore his friends took him up for dead, and carried him into his house, where he presently recovered, and stated, that while in the state of stupor he had a vision of Do-t'hlub, one of their mythological beings, and that he must be dressed as Do-t'hlub was and then he would have revelations. He described the appearance, as he saw it in his vision, in which Do-t'hlub presented himself with hands like deer's feet. He was naked to his hips, around which was a petticoat of cedar bark dyed red, which reached to his knees. His body and arms were red; his face painted red and black; his hair tied up in bunches with cedar twigs, and cedar twigs reaching down his back. When his friends had dressed him according to his direction, he fell into another trance, in which he saw the dances which were to be performed, heard the songs which were to be sung, and learned all the secret ceremonies to be observed. It was also revealed that each performer must have a piece of the haliotis shell in his nose, and pieces in his ears. He taught the rites to certain of his friends, and then performed before the tribe, who were so well pleased that they adopted the ceremony as their tamánawas, and retained its observance for many years, till it was superseded by the Dukwally. The haliotis shell worn by the Makahs in their noses is a custom originating from the Do-t'hlub. Other ceremonies are occasionally gone through with, but the description above given will serve to illustrate all those observed by the Makahs. Different tribes have some peculiar to themselves, the general character of which is, however, the same. It will be seen that the public part of these performances are rather in the nature of amusements akin to our theatrical pantomimes than of religious observances, though they are religiously observed.

The Makahs, like all other Indians, are exceedingly superstitious, believing in dreams, in revelations, necromancy, and in the power of individuals over the elements. An instance of the latter fell under my own observation. Early in April, 1864, there was a continuance of stormy weather which prevented them from going after whales or fishing. At length an Indian, who came from the Hosett village at Flattery Rocks informed me that his people had found out that Keyattie, an old man living with them, had caused the bad weather. A woman and a boy had found him at his incantations and reported him to the tribe; whereupon the whole village went to Keyattie's lodge, and told him that if he did not immediately stop and make fair weather, they would hang him. He promised to do so, and they gave him two days to calm the wind and sea. The Indian added with great gravity that now we should have fair weather. I told him that it was foolish talk. He said no, that the Indians in former times were capable of making it rain or blow at pleasure, and cited a recent case of a Kwilléyute Indian, who only a few summers previous had made bad weather during the halibut season. The Kwilléyutes hung him, and immediately the weather became fair. In the present instance we did have fair weather in two days after, and the Indians were confirmed in the belief that old Keyattie had caused the storm that prevented their going out in canoes, and that the fear of death had forced him to allay it. Through dreams they think they can foretell events and predict the sickness or death of their friends. Some are supposed to be more gifted in this respect than others, and many a marvellous tale has been related to me by these dreamers; but in every instance the events had already taken place which they pretended to have predicted. Their necromancy consists in the performance of the doctors, which will be alluded to more at length under the heading of "medicine."

It will be seen that though the Makahs are heathens in the fullest sense, they are not idolaters or worshippers of images, but that their secret addresses are to the sun as the representative of the Great Spirit. They seem, on the other hand, perfectly indifferent to teaching. They will not believe that the white man's God is the same as their Great Chief, nor give any attention to the truths of Christianity. If the children could be removed from their parents and the influences of the tribe, and placed in a civilized community, they might be led to embrace our religion as well as customs; but any efforts of a missionary on the spot, opposed as they would be by prejudice, superstition, and indifference, would be futile. The most that can be hoped for, at present, is to keep them at peace, and gradually teach them such simple matters as they can be made to take an interest in, and will tend to ameliorate their condition.

MAGIC AND "MEDICINE."—The Makahs have, as usual, certain persons, both male and female, who are supposed to be skilled in the art of healing. The male practitioners alone, however, go through an ordeal or tamánawas to constitute them "doctors." An ancient ceremony called Ka-háip was formerly always observed to endow them with supernatural powers, but it is seldom used of late years, and there are but three persons living in the tribe at present who have undertaken it. They obtain notoriety by occasional good fortune in apparently performing remarkable cures, and each is celebrated for some faculty peculiar to himself in removing disease. Every sickness for which they cannot assign some obvious cause is supposed to be the work of a "skoo-koom," or demon, who enters the mouth when drinking at a brook, or pierces the skin while bathing in salt water. These evil spirits assume the form of a little white worm which the doctor extracts by means of manipulations, and the patient recovers. Although I have repeatedly seen them at work on their patients, and pretending to take out these animals, I have never seen the object itself, which, as they generally informed me, is only seen by the doctor. In extracting these pretended evil spirits, he manipulates the part affected, frequently washing the hands during the operation, and warming them at the fire. This, he states, is to make the hands sensitive, so that on pressing them upon the patient's body he can the more easily feel where the evil is located. Sometimes he is an hour or two in finding the skoo-koom, particularly if the patient be a chief, as then not only the doctor's fees will be larger, but there will probably be a great company of friends assembled to sing and drum, and afterwards to feast.

Fig. 44. (No. 4120.)



Rattle used by medicine men.

When the doctor thinks that he has worked enough, he will then try to catch the *skookoom* and squeeze it out. If he succeeds, he blows through his hand toward the roof of the lodge, and assures the patient that it has gone. An instance occurred about Christmas time, 1864, of an old man who had been sick for two or three years of lingering consumption. He had exerted himself very much at a Dukwally performance, and by some violent strain had burst an abscess on his lungs and was in a very critical condition. I was sent for, and told he was dying, and went immediately to his lodge, where I found him under the immediate charge of an Indian doctor. By virtue of my position as dispenser of medicines for the reservation, I was permitted to remain as a sort of consulting physician. I was perfectly well aware of the circumstances attending the case, and that the patient was dying, and simply took with me an anodyne to relieve the pain of his last moments; but as I could do nothing while the Indian doctor was at work, I remained a spectator of the scene. The patient was upon his knees, his head supported by an Indian who was in front of him. The doctor, a muscular, powerful man, having washed his hands and warmed them, grasped the patient by the back of the neck, pressing his thumbs against the spinal column, and moving them with all his might as though he was trying to separate the skull from the backbone. He exerted himself to such a degree that every muscle and vein was distended, and drops of perspiration ran freely from his face. At length he gave a wrench and a twist, the patient uttered a yell, when it was announced to me by the doctor that the *skookoom* had been caught, and that the man would recover. I told him the man would die in half an hour, but if he had not been squeezed so hard, and had taken my medicine, he would possibly have lived two or three days. The doctor laughed, and replied that I did not know as well as the Indians did; but it proved as I predicted. The man did die, and in less than two hours from the time I had made the remark he was buried, myself assisting in the ceremonies, as I desired to see how they were performed.

They have a variety of songs and chants during the performance, each doctor seeming to have a tune of his own. But the method adopted by all, is first to remove the *skookoom* by manipulation, and after that administer other remedies. Some of the old women are skilled as physicians both in the above method and in the preparation of medicinal herbs. I saw the application of a most singular remedy in the case of a young man who had been shot through the left arm by a dragoon pistol, in the hand of another Indian who was drunk. The ball passed through the arm between the shoulder and the elbow, injuring, but not breaking the bone, and lodged in the muscles of the back, from whence it was extracted in a rude manner by an incision made with a jack-knife. I advised the friends to take him immediately to Port Angeles or Victoria, where he could have surgical advice, but they concluded to try their own remedies first. They attempted to stop the bleeding by applying hemlock bark chewed fine, which seemed to have the desired effect. They next went to where the young man's father was buried, and dug up the bone of the upper part of the left arm, which they washed, and then sawed or split in two, lengthwise, and formed splints of it. These were scraped, and the scrapings of the bone applied as a dressing. The bone splints were applied and the arm bandaged firmly. The Indians assured me that the bone from the father's arm would renew or replace the wounded one in the boy's arm; that they always tried it in the case of a broken bone, and it always effected a cure. Thus, if a leg, an arm, or a rib is broken, they take a similar one from the body of the nearest relative who has been dead over a year, and apply it either as a dressing by scraping, or in the form of splints. I have, however, seen none but the instance above quoted where the splints were applied. In this case fragments of the bone continually coming away, the remedy proved worthless, and after several months' suffering, the young man was carried to Victoria, where the arm was attended to by a skilful surgeon, and he shortly recovered. There is not an instance in the whole tribe where an amputation has been performed, although I have known several cases where life would have been saved had the patient or his friends submitted to or allowed the operation. But as they know nothing of the practice themselves, they are very reluctant to have any such operations performed, preferring death to the loss of a limb. Incised wounds and lacerations are treated either with a poultice of chewed hemlock, or elder bark, or wood ashes strewed on, which absorbs the discharge and forms a crust or scab. Wounds of this description heal very readily, which is to be wondered at, since their systems are so full of humors, but it is very rare that suppuration occurs; although in several instances of bruises on the leg, or the skin, I have seen bad ulcers that were a long time healing.

The whole tribe are pervaded by a scrofulous or strumous diathesis which shows itself in all its various forms; enlargement and suppuration of the cervical glands; strumous ulcers in the armpits, and swelling and suppuration in the groin and thigh. The strumous bubo is of common occurrence in infants, children of all ages, and adults. These are invariably cut, I cannot say lanced, for the instrument in all cases is a knife, and the wounds allowed to take care of themselves. Sores of this description are considered by most of the white people of the territory to be of syphilitic origin, but I am of opinion that such is not the case. This tribe is remarkably exempt from diseases of a venereal nature; and in a residence of three years among them, during two of which I have dispensed medicines, but three cases have come to my observation of syphilitic bubo. One was a squaw, who had contracted the disease in Victoria; the other two, men of the tribe to whom on her return she had imparted it; but I think I can safely assert that there is scarcely an individual in the whole tribe but what has had strumous buboes or ulcerations of the cervical glands at some period of life. Eruptive diseases, such as scald head, ringworm, and a species of itch, are very common among infants; all of which, and their scrofulous tumors, may be attributed to filthy habits and the nature of their food, which consists chiefly of fish and oil. A variety of the thorn oyster is frequently thrown ashore after heavy storms; or is found in the root of the kelp which has grown upon it, and, being torn up by the breakers, brings the oyster ashore in its grasp. These are not eaten, but I have seen the fresh ones made use of as a sort of poultice for boils, and also raw fish is occasionally applied to the same purpose. Sometimes, when they wish to apply a rubefacient to tumors, they use *Pyrola elliptica*, which is bruised into a pulpy mass, and applied by means of a bandage. This little plant is very common in the woods, and is capable of producing a blister on the skin of a white person; but the Indians seldom retain it long enough to create anything more than a redness or inflammation of the part.

One of their remedies to reduce a strumous tumor is by means of actual cautery, prepared from the dried inner bark of the white pine, which is applied by a moxa or cone. The skin is first wet with saliva at the desired point; the moxa then placed upon it and set on fire. The bark burns very rapidly and causes a deep sore, which is kept open by removing the scab as often as it forms, until relief is felt. Sometimes they apply several of these moxas to the person at one time. I have seen them give relief in many instances. This practice seems to be a common one among all the coast tribes in the vicinity, and it is rare to see an adult who has not scars produced by its means.

Burning the flesh is also resorted to for other purposes. Boys will apply moxas made of dried and partially charred pitch, to the back of the thumbs from the nail to the wrist. When the sores heal, they leave scars or callous spots, which are supposed not only to keep the bow-strings from hurting the hand, but to give a steadiness of aim, so that they can throw their arrows with more precision. I have seen school-boys sit down of an evening by the fire and amuse themselves in this manner, holding out their hands with the burning pitch singing into the flesh, and showing their bravery by the amount of pain they could bear. I usually found, however, that they were very willing for me to dress their hands with salve whenever they had attempted this performance. Blood-letting is not practised according to our methods, but in case of bruises when there is swelling and much pain, they scarify the skin by cutting longitudinal and transverse gashes just deep enough to make the blood flow by keeping the part moistened with water. Cauterizing the flesh is, however, the favorite and most generally practised remedy for all internal complaints, and answers with the Indian the double purpose of blisters and bleeding.

