A MANUAL OF THE HARMONIC ANALYSIS AND PREDICTION OF TIDES

U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

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E. LESTER JONES, DIRECTOR

TIDES

A MANUAL OF THE HARMONIC ANALYSIS AND PREDICTION OF TIDES

By

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PREFACE.

This volume was designed, primarily, as a working manual for the tidal computers of the U. S. Coast and Geodetic Survey, and the aim has been to produce a convenient work of reference on the subject of the harmonic analysis and prediction of the tides.

It is based largely upon the works of Sir William Thomson, Prof. George H. Darwin, and Dr. Rollin A. Harris. The tidal components scheduled in this volume are those which have been in general use in the harmonic prediction of the tides for many years, and they are sometimes called the Darwinian components. It may be added that Dr. A. T. Doodson, of the Tidal Institute, University of Liverpool, in a recent development of the tide-producing force by a method differing somewhat from that used by Professor Darwin, has obtained a new schedule of components which include some elements which were not contained in the Darwinian schedule. Although the additional components are generally of small theoretical magnitude, it is possible that some may be found by further investigation to be of sufficient importance to be taken into account in the analysis and prediction of the tides.

The volume includes a collection of tables used in the analysis and prediction of the tides, these tables being prepared with the aim of facilitating the work of the computer. At the end of the volume there is given a table of the principal tidal harmonic constants for many stations throughout the world, thus providing the data required for the harmonic prediction of the tides at these stations. A table of this kind is, of course, subject to growth and revision, and it is hoped that the present compilation may serve as a basis for future publications in which the entire maritime world is more comprehensively represented.

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HARMONIC ANALYSIS AND PREDICTION OF TIDES.

Part I.—DESCRIPTION.

INTRODUCTION.

1. HISTORICAL STATEMENT.

Sir William Thomson (Lord Kelvin) devised the method of reduction of tides by harmonic analysis about the year 1867. The principle upon which the system is based—which is that any periodic motion or oscillation can always be resolved into the sum of a series of simple harmonic motions—is said to have been discovered by Eudoxas as early as 356 B. C., when he explained the apparently irregular motions of the planets by combinations of uniform circular motions.[1] In the early part of the nineteenth century Laplace recognized the existence of partial tides that might be expressed by the cosine of an angle increasing uniformly with the time, and also applied the essential principles of the harmonic analysis to the reduction of high and low waters. Dr. Thomas Young suggested the importance of observing and analyzing the entire tidal curve rather than the high and low waters only. Sir George B. Airy also had an important part in laying the foundation for the harmonic analysis of the tides. To Sir William Thomson, however, we may give the credit for having placed the analysis on a practical basis.

In 1867 the British Association for the Advancement of Science appointed a committee for the purpose of promoting the extension, improvement, and harmonic analysis of tidal observations. The report on the subject was prepared by Sir William Thomson and was published in the Report of the British Association for the Advancement of Science in 1868. Supplementary reports were made from time to time by the tidal committee and published in subsequent reports of the British association. A few years later a committee, consisting of Profs. G. H. Darwin and J. C. Adams, drew up a very full report on the subject, which was published in the Report of the British Association for the Advancement of Science in 1883.

Among the American mathematicians who have had an important part in the development of this subject may be named Prof. William Ferrel and Dr. Rollin A. Harris, both of whom were associated with the U. S. Coast and Geodetic Survey. The Tidal Researches, by Professor Ferrel, was published in 1874, and additional articles on the harmonic analysis by the same author appeared from time to time in the annual reports of the Superintendent of the Coast and Geodetic Survey. The best known work of Doctor Harris is his Manual of Tides, which was published in several parts as appendices to the annual reports of the Superintendent of the Coast and Geodetic Survey. The subject of the harmonic analysis was treated principally in Part II of the Manual which appeared in 1897.

[1] Nautical Science, p. 279, by Charles Lane Poor.

2. GENERAL EXPLANATION.

A simple harmonic function is a quantity that varies as the cosine of an angle that increases uniformly with time. In the equation $y = A \cos at$, y is an harmonic function of the angle at, in which a is a constant and t represents time as measured from any initial epoch.

Harmonic analysis as applied to the tides is a process by which the actual observed tide at any place is separated into a number of partial or constituent tides of which it is composed, the rise and fall of each partial tide being a simple harmonic function of time.

Harmonic prediction of the tides consists in reuniting the partial tides in accordance with the relations which will prevail at the time for which the predictions are to be made.

The partial tides are called components and are usually represented by letters either with or without subscripts, as M_2, K_1, Mm, and Sa. Theoretically, the tides consist of innumerable components of various magnitudes, but only a comparatively few are of sufficient size to be of practical importance in the prediction of the tides. The predicting machine used by the Coast and Geodetic Survey is designed to take account of a maximum of 37 components.

Each component represents an elementary periodic cause producing or affecting the tide. The principal component, designated as M_2, represents the mean effect of the moon. Another component S_2, represents the mean effect of the sun. Other components take account of the various inequalities in the motions of the moon and the sun, such as changes in parallax and declination, and also inequalities resulting from shallow water and seasonal meteorological changes.

The amplitude of a component, commonly designated by the letter H, is the semirange between the maximum and minimum heights of the tide due to that component. The amplitude of any component varies with the locality, but for any particular place it is practically constant for all time.

The epoch of a component, commonly designated by the Greek letter kappa (κ), is an angle whose value depends upon the interval between the time of the maximum of the component as determined theoretically from the equilibrium theory and the actual time as determined from the analysis of the observations. The epoch of a component varies with the locality but, like the amplitude, is constant for any particular place.

The harmonic constants are the numerical values of the amplitudes and epochs of the components for any place. The determination of these constants from the records of tidal observations is the purpose of the harmonic analysis.

The rise and fall of the tide may be graphically represented by a curve, with the ordinates representing the height of the tide and the abscissas the time. The tidal record as traced by an automatic tide gauge is such a curve. The general equation of this curve, giving the height of the tide as a function of time, is usually written in the form

$$y = H_0 + A \cos (at + \alpha) + B \cos (bt + \beta) + C \cos (ct + \gamma) + \text{etc.} \qquad (1)$$

in which y is the height of the tide at any time t, H_0 is a constant depending upon the datum from which the heights are reckoned, and each cosine term represents the height of a component tide.

A single component tide referred to its mean level as the datum is expressed by the equation

$$y_1 = A \cos (at + \alpha) \tag{2}$$

in which y_1, the height of the component tide, is a function of t, the time reckoned from some initial epoch.

The coefficient A is the amplitude or semirange of the component. The angle $at + \alpha$ changes at the rate of a units of angle per unit of time, and this rate of change is called the speed of the component. The period of the component is the time required for the angle $at + \alpha$ to go through a cycle of 360° and is therefore equal to $\frac{360°}{a}$ when a is expressed in degrees. The phase of the component at any time t is the value of the angle $at + \alpha$, with multiples of 360° rejected, or it may be defined as the angular change in the component since the time of the preceding maximum or high water of the component. The initial phase is the phase at the instant from which the time is reckoned; that is, when $t = 0$, and is equal to α in the above angle.

A component tide is also expressed in the following forms:

$$y_1 = R \cos (at - \zeta) \tag{3}$$

$$y_1 = fH \cos [(V + u) - \kappa] \tag{4}$$

$$y_1 = fH \cos [at + (V_0 + u) - \kappa] \tag{5}$$

In an analysis theoretically perfect the coefficient A of formula (2) must be an absolute constant; but in practice it has been found convenient, in order to take account of the effects due to the changes in the longitude of the moon's node, to consider this coefficient as subject to certain variations. These variations are, however, so slow that for a series of observations not exceeding a year in length the coefficient may be treated as a constant, but factors are applied for reducing the results from different years to a mean value.

The coefficient R of formula (3) represents the unmodified amplitude applying to a particular series. The mean value of the amplitude for all years is represented by the H of formulas (4) and (5). The f is a factor, usually near unity, which gives the theoretical relation between the observed amplitude from any series of observations and the mean amplitude, this relation depending upon the longitude of the moon's node.

The angle ζ of formula (3) is the equivalent of $-\alpha$ of formula (2). The angle $(V + u)$ of formula (4) is the theoretical phase of the component for any time t as derived from the equilibrium theory, and the epoch κ is the difference between the theoretical and actual phase as determined from the tidal observations. The complete angle $(V + u) - \kappa$ is the equivalent of the angle $at + \alpha$ in formula (2).

The angle $(V_0 + u)$ of formula (5) is the value of the angle $(V + u)$ when t equals zero. The change in $(V + u)$ being the speed of the component, its value at any time t is equal to $at + (V_0 + u)$, and formula (5) is therefore equivalent to formula (4). The values of the mean amplitude H and the epoch κ of the above formulas are the harmonic constants which are to be determined by the analysis.

Figure 1 is a graphic representation of a component tide and illustrates certain relations of quantities given in the above formulas. In this figure the full horizontal line represents the mean level of the component, and distances along this line correspond to time as measured by an angle which increases uniformly with time. The height of the tide at any time is represented by an ordinate to the curve perpendicular to the mean level line. The height of the maximum or high water of the component is the coefficient fH of the formulas.

The point M in the figure indicates the instant of time at which high water would occur in accordance with the uncorrected equilibrium theory. The epoch κ is the angular expression for the interval between the time of the theoretical high water and the actual high water of the component as determined from observations. The interval between two consecutive high waters is the period of the component and is represented by the angular cycle of 360°. The interval measured backward from M to the preceding high water may therefore be expressed by $360° - \kappa$ or $-\kappa$.

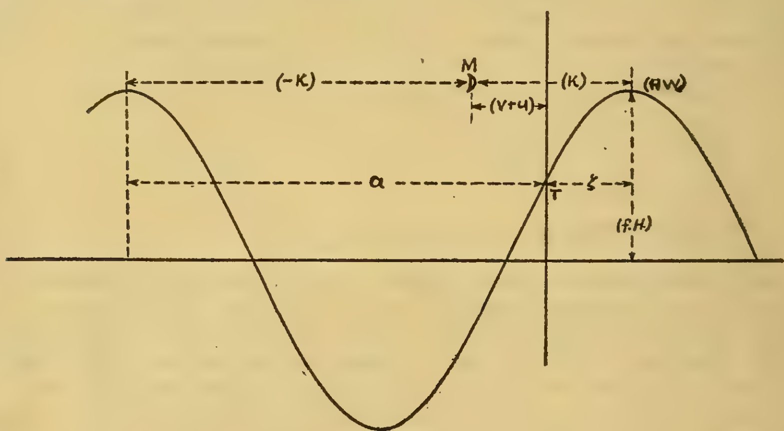

FIG. 1.

Let the vertical line through the point T indicate any instant of time t under consideration. Then the interval between M and this instant will correspond to the angle $(V+u)$ of formula (4). If this instant represents the initial epoch from which the time is to be reckoned, the $(V+u)$ becomes (V_0+u) of formula (5), and the interval from T to the time of the following high water becomes the ζ of formula (3). The interval measured backward from T to the preceding high water is the α of formula (2).

The epoch κ equals the sum of the (V_0+u) and ζ.

3. EQUILIBRIUM THEORY.

The equilibrium theory of the tides is a hypothesis under which it is assumed that the waters covering the face of the earth instantly respond to the tide-producing forces of the moon and the sun and form a surface of equilibrium under the action of these forces. A surface of equilibrium, also known as an equipotential or level surface, is a surface at every point of which the potential has the same value; that is to say, the potential energy of a particle in such a surface would be neither increased nor diminished by changing the position of that particle to any other point in the same surface. On a surface of equilibrium the resultant of all the forces at each point must be in the direction of the normal to the surface at that point.

The equilibrium theory assumes that the solid part of the earth is covered with water of considerable depth; that the water has neither inertia nor viscosity and may move without friction. These ideal conditions, differing so greatly from the actual conditions, it is not to be expected that the liquid surface of the earth will attain the state of equilibrium assumed under this theory. The presence of the great continental barriers, together with the inertia of the water, would make such a state of equilibrium impossible on the rotating earth. Nevertheless, the theory is of much service in the discussion of the harmonic analysis, because it affords a convenient and complete way of specifying the forces which act upon the ocean at each instant.

The attraction of either the moon or the sun will tend to draw the earth out in the shape of a prolate ellipsoid of revolution with the longest axis in the direction of the attracting body. Figures 2, 3, 4, and 5 illustrate the forms of tides which may be expected under the equilibrium theory when either the moon or the sun is acting alone. In these figures the oblateness of the earth due to its centrifugal force is ignored. Figures 2 and 4 may represent any section made by a plane passing through the center of the earth and the center of the moon, but here they are supposed to represent especially the section containing the earth's axis. In Figure 2 the moon is assumed to be in the plane of the earth's Equator, and in Figure 4 the declination is taken at about 28.5° N., which is approximately the maximum declination reached by the moon. The great circles show the mean undisturbed surface of the earth and the ellipses the surfaces as modified by the attraction of the moon. In these figures the ellipticity of the modified surface has been made about a million times greater than the theoretical ellipticity due to the attraction of the moon. If drawn to true scale, the disturbance due to the moon could not have been detected with the eye. This magnification of the ellipticity will introduce some discrepancies in the figures when compared with the true theoretical form but which are unimportant at this time. In Figures 3 and 5 are shown sections of the undisturbed and the modified surfaces made by planes perpendicular to the earth's axis in latitudes 0°, 30° N., and 60° N.

Let us now consider what tides may be expected under the equilibrium theory. We will suppose that the liquid surface of the earth retains its ellipsoidal form with the major axis always toward the center of the moon, and that the solid portion of the earth rotates on its axis. It is evident that every point of the solid part of the earth will describe a circle parallel to the Equator and with its center in the axis of the earth, and that in passing around this circle the water surface at the point will fluctuate in height. Referring to Figure 3, let us take a point P_1 of the undisturbed surface on the Equator and directly under the moon, the latter being in the plane of the Equator. At P_1 it will be high water. As the earth rotates the point P_1 will move to P_2, the height of the water gradually diminishing until at P_2 it is a minimum or low water. In passing on to P_3 the water will rise to a maximum and then fall to another minimum at P_4 and then

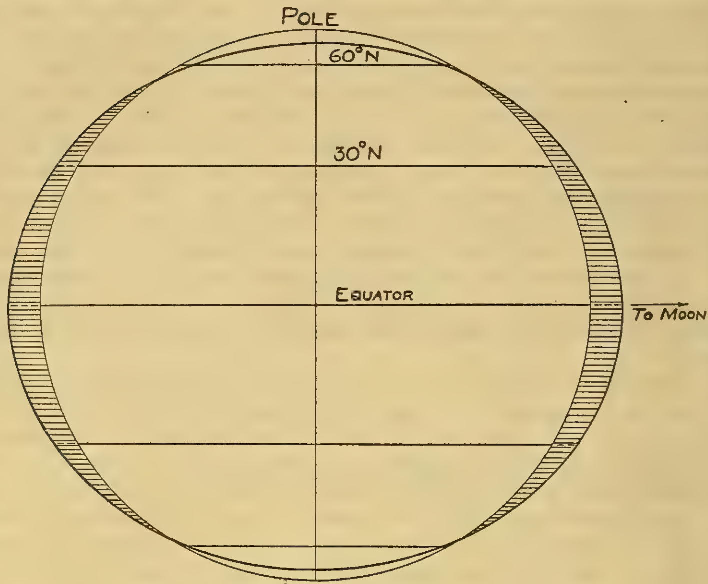

FIG. 2.

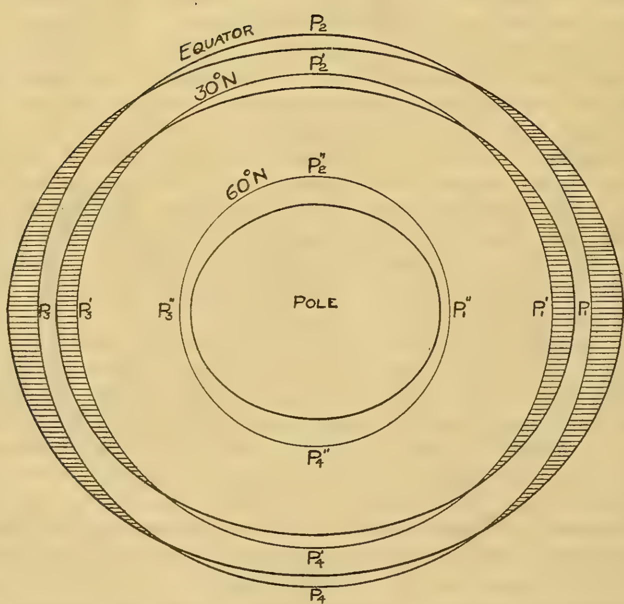

FIG. 3.

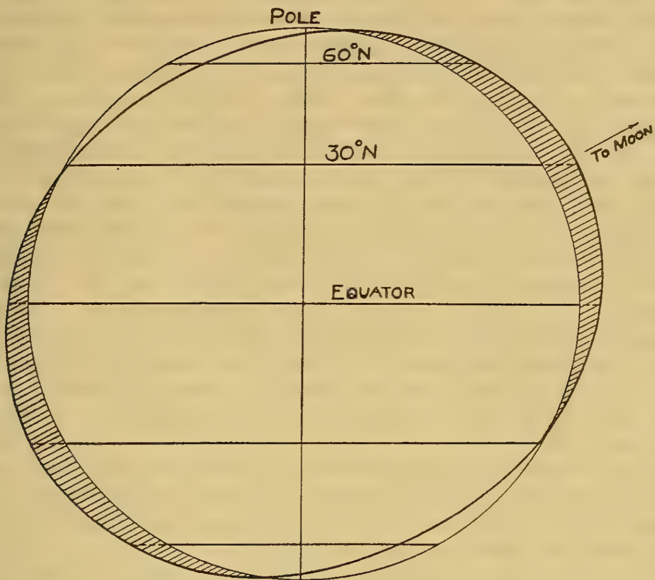
POLE
60°N
30°N
TO MOON
EQUATOR

FIG. 4.

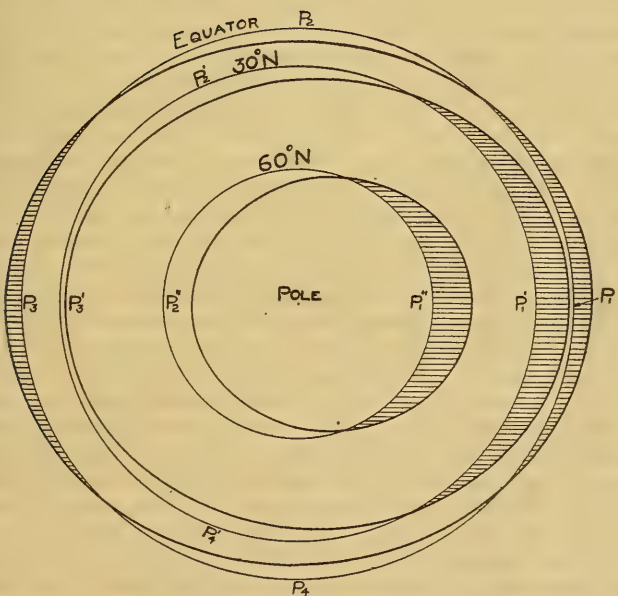
EQUATOR
P_2
30°N
P_2'
60°N
P_3
P_3'
P_2''
POLE
P_1''
P_1'
P_1
P_4'
P_4

FIG. 5.

rise until the point is again directly under the moon. The time required for the point P_1 to pass completely around the circle and back to its original position directly under the moon is approximately one day. During this period there have been two high waters of equal height and two low waters of equal depression. The height of the high waters above the mean level, however, is greater than the depression of the low waters, indicating that the average elevation of the water at the Equator has been raised above the normal by the presence of the moon. If we take a point P_1' in latitude 30° N., we again find two high waters of equal height and two low waters of equal depression occurring during the day, but the height of the high waters is more nearly equal to the depression of the low waters. In latitude 60° we again find two equal maximum and two equal minimum heights, but in this case the equilibrium surface is below the mean undisturbed surface during the entire rotation of the earth. From the foregoing we may conclude that under the equilibrium theory, when the moon is on the Equator, there will usually be in all latitudes two equal high waters and two equal low waters during each day, and that the presence of the moon will tend to raise the average level near the Equator and to lower it near the poles. It will also appear evident that the amount of these variations will depend upon the distance of the moon from the earth; the nearer the moon is to the earth the greater will be its effects.

Let us now examine Figure 5, which illustrates the tidal condition when the moon is near its greatest north declination. If we take a point P_1 in the Equator, as before, we find that in this case also we have two equal high waters and two equal low waters during the day, but the increase in the average height of water on the Equator is not as great as that shown in Figure 3. If we take the point P_1' and follow it around the small circle in latitude 30° N., we pass through a low water at P_2', a high water at P_3', a low water at P_4', and return to the high water at P_1'. We still have two high waters and two low waters during the day, but it will be noted that one high water is somewhat higher than the other, while the two low waters are of equal height. In latitude 60° N. we have during a single day only one high water, which is at P_1'', and a low water at P_2''. In this case the tide is said to be diurnal, while in the usual case of two high waters and two low waters each day the tide is called semidiurnal. If we were to take sections in the Southern Hemisphere corresponding to those for the Northern Hemisphere, with the moon still in its north declination, we would obtain ellipses similar to those in Figure 5, except that the centers of the ellipses instead of being on the side of the earth's axis nearest the moon would be displaced by an equal amount on the opposite side. From these figures we may conclude that, according to the equilibrium theory, there will be a semidiurnal tide with equal high and equal low water heights at all places on the Equator for any declination of the moon. If the moon is in north declination, and we travel from the Equator northward, we should expect to find the semidiurnal tides continuing with equal low waters, but with an increasing difference between the heights of the two high waters, the higher high being on the side of the earth toward the moon and the lower high on the opposite side. After reaching a certain latitude the lower high and the two low waters should, according to this theory, blend into a single low water on the side of the earth opposite the moon, the tide then becoming diurnal and remaining such for all latitudes north of this. If we were to proceed southward from the Equator while the moon is still in north declination, we should find similar conditions prevailing, except that the unequal high waters of the semidiurnal tide and the single high and single low waters of the diurnal tide would have their positions reversed; that is, the higher high water of the semidiurnal and the single high water of the diurnal tide would occur on the side of the earth farthest from the moon instead of on the side nearest to that body. If the moon is in south declination, the conditions in respect to the Northern and Southern Hemispheres will, of course, be exactly reversed.