There are many cases of deformity arising from strumous disease of hip-joint, white swelling of the knee, and rheumatic affection of feet. These cripples go about with the aid of a stick or pole, which they hold with both hands. I have made crutches for some, but they could never be persuaded to use them. There is one case of enlargement of the scrotum to an enormous size. The patient is a man about forty years of age, who has been troubled with the complaint for about twenty years, the sac gradually enlarging, so that now it reaches four inches below the knee and is of the size of a five gallon keg. He assures me that he suffers no pain from it, but the enormous size is quite inconvenient, and causes him to walk with a very peculiar gait. As his only covering is a blanket, the parts are frequently exposed. The complaint does not appear to be dropsical, but rather an adipose secretion. Doctor Davies, formerly physician and surgeon to the reservation, was desirous of making an examination, but the man was exceedingly opposed to it, and no opportunity has been had of ascertaining its real character.

The most common complaints are diarrhœa and dysentery, coughs, colds, and consumption. The first two are most frequent, and have been formerly very fatal. I find, however, that taken in their early stages they readily yield to simple treatment, and a dose of castor oil, followed by Dover's powder from five to ten grains, is quite sufficient in most cases to effect a cure. During my experience among the coast Indians for a period of more than twelve years, I have noticed, as a general rule, that they require less medicine than white men, and invariably when administering any (with the exception of castor oil), I have given but one-half the amount that would be given to one of the latter. There seem to be no general remedies among themselves, each doctor or doctress having his or her own peculiar herbs, roots, or bark which they prepare in secret and administer with ceremony. I have seen a woman pulverize charcoal and mix it with water for her child to drink, who had a diarrhœa. Some make a tea of hemlock bark for an astringent, others scrape that of the wild currant, elder, or wild cherry, and make tea of it.

The *Polypodium falcatum?* or, as it is commonly called, the sweet liquorice fern, is a most excellent alterative, and is much used by both white persons and Indians in the territory, having acquired a reputation in venereal complaints. In the form of a decoction it is an excellent medicine combined with iodide of potassium. There are two varieties found at Cape Flattery; one growing on the trunks of trees or old mossy logs; the other on the rocks. The plants are similar in general appearance, except that those growing on rocks have a stout, fleshy leaf. The taste of the roots and their medicinal virtues appear to be the same. From the very many evidences I have had of their beneficial effects, I am led to conclude that their virtues far surpass those of the *P. vulgare*, which was formerly of great repute, but which has been laid aside in modern practice. Perhaps the *Polypodium* growing upon the immediate sea-coast derives some peculiar quality from the atmosphere of the ocean, but it certainly seems to be as efficacious and to take the place in this latitude of the sarsaparilla of the equatorial regions. By the white settlers it is often mixed with the root of the "Oregon grape" (*Mahonia*), but the Makahs use it alone, either simply chewing it and swallowing the juice, or boiling it with water and drinking the decoction. A number of species of liverwort are found at Cape Flattery, one of which grows upon the ground, and when freshly gathered has the taste of spruce leaves. The Indians use this for coughs, and as a diuretic. When chewed it appears to be of a mucilaginous nature, somewhat like slippery elm. It loses its peculiar spruce flavor on being dried, and I think its virtues are greatest when the plant is green. A variety of bittersweet or wintergreen is used for derangement of the stomach and intestinal canal. This is simply chewed and swallowed. I was shown one day by a sick chief, a great medicine which he had received from a Clyoquot doctor. It was kept very secret, and I was permitted to examine it as a mark of great confidence and friendship. After a number of rags had been unrolled, a little calico bag was produced, and in this bag, very carefully wrapped up in another rag, were several slices of a dried root, which the Indian informed me was very potent. I tasted it and found it to be the Indian turnip (*Arisœma*). Dr. Bigelow (Am. Med. Bot.) says "the root loses nearly all its acrimony by drying, and in a short time becomes quite inert." But this which the Indian showed me was intensely acrid, and it had been dried for several months. I have not seen the plant growing in this vicinity, but if it is not a different variety from the eastern species, it certainly retains its potency for a much longer period.

The Indians have shown me at different times other plants which they said were good for certain complaints, but I have never seen them exhibited as medicine. It is to be observed, however, that there is scarcely an herb of any kind which grows on the Cape or its vicinity, but is considered a medicine in the hands of some one or other, and so what one considers good another ridicules, for as they have no knowledge of the diagnosis of disease, they are apt to think that what is good in one case is good in all. Thus, one doctor acquired quite a reputation by administering a pasty mass composed of the shell of the *Natica*, ground with water on a stone. This was useful in cases of acidity of the stomach arising from surfeits of butter and oil. Another tried the same remedy in the case of an abscess on the liver, but the patient died and the medicine was ridiculed. I think, as a general rule, they have but little confidence in their own preparations, as they invariably come to me after a trial of a day or two of their native remedies; and the whole of their materia medica is employed after the manner of the old women of all countries. But their ceremonials and tamánawas, and the manipulations and juggling feats of the doctor they have great faith in, and will probably continue them for a long time to come, if indeed they ever relinquish the practice.

Various plants have been shown me by the Indians as valuable during parturition, but I do not think they are in general use. As a rule the Indian women require but little assistance during labor, and it is very rare that one dies during childbirth. I saw an instance of one who was taken with labor pains while on her way to the brook for water. This was a very unusual occurrence, as they generally keep in the house at such times. My attention was called to the circumstance by seeing her sitting on the ground and another squaw supporting her back. I went out to learn the cause, and found that she had just been delivered of a child. The woman sat still for a few moments longer, then got up and walked into the house without assistance. They are seldom confined to the house over a day, and often not over a couple of hours. That the process is somewhat shorter, and apparently attended with less suffering than among white women, is probably owing to a much lower degree of nervous sensibility, rather than to any material physical difference. The children are, as a usual thing, well formed. I have heard of cases of malformation, but during three years past have not seen a single one. Twins are of rare occurrence, and during the same period I knew of but one instance, which happened on Tattoosh Island during the summer of 1864. The Indians did not seem to know what to do about it. They considered it as a sort of evil which would affect in some way the summer fisheries. So the woman and her husband were sent back to Neeah Bay, and prohibited from eating fish of any description for two or three months; and had it not been for the food procured at the Agency she must have starved. The twins died shortly after their birth, and I strongly suspect that they were killed by the Indians to get rid of the demons which were supposed to have come with them.[1]

In cases of sickness where the doctors consider that the patient cannot recover, it was formerly the custom to turn the sufferer out of doors to die, particularly if it was something they did not understand; the belief being, that if suffered to die in a house all the other occupants would die of the same disease. An instance came under my observation of a woman who was paralyzed so as to be utterly helpless. They dragged her out upon the beach on a cold wintry day, and left her on the snow to perish. The sympathies of the white residents were aroused, and several Indians were appealed to to take the woman into their lodges, and payment offered them for the performance of this simple act of humanity; but all refused through fear. They were, however, finally induced by promise of reward, and with the assistance of myself and another white person, to construct a rude hovel, in which she was placed, and food and fuel supplied her; but the Indians would do nothing more, and she was attended by the white residents and made as comfortable as the circumstances would admit, until death relieved her. Since then, and for the past two years, no instances of like inhumanity have occurred; the Indians fearing lest the agent would punish them for a repetition of the offence. But I have been frequently assured that, except for this, they would have treated several other patients in a similar manner.

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[1] The same superstition exists among other tribes. Some years ago a woman belonging to a party who were being conveyed on a California river steamer to their reservation, gave birth to twins, which were immediately thrown overboard.—G. G.

Funeral Ceremonies.—When a person dies the body is immediately rolled up in blankets and firmly bound with ropes and cords, then doubled up into the smallest possible compass and placed in a box which is also firmly secured with ropes. When all is ready, the boards of a portion of the roof are removed, and the box with the body taken out at the top of the house and lowered to the ground, from a superstition that if a dead body is carried through the doorway, any person passing through it afterwards would sicken and die. The box is then removed to a short distance from the house, and sometimes placed in a tree; but of late years the prevailing custom is to bury it in the earth. A hole is first dug with sticks and shells deep enough to admit the box, leaving the top level with the surface. Boards are then set up perpendicularly all around so as to completely inclose it, their ends rising above the ground from four to five feet. A portion of the property of the deceased is placed on top of the box; this, in the case of a man, consists of his fishing or whaling gear, or a gun with the lock removed, his clothing, and bedding. If a female, beads and bracelets of brass, iron, calico, baskets, and her apparel. A little earth is thrown on top, and then the whole space filled up with stones. Blankets, calico, shawls, handkerchiefs, looking glasses, crockery and tin ware, are then placed around and on the grave for show, no particular order being observed, but each being arranged according to the fancy of the relatives of the deceased. The implements used in digging the grave are also left and placed among the other articles. A description of a few of these graves may not be out of place. One was that of a woman who was buried at Baäda, the eastern extremity of Neeah Bay. The husband was a young chief, who decorated it as became his ideas of his dignity. In front of the grave was a board on which was painted the representation of a rainbow, which they believe has great claws at each end with which it grasps any one so unfortunate as to come within its reach. On top of the board, which formed its edge, was a sort of shelf containing the crockery ware of the deceased; and on the left corner a carved head of an owl, wrapped up with a white cloth. A short stick wound with calico at the right corner bore a handkerchief at its top, and from two tall poles similarly wound around with calico a shawl, a dress pattern, and some red flannel were displayed like flags. At the expiration of a year the cloth disappeared, having been rotted by the rains and torn into shreds by the wind.

Another was the grave of a chief named Hure-tall, known by the whites as "Swell," and who was killed by an Elwha Indian in 1861 while engaged in bringing supplies from Port Townsend for the trading post at Neeah Bay. As he was an Indian well known and very much respected by the whites, his body was received by some settlers at Port Angeles, and placed in a box, and was brought from thence to Neeah Bay by a brother of the deceased, assisted by myself and another white man. The box was deposited in the ground, after the custom of the Indians, and over his remains a monument was raised by the relatives. It is built of cedar boards, and surmounted by a pole on the top of which is a tin oil can. Around its base are the painted tamánawas boards which he had in his lodge. A third grave is that of an Indian boy, at Baäda. A couple of posts were set up at the ends, and boards fastened to them which were covered with blankets. In the centre of the upper edge of the boards an eagle's tail was fastened, spread out like a fan; two guns without locks were hung up at the ends, and a stick with a piece of calico served as a streamer. All these graves, with the exception of Swell's, are now denuded of their covering of cloth, nothing being replaced when once destroyed by the elements.

The tying a corpse in its blanket is of recent date. Formerly it was not considered necessary to be so particular, but a case of suspended animation, where the patient recovered, having occurred some ten years ago, they adopted it to prevent any future instances of the same kind. The circumstance, as related to me by some Indians, is as follows: The Indian, whose name was Harshlah, resided at Baäda village, and died, or was supposed to have died, after a very brief illness. He was buried in the usual manner, but in two days after he managed to free himself and to make his appearance among his friends, greatly to their consternation. After having assured them that he was no spirit, but really alive, they were induced to listen to his statement. He said that he had been down to the centre of the earth, which the Indians suppose to be the abode of the departed, and there he saw his relatives and friends, who were seated in a large and comfortable lodge enjoying themselves. They told him that he smelled bad like the live people, and that he must not remain among them. So they sent him back. The people he saw there had no bones; these they had left behind them on the earth; all they had taken with them was their flesh and skin, which, as it gradually disappeared by decomposition after death, was removed every night to their new abode, and when all was carried there, it assumed the shape each one wore on earth. It is one of the avocations of the dead to visit the bodies of their friends who have died, and gradually, night by night, remove the flesh from the bones, and carry it to the great resting-place, the lodge in the centre of the earth. He further stated that on his return to where he had been buried he struggled and freed himself from his grave-cloth and the box, and then discovered that he had been dead.[1]

This man Harshlah afterwards died of small-pox, and my informant remarked that the second time he was tied up so securely that he never came to life again. Since then they have been very particular to secure all bodies so firmly that a revival is hopeless. This circumstance, so fresh in the minds of all the adults of the tribe, and the revelations respecting the other world, which correspond so exactly with their ancient ideas, make it impossible to teach them our views of a future state. They do not doubt the white man's statement, but they say that his heaven, which is represented to be in the sky, is not intended for the Indian, whose abode is in the earth. I have known several instances where, from the attending circumstances, there is little doubt that persons have been buried while in a swoon, or in a simply comatose state, and I have repeatedly urged upon them the folly of burying such persons before means could be tried to resuscitate them; but I never have been able to get them to wait a single moment after they think the breath

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[1] Cases of apparent death, sometimes, perhaps, feigned for the purpose of acquiring influence, or notoriety, are not unfrequent among these coast tribes, and in all those I have known, a similar story has been told of a visit to the dead country.—G. G.

has left the body. On the 10th of October, 1864, Sierchy, a middle-aged man of general good health, was reported to me as having just died. It appeared that the evening previous he had eaten a raw carrot, which the farmer on the reservation had given him, and towards morning he complained of a pain in his breast, but as he made no request for assistance, his squaw took no notice of him, and at sunrise went about preparing the usual meal. While thus engaged, she noticed Sierchy to exhibit a slight convulsive motion, and as she supposed instantly die. She at once began to howl, and in this was joined by the rest of the squaws. I was sent for and went over to the lodge, which was only four or five rods from my quarters; but when I arrived, which could not have been over ten minutes from the time the man was supposed to have died, the others had wrapped him up in his blanket, and wound a stout cord tight around him from head to foot, drawing it so firmly about the neck that it would have suffocated a well person in five minutes. I tried to induce them to undo the face and let me attempt to restore him, for I thought he had only swooned away, or at the worst had but a fit from eating the carrot, which they had told me about, but I could not persuade them. "It was very bad to look on the face of the dead, and they must be covered from sight as soon as they cease to breathe." So they carried him out and buried him. I shall always, however, think that if proper means had been tried, he would have speedily revived. Another case was that of a squaw who had suddenly lost her husband a few days before. He had been sick for a long time and had apparently recovered; but taking a severe cold, he died from its effects in about twenty-four hours from the time of the attack. The woman was remarkably stout, and in good health. I saw her sitting by the bank of the brook, lamenting the death of her husband, and passed by to the upper village, about a quarter of a mile distance, where having attended some sick persons, I was about returning to the school building, when I heard the wailing cry of women announcing death. I quickened my steps and soon learned that it was the same woman I had passed but a short time previously, weeping for her husband, who was now also announced as dead. By the time I could get into the lodge, she too was tied up and in a box, ready to be buried, nor would the friends listen to a word I said, or permit me to use any measures for her recovery. Dead she was, they were sure, or if not, they took good means to insure that she should be so shortly.

As soon as an Indian dies the property, if there be any, is divided at once among the relations and friends. The time of mourning is one year, and at the expiration of the period, or on the return of the same season, or the same moon, the nearest surviving relative gives a feast and distributes presents, both to appease the spirit of the departed and to give notice that mourning is over. During the interval it is considered disrespectful to mention the name of the deceased in the hearing of relatives or friends, and whenever it is necessary to speak the name to a white person, it is invariably done in an undertone or whisper.

Although I have stated that it is the general custom to place the dead in a box, yet it is not the invariable practice, as, in case of persons of inferior rank who are either old or poor, it not unfrequently occurs that they are simply wrapped in a blanket and a mat and buried in the ground. The bodies of slaves are dragged a short distance from the lodge and covered over with a mat. In the case of the old man whom I mentioned in connection with the performance of the doctor, and whose body I assisted to bury, he was simply rolled in his blanket, lashed up firmly in a mat, and buried in a shallow grave. Over the remains were piled broken boxes, mats, old blankets, and the clothing he had worn. Care is always taken to render worthless everything left about a grave, so that the cupidity of the evil minded may not tempt them to rob the dead. Blankets are cut into strips, crockery ware is cracked or broken, and tin pans and kettles have holes punched through them.

No monuments of a lasting character mark the last resting place of even the greatest chief. Whatever of display there may be made at the time of burial is of an ephemeral nature calculated to last but for a year, and after that but little care or respect is shown the remains. As time elapses the graves go to decay, and the bones of the dead lie scattered around. During the clearing of land at Neeah Bay for the uses of the Agency a large number of bones and skulls were found, which were all gathered and burned, the sight of such relics of humanity being offensive to the feelings of the whites.

There are no antiquities connected with this tribe; such as earthworks, mounds, or other evidences of the usages of former generations. All that the antiquarian can find to repay him for his researches are arrow-heads of stone, and ancient daggers and hatchets of the same material, which are occasionally thrown up by the plough or occasionally found on the surface. The mounds of shells and other debris of ancient feasts are but the refuse of the lodges, and whatever may be found in them has not been so deposited from any design, but simply lost or thrown away. The only fortifications they have used as a defence against enemies were the rude stockades or pickets of poles, which I have before alluded to, and which have gradually decayed or have been used as firewood.

SUPERSTITIONS.—Besides the legends I have already related, there are others which may serve to convey an idea of the mental character of the tribe, and throw some light upon statements made by early explorers on the northwest coast. There is a remarkable rock standing detached from the cliff at the northwest extremity of the Cape, a little south of the passage between the main land and Tatoosh Island. This rock, the Indian name of which is Tsá-tsá-dak, rises like a pillar from the ocean over a hundred feet almost perpendicularly, leaning, however, a little to the northwest. Its base is irregular in form, and about sixty feet in diameter at its widest portion near the surface of the water. It decreases in size till at the top it is but a few yards across, and on its summit are low stunted bushes and grass. It is entirely inaccessible except on its southeastern side, where a person possessed of strength and nerve could, with great difficulty, ascend, but to get down by the same way would be impossible. The Indians have a tradition respecting this Pillar Rock, that many years ago an Indian climbed to its summit in search of young cormorants and gulls, which make it a resort during the breeding season; but after he had reached the top he could not again descend. All the attempts he made were fruitless, and at length his friends went to his relief, every expedient they could think of being resorted to without success. They tied strings to their arrows and tried to shoot them over, but they could not make them ascend sufficiently high. They caught gulls and fastened threads to their feet, and tried to make them fly over and draw the string across the rock, but all was of no avail. Six days were wasted in the vain attempt to save him, and on the seventh he lay down and died. His spirit, say the Indians, still lives upon the rock, and gives them warning when a storm is coming on, which will make it unsafe for them to go out to sea in pursuit of their usual avocations of killing whales or seals, or catching fish. Duncan, one of the early explorers, mentions this rock and gives a drawing of it, but he places it between the island and the main land. Vancouver, in alluding to Duncan's statement, says he saw no such rock. It does not exist where Duncan states he saw it, but it does exist about one mile a little east of south of Tatoosh Island. It is easily seen when sailing up the coast close in land; but when opposite to it at a short distance off it is so overtopped by the cliffs of the Cape as not to be particularly noticeable. The passage between the island and the main land is half a mile wide, and is not, as is stated by various authors, obstructed by a reef connecting the island and the cape, but has a depth of four and five fathoms of water through its entire distance; and although there are several rocks which are bare at low water, yet vessels can pass through at any stage of the tide, providing the wind is fair, for the ebb and flood tides rush through with great velocity, making tide rips which have been mistaken for shoals. I have passed through the passage in a schooner twice, and I know of several other vessels that have gone through without the slightest difficulty.

There is another rock not far from the Pillar Rock, near the top of which is a sort of cavity, across which rests a large spar which has been borne on the crest of some stupendous wave and tossed into its present resting place. It had been there long before the memory of the present generation of Indians, and is believed by them to have been placed there by supernatural agency, and is consequently regarded with superstitious awe. They think that any one who should attempt to climb up and dislodge it would instantly fall off the rock and be drowned. All down the coast from Cape Flattery to Point Grenville, pillar rocks are seen of various heights and sizes, and most fantastic shapes, and for each and all of them the Indians have a name and a traditionary legend. About midway between the cape and Flattery Rocks is one of these pillars, looking in the distance like a sloop with all sail set. The tide sets strongly round it both at flood and ebb. The Indians believe a spirit resides upon it, whose name is Se-kă-jéc-ta, and to propitiate it, and give them a good wind and smooth sea, they throw overboard a small present of dried fish or any other food they may have whenever they pass by.

The aurora borealis they think is the light caused by the fires of a mannikin tribe of Indians who live near the north pole, and boil out blubber on the ice. On one occasion while in a canoe on the Strait of Fuca at night, there was a magnificent display of the aurora, and I asked the chief who had charge of the canoe, if he knew what it was. He said, far beyond north, many moons' journey, live a race of little Indians not taller than half the length of this paddle. They live on the ice and eat seals and whales. They are so strong that they dive into the water and catch whales with their hands, and the light we saw was from the fires of those little people boiling blubber. They were skookooms, and he did not dare speak their names.[1] Drowned persons they supposed to turn into owls, and several years since a party of Indians having been lost by the accidental demolishing of their canoe by the tail of a whale they were killing, I was gravely assured that the night after the accident eight owls were seen perched on the houses of the drowned men, and each had suspended from his bill the shell worn in the nose of the man while alive.

A most ludicrous instance of their superstition occurred while I was making a survey of the reservation during the summer of 1862. A chief, Kobetsi, who lived at Tsuess village, owned a large cranberry meadow, of the possession of which he was very jealous. Among the Indians who accompanied me on the survey was a young man who had quite recently had a difficulty with Kobetsi, in which he felt that the chief was the aggressor. The Indians, who are very fertile in inventing tales, informed Kobetsi that the fellow had sold the cranberry meadow to me, and that I had a great medicine which I could set in the field which would gather all the cranberries. This medicine was a field compass. They had seen the mariner's compass, but a field compass on a Jacob staff was something they could not comprehend. Old Kobetsi believed the tale, and sent a party, armed and painted, from the island where he was then residing, to attack me and the surveying party at Tsuess. We did not happen to be there on their arrival, so they returned; but the following day I went down and finished the survey, and after returning home the old chief, who had been informed of the fact, came himself from Tatoosh Island with his warriors to demand redress for the supposed loss of his cranberries. He was soon convinced of the real facts, and left, quite mortified that he had worked himself up into such a state of excitement about nothing; but he still believed that the compass possessed great and mysterious properties, and requested me not to place it on his land again. Another instance of superstition was during the time of my taking a census of the tribe in 1861. The Indians at Hosett village were much opposed to giving me their names, from the belief that every man, woman, or child whose names were entered in my book, would have the small-pox and die.

The cliffs at the extreme point of Cape Flattery are pierced by deep caverns and arches that admit the passage of canoes, not only saving the distance of going around or outside the rocks during rough weather, but affording snug coves and shelter during high wind, and secure passages for the Indian to skulk along unseen. Some of the caverns extend a great distance under the cliff, and afford hiding places for seals, which, however, are not allowed to remain always in peace; for the Indian, watching an opportunity when it is calm, boldly ventures in as far as his canoe can be managed; then with a torch in one hand, and a knife in the other, he dashes into the water and wades or swims to where the seals are lying on the sandy bottom at the remote end of the cave. The light partially blinding and stupefying the

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[1] Traditions of the Eskimos as a race of dwarfs, possessing supernatural powers, who dwell in the "always night country," are current among the Indians of Puget Sound also. One of the incentives to desperate resistance by them during the war of 1855–56, was the circulation by their chiefs of a story that it was the intention of the whites to take them all there in a steamer. The idea of eternal cold and darkness carried with it indescribable horrors to their imaginations.—G. G.

animals, and the Indian, taking advantage of this, is enabled to kill as many as he can reach. But this is an exploit attended with great danger, for occasionally the torch will go out, and leave the cavern in the profoundest darkness. At such times the cries of the seals, mingled with the roar of the billows as it echoes through the caves, inspire the Indian with a mortal terror; and should he escape with his life, he will have most fearful tales to relate of the dark doings and still darker and mysterious sayings of the beings who are believed to inhabit these caverns and dens of the earth, and who being angry because their secret retreats were invaded, blew out the torch, and filled the air with the horrid sounds he heard. It is, however, but seldom that the usually turbulent waters in the vicinity of the cape are quiet enough to permit of such expeditions.