In this discussion only the moon has been considered. The sun alone should have an exactly similar effect, except that, on account of the greater distance, the magnitude of the tide would be only about one-half as great as that due to the moon. Theoretically, the height of the tide at any place due to each body can be computed separately and the sum taken to represent the height due to the combined effect.

As already stated, the actual conditions that exist on the earth differ so greatly from the ideal conditions assumed for the equilibrium theory that the tides as derived from that theory are expected to differ greatly from tides as actually observed. It will be interesting to note here some of the agreements and differences.

1. Generally two high waters and two low waters occur during each day, but the high waters do not necessarily occur when the moon and sun are on the meridian. The interval between a transit of the moon and the occurrence of a high water varies in different parts of the earth without any apparent regard for the equilibrium theory, and high water may occur at any hour between successive transits of the moon; but for any particular place the interval between the time of transit and the time of high water remains approximately constant.

2. Usually the alternate high waters or the alternate low waters are nearly equal in height when the moon is near the Equator and have an increasing diurnal inequality as the moon's declination increases north or south of the Equator. According to the equilibrium theory there should be a diurnal inequality in the high waters only, and with any given declination this inequality should depend upon the latitude. As an actual fact we find that at many places there is a much larger inequality in the low water heights than in the high water heights, and that the magnitude of the inequality apparently has no direct relation to the latitude of the place.

3. By the equilibrium theory the diurnal tides would be expected only in latitudes near the poles, but observations show that stations near the Equator as well as those near the poles have diurnal tides.

In the following chapter a formula will be obtained which will represent the approximate height of the tide at any time and place, based upon the equilibrium theory. Although it is recognized that any calculations of the tide based solely upon this theory may give results entirely at variance with the real tide, because the actual conditions on the earth differ so much from the assumed ideal conditions, yet such a formula is very useful, inasmuch as we may introduce into it certain factors and differences determined from actual observations of the tide at any place and obtain a corrected formula which will generally represent very satisfactorily the true height of the tide at that place for any desired time.

4. ASTRONOMICAL DATA.

The reader of this volume is presumed to have a knowledge of elementary astronomy, but it may be well to emphasize here some of the important details which pertain especially to the tides. Besides the earth the only celestial bodies with which we are directly concerned in this discussion are the sun and the moon. Because of the greater distance or smaller size of all the other heavenly bodies their direct effect upon the tides of the earth is negligible. The principal motions to be considered are the rotation of the earth on its axis, the revolution of the moon around the earth, and the revolution of the earth around the sun (or the apparent revolution of the sun around the earth).

The earth rotates on its axis once each day. There are however several kinds of days—the sidereal day, the tropical day, the solar day, the lunar day, and the component day—depending upon the object used as a reference for the rotation. Since the stars are the most nearly fixed objects we have for comparison, the sidereal day, which is the time between two successive passages of the same star across any given meridian of the earth, is usually considered as the true period of the earth's rotation. The tropical [2] day is the time between two successive passages of the vernal equinox over a given meridian, and the solar and lunar days are the time between two successive transits of the sun and moon, respectively, over a given meridian. A component day is the time between two successive transits over a given meridian of a fictitious satellite which is assumed to represent the cause of a component tide. Each diurnal component will have its own component day. The solar and lunar days vary a little in length because of the lack of uniform motion of the earth and moon in their orbits, and for this reason the average or mean values of each is taken as a standard unit of measure. The mean solar day corresponds, of course, to the ordinary calendar day. Each day of whatever kind may be divided into 24 equal parts, called hours, which are qualified by the name of the day which was subdivided, as sidereal hour, solar hour, lunar hour, or component hour.

The moon revolves around the earth in an elliptical orbit. Although the average eccentricity of this orbit remains approximately constant for long periods of time, there are a number of perturbations in the moon's motion due, primarily, to the attractive force of the sun. Besides the revolution of the line of apsides and the regression of the nodes which take place more or less slowly, the principal inequalities in the moon's motion which affect the tides are the evection and variation. The evection depends upon the alternate increase and decrease of the eccentricity of the moon's orbit, which is always a maximum when the sun is passing the moon's line of apsides, and a minimum when the sun is at right angles to it. The variation inequality is due mainly to the tangential component of the disturbing force. The period of the revolution of the moon around the earth

[2] The tropical day is also generally called a sidereal day, since its length differs from the true sidereal day within a hundredth part of a second.

is called a month. The month is designated as sidereal, tropical, anomalistic, nodical, or synodical, according to whether the revolution is relative to a fixed star, the vernal equinox, the perigee, the ascending node, or the sun. The calendar month is a rough approximation to the synodical month.

It is customary to refer to the revolution of the earth around the sun, although it may be more accurately stated that they both revolve around their center of gravity; but if we imagine the earth as fixed, the sun will describe an apparent path around the earth which is exactly the same in size and form as the orbit of the earth around the sun, and the effect upon the tides would be just the same. This orbit is an ellipse with an eccentricity that changes so slowly that it may be regarded as practically constant. The period of the revolution of the earth around the sun is one year, and, as with the day, we have several kinds of years—the sidereal year, the tropical year, and the anomalistic year, and also the calendar and the Julian years. The sidereal year is the time required for the earth to complete one revolution, so that the sun will have returned to its same position among the stars. The tropical year is the time included between two successive passages of the vernal equinox by the sun. As the declination of the sun, and consequently the changes in seasons, depend upon its relation to the equinox, this is the year with which we try to make our calendar approximately agree. The anomalistic year is the time between two successive passages of the perihelion by the sun. The calendar year is one consisting of an integral number of mean solar days, either 365 or 366 days, the average length of which is made to agree as nearly as practicable with the length of the tropical year.

The two principal kinds of calendars in use by most of the civilized world since the beginning of the Christian era are the Julian and the Gregorian calendars, the latter being the modern calendar, in which the dates are sometimes referred to as "new style" to distinguish them from the dates of the older calendars. Prior to the year 45 B. C. there was more or less confusion in the calendars, intercalations of months and days being arbitrarily made by the priesthood and magistrates to bring the calendar into accord with the seasons and for other purposes.

The Julian calendar received its name from Julius Cæsar, who introduced it in the year 45 B. C. By this calendar the true year is assumed to be exactly 365.25 days, and it was provided that the common year should consist of 365 days and every fourth year of 366 days, each year to begin on January 1. As proposed by Julius Cæsar, the 12 months beginning with January were to be alternately 31 days and 30 days in length, with the exception that February should have only 29 days in the common years. When Augustus succeeded Julius Cæsar a few years later, he slightly modified this arrangement by transferring one day from February to the month of Sextilis, or August, as it was then renamed, and also transferred the 31st day of September and November to October and December to avoid having three 31-day months in succession.

The Gregorian calendar received its name from Pope Gregory, who introduced it in the year 1582. It was immediately adopted by the Catholic countries, but was not accepted by England until 1752. Its use is becoming more and more general, but it is not as yet univer-

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sally accepted. By this calendar the true year is assumed to be 365.2425 days in length. It differs from the Julian calendar in having the century years, which are not exactly divisible by 400, to consist of only 365 days, while in the Julian calendar every century year as well as every other year divisible by 4 is taken as a leap year with 366 days. For dates before Christ the year number must be diminished by 1 before testing its divisibility by 4 or 400, since the year 1 B. C. corresponds to the year 0 A. D. The Gregorian calendar will gain on the Julian calendar three days in each 400 years. When originally adopted, in order to adjust the Gregorian calendar so that the vernal equinox should fall upon March 21, as it had at the time of the Council of Nice in 325 A. D., 10 days were dropped, and it was ordered that the day following October 4, 1582, of the Julian calendar, should be designated as October 15, 1582, of the Gregorian calendar. This difference of 10 days between the dates of the two calendars continued until 1700, which was a leap year, according to the Julian calendar, and a common year by the Gregorian calendar. The difference between the two then became 11 days and in 1800 was increased to 12 days. Since 1900 the difference has been 13 days, which will remain the same until the year 2100.

Dates of the Christian era prior to October 4, 1582, will, in general, conform to the Julian calendar. Since that time both calendars have been used. The Gregorian calendar was adopted in England by an act of Parliament passed in 1751, which provided that the day following September 2, 1752, should be called September 14, 1752, and also that the year 1752 and subsequent years should commence on the 1st day of January. Previous to this the legal year in England commenced on March 25. Except for this arbitrary beginning of the year, the old English calendar was the same as the Julian calendar. In Russia the Julian calendar has continued in general use up to the present time, but for scientific and commercial purposes the dates from both calendars are frequently written together. When Alaska was purchased from Russia by the United States, its calendar was altered by 11 days, one of these days being necessary because of the difference between the Asiatic and American dates when compared across the one hundred and eightieth meridian. Dates in the tables at the back of this volume refer to the Gregorian calendar.

There are three celestial planes to be considered—one containing the earth's equator, another the earth's orbit, and a third the moon's orbit. The intersection of these planes with the celestial sphere gives three great circles—the celestial equator, the ecliptic, and the intersection of the plane of the moon's orbit (see fig. 6). These three circles intersect in six points—the celestial equator and the ecliptic at the equinoxes, ♈ and $♈_1$; the ecliptic and the plane of the moon's orbit at the moon's nodes ☊ and $☊_1$ and the celestial equator and the plane of the moon's orbit at the intersections A and A_1. In the following discussions references will usually be made to only three of these intersections, namely, the vernal equinox ♈, the moon's ascending node ☊, and the ascending intersection of the plane of the moon's orbit with the celestial equator. For brevity these intersections may be respectively referred to as "the equinox," "the node," and "the intersection."

The three angles made by the intersections of these great circles, representing the angles between the corresponding planes, should be noted. The angle between the ecliptic and the celestial equator ω is known as the obliquity of the ecliptic. Its value is about $23\frac{1}{2}°$ at the present time, but it is subject to a very slow secular change (see Tables 1 and 2). The angle i, measuring the inclination of the moon's orbit to the ecliptic, has a constant value of a little more than 5°. The angle I, measuring the inclination of the moon's orbit to the plane of the earth's equator, varies in value from $\omega - i$ to $\omega + i$; that is, from about $18\frac{1}{2}$ to $28\frac{1}{2}°$. The complete cycle of this variation is approximately 19 years, so that if the angle is $18\frac{1}{2}°$ in any year it will gradually increase for about $9\frac{1}{2}$ years until it reaches its maximum value and then diminish for about $9\frac{1}{2}$ years until it returns to its minimum value.

The vernal equinox ♈ although subject to a very slow westward motion, known as the procession of the equinoxes, which amounts to only about 50 inches per year, is frequently taken as a fixed point

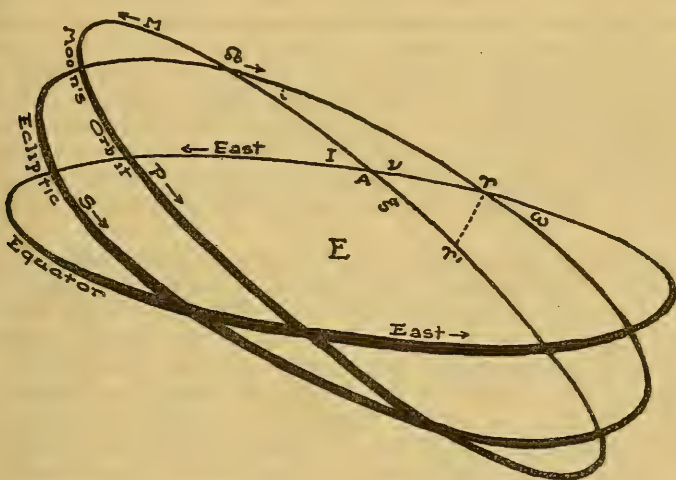


FIG. 6.

of reference for the motion of the other parts of the solar system. The moon's node ☊ has a westward motion of about 19° a year, which is sufficient to carry it entirely around a great circle in approximately 19 years. It is upon this motion that the variations in the value of the angle I depend, and it is of considerable importance in its effects upon the tides.

In the celestial sphere the terms "latitude" and "longitude" apply especially to measurements referred to the ecliptic and vernal equinox, but the terms may with propriety also be applied to measurements referred to other great circles and origins, provided they are sufficiently well defined to prevent any ambiguity. For example, we may say "longitude in the moon's orbit measured from the moon's node." Celestial longitude is always understood to be measured toward the east entirely around the circle. Longitude in the celestial equator reckoned from the vernal equinox is called right ascension, and the angular distance north or south of the celestial equator is called declination. The true longitude of any point referred to any great circle in the celestial sphere may be defined as the arc of that circle intercepted between the accepted origin and the projection of the point on the circle, the measurement being always eastward from the origin to the projection of the point. The true longitude of any point will generally be different when referred to different circles, although reckoned from a common origin; and the longitude of a body moving at a uniform rate of speed in one great circle will not have a uniform rate of change when referred to another great circle. The mean longitude of a body moving in an inclosed orbit and referred to any great circle may be defined as the longitude that would be attained by a point moving uniformly in the circle of reference at the same average angular velocity as that of the body and with the initial position of the point so taken that its mean longitude would be the same as the true longitude of the body at a certain selected position of that body in its orbit. With a common initial point, the mean longitude of a moving body will be the same in whatever circle it may be reckoned. Longitude in the ecliptic and in the celestial equator are usually reckoned from the vernal equinox ♈, which is common to both circles. In order to have an equivalent origin in the moon's orbit, we may lay off an arc ☊ ♈′ (see fig. 6) in the moon's orbit equal to ☊ ♈ in the ecliptic and for convenience call the point ♈′ the referred equinox. The mean longitude of any body, if reckoned from either the equinox or the referred equinox, will be the same in any of the three orbits represented. This will, of course, not be the case for the true longitude.

Let us now examine more closely the spherical triangle ☊ ♈ A in Figure 6. The angles ω and i are very nearly constant for long periods of time and have already been explained. The side ☊ ♈, usually designated by N, is the longitude of the moon's node and is undergoing a constant and practically uniform change due to the regression of the moon's nodes. This westward movement of the node, by which it is carried completely around the ecliptic in a period of approximately 19 years, causes a constant change in the form of the triangle, the elements of which are of considerable importance in the present discussion. The value of the angle I, the supplement of the angle ☊ A ♈, has an important effect upon both the range and time of the tide, which will be noted later. The side A ♈, designated by ν, is the right ascension or longitude in the celestial equator of the intersection A. The arc designated by ξ is equal to the side ☊ ♈ − side ☊ A and is the longitude in the moon's orbit of the intersection A. Since the angles i and ω are assumed to be constant, the values of I, ν, and ξ will depend directly upon N, the longitude of the moon's node, and may be readily obtained by the ordinary solution of the spherical triangle ☊ ♈ A. Table 6 gives the values of I, ν, and ξ for each degree of N. In the computation of this table the value of ω for the beginning of the twentieth century was used. However, the secular change in the obliquity of the ecliptic is so slow that a difference of a century in the epoch taken as the basis of the computation would have resulted in differences of less than 0.02 of a degree in the tabular values. The table may therefore be used without material error for reductions pertaining to any modern time.

Looking again at Figure 6, it will be noted that when the longitude of the moon's node is zero the value of the inclination I will equal the sum of ω and i and will be at its maximum. In this position the northern portion of the moon's orbit will be north of the ecliptic. When the longitude of the moon's node is 180°, the moon's orbit will be between the Equator and ecliptic, and the angle I will be equal to angle ω − angle i. The angle I will be always positive and will vary from $\omega - i$ to $\omega + i$. When the longitude of the moon's node equals zero or 180°, the values of ν and ξ will each be zero. For all positions of the moon's node north of the Equator as its longitude changes from 180 to 0°, ν and ξ will have positive values, as indicated in the figure, these arcs being considered as positive when reckoned eastward from ♈ and ♈′, respectively. For all positions of the node south of the Equator, as the longitude changes from 360 to 180°, ν and ξ will each be negative, since the intersection A will then lay to the westward of ♈ and ♈′.

Tables 1 and 2 contain a collection of astronomical constants and formulas to which reference will frequently be made in this work.

5. DEGREE OF APPROXIMATION.

The problem of finding an expression for the equilibrium height of the tide in terms of time and place does not admit of a strict solution, but an approximate expression may be obtained which may be carried to as high an order of precision as may be desired. In ordinary numerical computations exact results are seldom obtained, the degree of precision depending upon the number of decimal places used in the computations, which, in turn, will be determined largely by the magnitude of the quantity sought. In general, the degree of approximation to the value of any quantity expressed numerically will be determined by the number of significant figures used. With a quantity represented by a single significant figure, the error may be as great as $33\frac{1}{3}$ per cent of the quantity itself, while the use of two significant figures will reduce the maximum error to less than 5 per cent of the true value of the quantity. The large possible error in the first case renders it of little value, but in the latter case the approximation is sufficiently close to be useful when only rough results are necessary. The distance of the sun from the earth is popularly expressed by two significant figures as 93,000,000 miles.

With three or four significant figures fairly satisfactory approximations may be represented, and with a greater number very precise results may be expressed. For theoretical purposes the highest attainable precision is desirable, but for practical purposes, because of the increase in the labor without a corresponding increase in utility, it will be usually found advantageous to limit the degree of precision in accordance with the prevailing conditions.

Frequently a quantity that is to be used as a factor in an expression may be expanded into a series of terms. If the approximate value of such a series is near unity, terms which would affect the third decimal place, if expressed numerically, should usually be retained. The retention of the smaller terms will depend to some extent upon the labor involved, since their rejection would not seriously affect the final results.

The formulas for the moon's true longitude and distance in Table 1 are said to be given to the second order of approximation, a fraction of the first order being considered as one having an approximate value of 1/20 or 0.05, a fraction of the second order having an approximate value of $(0.05)^2$ or 0.0025, and a fraction of the third order having an approximate value of $(0.05)^3$ or 0.000125, etc. These formulas of the second order should, therefore, give the results correct to the third decimal place.

In Table 2 are given the numerical values of a number of astronomical relations which will appear in the following development of the subject. A knowledge of these values will enable us to determine what terms may be safely neglected in the development.

TIDAL COMPONENTS.

6. TIDE-PRODUCING FORCE.

As the sun and moon are similar in their action in the production of the tide, the force of either may be considered by itself, and the resulting forms of expression may then be readily adapted to the other.

The tide-producing force of the moon is that portion of its gravitational force which is effective in changing the water level on the earth's surface. This effective force is the difference between the attraction for the earth as a whole and the attraction for the different particles which constitute the yielding part of the earth's surface; or, if the entire earth were considered to be a plastic mass, the tide-producing force at any point within the mass would be the force that tended to change the position of a particle at that point relative to a particle at the center of the earth. That part of the earth's surface which is directly under the moon is nearer to that body than is the center of the earth and is therefore more strongly attracted since the force of gravity varies inversely as the square of the distance. For the same reason the center of the earth is more strongly attracted by the moon than is that part of the earth's surface which is turned away from the moon.

The tide-producing force, being the difference between the attraction for particles situated relatively near together, is small compared with the attraction itself. It may be interesting to note that, although the sun's attraction on the earth is nearly 200 times as great as that of the moon, its tide-producing force is less than one-half that of the moon. If the forces acting upon each particle of the earth were equal and parallel, no matter how great those forces might be, there would be no tendency to change the relative positions of those particles, and consequently there would be no tide-producing force.

The tide-producing force may be graphically represented as in Figure 7.

Let O = the center of the earth,
C = the center of the moon,
P = any point within or on the surface of the earth.

Then OC will represent the direction of the attractive force of the moon upon a particle at the center of the earth and PC will represent the direction of the attractive force of the moon upon a particle at P.

Let the magnitude of the moon's attraction at P be represented by the line PC. Now, since the attraction of gravitation varies inversely as the square of the distance, it is necessary, in order to represent the attraction at O on the same scale, to take a line CQ of such a length that $CQ:CP=\overline{CP}^2:\overline{CO}^2$.

The line PQ, joining P and Q, will then represent the direction and magnitude of the resultant force that tends to disturb the position of P relative to O, for it represents the difference between the force PC and a force through P equal and parallel to the force QC which acts upon O. This last statement may be a little clearer to the reader if he will consider the force PC as being resolved into a force PD equal and parallel to QC, and the force PQ. The force PD, acting upon the particle at P, being equal and parallel to the force QC, acting upon a particle at O, will have no tendency to change the position of P relative to O. The remaining force PQ will tend to alter the position of P relative to O and is the tide-producing force of the moon at P. The force PQ may be resolved into a vertical component PR, which tends to raise the water at P, and the horizontal component PT, which tends to move the water horizontally.

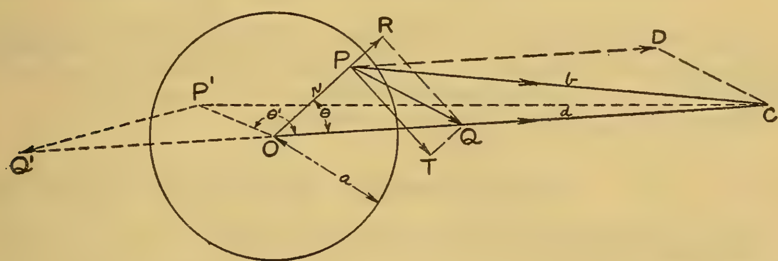


FIG. 7.

If the point P' is taken so that the distance CP' is greater than the distance CO, the tide-producing force $P'Q'$ will be directed away from the moon. While at first sight this may appear paradoxical, it will be noted that the moon tends to separate O from P', but as O is taken as the point of reference, this resulting force that tends to separate the points is considered as being applied at the point P' only.

We will now seek analytical expressions to represent the tide-producing force of the moon at any point P within or on the surface of the earth. Referring to Figure 7,

let $r=OP$ = distance of P from center of earth,
$b=PC$ = distance of P from center of moon,
$d=OC$ = distance from center of earth to center of moon,
$\theta=COP$ = angle at center of earth between OP and OC,
M = mass of moon,
μ = attraction of gravitation between unit masses at unit distance apart.