The craggy sides of the perpendicular cliffs afford resting places for numerous sea fowl, particularly the violet-green cormorant, which here builds its nest wherever it can find a hole left by some pebble or boulder fallen from the cliff, or where it can scratch or burrow into any loose soil that may form the summit. Harlequin ducks, mokes, guillemots, petrels and gulls abound, and during the breeding season the air is filled with their discordant cries. These birds are all considered as departed Indians, and the cries they utter in an approaching storm, are supposed to be warnings of dead friends not to venture around the cape till it shall have abated.

Lichens and moss collect on the sides of the cliffs above the direct action of the waves, and where the tides reach, the rocks are covered with barnacles and mussels, or else entirely hidden by sea-weeds which grow in rich profusion. In some places there are beds of clay slate in the conglomerate which have been bored full of holes by the borer clam (*Parapholas*), and present a singular appearance; elsewhere they are the resting places of a great variety of starfish, sea slugs, limpets, etc. Some of these to the Indian mind are great medicines, others of them are noxious, and some are used for food. The jutting promontories, the rocky islets, and detached boulders, the caverns and archways about the Cape have all some incident or legend, and in one large cave, opposite Tatoosh Island where the breakers make an unusual sound, which becomes fearful on the approaching of a storm, they think a demon lives, who, coming forth during the tempest, seizes upon any canoes that may be so unfortunate as to pass at the time, and takes them and their crews into the cave, from whence they issue forth as birds or animals, but never again in human shape. The grandeur of the scenery about Cape Flattery, and the strange contortions and fantastic shapes into which its cliffs have been thrown by some former convulsion of nature, or worn and abraded by the ceaseless surge of the waves; the wild and varied sounds which fill the air, from the dash of water into the caverns and fissures of the rocks, mingled with the living cries of innumerable fowl, the great waves of the ocean coming in with majestic roll and seemingly irresistible force, yet broken into foam, or thrown into the air in jets of spray, all combined, present an accumulation of sights and sounds sufficient to fill a less superstitious beholder than the Indian with mysterious awe.

The astronomical and meteorological ideas of the Makahs are wrapped in vague and mythological tales. Of the revolutions of the heavenly bodies they know nothing more than that the sun in summer is higher in the heavens than during the winter, and that its receding or approach causes the difference of cold and heat of the seasons. The stars are believed to be the spirits of Indians and representatives of every animal that has existed on earth, whether beast, bird, or fish. Their notions, however, are very confused, for as they think that all who die go immediately to the centre of the earth, they find it difficult to explain how they get from there to become luminaries in the sky.[1] Most, if not all the constellations have names, such as the whale, halibut, skate, shark, etc., but I have never had any of them pointed out to me; they seemed to have a superstitious repugnance to doing so, and although they will at times talk about the stars, they generally prefer cloudy weather for such conversations. The moon they believe is composed of a jelly-like substance, such as fishes eat. They think that eclipses are occasioned by a fish like the "cultus" cod, or toosh-kow, which attempts to eat the sun or moon, and which they strive to drive away by shouting, firing guns, and pounding with sticks upon the tops of their houses. On the 5th of December, 1862, I witnessed the total eclipse of the moon, and had an opportunity of observing their operations. There was a large party gathered that evening at the house of a chief who was giving a feast. I had informed some of the Indians during the day that there would be an eclipse that evening, but they paid no regard to what I said, and kept on with their feasting and dancing till nearly ten o'clock, at which time the eclipse had commenced. Some of them coming out of the lodge at the time, observed it and set up a howl, which soon called out all the rest, who commenced a fearful din. They told me that the toosh-kow were eating the moon, and if we did not drive them away they would eat it all up, and we should have no more. As the moon became more and more obscure, they increased their clamor, and finally, when totally obscured, they were in great excitement and fear. Thinking to give them some relief, I got out a small swivel, and with the assistance of one of the employés of the reservation, fired a couple of rounds. The noise, which was so much louder than any they could make, seemed to appease them, and as we shortly saw the silvery edge of the moon make its appearance after its obscuration, they were convinced that the swivel had driven off the toosh-kow before they had swallowed the last mouthful. I tried to explain the cause of the eclipse, but could gain no converts to the new belief, except one or two who had heard me explain and predict the eclipse during the previous day, and who thought as I could foretell so correctly what was going to take place, I could also account for the cause.

Their idea of the aurora borealis I have already explained. Comets and meteors are supposed to be spirits of departed chiefs. Rainbows are supposed to be of a malignant nature, having some connection with the Thlookloots, or Thunder Bird,

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[1] I believe that this may be explained: the stars are the spirits of the pre-human and not of the existing race. Almost all nations have given the names of animals to certain constellations; thus the Eskimo call the Great Bear the Cariboo, the Puget Sound Indians call it the Elk, etc.—G. G.

and to be armed at each end with powerful claws with which to grasp any unhappy person who may come within their reach.

Of time they keep but little record. They have names for the different months or moons, twelve of which constitute with them two periods, the warm and cold. They can remember and speak of a few days or a few months, but of years, according to our computation, they know nothing. Their "year" consists of six months or moons, and is termed *tsark-wark it-chie.* The first of these periods commences in December, when the days begin to lengthen, and continues until June. Then, as the sun recedes and the days shorten, another commences and lasts till the shortest days. It is owing to the fact of these periods being only six months in duration, that it is so difficult for them to tell their ages according to our estimate, for as their knowledge of counting is very limited, they cannot be made to understand our reckoning. I have never known them to remember the proper age of a child of over two years. Sometimes they give the age of an individual by connecting his birth with some remarkable event, as, for instance, the year of the smallpox, or when a white man came to reside among them, or that when a vessel was wrecked.

The seasons are recognized by them as they are by ourselves, namely, spring, by the name of klairk-shiltl; summer, by that of kla-pairtch; autumn, by kwi-atch; and winter, by wake-puett.

The names of the months are as follows:—

December is called se-hwow-as-put'hl, or the moon in which the se-whow, or chet-a-pook, the California gray whale, makes its appearance.

January is a-a-kwis-put'hl, or the moon in which the whale has its young.

February, kluk-lo-chis-to-put'hl, or the moon when the weather begins to grow better and the days are longer, and when the women begin to venture out in canoes after firewood without the men.

March is named o-o-lukh-put'hl, or the moon when the finback whales arrive.

April, ko-kose-kar-dis-put'hl. The moon of sprouts and buds.

May, kar-kwush-put'hl. Moon of the strawberry and "salmon berry."

June, hay-sairk-toke-put'hl. The moon of the red huckleberry.

July is kar-ke-sup-he-put'hl, or the moon of the wild currants, gooseberry, and sallal, *Gaultheria.*

August is wee-kookh, or season of rest; no fish taken or berries picked, except occasionally by the children or idle persons; but it is considered by the tribe as a season of repose.

September is kars-put'hl, when all kinds of work commence, particularly cutting wood, splitting out boards, and making canoes.

October, or kwar-te-put'hl, is the moon for catching the tsa-tar-wha, a variety of rockfish, which is done by means of a trolling line with a bladder buoy at each end, and a number of hooks attached.

November is called cha-kairsh-put'hl, or the season of winds and screaming birds.

The terminal put'hl seems to be equivalent to our word "season,"for although the words to which it is added signify but one moon, yet when speaking of a month's duration the word dah-kah is used, as tsark-wark dah-kah, one month.

Daylight or daytime is expressed by the word Kle-se-hark, which also means sun; but in enumerating days the word che-al'th is used, denoting a day and night, or twenty-four hours; thus, tsark-wark che-al'th, one day, &c. The divisions of the day are sunrise, yó-wie; noon, ta-kas′-sie; sunset, art'hl-há-chitl; evening, ar-tuktl; midnight, up'ht-ut-haie.

Wind is called wake-sie; the north wind, batl-et-tis; the south, kwart-see-die; the east, too-tooch-ah-kook; the southeast, too-chee; the west, wa-shel-lie, and the northwest yu-yoke-sis. These are each the breath of a fabulous being who resides in the quarter whence the wind comes, and whose name it bears.

Kwartseedie, the south wind, brings rain,[1] and the cause of it is this: Once upon a time the Mouse, the Flounder, the Cuttlefish, the Skate, with several other fishes and some land animals, resolved to visit Kwartseedie and see how he lived. After a journey of many days they found him asleep in his house, and thought they would frighten him; so the Cuttlefish got under the bed, the Flounder and Skate lay flat on the floor, and the other visitors disposed themselves as they thought best. The Mouse then jumped on the bed and bit Kwartseedie's nose, which suddenly awakened him; and as he stepped out of bed he slipped down by treading on the Flounder and Skate, while the Cuttlefish, twining round his legs, held him fast. This so enraged him that he began to blow with such force that the perspiration rolled down from his forehead in drops and formed rain. He finally blew all his tormentors home again; but he never has forgotten the insult, and comes at intervals to annoy his enemies, for the land animals at such times are very uncomfortable, and the fish are driven from their feeding grounds on the shoals by the great breakers, which also oftentimes throw vast numbers of them on shore to perish.

The legends respecting all the other winds are very similar, and their blowing is a sign of the displeasure of their imaginary beings.

The Indians are excellent judges of the weather, and can predict a storm or calm with almost the accuracy of a barometer. On a clear calm night, if the stars twinkle brightly they expect strong wind, but if there is but a slight scintillation they are certain of a light wind or a calm, and consequently will start at midnight for the fishing grounds, fifteen or twenty miles due westward from Cape Flattery, where they remain till the afternoon of the following day. Their skill is not surprising when it is understood that their time is in great measure passed upon the water, on a most rugged coast; that their only means of travel is by canoes, and that from childhood up it is as natural for them to watch the weather as it is for a sailor on the ocean to note the sky.

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[1] It is the prevalent winter wind of the northwest coast.—G. G.

MAKAH VOCABULARY.[1]

A

Above; or over head, (when spoken of things in a house.)	*hā-dás-suk.*
Above; up high (expression used out of doors.)	*hā-tárts-tl.*
Aboard	*hay-túks.*
go on board	*hay-túks-itl.*
it is on board	*hay-tuks-uk.*
Across; as to cross a stream	*kwit-swar-tis.*
Afraid	*win'natch.*
After	*wā-hark.*
Agreeable or pleasant, *to taste or smell*	*cháb-bas* or *chám-mas.*
Again	*klāo.*
give me again	*klao-káh.*
Another or **other**	*klá-oukh.*
Another; personal	*do-wá-do.*
Alive	*tee-chêe.*
All	*dobe.*
Always	*kay-uttl.*
Angry	*koh-sap'h.*
Ankle	*kul-lá-kul-lie.*
Arrive *at, to*	*wart-luk.*
When did you arrive at Victoria?	*ardis chealth kwiksa wartluk Bictolia.*
When did you arrive home?	*ardis chealth kwiksa ut-sáie.*
Arms	*wak-sas.*
right arm	*chah-bát-sas.*
left arm	*kart-sar.*
Arrow	*tsa-hút-chitl,* or *tsa-hat-tie.*
Arrow-head, *of wood*	*tsā-tsuk-ta-kwilth.*
of bone	*hah-sháh-biss.*
of iron	*chee-chair-kwilth.*
Autumn	*kwiatch.*
Axe	*he-sêe-ak.*

B

Back, the	*hey-túks-uthl.*
Bad	*klay-ass.*
Bag or **sack**	*klar-airsh.*
Barberry (berberis oregoniensis)	*klook-shítl-ko-bupt.*
Barbs of harpoon	*tsa-kwat.*
Bark	*tsar-kar-bis.*
Barrel	*bat-lap-tl.*
Barnacle	*kléep-ē-hud.*
Bat	*thlo-thle-kwok-e-batl.*
Battledore, or **boy's bat**	*klā-hairk.*
Basket	*bo-whie.*
little basket	*pe-koe.*
Beach	*sís-sá-bits.*
Beads	*cluk-partl-shitl.*
large cut beads	*kar-kwap-pah.*
Behind	*o-uk'-atl.*
Berries	*hoats-ak-tup.*
ripe berries	*sa-kâtch-tl.*
to gather berries	*chí-ark.*
Birds (generic)	*hooke-toop.*
young birds	*de-dak-tl.*
sea ducks	*ko-whaithl.*
cormorant (gracculus violaceus)	*klo-poise.*
crane	*kwar-less.*
crow	*char-kar-do.*
butter duck	*chish-kul-ly.*

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[1] In the Makah, as in all the languages of this part of the Western Coast, the letters *r*, *f*, and *v* are wanting; as also *th*, whether hard or soft. Mr. Swan has employed the *r* following the vowel *a* to indicate the Italian sound, as in f*a*ther, and after *ai*, &c., to represent the neuter vowel *u*, as in the English *but*, and the French *je*. The letter *v* in pronouncing English words is changed to *b* or *m*. These last are convertible letters, as are also *d* and *n*. *Th*, when it occurs in the text or the vocabulary, is to be understood as an aspirated *t*, as in the French *thé*.—G. G.]

Birds	
mallard duck	*dah-hah-tich.*
surf duck	*al-ló-hain.*
harlequin duck	*tsat-tsowl-chak.*
scaup duck	*ko-ho-ash.*
eagle, bald	*ar-kwár-tid.*
eagle, golden	*kwa-kwát-i-buks.*
goose	*hah-dikh.*
guillemot	*klo-klo-chuh-sooh.*
gulls	*kwá-lil.*
grebe (*Podiceps occidentalis*)	*ah-low-ah-háiu.*
grouse	*too-too-artsh.*
heron	*hah-to-bad-die.*
humming-bird	*kwe-tá-kootch.*
jay	*kwísh-kwish-ee.*
kingfisher	*chesh-kully.*
pigeon, *band-tailed*	*háy-aib.*
raven	*klook-shood.*
woodpecker, *red-headed*	*kla-kla-bethl-putch.*
woodpecker, *golden-winged*	*kle-haib.*
sandpiper	*ho-hope-sis.*
oyster-catcher	*kwe-kwe-aph.*
Black	*toop-kooh.*
Blanket	*hey-taid.*
blue blanket	*art-lartl.*
red blanket	*klā-har-thl.*
white blanket	*kle-sethl.*
green blanket	*kor-buk-athl.*
Blood	*klar-klar-wárk-a-bus.*
Blue	*kwish′-kwish-á-kartl.*
Board	*klo-ailth.*
Body	*chath-leet.*
Body, *parts of*	
head	*to-hote-sid.*
hair, *on head*	*app-sahp.*
hair, *on body*	*chee-pee.*
face	*hā-túk-witl.*
face, handsome woman	*kloolth-sooh hā-túk-witl.*
face, handsome man	*kloo-klo hā-túk-witl.*
forehead	*hā-tuk-ant.*
ear	*pay-paer.*
eye	*kóllay.*
nose	*choo-oáth-tl-tub.*
mouth	*hā-tárks-tl.*
tongue	*la-kairk.*
teeth	*chee-chee.*
beard	*hah-puks′-ub.*
neck	*tse-kwár-bits.*
shoulder	*hey-dah-kwitl.*
arm	*wah-sas.*
elbow	*hā-dah-park-tl.*
wrists	*he-he-diár-kwe-dook.*
Body, *parts of*	
hand	*klar-klar-he-do-koob.*
fingers	*tsar-tsár-kwle-de-koob.*
thumb	*bă-bă-bits-ă-de-koob.*
nails	*chath-latcht.*
breast or chest	*héy-dus-hothl.*
woman's bosom	*a-dab.*
back	*hā-tuks-itl.*
leg	*klā-ish-chid.*
ankle	*kul-la-kully.*
foot	*klar-klar-tsoob.*
toes	*tsark-tsark-itl-sub.*
bones	*hah-shah-biss.*
heart	*chah-pah* or *kle-buks-tie.*
blood	*klar-klar-wā′rk-a-bus.*
liver	*pil-lok.*
fat or tallow	*hā-biks.*
kidney	*atsh-pahb.*
bladder	*kal-láh-tah-chib.*
stomach	*koo-you.*
belly	*ko-só-ar-ty.*
intestines	*tse-keup.*
skin	*klā-hark′.*
penis	*che-war.*
pudenda (female)	*jude.*
testes	*kar-ko-bits.*
swelled or enlarged testes	*dā-uk-tl.*
Boil, *to*	*klo-báhkst.*
Bone	*hah-shah-biss.*
Bore a hole, *to*	*tséet-kā-tsit.*
Both	*dobe.*
Bottle	*chah-bát-sits.*
Bow	*bis-tat-tie.*
Bowstring	*tsee-tsúts-see-dub.*
Boy	*wík-we-ak.*
Bracelets	*klar-klár-do-whas.*
Break or **destroy**	*kokh-shitl.*
Breasts of woman	*a-dab.*
Bring, *to*	*o-hóse.*
Broad or **wide**	*klo-ko.*
Brother	
elder	*tak-ke-ai.*
younger	*kar-thlatl-ik.*
Bucket or **box** for carrying water	*hoot-uts.*
Buy, *to*	*bar-kwátl.*
Burying-ground	*péets-uks-sie.*
By and by	*ar-déei.*
Bread, *soft*	*tlay-tlay-skook.*
ship bread or hard biscuit	*ar-hósh-kook.*
Buttons	*hoop-sooelth.*
Butter	*tlat-say.*

C

Canoe, Chienook pattern	*chap-ats.*
large size for whaling, to carry eight men	*pah-dow-thl.*
medium size, to carry six men	*bó-kwis-tat.*
small size, to carry two to four persons	*ar-tlís-tat.*
very small, to carry one person	*ta-kaów-dah.*

(The whaling canoes are divided by thwarts or stretchers into five compartments, which are named as follows, as are also the occupants:—)

the bow	*hey-tuks-wad.*
the next behind	*kah-kai-woks.*
centre of canoe	*chah-thluk-do-as.*
the next behind	*hey-tuk-stas.*
stern	*klee-chah*
Candle, lamp, or **torch**	*la-kar-joss.*
Carry, *to*	*hā-dáiks.*
Carpenter, worker in wood	*kar-sár-kuk-tl.*
Calico for woman's dress	*hah-dah-kwits.*
Catch, *to*	*tsoo-kwitl.*
Cattle	*boos-a-boos* or *moos-a-moos* (borrowed).
Cedar-bark	*péet-sup.*
Chair	*ko-kóke-we-dook* or *ta-kwát-ses.*
Chest or **breast**	*hêy-dus-ho-thl.*
Chest or **box**	*klă-he-dethl* or *ar-hwe-dooks.*
Chisel for making canoes	*klar-kar-yuk.*
Chicken-pox	*yah-bass.*
Chief	*cha-bátth.*
Child	*yá-duk.*
infant	*ya-duk-kow-i-chee.*
Chop, *to*	*hē-sis.*
Clams (generic)	*cha-its.*
qua-haug	*cha-its.*
large clams (*Lutraria*)	*har-loe.*
blue striated	*har-ar-thlup.*
Clouds	*kle-deek-a-bus.*
Coat	*sa-se-tuk-lee.*
Cock	*ahá-hah-cha-kope.*
Cockle	*kla-lab.*
Codfish, *true*	*kár-dartl.*
Codfish (a variety called in the jargon *cultus* cod)	*toosh-ków.*
Codfish, *black*	*be-shŏwe.*
Cold, *I am*	*che-teer-hus.*
cold weather	*bat-lathl.*
Colors	
white	*kle-sook.*
red	*klay-hoke.*
black	*toop-kook.*
blue, dark	*toop-kook.*
blue, light	*bo-kobe.*
green	*kwar-buk-uk.*
Comb	*kle-pe-ak.*
Common person	*mis-che-mas* or *bis-che-bas.*
Come, *to*	*ut-sai-ee.*
I come	*ut-sai-atl-shie.*
you come	*shoo-oógh.*
Contempt, *expression of*	
to a male	*kā-shook.*
to a female	*hêy-hook.*
Cook, on stones	*tá-chope.*
Copulate	*koo-kook.*
Corpse	*kok-shitl.*
Cougar	*háy-aed.*
Cough	*wa'-wa-se-koss.*
Cradle	*ya-duk-spa-tie.*
Crab (generic)	*hol-lo-wah.*
Cranberries	*pap-pas.*
Crane	*kwar-less.*
Crow	*cha-kár-do.*
Crooked	*wake-iss-soo-its.*
Cry, *to*	*kay-hark.*
Cup	*tsiar-koob.*
Cut	*kart-sap.*
Cuttlefish	*te-thlope.*

D

Dance, *to*	*hóth-look.*
Darkness	*wis-tá-huk.*
Daughter (child)	*har-dów-e-chuk.*
Day	*kle-sê-hark.*

(This also means daylight. In enumerating days, the word *chealth* is used.)

Dead	*kok-shal.*
Deadland (country of the dead)	*hay-tár-puthl.*
Deep	*har-chée.*
Deer	*bo-kwitch.*

Demons (the primal race)	*che-che-wuptl.*
devils	*chê-war.*
Dig, *to*	*tsar-kwar-kethl.*
Dirt	*sar-kwák-ā-bus.*
Do, *to*	*bar-bóo-ak.*
Dog	*keh-deitl.*
Dogfish	*yáh-chah.*
Door	*boo-shoo-i-sub.*
Down, *bird's*	*pó-hoke.*
Down stream	*ik-tar-wárk-liss*
Dream, *to*	*o-oár-portl.*
Drink, *I*	*hoo-tuks-itl.*
Drive, *to*	*a-aiks* or *aáh-eks.*
Drunk	*a-whatl-youk.*
Dry	*klo-shówe.*
Duck, mallard	*dah-hah-tich.*
Dull	*wee-we-thuk-tl.*
Dung	*shab.*
to dung	*shab-bah.*

E

Ear	*pā-páer.*
Earth	*kwe-che-ar.*
dirt	*sar-kwák-a-bus.*
Eagle, bald	*ar-kwár-tid.*
osprey	*kwa-kwal-i-buks.*
Eat	*hah-ouk.*
Echinus (sea-urchin)	
large	*toot-sup.*
small	*koats-kappr.*
Eggs	*dóo-chak.*
Eight	*ar-tles-sub.*
Elbow	*hā-dah-park-tl.*
Elk	*tóo-suk.*
End (or point)	*yu-chíl-tish.*
Evening	*ar-tuk-tl*
Eye	*kollay.*
Exchange, *to*	*hó-oe-yah.*

F

Face	*hā-tuk-witl.*
Far	*táh-ness.*
Fat or **fleshy,** applied to persons	*ă-kít-ko-shee.*
Father	*do-waks.*
grandfather	*dar-dairks.*
Fathom	*ailtsh.*
one fathom	*tsark-we-ailtsh.*
two fathoms	*art-lailtsh.*
three fathoms	*wee-ailtsh.*
four fathoms	*bo-ailtsh,* &c.
Feathers	*shoo-hóobe.*
quills	*kī-thlā-id.*
down	*pó-koke.*
Fence	*klar-kub.*
Fight, *to*	*be-túk-we-dook.*
Find, *to*	*soo-kwartl.*
Finish, I have finished work or eating	*he-ártl.*
File	*tee-chair-uk.*
Fingers	*tsar-tsar-kwle-de-koob.*
Finger-ring	*kar-kar-buk-e-dóo-kup.*
Fir-tree	*sah-bah-tah-há-ko-bupt.*
Fire	*ah-dahk.*
make fire	*ah-dáhk-sa.*
get up and make a fire	*koo-dook-shitl-ah-dahk-sa.*
Firewood	*ar-tik-sáh.*
First or **before**	*o-oltht.*
Fish, *to*	*o-oash-taytl.*
Fish	

(There is no generic name for fish; but when going for fish, the species are designated; for instance, for halibut, *o-oash-taytl-shoo-yoult;* for codfish, *o-oash-taytl-kar-dartl,* &c.)