Since the force of gravitation varies directly as the mass and inversely as the square of the distance,

$$\text{Attraction of moon for unit mass at point } O \text{ in direction } OC=\frac{\mu M}{d^2} \quad (6)$$

$$\text{Attraction of moon for unit mass at point } P \text{ in direction } PC=\frac{\mu M}{b^2} \quad (7)$$

Let each of these forces be resolved in directions parallel and perpendicular to the radius through P, and let the direction from O toward P be taken as positive and the reverse as negative, and also the direction of the perpendicular to OP that most nearly conforms with the direction from O toward C as positive, and the reverse direction as negative. We then have from (6) and (7).

$$\text{Attraction at } O \text{ in direction } O \text{ to } P = \frac{\mu M}{d^2} \cos \theta \tag{8}$$

$$\text{Attraction at } O \text{ perpendicular to } OP = \frac{\mu M}{d^2} \sin \theta \tag{9}$$

$$\text{Attraction at } P \text{ in direction } O \text{ to } P = \frac{\mu M}{b^2} \cos CPR \tag{10}$$

$$\text{Attraction at } P \text{ perpendicular to } OP = \frac{\mu M}{b^2} \sin CPR \tag{11}$$

As the tide-producing force of the moon at the point P is measured by the difference between the attraction of the moon at P and at O, the following may be obtained from (8), (9), (10), and (11).

Tide-producing force at P in direction O to P

$$= \mu M \left[\frac{1}{b^2} \cos CPR - \frac{1}{d^2} \cos \theta \right] \tag{12}$$

Tide-producing force at P perpendicular to OP

$$= \mu M \left[\frac{1}{b^2} \sin CPR - \frac{1}{d^2} \sin \theta \right] \tag{13}$$

By a solution of the plane triangle COP the following relations are obtained:

$$b^2 = r^2 + d^2 - 2rd \cos \theta = d^2 \left[1 - 2 \frac{r}{d} \cos \theta + \frac{r^2}{d^2} \right] \tag{14}$$

$$\sin CPR = \sin CPO = \frac{d}{b} \sin \theta = \frac{\sin \theta}{\left[1 - 2 \frac{r}{d} \cos \theta + \frac{r^2}{d^2} \right]^{\frac{1}{2}}} \tag{15}$$

$$\cos CPR = \sqrt{1 - \sin^2 CPR} = \frac{\cos \theta - \frac{r}{d}}{\left[1 - 2 \frac{r}{d} \cos \theta + \frac{r^2}{d^2} \right]^{\frac{1}{2}}} \tag{16}$$

In Figure 7 it will be noted that the value of θ, being reckoned from the line OC in any plane may vary from zero to 180°, and also that the angle CPR increases as θ increases within the same limits. Sin θ and sin CPR will therefore always be positive. As the angle OCP is always very small, the angle CPR will differ by only a very small amount from the angle θ and will usually be in the same quadrant. In obtaining the square root for the numerator of (16) it was therefore necessary to use only that sign which would preserve this relationship. The denominators of (15) and (16) are to be considered as positive.

Substituting (14), (15), and (16) in (12) and (13), and designating the forces in the direction OP and perpendicular to the same as the vertical and horizontal components, respectively, we have

Vertical component of tide-producing force at P

$$=\frac{\mu M}{d^2}\left[\frac{\cos\theta-\frac{r}{d}}{\left(1-2\frac{r}{d}\cos\theta+\frac{r^2}{d^2}\right)^{3/2}}-\cos\theta\right] \tag{17}$$

Horizontal component of tide-producing force at P

$$=\frac{\mu M}{d^2}\left[\frac{\sin\theta}{\left(1-2\frac{r}{d}\cos\theta+\frac{r^2}{d^2}\right)^{3/2}}-\sin\theta\right] \tag{18}$$

By Maclaurin's theorem the fraction

$$\frac{1}{\left(1-2\frac{r}{d}\cos\theta+\frac{r^2}{d^2}\right)^{3/2}}$$

may be developed into a series arranged according to the ascending powers of $\frac{r}{d}$, which has a value of approximately 0.017 when r is taken as the mean radius of the earth and d as the mean distance of the moon from the earth. When d is taken as the mean distance of the sun from the earth, the value of $\frac{r}{d}$ is considerably smaller. In equation (19), which follows, the terms involving the higher powers of $\frac{r}{d}$ are relatively unimportant and may be neglected.

$$\frac{1}{\left(1-2\frac{r}{d}\cos\theta+\frac{r^2}{d^2}\right)^{3/2}}=1+3\cos\theta\frac{r}{d}+3/2\,(5\cos^2\theta-1)\frac{r^2}{d^2}$$
$$+\frac{5}{2}(7\cos^3\theta-3\cos\theta)\frac{r^3}{d^3}+\text{etc.} \tag{19}$$

Substituting (19) in (17) and (18) and neglecting all terms containing powers of $\frac{1}{d}$ above the fourth we obtain

Vertical component

$$=\frac{\mu Mr}{d^3}(3\cos^2\theta-1)+3/2\,\frac{\mu Mr^2}{d^4}(5\cos^3\theta-3\cos\theta) \tag{20}$$

Horizontal component

$$=3/2\,\frac{\mu Mr}{d^3}\sin 2\,\theta+3/2\,\frac{\mu Mr^2}{d^4}(5\cos^2\theta-1)\sin\theta \tag{21}$$

As the moon's parallax varies inversely as its distance d, the terms containing the reciprocal of d^3 are said to depend upon the cube of the moon's parallax and those containing the reciprocal of d^4 upon the fourth power of the moon's parallax. Assuming the approximate numerical value of $\frac{r}{d}$ as before, it is evident that the above terms involving the fourth power of the parallax will generally be only about 2 per cent of the entire tide-producing force and are therefore of little relative importance. They will, however, be given further attention.

For convenience, the force depending upon the fourth power of the moon's parallax will be treated separately from the principal tide-producing force, which depends upon the cube of the parallax. They may be expressed separately, as follows:

Tide-producing force depending upon the cube of moon's parallax

$$\text{Vertical component} = \frac{\mu Mr}{d^3}\,(3\cos^2\theta - 1) \tag{22}$$

$$\text{Horizontal component} = 3/2\,\frac{\mu Mr}{d^3}\sin 2\,\theta \tag{23}$$

Tide-producing force depending upon the fourth power of moon's parallax

$$\text{Vertical component} = 3/2\,\frac{\mu Mr^2}{d^4}\,(5\cos^3\theta - 3\cos\theta) \tag{24}$$

$$\text{Horizontal component} = 3/2\,\frac{\mu Mr^2}{d^4}\,(5\cos^2\theta - 1)\sin\theta \tag{25}$$

Similar expressions for the tide-producing force of the sun may be obtained by substituting the mass of the sun for M and the distance of the sun for d. Because of the greater distance of the sun the terms depending upon the fourth power of its parallax will be negligible.

The relation of the tide-producing force of the sun to that of the moon will be approximately

$$\frac{\text{Mass of sun}}{\text{Mass of moon}} \times \frac{(\text{mean distance of moon})^3}{(\text{mean distance of sun})^3} = 0.46 \tag{26}$$

Examining formulas (22) and (23) for the principal tide-producing force it will be noted that the vertical component becomes zero when $\cos\theta = \pm\sqrt{\tfrac{1}{3}}$, and the horizontal component becomes zero when $\theta = 0$, 90, or 180°. The vertical component has a maximum positive value when $\theta = 0$ or 180° and a maximum negative value when $\theta = 90°$, the latter force being only one-half as great as the maximum positive value. The horizontal component is at a maximum in the positive direction when $\theta = 45°$ and a maximum in the negative direction when $\theta = 135°$. These forces all become zero at the center of the earth where r is zero.

To express these forces in terms of gravity,

let g = mean force of gravity on earth's surface
a = mean radius of earth
E = mass of earth

$$\text{then } g = \frac{\mu E}{a^2}, \text{ and } \mu = \frac{a^2\,g}{E} \tag{27}$$

The substitution of this value of μ in equations (22) to (25) will give the forces in terms of gravity. If we assume r to be equal to the mean radius of the earth and d to be the mean distance of the moon, we may obtain numerical values from Table 2, which, when substituted in (22) and (23), will give the following expressions for the approximate tide-producing force of the moon:

$$\text{Vertical component} = 0.000{,}000{,}056\ (3\cos^2\theta - 1)\ g \tag{28}$$

$$\text{Horizontal component} = 0.000{,}000{,}084\ \sin 2\,\theta\ g \tag{29}$$

The tide-producing force of the sun will be 0.46 times as large.

7. TIDE-PRODUCING POTENTIAL.

The potential at any point due to a force is the amount of work that would be required to move a unit of matter from that point, against the action of the force, to a position where the force is zero. This amount of work will be independent of the path along which the unit of matter is moved. If the force being considered is the gravity of the earth, the potential at any point will be the amount of work required to move a unit mass, against the force of gravity, from that point to an infinite distance from the earth's center where the force of gravity becomes zero. With the symbols as in the preceding section, we have according to the law of attraction

$$\text{Force of gravity on or above earth's surface} = \frac{\mu E}{r^2} \tag{30}$$

The amount of work required to move a unit mass against this force through an infinitesimal distance dr

$$= \frac{\mu E}{r^2}\, dr \tag{31}$$

The total amount of work necessary to move this particle from a point r distance from the earth's center to infinity is the gravitational potential at that point, and will be here designated by V_g. Then,

$$V_g = \int_r^\infty \frac{\mu E}{r^2}\, dr = \frac{\mu E}{r} \tag{32}$$

The tide-producing potential at any point in the earth is the amount of work required to move a unit mass, against the tide-producing force, from that point to the center of the earth where the tide-producing force becomes zero. If we assume the particle to be moved along the radius of the earth directly to the center, we will be concerned with only the vertical component of the tide-producing force, since the horizontal component would not affect the amount of work required along this path.

Considering, first, the force depending upon the cube of the moon's parallax, the amount of work necessary to move a unit mass against the vertical component, formula (22), through an infinitesimal distance $-dr$ toward the center of the earth equals

$$= -\frac{\mu M}{d^3}\,(3\cos^2\theta - 1)\, r\, dr \tag{33}$$

Then, designating the tide-producing potential due to this force by V_t, we have as the total amount of work necessary to move the particle to the center of the earth—

$$V_t = -\int_r^0 \frac{\mu M}{d^3} (3 \cos^2 \theta - 1)\, r\, dr = \tfrac{1}{2} \frac{\mu M r^2}{d^3} (3 \cos^2 \theta - 1) \qquad (34)$$

The same result will be obtained by assuming the particle to be moved again against the horizontal component of the tide-producing force until it reaches a position where $\cos \theta = \frac{1}{3}$ and the vertical component becomes zero. From this point it can be moved directly to the center of the earth without additional work.

For that part of the tide-producing force depending upon the fourth power of the moon's parallax let the potential be designated by V_f. Then, assuming a unit mass to be moved against the vertical component, formula (24), directly to the center of the earth, we have

$$V_f = -\int_r^0 3/2 \frac{\mu M r^2}{d^4} (5 \cos^3 \theta - 3 \cos \theta)\, dr = \tfrac{1}{2} \frac{\mu M r^3}{d^4} (5 \cos^3 \theta - 3 \cos \theta) \quad (35)$$

This potential may also be obtained by assuming that the particle is first moved against the horizontal component, formula (25), to a position where $\theta = \pi/2$ and the vertical component becomes zero.

Similar expressions for the tide-producing potential of the sun may be obtained by substituting in the above formulæ the mass and distance of the sun for M and d, respectively. The tide-producing potential of the sun which involves the fourth power of its parallax is negligible.

8. SURFACE OF EQUILIBRIUM.

A surface of equilibrium is a surface at every point of which the sum of the potentials of all the forces is a constant. On such a surface the resultant of all the forces at each point must be in the direction of the normal to the surface at that point. If the earth were a homogeneous mass with gravity as the only force acting, the surface of equilibrium would be that of a sphere. Each additional force will tend to disturb this spherical surface, and the total deformation will be represented by the sum of the disturbances of each of the forces acting separately. In the following investigation we need not be especially concerned with the more or less permanent deformation due to the centrifugal force of the earth's rotation, since we may assume that the disturbances of this spheroidal surface due to the tidal forces will not differ materially from the disturbances in a true spherical surface due to the same cause.

Let us first consider the surface of equilibrium due to gravity and the principal tide-producing force of the moon. Designating the potential due to these two forces by V, we have as the condition of a surface of equilibrium,

$$V = V_g + V_t = \text{a constant} \qquad (36)$$

Substituting the values of V_g and V_t from (32) and (34),

$$V = \frac{\mu E}{r} + \tfrac{1}{2} \frac{\mu M r^2}{d^3} (3 \cos^2 \theta - 1) = \text{a constant} \qquad (37)$$

Equation (37) must be true for all points in the surface of equilibrium, so if a point be taken in the surface where the tide-producing potential is zero—that is, where $\cos\theta = \sqrt{1/3}$—and let a represent the value of r at this point we have

$$V = \frac{\mu E}{a} = \text{the constant} \tag{38}$$

Substituting this in (37)

$$\frac{\mu E}{r} + \frac{1}{2}\frac{\mu M r^2}{d^3}(3\cos^2\theta - 1) = \frac{\mu E}{a} \tag{39}$$

from which, by transposing and dividing,

$$\frac{1}{2}\frac{Ma^3}{Ed^3}(3\cos^2\theta - 1) = \frac{a^2}{r^3}(r - a) \tag{40}$$

Let

$$r = a + u \tag{41}$$

so that u will represent the equilibrium height of the tide due to the principal lunar force, referred to an undisturbed spherical surface of radius a.

Substituting (41) in (40), we obtain

$$\frac{1}{2}\frac{Ma^3}{Ed^3}(3\cos^2\theta - 1) = \frac{a^2 u}{(a+u)^3} = \frac{u}{a} - 3\left(\frac{u}{a}\right)^2 + 6\left(\frac{u}{a}\right)^3 - \text{etc.} \tag{42}$$

The fraction $\frac{u}{a}$ is approximately the ratio of the semirange of tide to the mean radius of the earth, and if we assume a range of 40 feet, the numerical value of this fraction would be about 0.000001. It is evident, therefore, that we may neglect the powers above the first, and write

$$\frac{u}{a} = \frac{1}{2}\frac{Ma^3}{Ed^3}(3\cos^2\theta - 1) \tag{43}$$

or

$$u = \frac{1}{2}\frac{Ma^3}{Ed^3}(3\cos^2\theta - 1)a \tag{44}$$

as the equilibrium height of the tide due to the principal lunar force.

In the preceding formulas a was taken as the radius of the earth along which the tide-producing potential of the force under consideration was zero. Let us now see whether this is the mean radius of the earth; that is to say, the radius of a perfect sphere having the same volume as the earth. It is evident that this volume must remain constant without regard to any deformation to which the surface may be subjected. Referring to Figure 7, consider the volume of the earth to be divided into infinitesimal solids by a series of planes with their common intersection in the line OC, the angle between two consecutive planes being designated by $d\,\phi$; a series of right conical surfaces with their common apex at O and common axis in line OC, the angle between the generating line and the axis being designated by θ; and a series of spherical surfaces with their common center at O and the radius designated by r; then the volume of one of these infinitesimal solids will be

$$dr \,.\, r\, d\,\theta \,.\, r \sin\theta\, d\,\phi = r^2 \sin\theta\, d\phi\, d\theta\, dr \tag{45}$$

and the entire volume of the earth as included in the surface represented by equation (44) will be

$$\text{Volume} = \int_0^{2\pi}\int_0^{\pi}\int_0^{(a+u)} r^2 \sin\theta\, d\phi\, d\theta\, dr \tag{46}$$

$$= 1/3 \int_0^{2\pi}\int_0^{\pi} (a+u)^3 \sin\theta\, d\phi\, d\theta \tag{47}$$

From (44) we may obtain

$$(a+u)^3 = a^3\left[1 + \tfrac{1}{2}\,\frac{M}{E}\,\frac{a^3}{d^3}(3\ \cos^2\theta - 1)\right]^3$$

$$= a^3\left[1 + 3/2\,\frac{M}{E}\,\frac{a^3}{d^3}\,(3\ \cos^2\theta - 1) + \text{etc.}\right] \tag{48}$$

the terms containing the powers of $\frac{a}{d}$ above the third being neglected.

Substituting (48) in (47),

$$\text{Volume} = 1/3\ a^3 \int_0^{2\pi}\int_0^{\pi}\left[1 + 3/2\,\frac{M}{E}\,\frac{a^3}{d^3}(3\ \cos^2\theta - 1)\right]\sin\theta\, d\phi\, d\theta$$

$$= 2/3\ a^3 \int_0^{2\pi} d\phi = 4/3\pi a^3 \tag{49}$$

As equation (49) represents the volume of a sphere with radius a, it is evident that a is the mean radius of the surface represented by (44), and that u is the amount of the disturbance in the mean surface due to the force under consideration. In other words, u is the equilibrium height of the tide as referred to mean sea level.

One of the conditions of an equilibrium surface is that the resultant of all the forces at each point must be in the direction of the normal to the surface at that point. Let us see if this condition is fulfilled as to equation (44). In Figure 8 let P represent any point on the surface defined by equation (44), and let ψ be the angle between the radius vector and the normal at this point. If we imagine the surface to be cut by a plane passing through the point P and the centers of the earth and moon, it is evident that the trace of the surface will intersect the arc of a concentric circle drawn through the point P with radius r at an angle equal to the angle ψ, and that

$$\tan\psi = -\frac{dr}{r d\theta} \tag{50}$$

From (41) and (44),

$$r = a + \tfrac{1}{2}\frac{Ma^3}{Ed^3}(3\ \cos^2\theta - 1)a \tag{51}$$

Then

$$\frac{dr}{d\theta} = -\frac{3}{2}\frac{Ma^4}{Ed^3}\sin 2\theta \qquad (52)$$

Substituting (51) and (52) in (50),

$$\tan\psi = \frac{3}{2}\frac{Ma^3}{Ed^3}\,\frac{\sin 2\theta}{1+\frac{1}{2}\frac{Ma^3}{Ed^3}(3\cos^2\theta-1)}$$

$$= \frac{3}{2}\frac{Ma^3}{Ed^3}\sin 2\theta\left[1-\frac{1}{2}\frac{Ma^3}{Ed^3}(3\cos^2\theta-1)+\text{etc.}\right] \qquad (53)$$

Since $\frac{a^3}{d^3}$ is very small compared with unity, we may neglect the higher powers in (53) and write

$$\tan\psi = \frac{3}{2}\frac{Ma^3}{Ed^3}\sin 2\theta \qquad (54)$$

as the tangent of the angle between the radius vector and the normal to the surface at the point P.

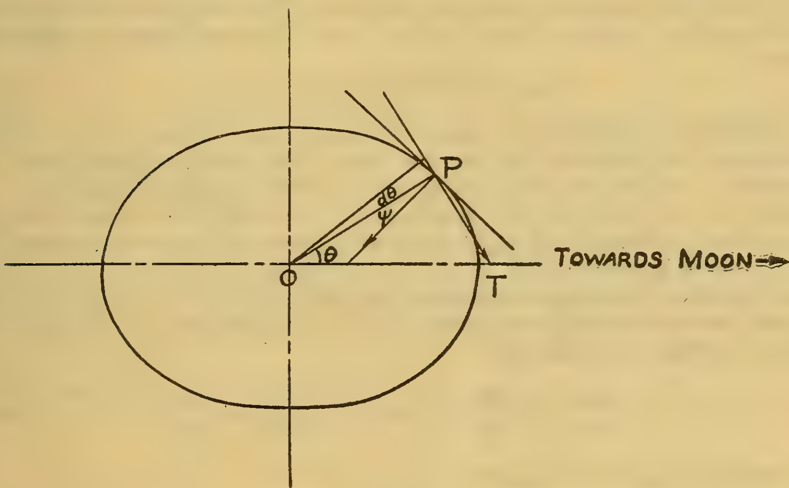


FIG. 8.

If we let ψ_1 represent the angle between the radius vector and the resultant of the forces under consideration at the same point P, we have from (22), (23), and (30),

$$\tan\psi_1 = \frac{\frac{3}{2}\frac{\mu Mr}{d^3}\sin 2\theta}{\frac{\mu E}{r^2}-\frac{\mu Mr}{d^3}(3\cos^2\theta-1)}$$

$$= 3/2\frac{Ma^3}{Ed^3}\sin 2\theta\left[\frac{\frac{r^3}{a^3}}{1-\frac{Mr^3}{Ed^3}(3\cos^2\theta-1)}\right] \qquad (55)$$

Substituting the value of r from (41),

$$\tan \psi_1 = 3/2 \frac{Ma^3}{Ed^3} \sin 2\theta \left[\frac{\left(1+\frac{u}{a}\right)^3}{1-\frac{M(a+u)^3}{Ed^3}(3\cos^2\theta-1)} \right] \tag{56}$$

The values of $\frac{u}{a}$ and $\frac{(a+u)^3}{d^3}$ are each very small compared with unity, and the value of the bracketed portion of (56) is therefore a very close approximation to unity. We may therefore write

$$\tan \psi_1 = \frac{3\, Ma^3}{2Ed^3} \sin 2\theta \tag{57}$$

as the tangent of the angle between the radius vector and the resultant of the forces at the point P. Comparing this with (54), we find it to be the same as the angle made by the normal with the radius vector, indicating that the resultant force is normal to the surface at any point P.

If we let d represent the mean distance of the moon and substitute the numerical values from Table 2 for the coefficient in (54) we obtain

$$\tan \psi = 0.000{,}000{,}084 \sin 2\,\theta \tag{58}$$

in which ψ as a maximum value of about 0.017″ when $\theta = 45°$. The maximum deflection of the normal due to the tide-producing force of the sun is about 0.46 times as great, or 0.008″, approximately.

Let us now consider the disturbance in a spherical surface due to the potential depending upon the fourth power of the moon's parallax (35). This potential will become zero when $\theta = 90°$, and also when $\cos\theta = \sqrt{3/5}$. Letting a represent the radius vector at either of these points, we have as the equation for the equilibrium surface due to the potentials (32) and (35)

$$\frac{\mu E}{r} + \tfrac{1}{2} \frac{\mu M r^3}{d^4} (5\cos^3\theta - 3\cos\theta) = \frac{\mu E}{a} \tag{59}$$

from which may be obtained

$$\tfrac{1}{2} \frac{M}{E} \frac{a^4}{d^4} (5\cos^3\theta - 3\cos\theta) = \frac{a^3}{r^4}(r-a) \tag{60}$$

Letting

$$r = a + u', \tag{61}$$

we have

$$\tfrac{1}{2} \frac{M}{E} \frac{a^4}{d^4} (5\cos^3\theta - 3\cos\theta) = \frac{a^3\, u'}{(a+u')^4} = \frac{u'}{a} - 4\left\{\frac{u'}{a}\right\}^2 + 10\left\{\frac{u'}{a}\right\}^3 - \text{etc.} \tag{62}$$

Neglecting powers of $\frac{u'}{a}$ above the first,

$$\frac{u'}{a} = \tfrac{1}{2} \frac{M}{E} \frac{a^4}{d^4} (5\cos^3\theta - 3\cos\theta) \tag{63}$$

or

$$u' = \tfrac{1}{2} \frac{M}{E} \frac{a^4}{d^4} (5 \cos^3 \theta - 3 \cos \theta) a \tag{64}$$

as the equilibrium height of the tide due to that part of the lunar force depending upon the fourth power of the moon's parallax.

In forming equation (59), a was taken at the radius vector along which the potential due to the fourth power of the moon's parallax was zero. To determine whether this is the mean radius, we find the volume included in the surface represented by (64).

$$\text{Volume} = \int_0^{2\pi} \int_0^{\pi} \int_0^{a+u'} r^2 \sin \theta \, d\phi \, d\theta \, dr$$

$$= 1/3 \int_0^{2\pi} \int_0^{\pi} (a+u')^3 \sin \theta \, d\phi \, d\theta \tag{65}$$

From (64)

$$(a+u')^3 = a^3 \left[1 + 3/2 \frac{M}{E} \frac{a^4}{d^4} (5 \cos^3 \theta - 3 \cos \theta) + \text{etc.} \right] \tag{66}$$

the terms containing the powers of $\frac{a}{d}$ above the fourth being neglected.

Substituting (66) in (65)

$$\text{Volume} = 1/3 \, a^3 \int_0^{2\pi} \int_0^{\pi} \left[1 + 3/2 \frac{M}{E} \frac{a^4}{d^4} (5 \cos^3 \theta - 3 \cos \theta) \right] \sin \theta \, d\phi \, d\theta$$

$$= 2/3 a^3 \int_0^{2\pi} d\phi = 4/3 \pi a^3 \tag{67}$$

As (67) is the volume of a sphere with radius a, it is evident that this is the mean radius of the volume included in the surface represented by (64), and that u' is the amount of the disturbance in the mean surface due to the force depending upon the fourth power of the moon's parallax.

Letting ψ' equal the angle between the radius vector and normal to any point P in this surface,

$$\tan \psi' = -\frac{dr}{r d\theta} \tag{68}$$

and from (61) and (63)

$$r = a + \tfrac{1}{2} \frac{M}{E} \frac{a^4}{d^4} (5 \cos^3 \theta - 3 \cos \theta) \, a \tag{69}$$

Then

$$\frac{dr}{d\theta} = -\tfrac{1}{2} \frac{M}{E} \frac{a^5}{d^4} (15 \cos^2 \theta - 3) \sin \theta \tag{70}$$

Substituting (69) and (70) in (68) and neglecting powers of $\frac{a}{d}$ above the fourth

$$\tan \psi' = 3/2 \frac{M}{E} \frac{a^4}{d^4} (5 \cos^2 \theta - 1) \sin \theta \tag{71}$$

For the tangent of the angle between the radius vector and the resultant of the forces under consideration we have from (24), (25), (30), and (61)

$$\frac{3/2\,\frac{\mu M r^2}{d^4}\,(5\cos^2\theta-1)\sin\theta}{\frac{\mu E}{r^2}-3/2\,\frac{\mu M r^2}{d^4}\,(5\cos^3\theta-3\cos\theta)}=3/2\,\frac{M}{E}\,\frac{a^4}{d^4}\,(5\cos^2\theta-1)\sin\theta \quad (72)$$

since $\frac{u'}{a}$ and $\frac{(a+u')^4}{d^4}$ are each very small compared with unity.

Comparing (72) with (71), it is found that the angle made by the resultant force with the radius vector is the same as the angle made by the normal at the same point.

Taking d as the mean distance of the moon and substituting numerical values from Table 2 for the coefficient in (71) we obtain

$$\tan\psi'=0.000{,}000{,}001{,}4\,(5\cos^2\theta-1)\sin\theta \quad (73)$$

in which ψ' has a maximum value of about 0.0004″ when $\theta=31.1°$. The maximum deflection of the normal due to the fourth power of the sun's parallax is only about 0.000,000,5″.

Expressions similar to (44) and (64) may be formed for the equilibrium height of the tide due to the sun, letting

S = mass of sun,
d_1 = distance from center of earth to center of sun,
θ_1 = angle at center of earth between line to sun and to point of observation on earth.

Then for the height (y) of equilibrium tide due to combined action of moon and sun we have

$$y=\tfrac{1}{2}\,\frac{M}{E}\,\frac{a^3}{d^3}\,(3\cos^2\theta-1)\,a \;\ldots\ldots\; \text{(approximate lunar tide).}$$

$$+\tfrac{1}{2}\,\frac{M}{E}\,\frac{a^4}{d^4}\,(5\cos^3\theta-3\cos\theta)\,a \;\ldots\; \text{(tide depending upon 4th power of moon's parallax).}$$

$$+\tfrac{1}{2}\,\frac{S}{E}\,\frac{a^3}{d_1^3}\,(3\cos^2\theta_1-1)\,a \;\ldots\ldots\; \text{(approximate solar tide).}$$

$$+\tfrac{1}{2}\,\frac{S}{E}\,\frac{a^4}{d_1^4}\,(5\cos^3\theta_1-3\cos\theta_1)\,a \;.\; \text{(tide depending upon 4th power of sun's parallax).} \quad (74)$$

In (74) it will be noted that M, E, S, and a are constants. The distance d and d_1 vary within certain limits because of the eccentricity of the orbits of the moon and earth. The angles θ and θ_1, which are practically the same as the zenith distances of the moon and sun, respectively, vary with the declinations and hour angles of these bodies and also depend upon the latitude of the place of observations.

If we ascribe the mean values to the distance d and d_1 and substitute the numerical values of the constants from Table 2, we obtain from (74) the following, the unit of height being the foot:

$y = 0.584\ (3 \cos^2 \theta - 1)$ . . . . (approximate lunar tide).
$+0.010\ (5 \cos^2 \theta - 3 \cos \theta)$ . . . (depending upon 4th power of moon's parallax).
$+0.270\ (3 \cos^2 \theta_1 - 1)$ . . . . (approximate solar tide).
$+0.000{,}01\ (5 \cos^3 \theta_1 - 3 \cos \theta_1)$. (depending upon 4th power of sun's parallax). (75)

From (75) it appears that the extreme ranges of the equilibrium lunar and solar tides are approximately 1.75 and 0.81 feet, respectively, and that the tides depending upon the fourth power of the parallax of the moon and of the sun are of little or no importance.

9. DEVELOPMENT OF EQUILIBRIUM TIDE.

In equation (74) an expression was obtained for the equilibrium height of the tide in terms of the linear distances and the zenith distances of the tide-producing bodies. It is now proposed to develop this equation in terms of variables which change uniformly with time. Let us consider, first, the term representing the principal lunar tide, which may be written

$$y = 3/2\ \frac{M}{E}\ \frac{a^4}{d^3}\ (\cos^2 \theta - 1/3) \qquad (76)$$

In Figure 9 let O represent the center of the earth and let projections on the celestial sphere be as follows:

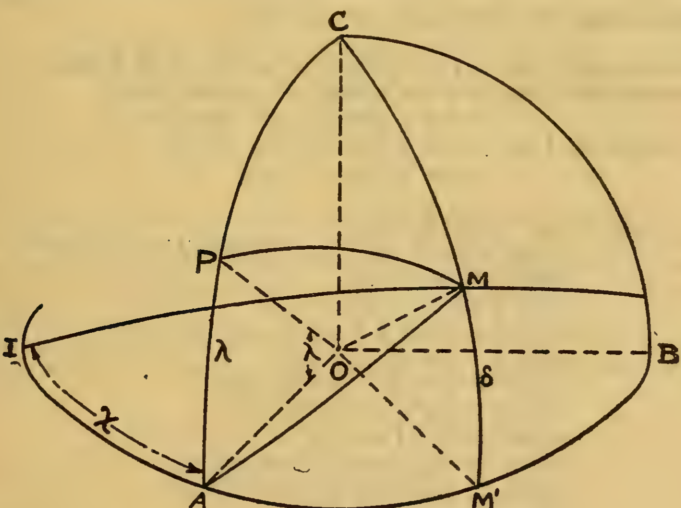


FIG. 9.

IAB, the earth's equator;
IM, the moon's orbit;
CPA, the meridan of place of observation;
CMM', the hour circle of the moon;
I, the intersection of moon's orbit with the Equator;
P, the place of observation;
M, the position of the moon.

Then the $\angle MOP$ will equal the $\angle \theta$ of equation (76).

Now, let $\lambda = AP$ = latitude of place of observation,
$\delta = M'M$ = declination of moon,
$C = \angle AOM'$ = arc AM' = hour angle of moon,
$I = \angle MIA$ = inclination of moon's orbit to the Equator,
$l = IM$ = longitude of moon in its orbit reckoned from the intersection I,
$\chi = IA$ = right ascension of meridian of place of observations reckoned from the intersection I.

In this discussion the radian is considered as the angular unit.
In the spherical triangle CMP

$$\begin{aligned}\text{Cos } PM = \cos\theta &= \cos CP \cos CM + \sin CP \sin CM \cos C \\ &= \sin\lambda \sin\delta + \cos\lambda \cos\delta \cos AM' \end{aligned} \tag{77}$$

In the right spherical triangle $MM'I$,

$$\sin\delta = \sin I \sin l \tag{78}$$

and in the right spherical triangle $MM'A$,

$$\cos\delta \cos AM' = \cos AM. \tag{79}$$

In the spherical triangle MAI

$$\cos AM = \cos l \cos\chi + \sin l \sin\chi \cos I \tag{80}$$

Substituting (78), (79), and (80) in (77)

$$\begin{aligned}\cos\theta &= \sin\lambda \sin I \sin l + \cos\lambda\,[\cos l \cos\chi + \cos I \sin l \sin\chi] \\ &= \sin\lambda \sin I \sin l + \tfrac{1}{2}\cos\lambda\,[\cos(l-\chi) + \cos(l+\chi) \\ &\qquad + \cos I\,\{\cos(l-\chi) - \cos(l+\chi)\}] \\ &= \sin\lambda \sin I \sin l + \cos\lambda\,[\cos^2\tfrac{1}{2} I \cos(l-\chi) \\ &\qquad + \sin^2\tfrac{1}{2} I \cos(l+\chi)] \end{aligned} \tag{81}$$

Then

$$\begin{aligned}\cos^2\theta &= \sin^2\lambda \sin^2 I \sin^2 l \\ &+ 2\sin\lambda\cos\lambda \sin I \sin l\,[\cos^2\tfrac{1}{2} I \cos(l-\chi) \\ &+ \sin^2\tfrac{1}{2} I \cos(l+\chi)] \\ &+ \cos^2\lambda\,[\cos^4\tfrac{1}{2} I \cos^2(l-\chi) \\ &+ 2\sin^2\tfrac{1}{2} I \cos^2\tfrac{1}{2} I \cos(l-\chi)\cos(l+\chi) \\ &+ \sin^4\tfrac{1}{2} I \cos^2(l+\chi)] \\ &= \tfrac{1}{2}\cos^2\lambda \cos^4\tfrac{1}{2} I \cos(2l-2\chi) \\ &+ \tfrac{1}{2}\cos^2\lambda \sin^4\tfrac{1}{2} I \cos(2l+2\chi) \\ &+ \tfrac{1}{4}\cos^2\lambda \sin^2 I \cos 2\chi \\ &+ \tfrac{1}{2}\sin 2\lambda \sin I \cos^2\tfrac{1}{2} I \sin(2l-\chi) \\ &+ \tfrac{1}{2}\sin 2\lambda \sin I \sin^2\tfrac{1}{2} I \sin(2l+\chi) \\ &+ \tfrac{1}{2}\sin 2\lambda \sin I \cos I \sin\chi \\ &+ (\tfrac{1}{4}\cos^2\lambda \sin^2 I - \tfrac{1}{2}\sin^2\lambda \sin^2 I)\cos 2l \\ &+ \tfrac{1}{2}(\cos^2\lambda\cos^4\tfrac{1}{2} I + \cos^2\lambda \sin^4\tfrac{1}{2} I + \sin^2\lambda \sin^2 I) \end{aligned} \tag{82}$$

The last two lines of (82) may be written

$$\begin{aligned}&(\tfrac{1}{2} - 3/2\sin^2\lambda)\,(\tfrac{1}{2}\sin^2 I \cos 2l) \\ &+ (\tfrac{1}{2} - 3/2\sin^2\lambda)\,(1/3 - \tfrac{1}{2}\sin^2 I) + 1/3 \end{aligned} \tag{83}$$

Substituting (82) and (83) in (76), we have

$$
\begin{aligned}
y=3/2\frac{M}{E}\frac{a^4}{d^3}\Big[& \tfrac{1}{2}\cos^2\lambda\cos^4\tfrac{1}{2}I\cos(2l-2\chi)\\
&+\tfrac{1}{2}\cos^2\lambda\sin^4\tfrac{1}{2}I\cos(2l+2\chi)\\
&+\tfrac{1}{4}\cos^2\lambda\sin^2 I\cos 2\chi\\
&+\tfrac{1}{2}\sin 2\lambda\sin I\cos^2\tfrac{1}{2}I\cos(2l-\chi-\pi/2)\\
&+\tfrac{1}{2}\sin 2\lambda\sin I\sin^2\tfrac{1}{2}I\cos(2l+\chi-\pi/2)\\
&+\tfrac{1}{4}\sin 2\lambda\sin 2I\cos(\chi-\pi/2)\\
&+(\tfrac{1}{2}-3/2\sin^2\lambda)(\tfrac{1}{2}\sin^2 I\cos 2l)\\
&+(\tfrac{1}{2}-3/2\sin^2\lambda)(1/3-\tfrac{1}{2}\sin^2 I)\Big] \qquad (84)
\end{aligned}
$$

In the above formula d, the moon's actual distance from the earth and l, the moon's true longitude in its orbit measured from the intersection, although functions of time, do not vary uniformly because of certain inequalities in the motion of the moon. It is desired, therefore, to find expressions for these quantities in terms of elements that will vary uniformly with time.

Letting σ = mean longitude of moon in radians measured from the intersection, then l being the true longitude from the same origin, we may obtain from Table 1

$$
\begin{aligned}
l=\sigma &+2e\sin(s-p)+5/4e^2\sin 2(s-p)\\
&+15/4\,me\sin(s-2h+p)\\
&+11/8\,m^2\sin 2(s-h) \qquad (85)
\end{aligned}
$$

Letting c = mean distance of moon from earth we may also obtain from Table 1

$$
\begin{aligned}
\frac{1}{d}=\frac{1}{c}&+a'\,e\cos(s-p)+a'\,e^2\cos 2(s-p)\\
&+15/8\,a'\,me\cos(s-2h+p)\\
&+a'\,m^2\cos 2(s-h) \qquad (86)
\end{aligned}
$$

in which $a'=\dfrac{1}{c\,(1-e^2)}$.

A reference to Table 2 will show that the quantities e and m may each be considered as fractions of the first order and the product of the two or the square of either as fractions of the second order. In the following development terms smaller than those of the second order will be neglected.

Substituting the value of a' in (86) and multiplying by c, we obtain after neglecting terms containing powers of e above the second

$$
\begin{aligned}
\frac{c}{d}=1&+e\cos(s-p)+e^2\cos 2(s-p)\\
&+15/8\,me\cos(s-2h+p)\\
&+m^2\cos 2(s-h) \qquad (87)
\end{aligned}
$$

Cubing (87),

$$
\begin{aligned}
\frac{c^3}{d^3}&=1+3\,e\cos(s-p)+3\,e^2\cos^2(s-p)\\
&\qquad+3\,e^2\cos 2(s-p)\ +45/8\,me\cos(s-2h+p)\\
&\qquad+3\,m^2\cos 2(s-h)\\
&=1+3/2\,e^2+3e\cos(s-p)+9/2\,e^2\cos 2(s-p)\\
&\qquad+45/8\,me\cos(s-2h+p)+3\,m^2\cos 2(s-h) \qquad (88)
\end{aligned}
$$

In equation (84) the functions involving l and χ may be expressed in the general form $\cos(2l+\alpha)$ or $\cos\alpha$, in which $\alpha=\pm 2\chi, (\pm\chi-\pi/2)$, or zero.

In equation (85) let

$$k=2e\sin(s-p)+5/4\, e^2 \sin 2(s-p) + 15/4\, me \sin(s-2h+p)+11/8\, m^2 \sin 2(s-h) \qquad (89)$$

Then

$$l=\sigma+k \qquad (90)$$

The maximum value of k is small. If numerical values for e and m be substituted in (89), it is found that the maximum value of $2k$ is 0.273 of a radian, the sine of which is 0.270. It may therefore be assumed without material error that the sine of any angle not greater than $2k$ is equal to the angle itself.

Then

$$\sin 2k=2k=4e\sin(s-p)+5/2\, e^2\sin 2(s-p) + 15/2\, me\sin(s-2h+p)+11/4\, m^2\sin 2(s-h) \qquad (91)$$

and

$$\cos 2k=1-2\sin^2 k=1-2k^2 = 1-8\, e^2\sin^2(s-p)=1-4e^2+4e^2\cos 2(s-p) \qquad (92)$$

if terms smaller than those of the second order are neglected.

From (90), (91), and (92) we may now obtain

$$\begin{aligned}
&\cos(2l+\alpha)=\cos(2\sigma+2k+\alpha)\\
&=\cos 2k\cos(2\sigma+\alpha)-\sin 2k\sin(2\sigma+\alpha)\\
&=[1-4e^2+4e^2\cos 2(s-p)]\cos(2\sigma+\alpha)\\
&-[4e\sin(s-p)+5/2\, e^2\sin 2(s-p)\\
&+15/2\, me\sin(s-2h+p)+11/4\, m^2\sin 2(s-h)]\sin(2\sigma+\alpha)\\
&=(1-4e^2)\cos(2\sigma+\alpha)\\
&+2e\cos(2\sigma+\alpha+s-p)-2e\cos(2\sigma+\alpha-s+p)\\
&+13/4\, e^2\cos(2\sigma+\alpha+2s-2p)+3/4\, e^2\cos(2\sigma+\alpha-2s+2p)\\
&+15/4\, me\cos(2\sigma+\alpha+s-2h+p)-15/4\, me\cos(2\sigma+\alpha-s+2h-p)\\
&+11/8\, m^2\cos(2\sigma+\alpha+2s-2h)-11/8\, m^2\cos(2\sigma+\alpha-2s+2h) \qquad (93)
\end{aligned}$$

The general coefficient of (84) may be written

$$3/2\,\frac{M}{E}\,\frac{a^4}{d^3}=3/2\,\frac{M}{E}\,\frac{a^4}{c^3}\left(\frac{c}{d}\right)^3 \qquad (94)$$

and the variable part of each of the terms in (84) may then be expressed by one of the following general forms:

$$\left(\frac{c}{d}\right)^3;\ \left(\frac{c}{d}\right)^3\cos\alpha;\ \text{or}\ \left(\frac{c}{d}\right)^3\cos(2l+\alpha)$$

The value of the first is given in equation (88). For the second we have from (88)

$$\begin{aligned}
\left(\frac{c}{d}\right)^3\cos\alpha=&(1+3/2\, e^2)\cos\alpha\\
&+3/2\, e\cos(\alpha+s-p)+3/2\, e\cos(\alpha-s+p)\\
&+9/4\, e^2\cos(\alpha+2s-2p)+9/4\, e^2\cos(\alpha-2s+2p)\\
&+45/16\, me\cos(\alpha+s-2h+p)+45/16\, me\cos(\alpha-s+2h-p)\\
&+3/2\, m^2\cos(\alpha+2s-2h)+3/2\, m^2\cos(\alpha-2s+2h) \qquad (95)
\end{aligned}$$

For the third form we may obtain from (88) and (93) to the second order of approximation the following:

$$\left(\frac{c}{d}\right)^3 \cos\,(2l+\alpha) = (1-5/2\ e^2)\ \cos\ (2\sigma+\alpha)$$
$$+7/2\ e \cos\,(2\sigma+\alpha+s-p) - 1/2\ e \cos\ (2\sigma+\alpha-s+p)$$
$$+17/2\ e^2 \cos\ (2\sigma+\alpha+2s-2p)$$
$$+105/16\ me \cos\,(2\sigma+\alpha+s-2h+p) - 15/16\ me \cos\,(2\sigma+\alpha-s+2h-p)$$
$$+23/8\ m^2 \cos\ (2\sigma+\alpha+2s-2h) + 1/8\ m^2 \cos\ (2\sigma+\alpha-2s+2h) \qquad (96)$$

Substituting (88), (95), and (96) in (84), and letting α equal $\pm 2\chi$, $(\pm\chi-\pi/2)$, or 0, as the case may be, we may obtain the following equation for the equilibrium height of the lunar tide. For convenience in reference each term is designated by the letter A with a subscript. Following each term is a numeral giving its maximum value in feet when I has its mean value. These numerical values include the general coefficient and are calculated from the constants in Table 2. They serve to indicate the relative importance of each term.