brook trout	*klar-klek-tso.*
codfish, *true*	*kar-dar-tl.*
cod, false	*toosh-kow.*
cod, black	*be-shŏwe.*
red rockfish, or grouper	*klā-háp-pahr.*
black or mottled rockfish	*tsā-bár-whar.*
catfish (*Porichthys notatus*)	*ā-o-wit.*
dogfish	*yah-chah.*
flounder	*klu-klu-bais.*
flounder, large spotted	*kar-láthl-choo.*
halibut	*shoo-yoult.*
herring	*kloo-soob.*
salmon, spring or silver	*tsoo-wit.*
salmon, young	*tsow-thl.*
salmon, summer	*háh-dib.*
salmon, dog-tooth or fall	*cheech-kó-wis.*
salmon trout	*hópe-id* or *ho-péd.*
sapphire perch (embiotoca perspicabilis)	*wa-ā-kupt.*
sculpin, buffalo	*kab-biss.*
sculpin, large	*tsa-dairtch.*

Fish	
skate	*bil-la-chie.*
shark	*sah-bass.*
Fish-club, *for killing fish*	*tíne-thl.*
Fish-gig	*heche-tl-tah.*
Fish-hook	*koo-yak.*
halibut-hook	*che-bood*
barb of halibut-hook	*kôo-sub.*
wood of halibut-hook	*tsar-whár-to-wik.*
Fishing-line of kelp	*sar-dat-tlh.*
Fish-weir	*boo-shóo-wah.*
Five	*sheutche.*
Flea	*bat-cha-seed.*
Flesh	*bēet-sie.*
Flounder, flatfish	*klu-klu-bais.*
Flour	*tlik-tlay-skoop.*
Fly, *the insect*	*bats-kwad.*
Food	*har-ouk.*
Foolish	*a-whatl-tsuck.*
drunk	*a-whatl-youk.*
Foot	*kla-ish-ted* or *klar-dark-sub.*
Forehead	*há-tuks-aht.*
Four	*boh.*
Formerly or **a long time ago**	*hó-ái.*
Freckled	*joke-see.*
Friend	*yár-kwe-dook-uks.*
Fry-pan	*soo-uk-itl.*
Full	*tsar-bar*

G

Gamble, *to*	*húl-láh-ah.*
to win at gambling	*hā-tarp.*
to lose at gambling	*hā-tā-itl*
Gambling-disks	*la-hullum.*
the wood from which the disks are made, a species of hazel	*hul-iár-ko-bupt.*
Get up, *to*	*koo-dóok-shitl.*
Get, *to,* or **receive**	*tsóo-kwitl.*
Girl	*har-dów-e-chuk.*
Give, *to*	*klā-kase.*
Go, *to*	*klark-shitl.*
I go	*he-de-ár-saiks.*
you go, *spoken to one*	*he-de-ar-sitl-gie.*
you go, *spoken to a number*	*he-de-ar-sitl-chik.*
one of you go	*ar-dé-siche har-du-ass.*
go quick	*wá-háh-tle-gie ā-ā'-shie.*
go along	*wa-hah-tle-gie.*
Go	
I go to the house	*wáttle-shaiks*
I am going	*wattle-she-áitl.*
Good-bye	*ā-kúth-lik-kar.*
Good	*kloo-klo* or *klo-shish.*
very good	*kwar-cés-sar.*
Goose	*hár-duk* or *háh-dikh.*
Grandfather	*dá-dairks.*
Grandmother	*dá-dairks.*
Grave, *a*	*peets-uk-sie.*
Grass	*klar-kúpt.*
Grain, growing	*á-hósh-ko-bupt.*
Grease	*tlair-bass.*
tallow	*hā-biks.*
oil	*kár-took.*
Grebe (*Podiceps*)	*ă-low-ah-haiu.*
Green	*kwar-búk-uk.*
Grind, *to*	*teh-chár-shitl.*
Grouse	*too-too-artsh.*
Guillemot	*klo-klo-chúk-sook.*
Gull	*wha-líl* or *kwa-líl.*
Gum or **pitch**	*kluk-áit-a-bis.*
Gun, double barrel	*artl-dooh.*
single barrel, with flint lock	*poo-yah*
single barrel, with percussion lock	*hah-kul-la-kubtl.*

H

Hail	*kart-see-die.*
Hair	*ahp-sahp.*
Haikwa (the dentalium)	*che-tā-dook.*
Half	*yóoh-tah-dit-lait-so.*
Halibut	*shoo-yoult.*
halibut-hook	*che-bood.*
Hand	*klar-klar-he-do-koob.*
right	*char-bat-sas.*
left	*kart-sar.*
left-handed	*kart-sook.*
Hands	*lo-la-pie.*
Hard or **tough**	*kar-tark.*
Hare, *rabbit*	*too-toop-jis.*
Haul, *to*	*cheatl.*
haul canoe	*cheatl-cha-pats.*
portage for hauling canoes	*cheatl-tar-shee.*
Hawk	*tast-át-wik.*
Hat	*se-ke-áh-poks.*
Hay	*klar-kupt.*
He, when present	*o-hok.*
if absent	*o-hoh.*
Head	*to-hóte-sid.*

Head-dress of dentalium, worn by young girls	*batl-kup-klā-o-koob.*
Hear	*dah-áhh.*
Heart	*cháh-páh.*
Hen	*ah-hah-ha hai-up.*
Here, *I am*	*yath-tláy-ad.*
Here	*tee.*
Heron	*háh-to-bad-die.*
Herring	*kloo-sóob.*
Hide, *to*	*úptah.*
Hit, *I*	*há-pórp.*
Hole	*kó-we-tar.*
Holla	*hō'hh-shitl.*
Hog	*klā-klā-kwar-tiltl.*
How many	*ár-dis.*
Hoe	*e-túks-darp.*
House	*ba-as.*
Hundred	*klă-hó-oke* or *sheutch-e-uk.*
Hungry	*hár-koh.*
are you hungry	*hár-koh-kuk.*
I am hungry	*hár-koh-huss.*
Husband	*chá-kope.*
Hurry, make haste	*ā-ā-shie.*

I

I	*sé-ir.*
Ice	*koo-hooh.*
Indians, *people*	*kleits-ā-kwad-die.*
Infant	*ya-duk-kow-it-chie* or *ya-duk-kwa-ow-i-chuh.*
Iron	*klair-yuh.*
Island	*oper-jec-ta.*

J

Jay	*kwish-kwish-shée.*
Just now	*kluh.*
Jest, *to,* or **a jesting person**	*tlá-tla-wik.*

K

Kamass (*Scilla esculenta*)	*kwad-dis* or *kwa-niss.*
Kettle or **pot**	*o-páh-suk.*
Key	*tluk-tlairk.*
Kill, *to*	*kokh-saph.*
Knee	*ko-ko-shák-le-de-koob.*
Knee-pan	*klu-thlúk-le-de-koob.*
Knife, sheath	*kar-kairk.*
pocket	*kar-kairk.*
dagger	*to-kwark.*
for splitting halibut	*kó-che-tin.*
Know, *I*	*kum-ber-tups se-ir.*
I don't know, or perhaps, or implying a doubt	*kwóws.*

L

Lake	*chā-uk-tsope.*
Large, great	*ā-ā'-ho.*
Lately, just now	*kluh.*
Laugh, *to*	*kle-war.*
Lazy	*wee-wa-i.*
I am lazy	*wee-wā-i thluk-ā-thlits.*
you are lazy	*wee-wa-i thluk-a-thlus.*
Leaf	*klā-kupt.*
Leap	*á-úts-kutch.*
Left, *the*	*kart-sass.*
left-handed	*kart-sook.*
Leg	*klā-ish-chid*
Lice	*kā-cheed.*
nits or eggs of lice	*karts-ar-kleed.*
Lie, *to;* a falsehood	*ká'-tah-bat-soot.*
Light	*dah-chówtl.*
day-dawn	*you-oui.*
Lightning	*kā-káirtch.*
Like, similar	*o-bobe-te.*
Listen	*dah-áhh.*
Lively, spry	*hāh-háhts-tzae.*
Long	*há-ă-tse.*
long time	*kail-chiltl.*
Look! to call the attention	*kled-da.*
Look for, *to*	*dā-dáh-chu-chish.*
look here	*har-dássie.*
Love, *to*	*yáh-ah-kups.*
Low tide	*klu-shów-a-chish-chuck.*
high tide	*tsu-bá-i-chish-chuk.*
Lynx	
Looking-glass	*dah-chówtl.*
Lose, *to*	*eesh-sap.*

M

Mallard duck	*dah-hah-tih.*
Mammals	
bat	*thle-thle-kwok-e-battl.*
bear, black	*árt-leit-kwitl.*

Mammals	
beaver	*de-hai-choo.*
cougar	*hā-aēd.*
deer	*bo-kwitch.*
dog	*keh-dēitl.*
elk (*C. Canadensis*)	*too-suk.*
hare, *rabbit*	*too-toop-jis.*
mink	*kwár-tie.*
mole	*took-tooksh.*
mouse	*se-bit-sa-bee.*
land-otter	*kar-to-wee.*
sea-otter	*tee-juk.*
sea-lion	*ar-kar-wad-dish.*
seal (hair)	*kars-chowee.*
seal (fur)	*káith-la-dose.*
skunk	*e-aíl-ā-hai-use.*
squirrel	*se-bi-to-wie.*
wolf	*choo-choo-hu-wistl.*
whale (generic)	*chēt-ā-pook.*
sperm	*koats-kay.*
right	*yách-yo-bad-die.*
fin-back	*kow-wíd.*
blackfish	*klos-ko-kopphr.*
sulphur-bottom	*kwa-kwow-yák-thle.*
killer	*che-che-wid.*
California gray	*se-whow* or *chet-a-pook.*
porpoise	*ár-ich-pethl.*
puffing pig	*tsailth-ko.*
white-fin porpoise	*kwar-kwartl.*
Man	*cha-kope.*
young man	*kla-hoke-she-thlar-sad.*
old man	*ai-choob-e-chul.*
Many, *how*	*ar-dis-ailth.*
Masks used in ceremonies	*hooh-ków-itl-ik.*
Mat of cedar-bark	*bak-lap.*
large mat	*kla-hairlt.*
small mat	*che-bat.*
rush mat	*to-dahh.*
Meat, *fresh*	*beet-sie.*
Medicine	*ko-ie* or *kow-ie.*
Medicine man, magician, or **doctor**	*oash-tā-kay.*
Medicine performances	*tsi-ark.*
Medicine or **tamanawas ceremonies**	*du-kwally* or *klook-wally.*
Middle or **midway**	*ah-pów-wad.*
Milk	*a-dab.*
Mill	*chit-chit.*
Mind, *the*	
male	*kla-buks-tie.*
female	*ha-dáh-dittl.*
Mink	*kwar-tie.*
Miss	
a mark, to	*wake-tuch-e-dook.*
miss the road	*wee-kuttl-shishtar-shee.*
mistake in speech	*kā-tárk-lish.*
Molasses	*chám-o-set.*
Mole	*took-took-sh.*
Mollusks	
barnacle	*kle-be-húd.*
clams	
large (*lutraria*)	*har-loe.*
blue striated	*har-ar-thlup.*
cockle	*klá-lab.*
haikwa (*dentalium*)	*che-têh-dook.*
mussel	*klo-chab.*
oyster	*kloh-kloh.*
thorn oyster	*ko-okh-sā-de-buts.*
scallop, large	*klá-er-kwa-tie.*
small	*wad-dish.*
sea-egg	*koats-kapphr.*
Month	*dah-kah.*
Months, *names of*	
January	*a-a-kwis-puthl.*
February	*klo-k' lo-chis-puthl.*
March	*o-o-tukh-puthl.*
April	*ko-kose-kar-dis-puthl.*
May	*kar-kwush-puthl.*
June	*hā-sairk-toke-puthl.*
July	*kar-ke-supphr-puthl.*
August	*wee-kooth.*
September	*kars-puthl.*
October	*kwar-te-puthl.*
November	*chā-kairsh-puthl.*
December	*se-whow-ah-puthl.*
(The year consists of six months, and is called *tsark-wark-itchie.*)	
Moon	*dah-kah.*
More	*tah-kah.*
Morning	*yóo-ie.*
Mosquito	*wah-háts-tl.*
Mother, *my*	*a-bairks.*
Mountain	*hai-airch.*
Mouse	*se-bit-sa-bee.*
Mouth	*hā-tarks-tl.*
Moxa, a small cone of combustible matter burnt slowly in contact with the skin, to produce an eschar	*bóo-chitl.*
(The inner bark of the white pine is used for the purpose.)	
Music or **bell-ringing**	*tsar-sík-sap.*

Mussel	*klo-chab.*
My house	*seir-bass.*
My sister	*klo-chuk-sub.*
My things	*ko-kote-sa-kut-liks.*
Mythology	*ho-hó-e-up* or *ho-ho-e-up-béss.*

(Names of two fabulous men of antiquity who changed men into animals, trees, and stones.)