$$y = 3/2\ \frac{Ma^4}{Ec^3} \times$$

$(A)_1$	$[1/2 \cos^2\lambda \cos^4 \frac{1}{2} I\{(1-5/2\ e^2) \cos(2\sigma-2\chi)$	(0.7869)
$(A)_2$	$+7/2\ e \cos\ (2\sigma-2\chi+s-p)$	(0.1524)
$(A)_3$	$-1/2\ e \cos\ (2\sigma-2\chi-s+p)$	(0.0218)
$(A)_4$	$+17/2\ e^2 \cos\ (2\sigma-2\chi+2s-2p)$	(0.0203)
$(A)_5$	$+105/16\ me \cos\ (2\sigma-2\chi+s-2h+p)$	(0.0214)
$(A)_6$	$-15/16\ me \cos\ (2\sigma-2\chi-s+2h-p)$	(0.0031)
$(A)_7$	$+23/8\ m^2 \cos\ (2\sigma-2\chi+2s-2h)$	(0.0128)
$(A)_8$	$+1/8\ m^2 \cos\ (2\sigma-2\chi-2s+2h)\}$	(0.0006)
$(A)_9$	$+1/2 \cos^2\lambda \sin^4 \frac{1}{2} I\ \{(1-5/2\ e^2) \cos\ (2\sigma+2\chi)$	(0.0015)
$(A)_{10}$	$+7/2\ e \cos\ (2\sigma+2\chi+s-p)$	(0.0003)
$(A)_{11}$	$-1/2\ e \cos\ (2\sigma+2\chi-s+p)$	(0.00004)
$(A)_{12}$	$+17/2\ e^2 \cos\ (2\sigma+2\chi+2s-2p)$	(0.00004)
$(A)_{13}$	$+105/16\ me \cos\ (2\sigma+2\chi+s-2h+p)$	(0.00004)
$(A)_{14}$	$-15/16\ me \cos\ (2\sigma+2\chi-s+2h-p)$	(0.00001)
$(A)_{15}$	$+23/8\ m^2 \cos\ (2\sigma+2\chi+2s-2h)$	(0.00002)
$(A)_{16}$	$+1/8\ m^2 \cos\ (2\sigma+2\chi-2s+2h)\}$	(0.000001)
$(A)_{17}$	$+1/4 \cos^2\lambda \sin^2 I\ \{(1+3/2\ e^2) \cos 2\chi$	(0.0686)
$(A)_{18}$	$+3/2\ e \cos\ (2\chi+s-p)$	(0.0056)
$(A)_{19}$	$+3/2\ e \cos\ (2\chi-s+p)$	(0.0056)
$(A)_{20}$	$+9/4\ e^2 \cos\ (2\chi+2s-2p)$	(0.0005)
$(A)_{21}$	$+9/4\ e^2 \cos\ (2\chi-2s+2p)$	(0.0005)
$(A)_{22}$	$+45/16\ me \cos\ (2\chi+s-2h+p)$	(0.0008)
$(A)_{23}$	$+45/16\ me \cos\ (2\chi-s+2h-p)$	(0.0008)
$(A)_{24}$	$+3/2\ m^2 \cos\ (2\chi+2s-2h)$	(0.0006)
$(A)_{25}$	$+3/2\ m^2 \cos\ (2\chi-2s+2h)\}$	(0.0006)
$(A)_{26}$	$+1/2 \sin 2\lambda \sin I \cos^2 \frac{1}{2} I\{(1-5/2\ e^2) \cos\ (2\sigma-\chi-\pi/2)$	(0.3266)
$(A)_{27}$	$+7/2\ e \cos\ (2\sigma-\chi+s-p-\pi/2$	(0.0632)
$(A)_{28}$	$-1/2\ e \cos\ (2\sigma-\chi-s+p-\pi/2)$	(0.0090)
$(A)_{29}$	$+17/2\ e^2 \cos\ (2\sigma-\chi+2s-2p-\pi/2)$	(0.0084)
$(A)_{30}$	$+105/16\ me \cos\ (2\sigma-\chi+s-2h+p-\pi/2)$	(0.0089)
$(A)_{31}$	$-15/16\ me \cos\ (2\sigma-\chi-s+2h-p-\pi/2)$	(0.0013)
$(A)_{32}$	$+23/8\ m^2 \cos\ (2\sigma-\chi+2s-2h-\pi/2)$	(0.0053)
$(A)_{33}$	$+1/8\ m^2 \cos\ (2\sigma-\chi-2s+2h-\pi/2)\}$	(0.0002)
$(A)_{34}$	$+1/2 \sin 2\lambda \sin I \sin^2 \frac{1}{2} I\ \{(1-5/2\ e^2) \cos\ (2\sigma+\chi-\pi/2)$	(0.0141)
$(A)_{35}$	$+7/2\ e \cos\ (2\sigma+\chi+s-p-\pi/2)$	(0.0027)
$(A)_{36}$	$-1/2\ e \cos\ (2\sigma+\chi-s+p-\pi/2)$	(0.0004)
$(A)_{37}$	$+17/2\ e^2 \cos\ (2\sigma+\chi+2s-2p-\pi/2)$	(0.0004)
$(A)_{38}$	$+105/16\ me \cos\ (2\sigma+\chi+s-2h+p-\pi/2)$	(0.0004)
$(A)_{39}$	$-15/16\ me \cos\ (2\sigma+\chi-s+2h-p-\pi/2)$	(0.0001)
$(A)_{40}$	$+23/8\ m^2 \cos\ (2\sigma+\chi+2s-2h-\pi/2)$	(0.0002)
$(A)_{41}$	$+1/8\ m^2 \cos\ (2\sigma+\chi-2s+2h-\pi/2)\}$	(0.00001)

$(A)_{42}$	$+1/4 \sin 2\lambda \sin 2I \{(1+3/2\,e^2) \cos (\chi-\pi/2)$	(0.3164)	
$(A)_{43}$	$+3/2\, e \cos (\chi+s-p-\pi/2)$	(0.0259)	
$(A)_{44}$	$+3/2\, e \cos (\chi-s+p-\pi/2)$	(0.0259)	
$(A)_{45}$	$+9/4\, e^2 \cos (\chi+2s-2p-\pi/2)$	(0.0021)	
$(A)_{46}$	$+9/4\, e^2 \cos (\chi-2s+2p-\pi/2)$	(0.0021)	
$(A)_{47}$	$+45/16\, me \cos (\chi+s-2h+p-\pi/2)$	(0.0036)	
$(A)_{48}$	$+45/16\, me \cos (\chi-s+2h-p-\pi/2)$	(0.0036)	
$(A)_{49}$	$+3/2\, m^2 \cos (\chi+2s-2h-\pi/2)$	(0.0026)	
$(A)_{50}$	$+3/2\, m^2 \cos (\chi-2s+2h-\pi/2)\}$	(0.0026)	
$(A)_{51}$	$+1/2\,(1/2-3/2 \sin^2 \lambda) \sin^2 I \{(1-5/2\,e^2) \cos 2$	(0.1356)	Mf
$(A)_{52}$	$+7/2\, e \cos (2\sigma+s-p)$	(0.0263)	
$(A)_{53}$	$-1/2\, e \cos (2\sigma-s+p)$	(0.0037)	
$(A)_{54}$	$+17/2\, e^2 \cos (2\sigma+2s-2p)$	(0.0035)	
$(A)_{55}$	$+105/16\, me \cos (2\sigma+s-2h+p)$	(0.0037)	
$(A)_{56}$	$-15/16\, me \cos (2\sigma-s+2h-p)$	(0.0005)	
$(A)_{57}$	$+23/8\, m^2 \cos (2\sigma+2s-2h)$	(0.0022)	
$(A)_{58}$	$+1/8\, m^2 \cos (2\sigma-2s+2h)\}$	(0.0001)	
$(A)_{59}$	$+(1/2-3/2 \sin^2 \lambda)\,(1/3-1/2 \sin^2 I)\,\{(1+3/2\,e^2)$	(0.4404)	
$(A)_{60}$	$+3\, e \cos (s-p)$	(0.0722)	Mm
$(A)_{61}$	$+9/2\, e^2 \cos (2s-2p)$	(0.0059)	
$(A)_{62}$	$+45/8\, me \cos (s-2h+p)$	(0.0101)	
$(A)_{63}$	$+3\, m^2 \cos (2s-2h)\}]$	(0.0074)	(97) MSf

Referring to section 4 and Figure 6, it will be noted that the longitude measured in the moon's orbit from the intersection A equals the longitude measured from the referred equinox ♈′ less the distance ξ, and that longitude measured in the Equator from the intersection A equals the longitude measured from the equinox ♈ less the distance ν.

In Figure 10, let S' and P' be the points where the hour circles of the mean sun and of the place of observations intersect the celestial

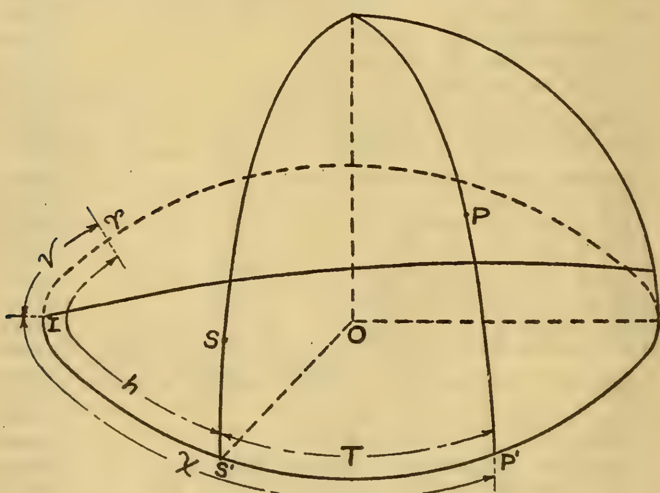


FIG. 10.

equator, and let T = the hour angle of the mean sun measured westward from the meridian of the place of observations. It is evident that the difference between the mean longitude of the sun and the right ascension of the meridian of the place of observation when reckoned from the same origin will be equal to the hour angle of the mean sun.

With other notations as before, we then have

$$\sigma = s - \xi \tag{98}$$

$$\chi = T + h - \nu \tag{99}$$

Substituting (98) and (99) in (97), making all coefficients positive by adding or substracting π from the angle, since $-\cos\chi = +\cos(\chi \pm \pi)$, and neglecting all the smaller terms whose numerical maximum values as indicated are less than 0.003, we obtain the following:

$$y = 3/2 \frac{M}{E} \left(\frac{a}{c}\right)^3 a \cos^2 \lambda \times$$

$(A)_1$ $[(1/2 - 5/4\, e^2) \cos^4 \frac{1}{2} I \cos (2T + 2h - 2s + 2\xi - 2\nu)$ .... M_2

$(A)_2$ $+7/4\, e \cos^4 \frac{1}{2} I \cos (2T + 2h - 3s + p + 2\xi - 2\nu)$ .... N_2

$(A)_3$ $+1/4\, e \cos^4 \frac{1}{2} I \cos (2T + 2h - s - p + 2\xi - 2\nu + \pi)$ .... $[L_2]$

$(A)_4$ $+17/4\, e^2 \cos^4 \frac{1}{2} I \cos (2T + 2h - 4s + 2p + 2\xi - 2\nu)$ 2N

$(A)_5$ $+105/32\, me \cos^4 \frac{1}{2} I \cos (2T + 4h - 3s - p + 2\xi - 2\nu)$ .... ν_2

$(A)_6$ $+15/32\, me \cos^4 \frac{1}{2} I \cos (2T - s + p + 2\xi - 2\nu + \pi)$ .... λ_2

$(A)_7$ $+23/16\, m^2 \cos^4 \frac{1}{2} I \cos (2T + 4h - 4s + 2\xi - 2\nu)$ .... μ_2

$(A)_{17}$ $+(1/4 + 3/8\, e^2) \sin^2 I \cos (2T + 2h - 2\nu)$ .... $[K_2]$

$(A)_{18}$ $+3/8\, e \sin^2 I \cos (2T + 2h + s - p - 2\nu)$

$(A)_{19}$ $+3/8\, e \sin^2 I \cos (2T + 2h - s + p - 2\nu)]$ .... $[L_2]^1$

$$+3/2 \frac{M}{E} \left(\frac{a}{c}\right)^3 a \sin 2\lambda \times$$

$(A)_{26}$ $[(1/2 - 5/4\, e^2) \sin I \cos^2 \frac{1}{2} I \cos (T + h - 2s + 2\xi - \nu + \pi/2)$ ...... O_1

$(A)_{27}$ $+7/4\, e \sin I \cos^2 \frac{1}{2} I \cos (T + h - 3s + p + 2\xi - \nu + \pi/2)$ .... Q_1

$(A)_{28}$ $+1/4\, e \sin I \cos^2 \frac{1}{2} I \cos (T + h - s - p + 2\xi - \nu - \pi/2)$ .... $[M_1]^1$

$(A)_{29}$ $+17/4\, e^2 \sin I \cos^2 \frac{1}{2} I \cos (T + h - 4s + 2p + 2\xi - \nu + \pi/2)$ 2Q

$(A)_{30}$ $+105/32\, me \sin I \cos^2 \frac{1}{2} I \cos (T + 3h - 3s - p + 2\xi - \nu + \pi/2)$ ... ρ_1

$(A)_{32}$ $+23/16\, m^2 \sin I \cos^2 \frac{1}{2} I \cos (T + 3h - 4s + 2\xi - \nu + \pi/2)$

$(A)_{34}$ $+(1/2 - 5/4\, e^2) \sin I \sin^2 \frac{1}{2} I \cos (T + h + 2s - 2\xi - \nu - \pi/2)$ ... OO

$(A)_{42}$ $+(1/4 + 3/8\, e^2) \sin 2 I \cos (T + h - \nu - \pi/2)$ .... $[K_1]$

$(A)_{43}$ $+3/8\, e \sin 2 I \cos (T + h + s - p - \nu - \pi/2)$ .... J_1

$(A)_{44}$ $+3/8\, e \sin 2 I \cos (T + h - s + p - \nu - \pi/2)$ .... $[M_1]$

$(A)_{47}$ $+45/64\, me \sin 2 I \cos (T - h + s + p - \nu - \pi/2)$

$(A)_{48}$ $+45/64\, me \sin 2 I \cos (T + 3h - s - p - \nu - \pi/2)]$

$$+3/2 \frac{M}{E} \left(\frac{a}{c}\right)^3 a\, (1/2 - 3/2 \sin^2 \lambda) \times$$

$(A)_{51}$ $[(1/2 - 5/4\, e^2) \sin^2 I \cos (2s - 2\xi)$ .... Mf

$(A)_{52}$ $+7/4\, e \sin^2 I \cos (3s - p - 2\xi)$

$(A)_{53}$ $+1/4\, e \sin^2 I \cos (s + p - 2\xi + \pi)$

$(A)_{54}$ $+17/4\, e^2 \sin^2 I \cos (4s - 2p - 2\xi)$

$(A)_{55}$ $+105/32\, me \sin^2 I \cos (3s - 2h + p - 2\xi)$

$(A)_{59}$ $+(1/3 + 1/2\, e^2)\, (1 - 3/2 \sin^2 I)$

$(A)_{60}$ $+e\, (1 - 3/2 \sin^2 I) \cos (s - p)$ .... Mm

$(A)_{61}$ $+3/2\, e^2\, (1 - 3/2 \sin^3 I) \cos (2s - 2p)$

$(A)_{62}$ $+15/8\, me\, (1 - 3/2 \sin^2 I) \cos (s - 2h + p)$

$(A)_{63}$ $+m^2\, (1 - 3/2 \sin^2 I) \cos (2s - 2h)$ .... $[MSf]$ (100)

If we disregard for the present the slow variations in the value of I, ξ, and ν, which for a series of observations of a year or less may be considered as practically constant, each term in the above formula, excepting $(A)_{59}$, is an harmonic function of an angle which changes uniformly with time. Each term represents an harmonic component of the lunar tide, and, if the ideal conditions assumed under the equilibrium theory (section 3) actually existed, each term including the general coefficient would represent the approximate true height of that component referred to mean sea level and the sum of all the terms the approximate height of the entire lunar tide.

The notation following each term in the formula is the generally recognized symbol for the component represented. The bracketed symbols indicate that the terms only partially represent the components designated. These will later be given special consideration. The terms without symbols are of little practical importance and are generally neglected.

Terms with coefficients e and e^2 represent the elliptic components, since they depend directly upon the eccentricity of the moon's orbit. Terms with coefficients me, and m^2 represent the evectional and variational components, respectively, since they are derived from the corresponding inequalities in the motion of the moon. (See formulas for the true longitude and distance of the moon in Table 1.)

10. EQUILIBRIUM ARGUMENT.

Although the actual height of the tide and the time of occurrence of the maxima and minima are greatly modified by conditions upon the earth's surface, equation (100) furnishes us with important representations of the elementary periodic forces which tend to produce the lunar tide. These forces may be defined by their periods which depend upon the varying angles of the several terms of the equation. Disregarding for the time being the slow changes in the functions of the angle I, the value of each term in general is the product of a constant coefficient and the cosine of a varying angle. This angle is called the equilibrium argument of the component represented. The numerical value of the argument is constantly changing. The mean rate of change is called the speed of the component, and the time required for the argument to complete one cycle of 360° is the period of the component.

Examining equation (100) it will be noted that each argument is composed of a combination of some of the following elements:

> T, hour angle of the mean sun at the place of observation;
> h, longitude of the mean sun;
> s, longitude of the mean moon;
> p, longitude of the moon's perigee;
> p_1, longitude of sun's perigee (for solar tides only);
> ξ, longitude in moon's orbit of intersection (fig. 6);
> ν, right ascension of intersection (fig. 6).

The hour angle T is zero at mean local noon at the place of observation and increases uniformly at the rate of 15° per solar hour. At any given instant of time the value of T will be different for each meridian of the earth, but will be identical for all places on the same meridian. Formulas for h, s, p, and p_1 are given in Table 1. Although the rates of change in these elements are not absolutely uniform, the variations from uniformity are negligible in this work. The values for the beginning of the present century and the hourly rates of change will be found in Table 2. The values of ξ and ν for each degree of N are given in Table 6. They vary slowly between small positive and negative limits, but do not affect the mean speed of an argument, since an acceleration in the speed at one time due to the positive values of these elements will be compensated for at another time by the retardation due to corresponding negative values.

The argument of a component is divided into two parts designated by V and u, respectively, so that the entire argument may be expressed by $(V+u)$. The principal part V is composed of a combination of the elements T, h, s, p, and p_1, together with any constant, such as a multiple of 90°. The V changes uniformly throughout the entire cycle of 360° and determines the speed and period of the component. The u includes the elements ξ and ν, and alternately increases and decreases through small limits with a mean value of zero. The change in the u is very slow, and for the reduction of any series of observations not exceeding 369 days in length it is assumed to be constant with its value as of the middle of the series, but for the comparison of results from different years of observations the change in this quantity must be taken into account. The u, being a function of N, has a period of approximately 19 years.

Of the elements that may enter into the V it will be noted that T has a speed of 15° per hour, giving a period of one solar day for this element, while the speeds of the other elements (Table 2) are each less than 1° per hour. The approximate period of the elements s, h, p, and p_1 are 1 month, 1 year, 9 years, and 20,000 years, respectively. In a combination of elements of which the speeds differ so greatly it is apparent that the approximate period of the component will be determined by the element of greatest speed and shortest period. Thus all the components which contain the element T in their arguments must have periods that will not greatly exceed the length of a solar day, but if the element of greatest speed in the argument is s the period will be approximately one month.

Tidal components are considered under two classes, short-period components with periods of approximately one day or less and long-period components with periods extending over a longer time. The former contain the element T in their arguments, while the latter are independent of this element.

The short-period components may be subdivided and classed as diurnal, semidiurnal, terdiurnal, quarter-diurnal, etc. The diurnal components have periods approximately equal to a solar day, and they are distinguished by the presence of a single T in the argument. The actual period of such a component is called a component day. The semidiurnal components have periods approximately equal to one-half of a solar day and are distinguished by the presence of $2T$ in the argument. For these components the component day will be exactly twice the length of the period of the component. Terdiurnal and quarter-diurnal components will have three and four periods each component day and will be distinguished by the multiples $3T$ and $4T$ in their arguments. In formula (100) the only short-period components represented are the diurnal and semidiurnal components.

The long-period components are of much less practical importance and only five are usually considered in the analysis. The lunar monthly Mm, with a period of approximately one month indicated by the single s in its argument, and the lunar fortnightly Mf, and the lunisolar-synodic fortnightly MSf, with periods of approximately one-half of a month, as indicated by the $2s$ in their arguments, may be found represented in formula (100). The annual and semiannual components will be referred to later.

In order to visualize the equilibrium arguments of the short-period components, the periods of which depend primarily upon the rotation of the earth, it may be found convenient to conceive of a system of fictitious stars, or "astres fictifs," as they are frequently called, which move in the celestial equator. Each diurnal component may be represented by such a star moving at a rate which will cause it to transit the meridian of the place of observation at the instant the argument of the component is zero, the interval between successive transits corresponding to the period of the component. We might conceive the motion of the star relative to the earth's meridian to be strictly uniform corresponding to the rate of change in the V of the argument. In this case the intervals between successive transits will be equal and will determine the length of the mean component day, just as successive transits of the mean sun determined the length of the mean solar day. It may be more convenient, however, to assume that the motion is subject to the inequalities of the u of the argument. In this case the hour angle of the fictitious star will at each instant of time correspond exactly with the argument of the diurnal component that is represented.

For the semidiurnal components the conception is a little less simple. Perhaps the best assumption is a system of two fictitious stars at 180° apart for each component, moving so that the argument of the component will always be equal to twice the hour angle of either star. Similarly, for the terdiurnal and quarter-diurnal components, systems of 3 and 4 fictitious stars moving so that the argument of the component is always three or four times, as the case may be, the hour angle of the component star. The conception of the astres fictifs is not adapted to the long-period tides, as these do not depend upon the rotation of the earth for their periods.

Under the equilibrium theory the time of a component high water will correspond to the zero value of its argument, but under actual conditions the occurrence of a component high water will, in general, be delayed by an amount which is constant for a given place. The lag, expressed in angular measure, is called the epoch of the component and is usually designated by the Greek letter κ. The epochs for any place are determined from actual observations of the tide, and if applied to the equilibrium arguments will give corrected arguments which will correspond to the true phases of the component tides at that place. The general expression for the corrected arguments is $V+u-\kappa$, which will equal zero at the time of the high water of the corresponding component.

If we adopt some initial instant from which to reckon time, such as the beginning of any series of observations or predictions, and let

t = number of time units from the initial instant,
V_0 = value of V when $t=o$,
a = rate of change in V per unit of time,

then we may write

$$(V+u-\kappa)=(at+V_0+u-\kappa) \tag{101}$$

In (101) u will be assigned a value corresponding to the middle of the series under consideration and will be assumed to hold that value as a constant for the entire series.

Table 3 contains the formulas for the arguments of the principal components and also the hourly rates of change in the argument, and Table 15 gives the values of V_0+u for the meridian of Greenwich for the beginning of each year from 1850 to 2000 as computed from the formulas.

A graphical representation of the relations between V_0+u, ζ, and κ is shown in Figure 11. The heavy horizontal line represents the time argument advancing to the right, the distance being expressed in angular measurement that increases uniformly with the advance of time. The figure takes account of a single typical short-period component with an hourly speed of a, the ratio of this speed to that

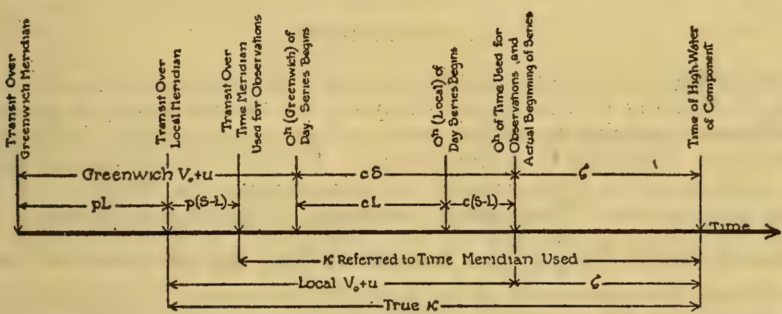


FIG. 11.

of the mean sun being represented by c. In the figure the horizontal distance that corresponds to one hour in time is equivalent to a units of the angular measurement.

The point indicated as "0^h of time used for observations" is assumed to represent the exact beginning of the series of observations analyzed; that is, the time of the first hourly height of the tabulations. The interval between the beginning of the observations and the time of the first following component high water is indicated by ζ. The interval between the next preceding transit of the astre fictif over the local meridian and the beginning of the series is designated as the local V_0+u. The true epoch or κ is the interval between the transit of the astre fictif over the local meridian and the time of the following component high water, and therefore equals the sum of the local V_0+u and the ζ.

The Greenwich V_0+u as given in Table 15 is the interval between the transit of the astre fictif over the meridian of Greenwich and the 0 hour of the following Greenwich day. The interval between the transit over the meridian of Greenwich and the transit over any other meridian is equal to the product of the subscript of the component and the difference in longitude, the subscript indicating the number of component periods in a component day. For east longitude the transit would occur earlier and for west longitude later than the transit over the meridian of Greenwich. For the long-period components an initial epoch of the V_0+u is reckoned from certain astronomical relations independent of the rotation of the earth and is consequently independent of longitude on the earth. Therefore, to adapt Figure 11 to the long-period component, the subscript p must be assumed to be zero.

The change in the V_0+u from the 0 hour of a Greenwich day to the 0 hour of the same calendar day defined by another time meridian equals the product of the speed ratio c and the difference in longitude of the time meridians.

From the figure it is evident that a correction of $(-pL+cS)$ must be applied to the Greenwich V_0+u to obtain the local V_0+u.

If the epochs or κ's are referred to some standard time meridian instead of the local meridian at the place of observations, a correction equal to the product of the component subscript and the difference between the longitude of the local and standard meridians must be applied to reduce such epochs to the local meridian, the subscript being taken as zero for all the long-period components.

11. COEFFICIENTS.

Referring to formula (100), on page 35, it will be noted that the coefficients of the terms are made up of two parts—a general coefficient applying to all the terms within a group and an individual coefficient applying to a single term. In this formula three groups of components are represented—the semidiurnal, the diurnal, and the long-period tides. The general coefficient of each group includes the common factor $3/2\,\frac{M}{E}\left(\frac{a}{c}\right)^3 a$, but differs from the others in the factor involving the latitude (λ) of the place of observation. The individual coefficients of the components of a single group are therefore directly comparable with each other and will give the relative theoretical importance of the components of that group. The relative importance of the components in different groups will depend also upon the latitude of the place of observation. For the semidiurnal components the general coefficient will have a maximum value for places on the Equator; for the diurnal tides in latitude 45° north or south; and for the long-period tides at the north and south poles. For convenience the term coefficient is frequently applied to the individual coefficient, exclusive of the general factor, and may be so used in the following discussion of mean values.

A general expression for each term in equation (100) is

$$J\cos(V+u) \tag{102}$$

in which the coefficient J is a function of I, and u is a function of ν and ξ. Since I, ν, and ξ are all functions of the longitude of the moon's node, which is usually represented by N, the values of J and u will also be functions of N. If we assume a succession of a great many short series of tidal observations to be analyzed, the mean of the resulting amplitudes for any component might be represented by the mean value of J in (102); but if a single very long continuous series is to be analyzed the resulting amplitude will be more accurately represented by the mean value of the product $J\cos u$. The difference may be explained as follows: The inequalities due to the u in the argument cause the intervals between successive maxima and minima to vary slightly in length. In the analysis of a succession of short series the amplitude obtained from each has the maximum value of the function which occurs when $(V+u)$ is 0 or a multiple of 2π; but in the analysis of a single long series covering a great many years the resulting amplitude represents the average of the values of the function when V equals 0 or a multiple of 2π. It will be readily seen that the value of (102) is J when $(V+u)=0$ or a multiple of 2π, and $J \cos u$ when $V=0$ or a multiple of 2π.

The expression "mean value of coefficient," as applied to the terms in the formula for the equilibrium height of the lunar tide, is usually taken to represent the mean value of the product $J \cos u$. With the value of u small, $\cos u$ has a value near unity and the mean value of $J \cos u$ differs but little from the mean value of J. In the practical application of the equilibrium theory to the harmonic analysis and prediction of the tides it is of no consequence whether the mean value J alone or of the product $J \cos u$ be taken as the mean coefficient, but for the sake of uniformity in representing the results the practice heretofore adopted will be followed.

With the factor $\cos u$ always near unity, the mean value of the product $J \cos u$ can be shown to be approximately equivalent to the product of the mean value of each, and is so taken in the computations that follow.

Referring to (100), the mean value of the following variables will be required:

$\cos^4 \frac{1}{2} I \cos (2\xi - 2\nu)$ for terms $(A)_1$ to $(A)_7$
$\sin^2 I \cos 2\nu$ for terms $(A)_{17}$ to $(A)_{19}$
$\sin I \cos^2 \frac{1}{2} I \cos (2\xi - \nu)$ for terms $(A)_{26}$ to $(A)_{32}$
$\sin I \sin^2 \frac{1}{2} I \cos (2\xi + \nu)$ for term $(A)_{34}$
$\sin 2 I \cos \nu$ for terms $(A)_{42}$ to $(A)_{48}$
$\sin^2 I \cos 2\xi$ for terms $(A)_{51}$ to $(A)_{55}$
$(1 - 3/2 \sin^2 I)$ for terms $(A)_{59}$ to $(A)_{63}$

The first step will be to express the functions of I, ν, and ξ in terms of N, the longitude of the moon's node. The latter changes uniformly with time, and it is in reference to time that the mean values are desired.

Referring to Figure 6, the following formulas may be readily derived from the spherical triangle ☊♈A. Noting that the side ☊♈ $= N$, the longitude of the moon's node; side ☊A = ☊♈$' - \xi$ = ☊♈ $- \xi = N - \xi$; and side ♈$A = \nu$; and that the opposite angles are $(\pi - I)$, ω, and i, respectively; we have

$$\cos I = \cos i \cos \omega - \sin i \sin \omega \cos N \tag{103}$$

$$\tan \tfrac{1}{2} [(N-\xi) + \nu] = \frac{\cos \frac{1}{2} (\omega - i)}{\cos \frac{1}{2} (\omega + i)} \tan \tfrac{1}{2} N \tag{104}$$

$$\tan \tfrac{1}{2} [(N-\xi) - \nu] = \frac{\sin \frac{1}{2} (\omega - i)}{\sin \frac{1}{2} (\omega + i)} \tan \tfrac{1}{2} N \tag{105}$$

$$\tan \nu = \frac{\sin i \sin N}{\cos i \sin \omega + \sin i \cos \omega \cos N} \tag{106}$$

$$\tan (N-\xi) = \frac{\sin N}{\cot \omega \sin i + \cos i \cos N} \tag{107}$$

Since

$$\tan (N-\xi)=\frac{\tan N-\tan \xi}{1+\tan N \tan \xi} \tag{108}$$

we have from (107) and (108)

$$\tan \xi=\frac{\sin i \cot \omega \tan N+(\cos i-1) \sin N}{\sin i \cot \omega+\cos i \cos N+\sin N \tan N}$$

$$=\frac{\sin i \cot \omega \sin N-\sin^2 \tfrac{1}{2}i \sin 2 N}{\sin i \cot \omega \cos N-2 \sin^2 \tfrac{1}{2}i \cos^2 N+1} \tag{109}$$

For the computations of tables of the values of I, ν, and ξ, with N as the argument, formulas (103), (104), and (105) will be found especially convenient. Formulas (106) and (109) provide for the direct computations of ν and ξ independent of each other. For the computations of the mean values now sought it will be found desirable to modify formulas (103), (106), and (109) and represent the values of I, ν, and ξ in approximate forms that are more easily developed. By Table 2 it will be noted that i is small, being equal to 5.145°, or 0.090 of a radian; therefore, using the radian as the unit angle, the sine of i, or of any fraction thereof, may be taken as approximately equal to the angle itself.

Then

$$\sin i=i \tag{110}$$

$$\cos i=1-2 \sin^2 \tfrac{1}{2}i=1-\tfrac{1}{2} i^2 \tag{111}$$

Substituting (110) and (111) in (103), (106), and (109), and developing to the second power of i, we may obtain the following:

$$\operatorname{Cos} I=\cos \omega-i \sin \omega \cos N-\tfrac{1}{2}i^2 \cos \omega \tag{112}$$

$$\tan \nu=\frac{i \sin N}{(1-\tfrac{1}{2}i^2) \sin \omega+i \cos \omega \cos N}$$

$$=i \operatorname{cosec} \omega \sin N-\tfrac{1}{2}i^2 \cos \omega \operatorname{cosec}^2 \omega \sin 2 N \tag{113}$$

$$\tan \xi=\frac{i \cot \omega \sin N-\tfrac{1}{4}i^2 \sin 2 N}{i \cot \omega \cos N-\tfrac{1}{2}i^2 \cos^2 N+1}$$

$$=i \cot \omega \sin N-\tfrac{1}{2}i^2 [\cot^2 \omega+\tfrac{1}{2}] \sin 2N \tag{114}$$

From (112)

$$\cos^2 I=\cos^2 \omega-i \sin 2\omega \cos N+i^2 (\sin^2 \omega \cos^2 N-\cos^2 \omega) \tag{115}$$

$$\sin I=(1-\cos^2 I)^{\frac{1}{2}}=\sin \omega+i \cos \omega \cos N+\tfrac{1}{2}i^2 \frac{\cos^2 \omega-\cos^2 N}{\sin \omega} \tag{116}$$

$\sin I \cos I$

$$=\tfrac{1}{2} \sin 2\omega+i \cos 2\omega \cos N+\tfrac{1}{2} i^2 \cot \omega [\cos 2\omega-\cos^2 N (1+2 \sin^2 \omega)] \tag{117}$$

From (113)

$$\cos \nu=\frac{1}{(1+\tan^2 \nu)^{\frac{1}{2}}}=1-\tfrac{1}{2} i^2 \operatorname{cosec}^2 \omega \sin^2 N \tag{118}$$

$$\sin \nu=\tan \nu \cos \nu=i \operatorname{cosec} \omega \sin N-\tfrac{1}{2} i^2 \cos \omega \operatorname{cosec}^2 \omega \sin 2N \tag{119}$$

$$\cos 2\nu=2 \cos^2 \nu-1=1-2i^2 \operatorname{cosec}^2 \omega \sin^2 N \tag{120}$$

$$\sin 2\nu=2 \sin \nu \cos \nu=2i \operatorname{cosec} \omega \sin N-i^2 \cos \omega \operatorname{cosec}^2 \omega \sin 2N \tag{121}$$

From (114)

$$\cos\ \xi = \frac{1}{(1+\tan^2\xi)^{\frac{1}{2}}} = 1 - \tfrac{1}{2} i^2 \cot^2\omega \sin^2 N \tag{122}$$

$$\sin\ \xi = \tan\xi \cos\xi = i \cot\omega \sin N - \tfrac{1}{2} i^2 [\cot^2\omega + \tfrac{1}{2}] \sin 2N \tag{123}$$

$$\cos 2\xi = 2\cos^2\xi - 1 = 1 - 2i^2 \cot^2\omega \sin^2 N \tag{124}$$

$$\sin 2\xi = 2\sin\xi\cos\xi = 2i\cot\omega\sin N - i^2[\cot^2\omega + \tfrac{1}{2}]\sin 2N \tag{125}$$

From (118) to (125)

$$\cos 2\xi \cos 2\nu = 1 - 2i^2[\operatorname{cosec}^2\omega + \cot^2\omega]\sin^2 N \tag{126}$$

$$\sin 2\xi \sin 2\nu = 4i^2 \operatorname{cosec}\omega \cot\omega \sin^2 N \tag{127}$$

$$\cos 2\xi \cos\ \nu = 1 - i^2[\tfrac{1}{2}\operatorname{cosec}^2\omega + 2\cot^2\omega]\sin^2 N \tag{128}$$

$$\sin 2\xi \sin\ \nu = 2i^2 \operatorname{cosec}\omega\cot\omega\sin^2 N \tag{129}$$

Since N is an angle that changes uniformly throughout the entire circumference, it may readily be shown that the mean value of sin N, cos N, sin 2 N, and cos $2N$ is zero for each, since for each positive value there will be a corresponding negative value in the same period. Indicating the mean value of a variable by the subscript o, we may now write

$$[\sin N]_o = [\cos N]_o = [\sin 2N]_o = [\cos 2N]_o = 0 \tag{130}$$

and

$$[\sin^2 N]_o = [\tfrac{1}{2} - \tfrac{1}{2}\cos 2N]_o = \tfrac{1}{2} \tag{131}$$

since the mean value of the sum of several terms equals the sum of the mean value of each term.

Substituting (130) and (131) in formulas (112), (115) to (118), (120), (124), and (126) to (129), and indicating the resulting mean values by subscript o, the following may be obtained:

$$[\cos I]_o = (1 - \tfrac{1}{2}i^2)\cos\omega \tag{132}$$

$$\begin{aligned}[\cos^2 I]_o &= \cos^2\omega + i^2(\tfrac{1}{2}\sin^2\omega - \cos^2\omega)\\ &= \cos^2\omega + i^2(\tfrac{1}{2} - \tfrac{3}{2}\cos^2\omega)\end{aligned} \tag{133}$$

$$[\sin I]_o = \sin\omega + \tfrac{1}{2}i^2\frac{\cos^2\omega - \tfrac{1}{2}}{\sin\omega} \tag{134}$$

$$\begin{aligned}[\sin I\cos I]_o &= \sin\omega\cos\omega + \tfrac{1}{2}i^2\cot\omega[\cos^2\omega - \sin^2\omega - \tfrac{1}{2} - \sin^2\omega]\\ &= \sin\omega\cos\omega + \tfrac{1}{2}i^2\cot\omega[\tfrac{1}{2} - 3\sin^2\omega]\end{aligned} \tag{135}$$

$$[\cos\nu]_o = 1 - \tfrac{1}{4}i^2\operatorname{cosec}^2\omega \tag{136}$$

$$[\cos 2\nu]_o = 1 - i^2\operatorname{cosec}^2\omega \tag{137}$$

$$[\cos 2\xi]_o = 1 - i^2\cot^2\omega \tag{138}$$

$$[\cos 2\xi\cos 2\nu]_o = 1 - i^2[\operatorname{cosec}^2\omega + \cot^2\omega] \tag{139}$$

$$[\sin 2\xi\sin 2\nu]_o = 2i^2\operatorname{cosec}\omega\cot\omega \tag{140}$$

$$[\cos 2\xi\cos\nu]_o = 1 - \tfrac{1}{4}i^2[\operatorname{cosec}^2\omega + 4\cot^2\omega] \tag{141}$$

$$[\sin 2\xi\sin\nu]_o = i^2\operatorname{cosec}\omega\cot\omega \tag{142}$$

Then, for the functions of I in the coefficients of (100), we may obtain from (132) to (135) the following:

$$[\cos^4 \tfrac{1}{2} I]_0 = \tfrac{1}{4} [1 + 2 \cos I + \cos^2 I]_0$$

$$= \tfrac{1}{4} [1 + 2 \cos \omega + \cos^2 \omega + \tfrac{1}{2} i^2 (1 - 2 \cos \omega - 3 \cos^2 \omega)]$$

$$= \tfrac{1}{4} [(1 + \cos \omega)^2 + \tfrac{1}{2} i^2 (1 + \cos \omega) (1 - 3 \cos \omega)]$$

$$= \cos^4 \tfrac{1}{2} \omega + \tfrac{1}{2} i^2 \cos^4 \tfrac{1}{2}\omega \frac{1 - 3 \cos \omega}{1 + \cos \omega}$$

$$= \cos^4 \tfrac{1}{2} \omega \left[1 + \tfrac{1}{2} i^2 \frac{1 - 3 \cos \omega}{1 + \cos \omega} \right] \tag{143}$$

$$[\sin^2 I]_0 = [1 - \cos^2 I]_0$$
$$= \sin^2 \omega - \tfrac{1}{2} i^2 (1 - 3 \cos^2 \omega)$$

$$= \sin^2 \omega \left[1 + \tfrac{1}{2} i^2 \left(\frac{2 - 3 \sin^2 \omega}{\sin^2 \omega} \right) \right] \tag{144}$$

$$[\sin I \cos^2 \tfrac{1}{2} I]_0 = \tfrac{1}{2} [\sin I + \sin I \cos I]_0$$

$$= \tfrac{1}{2} \left[\sin \omega + \sin \omega \cos \omega + \tfrac{1}{2} i^2 \frac{\cos^2 \omega - \tfrac{1}{2} + \tfrac{1}{2} \cos \omega - 3 \cos \omega \sin^2 \omega}{\sin \omega} \right]$$

$$= \tfrac{1}{2} \left[\sin \omega + \sin \omega \cos \omega - \tfrac{1}{4} i^2 \frac{1 + 5 \cos \omega - 2 \cos^2 \omega - 6 \cos^3 \omega}{\sin \omega} \right]$$

$$= \tfrac{1}{2} \left[\sin \omega + \sin \omega \cos \omega - \tfrac{1}{4} i^2 \frac{(1 + \cos \omega) (1 + 4 \cos \omega - 6 \cos^2 \omega}{\sin \omega} \right]$$

$$= \sin \omega \cos^2 \tfrac{1}{2} \omega \left[1 - \tfrac{1}{4} i^2 \frac{1 + 4 \cos \omega - 6 \cos^2 \omega}{\sin^2 \omega} \right] \tag{145}$$

$$[\sin I \sin^2 \tfrac{1}{2} I]_0 = \tfrac{1}{2} [\sin I - \sin I \cos I]_0$$

$$= \tfrac{1}{2} \left[\sin \omega - \sin \omega \cos \omega + \tfrac{1}{2} i^2 \frac{\cos^2 \omega - \tfrac{1}{2} - \tfrac{1}{2} \cos \omega + 3 \cos \omega \sin^2 \omega}{\sin \omega} \right]$$

$$= \tfrac{1}{2} \left[\sin \omega - \sin \omega \cos \omega - \tfrac{1}{4} i^2 \frac{1 - 5 \cos \omega - 2 \cos^2 \omega + 6 \cos^3 \omega}{\sin \omega} \right]$$

$$= \tfrac{1}{2} \left[\sin \omega - \sin \omega \cos \omega - \tfrac{1}{4} i^2 \frac{(1 - \cos \omega) (1 - 4 \cos \omega - 6 \cos^2 \omega)}{\sin \omega} \right]$$

$$= \sin \omega \sin^2 \tfrac{1}{2} \omega \left[1 - \tfrac{1}{4} i^2 \frac{1 - 4 \cos \omega - 6 \cos^2 \omega}{\sin^2 \omega} \right] \tag{146}$$

$$[\sin 2 I]_0 = 2 [\sin I \cos I]_0 =$$
$$= 2 \sin \omega \cos \omega + i^2 \cot \omega [\tfrac{1}{2} - 3 \sin^2 \omega]$$
$$= \sin 2\omega \left[1 + \tfrac{1}{4} i^2 \frac{1 - 6 \sin^2 \omega}{\sin^2 \omega} \right] \tag{147}$$

$$[1-3/2 \sin^2 I]_0 = 1-3/2 \text{ (144)}$$
$$= 1-3/2 \sin^2 \omega - 3/4\, i^2\, (2-3 \sin^2 \omega)$$
$$= (1-3/2 \sin^2 \omega)\,(1-3/2\, i^2) \tag{148}$$

From (136) to (142) we may obtain the following:

$$[\cos(2\xi-2\nu)]_0 = [\cos 2\xi \cos 2\nu + \sin 2\xi \sin 2\nu]_0$$
$$= 1 - i^2 [\operatorname{cosec}^2 \omega + \cot^2 \omega - 2 \operatorname{cosec} \omega \cot \omega]$$
$$= 1 - i^2 [\operatorname{cosec} \omega - \cot \omega]^2$$
$$= 1 - i^2 \left[\frac{1-\cos\omega}{\sin\omega}\right]^2 = 1 - i^2 \left[\frac{1-\cos\omega}{1+\cos\omega}\right] \tag{149}$$

$$[\cos 2\nu]_0 = 1 - i^2 \operatorname{cosec}^2 \omega = 1 - i^2 \frac{1}{\sin^2 \omega} \tag{150}$$

$$[\cos(2\xi-\nu)]_0 = [\cos 2\xi \cos \nu + \sin 2\xi \sin \nu]_0$$
$$= 1 - \tfrac{1}{4} i^2 [\operatorname{cosec}^2 \omega + 4 \cot^2 \omega - 4 \operatorname{cosec} \omega \cot \omega]$$
$$= 1 - \tfrac{1}{4} i^2 [\operatorname{cosec} \omega - 2 \cot \omega]^2 \tag{151}$$
$$= 1 - \tfrac{1}{4} i^2 \left[\frac{1-2\cos\omega}{\sin\omega}\right]^2$$

$$[\cos(2\xi+\nu)]_0 = [\cos 2\xi \cos \nu - \sin 2\xi \sin \nu]_0$$
$$= 1 - \tfrac{1}{4} i^2 [\operatorname{cosec}^2 \omega + 4 \cot^2 \omega + 4 \operatorname{cosec} \omega \cot] \tag{152}$$
$$= 1 - \tfrac{1}{4} i^2 \left[\frac{1+2\cos\omega}{\sin\omega}\right]^2$$

$$[\cos \nu]_0 = 1 - \tfrac{1}{4} i^2 \operatorname{cosec} \omega = 1 - \tfrac{1}{4} i^2 \frac{1}{\sin^2 \omega} \tag{153}$$

$$[\cos 2\xi]_0 = 1 - i^2 \cot^2 \omega = 1 - i^2 \frac{\cos^2 \omega}{\sin^2 \omega} \tag{154}$$

By taking the products indicated on page 41 the mean values for the variable factors of the coefficients of (100) may be obtained as indicated below. By substituting $\cos^4 \frac{1}{2} i$ as the equivalent of $1-\frac{1}{2} i^2$, and $1-3/2 \sin^2 i$ as the equivalent of $1-3/2\, i^2$, the results are obtained in the forms adopted by Professor Darwin. The numerical equivalents of the formulas are obtained by substituting the values of ω and i from Table 2.