N

Nails (finger)	*chath-latch.*
iron nails	*klap-a-koob.*
Naked (without clothing)	
male	*sho-she-dáhh.*
female	*she-she-dă-tartl.*
Name	*á-júk-kluk-kik.*
Near	*klar-weích-i-ka.*
Neck	*tse-kwar-bits.*
Needle	*kar-juk.*
Nest (bird's)	*par-huts.*
Never	*wake-kā-kwows.*
New	*soost-ko.*
Night	*ut-haie.*
Nine	*sar-kwas-sub.*
No	*wā-kee* or *wake-isse.*
None	*wake-kade.*
Noon	*takh-assie.*
Nose	*choo-oath-tl-tub.*
Now	*kluh-o-ko-wie* or *kluh.*
Numerals[1]	

(In counting, it is usual to enumerate ten, and then commence at one, repeating in tens, and at the end of each call the number, thus: ten, *kluh;* two tens or twenty, *tsar-kaits;* three tens or thirty, *kar-hook,* &c.)

1	*tsark-wark* or *tsar-kwok.*
2	*attl* or *uttl.*
3	*wee.*
4	*boh.*
5	*sheutche.*
6	*cheh-partl.*
7	*at-tleph* or *attl-poh.*
8	*ar-tlês-sub.*
9	*sar-kwás-sub.*
10	*kluh.*

Numerals

11	*tsark-woke.*
12	*ut-tlai-ouk.*
13	*wee-ouk.*
14	*boh-kwe-ouk*
15	*sheutch-e-ouk.*
16	*cheh-pártl-ouk.*
17	*artl-pook.*
18	*ar-tles-sub-ouk*
19	*sar-kwas-sub-tsar-kart-sit.*
20	*tsar-kaits.*
30	*kar-hook.*
40	*art-leik.*
50	*art-lei-kish-kluh.*
60	*wee-oúk-ish.*
70	*wee-ouk-ish-kluh.*
80	*boh-kwe-uk.*
90	*boh-kwe-uk-ish-kluh.*
100	*sheutch-e-uk.*

(Any things round or oval, as pans, cups, plates, eggs, beads, &c., are counted with the following terminals to the simple numbers:—)

1	*tsark-wark.*
2	*attl-kuptl.*
3	*wee-ā-kuptl.*
4	*boh-kuptl.*
5	*sheutche-a-kuptl.*
6	*cheh-partl-kuptl.*
7	*at-tleph-o-kuptl.*
8	*ar-tles-sub-o-kuptl.*
9	*sar-kwassub-o-kuptl.*
10	*kluh-o-kuptl.*

(Articles having length, as rope, cloth, &c., have the terminal *ailsh,* which also means fathoms.)

1	*tsark-wark-ailsh.*
2	*attl-ailsh.*
3	*wee-ailsh.*
4	*boh-ailsh.*
5	*sheutche-ailsh.*
6	*cheh-partl-ailsh.*
7	*at-tleph-ailsh.*
8	*ar-tlessub-ailsh.*
9	*sar-kwás-sub-ailsh.*
10	*kluh-ailsh.*

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[1] The method of counting on the fingers is as follows: they commence with the little finger of the left hand, closing each finger as it is counted; then pass from the left thumb, which counts five, to the right thumb, which counts six, and so on to the little finger of the right hand, which counts ten. I have sometimes seen Indians commence counting with the little finger of the right hand, but it is invariably the custom to commence with that finger instead of a thumb.

Numerals

(In counting fish, or measuring oil or potatoes, they make use of the terminal *ul*, which is an expression of assent. One person will call the number, which another will repeat, adding the terminal *ul*, meaning, as we would say, this is one, this is two, &c.)

1	*tsark-wark.*
2	*attl-ul.*
3	*wee-ul.*
4	*boh-ul.*
5	*sheutche-ul.*
6	*cheh-partl-ul.*
7	*at-tleph-ul.*
8	*ar-tles-sub-ul.*
9	*sar-kwas-sub-ul.*
10	*kluh-ul.*

O

Oar	*e-sáib-e-suk.*
Off shore	*hai-árt-stat.*
Oil	*kár-took.*
Olden time or **formerly**	*ho-ái-o-kwi.*
Old man	*ai-chope.*
Old woman	*ái-chub.*
On or **towards shore**	*klar-wárt-stat.*
One	*tsar-kwart* or *tsar-kwoks.*
Open	*kotle-tah.*
Opposite or **the other side**	*kwis-pairk.*
Otter	*kar-tówe.*
Ours, we, or **us**	*do-wár-do.*
Outdoors	*uée-á-aiks* or *kwee-á-aiks.*
Out of the canoe	*oós-tah-setl.*
Overturn	*hoke-shitl.*
Owl	*took-te-kwad-die.*
Oyster	*kloh-kloh.*
thorn oyster (*Spondylus*)	*ko-ok'h-sa-aê-buts.*

P

Paddle, *a*	*kla-táh-juk.*
Paddle, *to*	*klé-huk.*
Peas	*tsóosk-shitl.*
Penis	*ché-war.*
People	*kleits-ā-kwad-die.*
Pigeon	*háy-aib.*
Pipe	*kŭsh-sets.*
Pitch	*kluk-áit-ā-bis.*
Plank	*kló-ailth.*
Plants	
barberry	*klook-shitl-ko-bupt.*
berries	*hóats-á-kupt.*
fern	*dit-se-bupt.*
grass	*klar-kupt.*
kamass	*kwad-dis.*
rush	*sal-láh-hutl.*
sallal (*Gualtheria*)	*sal-láh-ha-bupt.*
salmon-berry	*kar-ke-wai.*
salmon-bush	*kar-ke-weep.*
salmon-sprouts	*ko-kose-kárdlth.*
strawberry	*hár-de-tup.*
thumb-berry (*Rubus odoratus*)	*lo-lo-wits.*
sprouts of the same	*kothl-kowie.*
cranberry	*páp-pas.*
red huckleberry	*hêy-se-ahd.*
blue huckleberry	*ko-ho-ák-tl.*
gooseberry	*shatch-káh-bupt.*
currant	*hă-pá-pá-bupt.*
crab apple	*dôpt-ko-bupt.*
white birch	*klā-hap-partl.*
alder	*kwárk-sah-bupt.*
spruce	*do-hó-bupt.*
hemlock	*klar-kár-bupt.*
cedar	*klá-e-shook.*
yew	*klā-hairk-tle-bupt.*
dogwood	*kitl-che-bupt.*
elder	*sik-ke-ár-she-bupt.*
liverwort	*thle-thle-sús-sok-kowie.*
bittersweet	*bar-chíl-loh-kowie.*
liquorice (*Polypodium falcatum*)	*hur-há-tee.*
nettles	*kau-lup-kay.*
blind nettles	*a-dab-a-bupt.*
arbutus uva ursi	*klár-kupt.*
vine evergreen	*tsee-tsee-ess.*
tobacco	*kóo-shá.*
Plenty	*ar-ke-yúk.*
Point, *to*	*kope-shitl.*
Point or **end**	*yu-chíl-tish.*
Poor	*há-há-datl.*
very poor, unfortunate	*tlá-kwo.*
Porpoise	*tsáilth-ko.*
Potatoes	*kau-its.*
Poultry	*a-hă-há*
cock	*a-hă-hácha-kope.*
hen	*a-hă-háhai-up.*
Pound, *to*	*kláts-klai.*

Pour, *to*	*klook-sáp-gie.*
Powder	*bóot-sis-suk.*
Pregnant	*kleet-séet.*
Presently	*ar-dêei.*
Prongs of fish-gig	*héche-ta-kethl-tub.*
Pronouns	
I	*seir.*
I work	*ohó-bits-kwi-seir.*
I laugh	*ohóse-ā-ā-wika.*
my	*o-kwiks-te.*
thou	*sú-er.*
he	*ohó-te-da.*
we	*ohode.*
ye	*do-bits.*
they	*ah-dithl-tits.*
Proud	*to-póh.*
I am proud	*to-póots.*
he is proud	*to-tó-bush.*
they are proud	*tóp-kwitl.*
Pudenda	*jude.*
Push, *to.*	*chák-shitl.*

Q

Quick; *come quick*	*ut-sai-shoo-oókh.*
Quills	*ki-thla-id.*

R

Rain	*beit-la* or *beitlal.*
Rainbow	*tsów-a-ūse.*
Rake	*kle-pé-ak.*
Raven	*klook-shóod.*
Receive, *to*	*tsoo-kwitl.*
Red	*klā-hoke.*
Relations	*ó-o-arts.*
father	*dó-wiks* or *dó-aks.*
mother	*ā-baiks.*
grandfather	*da-dairks.*
grandmother	*ko-iāks.*
son, *my* (child)	*a-kūse-ch.*
son (grown up)	*ó-sha-hode.*
daughter, *my* (child)	*há-dów-e-chuk.*
(grown up)	*ā-tuk-hu-áttl-bus.*
husband, *my*	*chá-kope.*
wife, *my*	*hái-up.*
brother, *elder*	
said by a male	*tak-ke-ai.*
said by a female	*hah-chóop-siks.*
brother, *younger*	*kar-thlátl-ik.*
sister, *elder*	*kloo-chuk-sub.*
younger	*bá-bā-ik-sa.*
half-sister	*yu-kwa-uk-sa.*
Return	*hó-wái.*
by and by return	*ar-deei-ho-wái.*
Rifle	*tsoo-tsark-witl.*
Ring, *finger*	*kă-ká-buk-e-dú-kup.*
River	*tsā-ark.*
Road or **trail**	*tar-shee.*
Roast by the fire	*kla-ah-pis.*
Rope	*ses-tópe.*
Rotten, as wood	*kwer-kwer-juk-tl.*
as fruit	*ko-it-ják.*
Rum	*lum-muks.*
Run, *I*	*ā-hárts-its.*
Rush	*sal-láh-hutl*

S

Sallal berries	*kár-ke-sup*
Salmon	
spring or silver	*tsóo-it.*
young	*tsow-thl.*
summer	*háh-did.*
dog-tooth	*cheéch-kowis.*
trout	*hó-pid.*
Salmon roe	*ách-pahb.*
Salmon berries	*kar-ke-wai.*
Salt	*too-páthl.*
Salute on meeting a friend	
to a male	*kwátch-im.*
to a female	*koáth-lub.*
Sand	*ses-sá-bits.*
Sandpiper	*ho-hôpe-sis.*
Saw	*chee-te-ak.*
Scallop	*bo-whits-ae.*
Sculpin	*ka-biss.*
Sea (salt water)	*too-páthlcha-uk.*
Sea-fowl	*hooke-toop.*
Sea-lion	*ár-ká-wad-dish.*
Seal, hair	*kars-chówe.*
fur	*kaíth-la-doos.*
Seal's bladder	*kal-lá-ka-chub.*
Seal's paunch	*koo-yow.*
Seal-skin buoy	*du-koop-kuptl* or *do-ko-kuptl.*
Seasons	
spring	*klairk-shiltl.*
summer	*klu-pairtch.*
autumn	*kwi-atch.*
winter	*wake-pentl.*
Seat, *the*	*wāk-its.*
See, *to*	*dartl-shitl.*
I see	*ohose-dartl-chatl.*
I do not see	*chár-dis.*

See; look; to call the attention	*klêd-da.*
Seine	*ché-iks.*
Seven	*attleph* or *attl-poh.*
Sew, *to*	*de-kā-dek.*
thread	*de-káib.*
Shadow	*ko-ái-e-chid.*
Shark	*sah-bass.*
Sharp	*káek-shitl.*
Shells	*kai-ish-kud-dy.*
Ship	*bar-bethld.*

(This is a Nootkan word, *mar-meth-ld*, and signifies a house on the water. It is also applied to all white men, and signifies, when so applied, those who came in or who live in houses on the water.)