For terms $(A)_1$ to $(A)_7$

$$[\cos^4 \tfrac{1}{2} I]_0 [\cos(2\xi-2\nu)]_0 = (143) \times (149) = \cos^4 \tfrac{1}{2}\omega\, [1-\tfrac{1}{2} i^2]$$
$$= \cos^4 \tfrac{1}{2}\omega \cos^4 \tfrac{1}{2} i = 0.9154 \tag{155}$$

For terms $(A)_{17}$ to $(A)_{19}$

$$[\sin^2 I]_0 [\cos 2\nu]_0 = (144) \times (150) = \sin^2 \omega\, [1-3/2\, i^2]$$
$$= \sin^2 \omega\, [1-3/2 \sin^2 i] = 0.1565 \tag{156}$$

For terms $(A)_{26}$ to $(A)_{32}$

$$[\sin I \cos^2 \tfrac{1}{2} I]_0 [\cos(2\xi-\nu)]_0 = (145) \times (151)$$
$$= \sin\omega \cos^2 \tfrac{1}{2}\omega\, [1-\tfrac{1}{2} i^2] = \sin\omega \cos^2 \tfrac{1}{2}\omega \cos^4 \tfrac{1}{2} i = 0.3800 \tag{157}$$

For terms $(A)_{34}$

$$[\sin I \sin^2 \tfrac{1}{2} I]_0 [\cos(2\xi+\nu)]_0 = (146) \times (152)$$
$$= \sin\omega \sin^2 \tfrac{1}{2}\omega\, [1-\tfrac{1}{2} i^2] = \sin\omega \sin^2 \tfrac{1}{2}\omega \cos^4 \tfrac{1}{2} i = 0.0164 \tag{158}$$

For terms $(A)_{42}$ to $(A)_{48}$

$$[\sin 2\,I]_0\,[\cos \nu]_0 = (147) \times (153) = \sin 2\,\omega\,[1 - 3/2\,i^2] = \sin 2\,\omega\,[1 - 3/2\,\sin^2 i] = 0.7214 \qquad (159)$$

For terms $(A)_{51}$ to $(A)_{55}$

$$[\sin^2 I]_0\,[\cos 2\,\xi]_0 = (144) \times (154) = \sin^2 \omega\,[1 - \tfrac{1}{2}\,i^2] = \sin^2 \omega\,\cos^4 \tfrac{1}{2}\,i = 0.1578 \qquad (160)$$

For terms $(A)_{59}$ to $(A)_{63}$

$$[1 - 3/2\,\sin^2 I]_0 = (148) = (1 - 3/2\,\sin^2 \omega)\,(1 - 3/2\,i^2) = (1 - 3/2\,\sin^2 \omega)\,(1 - 3/2\,\sin^2 i) = 0.7532 \qquad (161)$$

The mean value of the coefficient of each term of (100) may now be readily obtained by substituting for the variable factor the corresponding mean value from formulas (155) to (161). Table 3 contains a compilation of such mean values.

12. FACTORS OF REDUCTION.

For the analysis of a series of observations not exceeding 369 days, the coefficient may be considered as practically constant, with I having a value corresponding to the middle of the series, but in order that the results from several years of observations may be comparable it is necessary to take account of the changes in I and apply a factor of reduction to the amplitude as obtained from any particular series of observations. For these factors it is assumed that the variations in the actual tidal components due to the changes in the longitude of the moon's node will be proportional to the corresponding variations in the coefficients of the terms of (100).

Representing the mean value of any component amplitude by H and the amplitude for any particular time by R let

$$F = \frac{H}{R},\ \text{or}\ H = FR \qquad (162)$$

and

$$f = \frac{R}{H},\ \text{or}\ R = fH \qquad (163)$$

Then F will be the factor for reducing an amplitude for a particular series to its mean value and f the reciprocal of F, the factor for adapting a mean amplitude to a particular time.

Using the notation of the preceding section, this factor may be expressed

$$F = \frac{J_0\,[\cos u]_0}{J} \qquad (164)$$

The constant factors of the coefficients of (100) being common to both the numerator and denominator of (164) need not here be considered. Making the substitutions of the mean values represented by J_0 [cos $u]_0$ from formulas (155) to (161) the following factors of reduction for the components represented by the terms of (100) may be readily obtained.

F for terms $(A)_1$ to $(A)_7$, including components M_2, N_2, $2N$, ν_2, λ_2, and μ_2,

$$= \frac{\cos^4 \tfrac{1}{2}\omega\,\cos^4 \tfrac{1}{2}\,i}{\cos^4 \tfrac{1}{2}\,I} = \frac{0.9154}{\cos^4 \tfrac{1}{2}\,I} \qquad (165)$$

F for terms $(A)_{17}$ to $(A)_{19}$, including component lunar (K_2),

$$=\frac{\sin^2\omega\,[1-3/2\sin^2 i]}{\sin^2 I}=\frac{0.1565}{\sin^2 I} \tag{166}$$

F for terms $(A)_{26}$ to $(A)_{32}$, including components O_1, Q_1, 2Q, and ρ_1,

$$=\frac{\sin\omega\cos^2\frac{1}{2}\omega\cos^4\frac{1}{2}i}{\sin I\cos^2\frac{1}{2}I}=\frac{0.3800}{\sin I\cos^2\frac{1}{2}I} \tag{167}$$

F for term $(A)_{34}$ for component OO

$$=\frac{\sin\omega\sin^2\frac{1}{2}\omega\cos^4\frac{1}{2}i}{\sin I\sin^2\frac{1}{2}I}=\frac{0.0164}{\sin I\sin^2\frac{1}{2}I} \tag{168}$$

F for terms $(A)_{42}$ to $(A)_{45}$, including components lunar (K_1) and J_1,

$$=\frac{\sin 2\omega\,[1-3/2\sin^2 i]}{\sin 2I}=\frac{0.7214}{\sin 2I} \tag{169}$$

F for terms $(A)_{51}$ to $(A)_{55}$, including component Mf,

$$=\frac{\sin^2\omega\cos^4\frac{1}{2}i}{\sin^2 I}=\frac{0.1578}{\sin^2 I} \tag{170}$$

F for terms $(A)_{59}$ to $(A)_{63}$, including component Mm,

$$=\frac{(1-3/2\sin^2\omega)\,(1-3/2\sin^2 i)}{1-3/2\sin^2 I}=\frac{0.7532}{1-3/2\sin^2 I} \tag{171}$$

The last is also the factor of reduction for the equilibrium component MSf; but as there is also a compound component having the same argument and generally a greater amplitude, which unites with the equilibrium component, the factor of reduction is usually determined from the compound part, which will be discussed in a later section. The factor of reduction for a number of other special cases will be treated separately in the text.

The factor f may, of course, be readily obtained by taking the reciprocals of the above expressions for the factor F.

Table 12 gives the logarithm of the factor F for the principal components corresponding to every tenth of a degree of I, and Table 14 gives the natural factor f for the principal components for the middle of each year from 1850 to 1999.

13. THE L_2 TIDE.

The separation of the components from each other by the processes of the analysis depends upon the differences in the speeds of the components. If two components have speeds that are very nearly equal, the analysis of a series of observations, unless of a very long period, will not separate such components from each other but will give a single component that is a resultant of the two. Referring to equation (100), we note that the speeds of the terms $(A)_3$ and $(A)_{19}$ are very nearly equal, the difference being twice the rate of change in p, the longitude of the moon's perigee, and this changes only about 41° in an entire year.

Because of this fact it is customary to treat these two terms as a single component known as the L_2 tide and having the speed of $(A)_3$, since this has the larger theoretical amplitude.

Omitting for the present the general coefficient applying alike to both terms, we have

$$\text{term } (A)_3 = 1/4\ e \cos^4 \tfrac{1}{2} I \cos (2T+2h-s-p+2\xi-2\upsilon+\pi) \tag{172}$$

$$\text{and term } (A)_{19} = 3/8\ e \sin^2 I \cos (2T+2h-s+p-2\upsilon) \tag{173}$$

$$\text{Let } \theta = 2T+2h-s-p+2\xi-2\nu+\pi \tag{174}$$

$$\text{and } P = p-\xi \tag{175}$$

Substituting (174) and (175) in (172) and (173) and combining the latter we have

$$\begin{aligned}
&1/4\ e \cos^4 \tfrac{1}{2} I \cos \theta + 3/8\ e \sin^2 I \cos (\theta+2p-2\xi-\pi) \\
&= 1/4\ e \cos^4 \tfrac{1}{2} I\,[\cos \theta - 6 \tan^2 \tfrac{1}{2} I \cos (\theta+2P)] \\
&= 1/4\ e \cos^4 \tfrac{1}{2} I\,[\cos \theta - 6 \tan^2 \tfrac{1}{2} I \cos \theta \cos 2P + 6 \tan^2 \tfrac{1}{2} I \sin \theta \sin 2P] \\
&= 1/4\ e \cos^4 \tfrac{1}{2} I\,[(1-6 \tan^2 \tfrac{1}{2} I \cos 2P) \cos \theta + 6 \tan^2 \tfrac{1}{2} I \sin 2P \sin \theta] \\
&= 1/4\ e \cos^4 \tfrac{1}{2} I\,[1-12 \tan^2 \tfrac{1}{2} I \cos 2P + 36 \tan^4 \tfrac{1}{2} I]^{\frac{1}{2}} \\
&\qquad\qquad \times \cos\left(\theta - \tan^{-1} \frac{6 \tan^2 \tfrac{1}{2} I \sin 2P}{1-6 \tan^2 \tfrac{1}{2} I \cos 2P}\right)
\end{aligned}$$

$$= 1/4\ e\, \frac{\cos^4 \tfrac{1}{2} I}{R_a} \cos (2T+2h-s-p+\pi+2\xi-2\upsilon-R) \tag{176}$$

$$\text{in which } \frac{1}{R_a} = [1-12 \tan^2 \tfrac{1}{2} I \cos 2P + 36 \tan^4 \tfrac{1}{2} I]^{\frac{1}{2}} \tag{177}$$

and

$$R = \tan^{-1} \frac{6 \tan^2 \tfrac{1}{2} I \sin 2P}{1-6 \tan^2 \tfrac{1}{2} I \cos 2P} = \tan^{-1} \frac{\sin 2P}{1/6 \cot^2 \tfrac{1}{2} I - \cos 2P} \tag{178}$$

The values of log R_a and R corresponding to different values of I and P will be found in Tables 7 and 8, respectively.

Formula (176) represents the composite L_2 tide. The V of the argument is $2T+2h-s-p+\pi$, with a speed identical with that of (172). The inequality u of the argument is $2\xi-2\nu-R$.

For the mean value of the variable factors of the coefficient we have

$$\begin{aligned}
&\left[\frac{\cos^4 \tfrac{1}{2} I}{R_a} \cos (2\xi-2\nu-R)\right]_0 \\
&= \left[\cos^4 \tfrac{1}{2} I \left\{\frac{\cos R}{R_a} \cos (2\xi-2\nu) + \frac{\sin R}{R_a} \sin (2\xi-2\nu)\right\}\right]_0
\end{aligned} \tag{179}$$

From (177) and (178)

$$\frac{\cos R}{R_a} = 1-6 \tan^2 \tfrac{1}{2} I \cos 2P \tag{180}$$

$$\frac{\sin R}{R_a} = 6 \tan^2 \tfrac{1}{2} I \sin 2P \tag{181}$$

substituting (180) and (181) to (179).

Mean value of variable factors of coefficient

$$=[\cos^4 \tfrac{1}{2}I\,\{(1-6\tan^2 \tfrac{1}{2}I \cos 2P) \cos (2\xi-2\nu) + 6\tan^2 \tfrac{1}{2}I \sin 2P \sin (2\xi-2\nu)]_0 \tag{182}$$
$$=[\cos^4 \tfrac{1}{2}I \cos (2\xi-2\nu) - 6\sin^2 \tfrac{1}{2}I \cos^2 \tfrac{1}{2}I \cos (2P+2\xi-2\nu)]_0$$

Substituting the equivalent of P from (175), the last term of (182) becomes

$$3/2 \sin^2 I \cos (2p-2\nu) \tag{183}$$

Now p increases uniformly throughout the entire circumference, while I and ν are functions of N, the period of which is incommensurate with that of p. It is evident, therefore, that in a series of infinite length, the sum of the positive values of (183) will equal the sum of the negative values, and the mean value of the term becomes zero. The mean value of the first term is given by formula (155).

For the mean value of the variable coefficient of the composite L_2 tide, we may now write

$$\left[\frac{\cos^4 \tfrac{1}{2}I}{R_a} \cos (2\xi-2\nu-R)\right]_0 = [\cos^4 \tfrac{1}{2}I \cos (2\xi-2\nu)]_0 = \cos^4 \tfrac{1}{2}\omega \cos^4 \tfrac{1}{2}i = 0.9154 \tag{184}$$

For the factor of reduction,

$$F \text{ of } L_2 = \frac{\cos^4 \tfrac{1}{2}\omega \cos^4 \tfrac{1}{2}i}{\dfrac{\cos^4 \tfrac{1}{2}I}{R_a}} = \frac{0.9154}{\cos^4 \tfrac{1}{2}I} \times R_a \tag{185}$$

A comparison of (185) with (165) shows that

$$F \text{ of } L_2 = (F \text{ of } M_2) \times R_a \tag{186}$$

14. THE M_1 TIDE.

In equation (100) we also have the terms $(A)_{28}$ and $(A)_{44}$ with a difference in speed equal to twice the rate of change in p.

Neglecting for the present the general coefficient applying to both terms, we have

$$\text{term } (A)_{28} = 1/4\, e \sin I \cos^2 \tfrac{1}{2}I \cos (T+h-s-p+2\xi-\nu-\pi/2) \tag{187}$$

$$\text{term } (A)_{44} = 3/8\, e \sin 2I \cos (T+h-s+p-\nu-\pi/2) \tag{188}$$

A reference to (99) indicates that the coefficient of the term $(A)_{28}$ is only about one-third that of term $(A)_{44}$. The latter will therefore predominate and determine the mean period of the composite tide formed by the combination of the two, while the former will introduce certain inequalities in the resultant amplitudes and epochs.

$$\text{Let } \theta = T+h-s+p-\pi/2-\nu \tag{189}$$
$$\text{and } P = p-\xi \text{ as in (175)}$$

The sum of the terms (187) and (188) may then be written

$$1/4\ e \sin I \cos^2 \tfrac{1}{2}I \left[\cos(\theta-2P)+3\frac{\cos I}{\cos^2\frac{1}{2}I}\cos\theta\right]$$

$$=1/4\ e \sin I \cos^2 \tfrac{1}{2}I \left[\cos\theta\cos 2P+\sin\theta\sin 2P+3\frac{\cos I}{\cos^2\frac{1}{2}I}\cos\theta\right]$$

$$=1/4\ e \sin I \cos^2 \tfrac{1}{2}I \left[9\frac{\cos^2 I}{\cos^4\frac{1}{2}I}+6\frac{\cos I}{\cos^2\frac{1}{2}I}\cos 2P+1\right]^{\frac{1}{2}} \tag{190}$$

$$\times\cos\left(\theta-\tan^{-1}\frac{\sin 2P}{3\dfrac{\cos I}{\cos^2\frac{1}{2}I}+\cos 2P}\right)$$

$$=\frac{\frac{1}{2}\ e\sin I\cos^2\frac{1}{2}I}{Q_a}\cos\left(T+h-s+p-\pi/2-\nu-Q_u\right)$$

where

$$\frac{1}{Q_a}=\tfrac{1}{2}\left[9\frac{\cos^2 I}{\cos^4\frac{1}{2}I}+6\frac{\cos I}{\cos^2\frac{1}{2}I}\cos 2P+1\right]^{\frac{1}{2}} \tag{191}$$

$$=\left[5/2-\frac{9}{2}\tan^2\tfrac{1}{2}I+\frac{9}{4}\tan^4\tfrac{1}{2}I+3/2\left(1-\tan^2\tfrac{1}{2}I\right)\cos 2P\right]^{\frac{1}{2}}$$

and

$$Q_u=\tan^{-1}\frac{\sin 2P}{3\dfrac{\cos I}{\cos^2\frac{1}{2}I}+\cos 2P}=\tan^{-1}\frac{\sin 2P}{3\left(1-\tan^2\frac{1}{2}I\right)+\cos 2P} \tag{192}$$

Formula (190) represents the composite M_1 tide, the mean speed and period of which are determined by the V of the argument, which is $T+h-s+p-\pi/2$. The u, which equals $-\nu-Q_u$, may be shown to vary between the limits of approximately $\pm 70°$, and will therefore not affect the mean period as determined by the V of the argument. The period of this component is very nearly an exact multiple of the period of the principal lunar component M_2, and for this reason the summations which are necessary in the analysis for the latter may be conveniently adapted to the analysis for component M_1.

Let

$$\theta=T+h-s-\pi/2+\xi-\nu \tag{193}$$

and P as before.

The sum of terms (187) and (188) may then be written

$$1/4\ e\sin I\cos^2\tfrac{1}{2}I\left[\cos(\theta-P)+3\frac{\cos I}{\cos^2\frac{1}{2}I}\cos(\theta+P)\right]$$

$$=1/4\ e\sin I\cos^2\tfrac{1}{2}I\left[\left(1+3\frac{\cos I}{\cos^2\frac{1}{2}I}\right)\cos\theta\cos P\right.$$

$$\left.+\left(1-3\frac{\cos I}{\cos^2\frac{1}{2}I}\right)\sin\theta\sin P\right]$$

$$=1/4\, e \sin I \cos^2 \tfrac{1}{2}I \left[1+6\frac{\cos I}{\cos^2 \frac{1}{2}I}\cos 2P+9\frac{\cos^2 I}{\cos^4 \frac{1}{2}I}\right]^{\frac{1}{2}}$$

$$\times \cos\left(\theta-\tan^{-1}\frac{1-3\dfrac{\cos I}{\cos^2 \frac{1}{2}I}}{1+3\dfrac{\cos I}{\cos^2 \frac{1}{2}I}}\tan P\right)$$

$$=1/2\, e\frac{\sin I \cos^2 \frac{1}{2}I}{Q_a}\cos\,(T+h-s-{}^{\pi}/_{2}+\xi-\nu+Q) \tag{194}$$

in which Q_a = same as in (191)

and

$$Q=\tan^{-1}\frac{3\dfrac{\cos I}{\cos^2 \frac{1}{2}I}-1}{3\dfrac{\cos I}{\cos^2 \frac{1}{2}I}+1}\tan P=\tan^{-1}\frac{2-3\tan^2 \frac{1}{2}I}{4-3\tan^2 \frac{1}{2}I}\tan P \tag{195}$$

The values of log Q_a and Q corresponding to different values of P and the mean value of I will be found in Tables 9 and 10, respectively.

In formula (194) the V of the argument is taken as $T+h-s-{}^{\pi}/_{2}$ and the u as $\xi-\nu+Q$. Formulas (190) and (194) both represent the composite M_1 tide and are equal to each other, since each is the sum of the terms (187) and (188). It may also be shown from (192) and (195) that

$$Q_u+Q=P=p-\xi \tag{196}$$

and therefore

$$p-Q_u=\xi+Q \tag{197}$$

The complete argument of (190) is therefore equivalent to the argument of (194), the distinction being that the uniformly varying element p in the V of the first argument has been transferred to the u in the latter, where it is assumed to be constant in the analysis of any given series of observations. The speed of the component as determined by the remaining part of the V is then exactly one-half the speed of the component M_2 [term $(A)_1$ of (100)]; and with this assumption the summations for component M_2 will be adapted to the analysis for the component M_1. It will be noted, however, that the u in this case, unlike the u's of any of the other components discussed, has a progressive forward change that takes it entirely around the circumference (see Table 10 for values of Q). The true average speed of this component is therefore determined by the V of the argument of (190), the approximate average speed determined by the V of formula (194) being assumed when the summations for component M_2 are to be used for M_1.