Shirt	*kle-hairk-tl.*
Shoes	*klā-klā-kús-tobe.*
Short	*dé-its.*
Shot	*klā-klā-to-kwók-ut-shiltl.*
Shoulder	*klá-ho-pa-tie.*
Shovel	*chat-kard.*
Shut or **close,** *to*	*boo-shú-it-tá.*
Shuttlecock	*o-kó-ey.*
Sick	*tá-ithl.*
Sing	*du-duke.*
Sister	
elder	*klu-chúk-sub.*
younger	*bar-bā-ík'-sa.*
Sit, *to*	*klă-dairk.*
squat down	*klā-deilth.*
you sit down	*ta-kwit-la-dáit-so* or *ta-kwitl-suer.*
I will sit down	*ta-kwit-lik-seir.*
all sit	*ta-kwilsh.*
Six	*cheh-partl.*
Skate (the fish)	*bil-lá-chie.*
Skin	*klā-hark.*
Skunk	*ā-āil-ā-hai-use.*
Sky	*hae-tah-ártstl.*
Slave	*ko-thlo.*
common person	*mis-che-mas* or *bis-che-bas.*
Sleep	*wêe-atch.*
Slow	*klā-wá.*
when applied to persons	*wee-wich-kub-bik.*
when applied to ships or canoes	*wêe-chook.*
when applied to animals	*wêe-chu-kuptl.*
Small	*kwā-ów-e-chuk.*
Smallpox	*he-he-dathl.*
Smell, *to*	*bê-shitl.*
Smell	
unpleasant smell	*u-bus-suk be-shitl.*
agreeable smell	*chab-bas be-shitl.*
Smoke	*kóo-sha.*
Snake	*tlay-ee.*
Sneeze, *to*	*too-toóp-uks.*
Snow	*koo-sié.*
Sorrow	*kwă-úk-wiks-seuk-iktl.*
Speak, *to*	*ó-she-buts.*
Spear	*beelt-sie.*
bird-spear	*heich-il-tah.*
Spear fish, *to*	*hă-poorp.*
Spill	*hóke-sah.*
Split	*hey-sís.*
Spoon	*chat-káirk.*
Spring	*kláirk-shitl.*
Squirrel	*síb-be-tab-be.*
Stand, *to*	*klaerk-shitl.*
Star	*tówie-sub-buts.*
Steal, *to*	*koathl.*
to snatch or take a thing forcibly	*kåp-shitl.*
Stone	*teh-deh-chooh.*
Stone pestle or **maul** for splitting wood	*tă-kă-wă-dă-ăks.*
Stop (imperatively)	*e-yáhh.*
remain	*e-yáh-has-sie.*
Stop; to finish	*hé-artl.*
Story	*kúm-itl-kups.*
Straight	*tar-kárpt.*
Stranger	*hó-o-war-te-duks.*
Strawberries	*háh-de-tup.*
Strike, *to*	*kok-sap.*
Strong	*dah-shook.*
Stubborn	
male	*wáy-a-buktl.*
female	*wā-áib.*
Summer	*kloop-pairtch.*
Sun	*kle-sā-kairk.*
Suppose (if)	*kwá-kai.*
Surf	*sis-să-káh-dá-kās.*
Sweet, or pleasant to taste or smell	*chab-bas* or *cham-mas.*
Swim	*soo-soóke.*

T

Table	*ko-aph.*
Table with food	*how-athl.*
Tail	*wáh-huts.*
Take, *to*	*suk-wítl.*
Talk, *to*	*ó-she-buts.*
Talk, *trifling*	*hé-he-huy.*

Talk	
stop your talk, or you talk foolishly	*uthl-kud.*
Tallow	*hā-biks.*
Taste, *to*	*he-dáouks-tl.*
Tell the truth, you	*tā-ko-bats-suer.*
do not lie	*wake-íss kā-túk-tliss.*
Ten	*kluh.*
Testicles	*kar-kó-bits.*
Thanks	*ho-shee-árk-shis.*
That	*teé-dah.*
There	*téit-ser.*
They	*do-dóbe.*
Thick	*ár-took* or *utt-he.*
Thin	*wát-chid.*
Thirsty	*cha-éer-hus.*
This	*têe-kah.*
Thou	*suer.*
Thunder	*thleu-kloots.*
Thus, or the same	*kwar-ces-sie.*
very good	*kwar-ces-sar.*
Thread	*de-kábe.*
Three	*oui* or *wee.*
Throw away, *to*	*hêsh-tsap.*
Tide, *high*	*tsu-bā-i-chish-chuk.*
Tide, *low*	*klu-show-a-chish-chuk.*
Tie, *to*	*bátl-shitl.*
tie canoe	*batl-sap.*
Tired, weary, or **exhausted**	*tahk-ke-á-you.*
Tobacco	*kush-á.*
smoke	*kush-á.*
Tobacco-pipe	*kush-sets.*
to smoke a pipe	*kush-she-áiks.*
To-day	*kle-sée-ă-kow-ă-ka-die.*
yesterday	*kláo-cheelth.*
Toes	*tsark-tsárk-itl-sub.*
Together	*do-dó-buks.*
To-morrow	*ár-bei* or *ár-bi.*
To-night	*ut-hāi-u.*
Tongue	*lā-kairk.*
Towards shore	*klar-wárt-sat.*
Trade, *to*	*bar-kwátl.*
Trail or **road**	*tár-shee.*
Trap	*kap-páirk.*
Tree	*ah-hahts-ish.*
Trencher or **wooden dish**	*klo-kwaks.*
Trifling (jargon *cultus*)	*wake-isse.*
very trifling	*hah-háh-datl-wake-isse.*
Trout, *brook*	*klá-klek-tso.*
Trowsers	*kla-ísh-ja-kuk.*
True	*klu-klo-oshe-buts.*
Trunk or **chest**	*ă-huy-dookst.*
Turn around	
a kettle	*arts-kwe-dúk-sah.*
a canoe	*hóh-who-al.*
or look here	*ar-tís-kwe-dook.*
Two	*attl* or *uttl.*

U

Under	*há-tá-post-luk.*
Understand	*kúm-ber-tups.*
Unpleasant, or offensive to taste or smell	*u-bús-suk.*

(For instance, the smell of a skunk, snuff, ammonia, pungent spices, carrion, &c.; or the taste of vinegar, spice, anything bitter, &c. Whatever is pleasant to taste or smell is termed *cháb-bas* or *chám-mas.*)

Untie	*klúk-tl-sup.*
Up	*hi-ér-chi-dítl.*
Up, to place anything	*he-dás-ho.*
to take anything up and place it on a table	*he-dás-pe-tup.*
to place anything from a table on the ground or floor	*oas-tap-a-ter.*
Upright, as to stand up or put up a post	*klár-kisht.*
to drive down a stake perpendicularly	*klar-kisht-să-ho.*
Upset	*kook-sah.*
Up stream	*hă-dárd-tl.*
down stream	*ik-tark-wárk-kliss.*
get up, applied to a child	*sé-kah.*

V

Vinegar	*tse-há-puthl.*

W

Wagon	*tsark-tsárk-as.*
Walk, *to*	*tlā-uk.*
Want, *to*	*o-ote-sus.*
Warm	*kloo-partl.*
Warrior	*wé-e-buktl.*
Wash, *to,* the head	*tso-ai-ouk.*
the face	*tso-kwów-itl.*
the person	*hah-táhd.*
clothes	*tso-kwitl-gee.*

Water	*chă-ouk* or *chá-uk.*
Waterfall	*toó-withl.*
Waves	*whe-ups.*
Weary; exhausted	*tahk-ke-ā-you.*
We	*ohóde.*
Wedge	*klár-dit.*
Weir for fish	*boo-shóo-war.*
Whale (generic)	*chet-a-pook.*
What	*buk-kuk* or *art-juk.*
what do you want	*búk-ke-klair-sik.*
what are you doing	*búk-ke-da-har-pik.*
what is your name	*art-juk-klúk-ish.*
what is his name; *an expression of doubt when trying to think of a person's name*	*cha-ká-dah.*
Wheat	*bar-ba-chéss-kook.*
Where	*wa-as.*
where are you going	*wa-ás-a-kleesh* or *wa-ás-a-kartl.*
where do you come from	*wa-ás-ă-te-kleek.*
where do you go	*wa-ás-a-te-kleesh.*
Whistle, *to*	*sā-sáhb.*
White	*kle-sóok.*
White men	*bar-bethld.*
Who	*art-juk.*
Why	*ba-ka-dah.*
Wife	*hai-up.*
Wind	*wake-sie.*
north wind	*batl-el-tis.*
south wind	*kwart-see-die*
Wind	
east wind	*too-toóch-ah-kook.*
west wind	*wa-shél-lie.*
southeast wind	*too-chée.*
northwest wind	*yu-yoke-sis.*
Wings	*klap-ā-hub.*
Winter	*wake-parthl* or *bat-láthl.*
Within or **in**	
canoe	*e-túks-is.*
house	*bát-che-ailth.*
Wolf	*choo-choo-ukstl.*
Woman	*har-dairk.*
old woman	*ai-chub.*
Wood, *dead*	*pathl-hukt.*
Work	*bar-boo-ak.*
Worthless	*pé-shak.*
Wrist	*he-he-diár-kwe-dook.*
Write, *to*	*char-tar-tle.*
writing or drawing	*char-tái-ouks.*
writer or painter	*chár-tik.*

Y

Yard, *measure*	*kart-sark.*
Yawn, *to*	*pas-táhk-shitl.*
Yes	*a-ah* or *háh.*
Yesterday	*clá-o-cheelth.*
You	*suer.*
Young man	*klā-hoke-shé-tlāi-sad.*
Yours	*su-wátch.*

NOTE.—The following words which appear in the text do not belong to the Makah, but are "Jargon" words, derived from other languages.—G. G.

Cultus, Chinook *kal-tas,* worthless; good for nothing; inferior.

Skookoom, Chihelis *sku-kūm,* a ghost; an evil spirit or demon.

Tamanawas, Chinook *i-ta-ma-na-was,* a guardian or familiar spirit; magic; luck; fortune; anything supernatural; conjuring.

LOCAL NOMENCLATURE OF THE MAKAH.

Kwe-nait-che-chat. Tribal name.

Deeart or *Deeah.* Neeah Bay and village.

Chardi. Tatoosh Island. This is also termed *Opa-jecta,* or the island.

Ho-selth. Village at Flattery Rocks.

Tsoo-ess. Village on the Tsooyes River, near its mouth.

Tsów-iss. The rock at the mouth of the river, on its southwest side.

Ba-hó-bo-hosh. The rocky point on the north side of the mouth of the river.

Tsoo-yescha-uk. The river flowing past the Tsooess village.

Wa-atch. Village at mouth of Waätch Creek.

Ar-kút-tle-kower. Point west of Waätch village.

Kid-de-kúb-but. A village half-way between Tatoosh Island and Neeah Bay.

Bā-á-dah. The eastern point of Neeah Bay.

Koit-láh. The western point of Neeah Bay.

Wa-ád-dah. Island between Bā-á-dah and Koit-láh points.

Sah-da-ped-thl. Rocks west of Kiddekubbut village, on which H. B. M. steamer Hecate struck in 1861 (Aug. 19th).

Kee-sis-so. The rocks at the extreme point of Cape Flattery.

Tsar-tsar-dark. The conspicuous pillar rock at the northwest extremity of Cape Flattery.

To-kwák-sose. A small stream running into the Straits of Fuca, two miles east of Neeah Bay.

Kaithl-ka-ject. Sail rock opposite the mouth of Tokwaksose River.

Sik-ke-u. A river east of the Tokwaksose.

Hó-ko. A river six miles east of the Tokwaksose, a fork of the Sikkeu.

(This river is incorrectly spelled Okĕho. The Makahs strongly aspirate the first syllable, and pronounce as I have written it, *Hó-ko.*)

Klā-klá-wice. Clallam Bay.

INDEX.

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