In obtaining an expression for the mean value of the variable factors of the coefficient of this component the u from formula (190) must be used. For this coefficient we have

$$\left[\frac{\sin I \cos^2 \frac{1}{2}I}{Q_a}\cos\,(\nu+Q_u)\right]_0$$

$$=\left[\sin I \cos^2 \tfrac{1}{2}I\left\{\frac{\cos Q_u}{Q_a}\cos\nu-\frac{\sin Q_u}{Q_a}\sin\nu\right\}\right]_0 \tag{198}$$

From (191) and (192)

$$\frac{\cos Q_u}{Q_a}=\tfrac{1}{2}\left[3\frac{\cos I}{\cos^2\frac{1}{2}I}+\cos 2P\right] \tag{199}$$

$$\frac{\sin Q_u}{Q_a}=\tfrac{1}{2}\sin 2P \tag{200}$$

Substituting (199) and (200) in (198), the mean value of variable factors of the coefficient is as follows:

$$\left[\tfrac{1}{2}\sin I\cos^2\tfrac{1}{2}I\left\{3\frac{\cos I}{\cos^2\frac{1}{2}I}\cos\nu+\cos 2P\cos\nu-\sin 2P\sin\nu\right\}\right]_0$$
$$=[3/4\sin 2I\cos\nu+\tfrac{1}{2}\sin I\cos^2\tfrac{1}{2}I\cos(2P+\nu)]_0 \tag{201}$$

For reasons similar to those given on page 49 the mean value of the last term in the above is zero for an infinite series. The mean value of $\sin 2I\cos\nu$ is given by formula (159), which when substituted in the above gives the following:

$$\left[\frac{\sin I\cos^2\frac{1}{2}I}{Q_a}\cos(\nu+Q_u)\right]_0 \tag{202}$$
$$=3/4\sin 2\omega\,[1-3/2\sin^2 i]=0.5410$$

For the factor of reduction we have

$$F\text{ of }\mathrm{M}_1=\frac{3/4\sin 2\omega[1-3/2\sin^2 i]}{\dfrac{\sin I\cos^2\frac{1}{2}I}{Q_a}}=\frac{0.5410}{\sin I\cos^2\frac{1}{2}I}\times Q_a \tag{203}$$

The factor F for reduction of M_1, originally adopted and now in general use for analysis made in accordance with the system of Sir George H. Darwin, is as follows:

$$\frac{\sin\omega\cos^2\frac{1}{2}\omega\cos^4\frac{1}{2}i}{\sin I\cos^2\frac{1}{2}I[5/2+3/2\cos 2P]^{1/2}}=\frac{0.38005}{\sin I\cos^2\frac{1}{2}I[5/2+3/2\cos 2P]^{1/2}} \tag{204}$$

In the above the factor $\dfrac{1}{[5/2+3/2\cos 2P]^{1/2}}$ is the approximate equivalent of the factor Q_a in (203). The ratio of (203) to (204) is therefore approximately $\dfrac{0.5410}{0.38005}=1.42$ (205)

This discrepancy appears to be due principally to the accidental omission of the factor $\sqrt{2.5}$, or 1.58, from the original formula. (See Scientific Papers by Sir George H. Darwin, vol. 1, p. 39.)

The effect of this error has been that all the mean amplitudes for component M_1 obtained by the formula of Darwin are too small and should be increased by nearly 50 per cent in order to be theoretically correct.

Since the primary purpose of reducing the amplitudes to their mean values is to render the results from different series comparable with each other, this purpose has not been frustrated by the introduction of a factor error which has been applied alike to all amplitudes for this component. Neither has the use of these components in the prediction of the tides led to any error in that work, since the error in the factor for reduction to the mean value has been exactly compensated by a corresponding error in the reciprocal factor used for reducing the mean value to the amplitude for the year of prediction. Therefore no practical difficulties have resulted from this error. To change now to the corrected formula, unless the change were universally adopted, would lead to considerable confusion in the comparison of the amplitudes as determined and published by different authorities. It seems wisest, therefore, for the time being to adhere to the present practice of using formula (204) or its approximate equivalent

$$\frac{\sin \omega \cos^2 \tfrac{1}{2}\omega \cos^4 \tfrac{1}{2} i}{\sin I \cos^2 \tfrac{1}{2} I} \times Q_a = (F \text{ of } O_1) \times Q_a \qquad (206)$$

for the reduction of the component M_1.

The resulting amplitudes may at any time be readily converted into the corrected means by the application of the factor 1.42 from (205).

15. TIDES DEPENDING UPON THE FOURTH POWER OF MOON'S PARALLAX.

A reference to equations (74) and (75), pages 28–29, shows that the tide depending upon the fourth power of the moon's parallax is very small, the maximum value being only about 2 per cent of the total lunar tide. In developing the term representing this tide we need, therefore, seek only a rough approximation to its true value, neglecting the elements which are relatively small compared with the entire term. As the angle I is never very large, the sine will always be smaller than the cosine, and for our approximation the powers of sin I and sin $\tfrac{1}{2} I$ above the first may be neglected in this development.

Substituting the value of cos θ from (81) in the second term of (74) and neglecting powers of sin I and sin $\tfrac{1}{2} I$ above the first, we obtain the following:

$$\begin{aligned}
&3/2 \frac{M}{E}\frac{a^5}{d^4} [5/3 \cos^3\theta - \cos\theta] \\
&\quad = 3/2 \frac{M}{E}\frac{a^5}{d^4} [5/3\{3 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I \sin l \cos^2 (l-\chi) \\
&\qquad\qquad + \cos^3\lambda \cos^6 \tfrac{1}{2} I \cos^3 (l-\chi)\} - \sin\lambda \sin I \sin l \\
&\qquad\qquad - \cos\lambda \cos^2 \tfrac{1}{2} I \cos (l-\chi)] \\
&\quad = 3/2 \frac{M}{E}\frac{a^5}{d^4} [5 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I\{\tfrac{1}{2} \sin l - 1/4 \sin (l-2\chi) \\
&\qquad\qquad + 1/4 \sin (3l-2\chi)\} + 5/3 \cos^3\lambda \cos^6 \tfrac{1}{2} I\{3/4 \cos (l-\chi) \\
&\qquad\qquad + 1/4 \cos 3 (l-\chi)\} - \sin\lambda \sin I \sin l \\
&\qquad\qquad - \cos\lambda \cos^2 \tfrac{1}{2} I \cos (l-\chi)] \\
&\quad = 3/2 \frac{M}{E}\frac{a^5}{d^4} [5/12 \cos^3\lambda \cos^6 \tfrac{1}{2} I \cos 3 (l-\chi) \\
&\qquad\qquad + 5/4 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I \cos (3l-2\chi-\pi/_2) \\
&\qquad\qquad + 5/4 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I \cos (l-2\chi+\pi/_2) \\
&\qquad\qquad + \{5/4 \cos^3\lambda \cos^6 \tfrac{1}{2} I - \cos\lambda \cos^2 \tfrac{1}{2} I\} \cos (l-\chi) \\
&\qquad\qquad + \{5/2 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I \\
&\qquad\qquad - \sin\lambda \sin I\} \cos (l-\pi/_2)] \qquad (207)
\end{aligned}$$

Neglecting the eccentricity of the moon's orbit as being unimportant for this tide, we may take the mean distance c of the moon as the equivalent of the actual distance d, and the mean longitude σ measured from the intersection as the equivalent of the actual longitude l from the same origin. Substituting these equivalents and (98) and (99) in (207) we obtain:

$$\begin{aligned}
&3/2\,\frac{M}{E}\frac{a^5}{c^4}[5/12 \cos^3\lambda \cos^6 \tfrac{1}{2} I \cos (3T+3h-3s+3\xi-3\nu) \\
&\qquad\qquad\qquad\qquad \mathrm{M}_3\ (0.0107) \\
&+5/4 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I \cos (2T+2h-3s+3\xi-2\nu+\pi/_2) \\
&\qquad\qquad\qquad\qquad (0.0051) \\
&+5/4 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I \cos (2T+2h-s+\xi-2\nu-\pi/_2) \\
&\qquad\qquad\qquad\qquad (0.0051) \\
&+\{5/4 \cos^3\lambda \cos^6 \tfrac{1}{2} I-\cos\lambda \cos^2 \tfrac{1}{2} I\} \cos (T+h-s+\xi-\nu) \\
&\qquad\qquad\qquad\qquad [\mathrm{M}_1]\ (0.0100) \\
&+\{5/2 \sin\lambda \cos^2\lambda \sin I \cos^4 \tfrac{1}{2} I-\sin\lambda \sin I\} \cos (s-\xi-\pi/_2)] \\
&\qquad\qquad\qquad\qquad (0.0116)
\end{aligned} \tag{208}$$

The maximum theoretical value in feet of the amplitude of each term, when I has its mean value, is given after the term. For the first term the maximum amplitude will apply to the Equator, where $\cos\lambda=1$; for the second and third terms to latitude $\lambda=\cos^{-1}\sqrt{2/3}$, where $\sin\lambda \cos^2\lambda$ will have the maximum value of $2/3\sqrt{1/3}$; for the fourth term to latitude $\lambda=\cos^{-1}\dfrac{2}{\sqrt{15}\cos^2 \frac{1}{2} I}$; and for the last term to latitude 90°, where $\sin\lambda=1$.

It will be noted that the first term containing $3T$ in its argument is a terdiurnal component with a speed exactly three halves that of the semidiurnal M_2 term $(A)_1$ of (100). This component is usually designated as M_3. The fourth term is a diurnal component with a speed exactly one half that of M_2. This component might be appropriately designated as M_1 but a distinction should be made between this and the composite M_1 described in the preceding section. The M_1 depending upon the fourth power of the moon's parallax is usually ignored in the analysis, as its effects are negligible. All of the terms of (208) are so small that they are of no practical importance in the analysis and predictions of the tide. The component M_3, however, being obtained with very little additional labor when analyzing for M_2, is usually evaluated.

The mean value of the variable coefficient of M_3 is

$$[\cos^6 \tfrac{1}{2} I]_0\, [\cos (3\xi-3\nu)]_0 \tag{209}$$

Developing in a manner similar to that described in section 11, we find

$$[\cos^6 \tfrac{1}{2} I]_0=\cos^6 \tfrac{1}{2}\omega\left[1+3/2\, i^2\,\frac{1-2\cos\omega}{1+\cos\omega}\right] \tag{210}$$

$$[\cos (3\xi-3\nu)]_0=1-9/4\, i^2\,\frac{1-\cos\omega}{1+\cos\omega} \tag{211}$$

$$[\cos^6 \tfrac{1}{2}I]_0\ [\cos (3\xi-3\nu)]_0=\cos^6 \tfrac{1}{2}\omega\ [1-3/4\ i^2]=\cos^6 \tfrac{1}{2}\omega \cos^6 \tfrac{1}{2}i =0.8758 \tag{212}$$

The factor F of M_3 is therefore

$$\frac{\cos^6 \frac{1}{2}\omega \cos^6 \frac{1}{2} i}{\cos^6 \frac{1}{2} I} = \frac{0.8758}{\cos^6 \frac{1}{2} I} \qquad (213)$$

Comparing (213) with (165) we find

$$F \text{ of } M_3 = [F \text{ of } M_2]^{3/2} \qquad (214)$$

16. SOLAR TIDES.

The development of the term in (74) that represents the approximate solar tide will be similar to that for the lunar tide. By making the proper substitutions of the solar elements for the lunar elements in (100) a corresponding expression for the solar tide may be obtained.

For mass of moon (M) substitute mass of sun (S).

For mean distance of moon (c) substitute mean distance of sun (c_1).

For eccentricity of moon's orbit (e) substitute eccentricity of earth's orbit (e_1).

For inclination of moon's orbit to Equator (I) substitute obliquity of ecliptic (ω).

For mean longitude of moon (s) substitute mean longitude of sun (h).

For mean longitude of moon's perigee (p) substitute longitude of sun's perigee (p_1).

For longitude of intersection of moon's orbit with Equator, in the Equator and in the moon's orbit, ν and ξ, respectively, substitute zero, the longitude of vernal equinox.

All terms in (100) representing the evection and variational inequalities in the moon's motion may, of course, be omitted, and also because of the small eccentricity of the solar orbit all elliptical terms of the second power of e_1 and elliptical terms of the first power of e_1 when combined as a factor with a sine function of the angle ω are negligible. In terms such as $(A)_1$ and $(A)_{26}$, where the second power of e_1 is a part of a larger coefficient, the entire coefficient is retained.

With the above-named substitutions and omissions, the following formula is obtained for the equilibrium height of the solar tide:

$$y = 3/2 \frac{S}{E}\left(\frac{a}{c_1}\right)^3 a \cos^2 \lambda \times$$

$$\left.\begin{array}{lll}
(B)_1 & [(1/2 - 5/4\, e_1^2) \cos^4 1/2\, \omega \cos (2T) & S_2\ (0.3716) \\
(B)_2 & +7/4\, e_1 \cos^4 1/2\, \omega \cos (2T - h + p_1) & T_2\ (0.0218) \\
(B)_3 & +1/4\, e_1 \cos^4 1/2\, \omega \cos (2T + h - p_1 + \pi) & R_2\ (0.0031) \\
(B)_{17} & +(1/4 + 3/8\, e_1^2) \sin^2 \omega \cos (2T + 2h) & [K_2]^1\ (0.0321) \\
 & +3/2 \frac{S}{E}\left(\frac{a}{c_1}\right)^3 a \sin 2\lambda \times & \\
(B)_{26} & [(1/2 - 5/4 e_1^2) \sin \omega \cos^2 1/2\, \omega \cos (T - h + \pi/2) & P_1\ (0.1542) \\
(B)_{34} & +(1/2 - 5/4\, e_1^2) \sin \omega \sin^2 1/2\, \omega \cos (T + 3h - \pi/2) & (0.0066) \\
(B)_{42} & +(1/4 + 3/8\, e_1^2) \sin 2\,\omega \cos (T + h - \pi/2) & [K_1]^1\ (0.1478) \\
 & +3/2 \frac{S}{E}\left(\frac{a}{c_1}\right)^3 a\ (1/2 - 3/2 \sin^2 \lambda) \times \quad = 0 \text{ at } 35^\circ & \\
(B)_{51} & [(1/2 - 5/4\, e_1^2) \sin^2 \omega \cos (2h) & Ssa\ (0.0640) \\
(B)_{59} & +(1/3 + 1/2\, e_1^2)\ (1 - 3/2 \sin^2 \omega) & (0.2057) \\
(B)_{60} & +e_1\ (1 - 3/2 \sin^2 \omega) \cos (h - p_1)] & (0.0103)
\end{array}\right\} (215)$$

The subscript of the notation at the left of each term refers to the corresponding term in the development of the lunar tide. The notation at the right gives the usual designation of the component represented, the brackets indicating that the term only partially represents that component. The numerical value at the right of each term gives its maximum value in the foot unit. Term $(B)_{34}$, although having a larger theoretical value than some of the lunar terms which were retained in (100), is usually neglected in the solar tide. Term $(B)_{59}$ is a constant and therefore does not affect the rising and falling of the tide but does cause a permanent deformation of the earth's surface. Term $(B)_{60}$ has a period of an anomalistic year which differs very little from a tropical year, the latter being the period of the meteorological component Sa, to which later reference will be made.

The coefficients and arguments of the terms of (215) are free from the quantities depending upon the longitude of the moon's node. The u's of the arguments of the solar tides may therefore be considered as zero, and as all the coefficients are constant the factor F of reduction will be unity for each.

It will be noted that the general coefficient of each group of terms of (215) differs from the corresponding general coefficients of (100) by the factor $\frac{S}{M}\left(\frac{c}{c_1}\right)^3$. In order that the coefficients of the individual terms of the solar and lunar tides may be more conveniently compared with each other, this factor $\frac{S}{M}\left(\frac{c}{c_1}\right)^3$ is usually transferred from the general coefficient of the solar tide to each of the individual terms, thus leaving the general coefficients the same for both formulas. For brevity this factor is represented by G in Table 3.

17. LUNISOLAR K_1 AND K_2 TIDES.

Comparing (100) and (215), we find that the terms $(A)_{17}$ and $(A)_{42}$ have the same speeds as $(B)_{17}$ and $(B)_{42}$, respectively, the small inequalities represented by 2ν and ν not affecting the mean speeds of the terms in which they occur. In the analysis and predictions of the tides the components of equal speeds are combined into single components, known as the lunisolar tides, and designated as K_1 for the diurnal component and K_2 for the semidiurnal component.

For brevity in the following discussion let

$$C=3/2\,\frac{M}{E}\left(\frac{a}{c}\right)^3 a \qquad (216)$$

$$C_1=C\sin 2\lambda \qquad (217)$$

$$C_2=C\cos^2\lambda \qquad (218)$$

$$G=\frac{S}{M}\left(\frac{c}{c_1}\right)^3 \qquad (219)$$

$$A=(1/4+3/8\,e^2) \qquad (220)$$

$$A_1=A\sin 2I \qquad (221)$$

$$A_2=A\sin^2 I \qquad (222)$$

$$B=(1/4+3/8\,e_1^2)\,G \qquad (223)$$

$$B_1=\mathrm{B}\sin 2\omega \qquad (224)$$

$$B_2=B\sin^2\omega \qquad (225)$$

The lunar K_1 term $(A)_{42}$ of (100) may then be written

$$C_1 A_1 \cos(T+h-\nu-\pi/2) \tag{226}$$

and the solar K_1 term $(B)_{42}$ of (215)

$$C_1 B_1 \cos(T+h-\pi/2) \tag{227}$$

Taking the sum of (226) and (227) we have

$$\begin{aligned}
\text{Lunisolar } K_1 &= C_1[A_1 \cos(T+h-\nu-\pi/2)+B_1 \cos(T+h-\pi/2)] \\
&= C_1 [A_1 \cos \nu \cos(T+h-\pi/2)+A_1 \sin \nu \sin(T+h-\pi/2) \\
&\quad +B_1 \cos(T+h-\pi/2)] \\
&= C_1 [(A_1 \cos \nu+B_1) \cos(T+h-\pi/2) \\
&\quad +A_1 \sin \nu \sin(T+h-\pi/2)] \\
&= C_1 (A_1^2+B_1^2+2A_1B_1 \cos \nu)^{\frac{1}{2}} \cos(T+h-\pi/2-\nu') \\
&= C \sin 2\lambda\ [A^2 \sin^2 2I+B^2 \sin^2 2\omega \\
&\quad +2AB \sin 2I \sin 2\omega \cos \nu]^{\frac{1}{2}} \cos(T+h-\pi/2-\nu')
\end{aligned} \tag{228}$$

in which

$$\begin{aligned}
\nu' &= \tan^{-1} \frac{A_1 \sin \nu}{A_1 \cos \nu+B_1} \\
&= \tan^{-1} \frac{\sin \nu}{\cos \nu+\dfrac{2+3e_1^2}{2+3e^2}\,\dfrac{G \sin 2\omega}{\sin 2I}} \\
&= \tan^{-1} \frac{\sin \nu \sin 2I}{\cos \nu \sin 2I+0.3357}
\end{aligned} \tag{229}$$

the values for the constants in (229) being obtained from Table 2.

Similarly, for the semidurnal component from A_{17} of (100) and B_{17} of (215), using the abbreviations of (216) to (225), we have

$$\begin{aligned}
\text{Lunisolar } K_2 &= C_2 (A_2^2+B_2^2+2A_2B_2 \cos 2\nu)^{\frac{1}{2}} \cos(2T+2h-2\nu'') \\
&= C \cos^2 \lambda\ [A^2 \sin^4 I+B^2 \sin^4 \omega \\
&\quad +2AB \sin^2 I \sin^2 \omega \cos 2\nu]^{\frac{1}{2}} \cos(2T+2h-2\nu'')
\end{aligned} \tag{230}$$

in which

$$\begin{aligned}
2\nu'' &= \tan^{-1} \frac{A_2 \sin 2\nu}{A_2 \cos 2\nu+B_2} \\
&= \tan^{-1} \frac{\sin 2\nu}{\cos 2\nu+\dfrac{2+3e_1^2}{2+3e_2}\,\dfrac{G \sin^2 \omega}{\sin^2 I}} \\
&= \tan^{-1} \frac{\sin 2\nu \sin^2 I}{\cos 2\nu \sin^2 I+0.0728}
\end{aligned} \tag{231}$$

Values of ν' and $2\nu''$ for each degree of N are given in Table 6.

For the mean value of the variable part the coefficient of (228) we have

$$[(A_1^2+B_1^2+2A_1B_1 \cos \nu)^{\frac{1}{2}} \cos \nu']_0 \tag{232}$$

From (229)

$$\cos \nu' = \frac{A_1 \cos \nu + B_1}{(A_1^2+B_1^2+2A_1B_1 \cos \nu)^{\frac{1}{2}}} \tag{233}$$

Therefore

$$[(A_1^2+B_1^2+2A_1B_1 \cos \nu)^{\frac{1}{2}} \cos \nu']_0$$

$$=[A_1 \cos \nu + B_1]_0$$

$$=[A \sin 2I \cos \nu + B \sin 2\omega]_0 \tag{234}$$

Substituting (159) in (234),
mean value of variable part of coefficient of K_1

$$=A \sin 2\omega\ [1-3/2 \sin^2 i]+B \sin 2\omega = 0.2655 \tag{235}$$

Referring to (228) and (235),

$$F \text{ of } K_1 = \frac{A \sin 2\omega\ [1-3/2 \sin^2 i]+B \sin 2\omega}{[A^2 \sin^2 2I + B^2 \sin^2 2\omega + 2AB \sin 2I \sin 2\omega \cos \nu]^{\frac{1}{2}}} \tag{236}$$

From the spherical triangle ☊♈A in Figure 6 it may be shown that

$$\cos \nu = \frac{\cos i - \cos \omega \cos I}{\sin \omega \sin I} \tag{237}$$

From which it follows that

$$\cos 2\nu = \frac{2\ (\cos i - \cos \omega \cos I)^2 - \sin^2 \omega \sin^2 I}{\sin^2 \omega \sin^2 I} \tag{238}$$

Substituting (237) and the numerical values of the constants from Table 2 in (236) we obtain

$$F \text{ of } K_1 = [0.1009+3.0073 \cos I + 0.8093 \cos^2 I - 3.5793 \cos^4 I]^{-\frac{1}{2}} \tag{239}$$

For the mean value of the variable part of the coefficient of (230), referring to (231) and (156), we have

$$[(A_2^2+B_2^2+2A_2\ B_2 \cos 2\upsilon)^{\frac{1}{2}} \cos 2\upsilon'']_0$$
$$=[A_2 \cos^2 \upsilon + B_2]_0$$
$$=[A \sin^2 I \cos 2\upsilon + B \sin^2 \omega]_0$$
$$= A \sin^2 \omega\ (1-3/2 \sin^2 i) + B \sin^2 \omega = 0.0576 \tag{240}$$

Referring to (230), (239), and (240), and to Table 2,

$$F \text{ of } K_2 = \frac{A \sin^2 \omega\ (1-3/2 \sin^2 i)+B \sin^2 \omega}{[A^2 \sin^4 I + B^2 \sin^4 \omega + 2\ AB \sin^2 I \sin^2 \omega \cos^2 \upsilon]^{\frac{1}{2}}}$$

$$=[51.0453-63.9167 \cos I - 5.8300 \cos^2 I + 19.0186 \cos^4 I]^{-\frac{1}{2}} \tag{241}$$

18. OVERTIDES.

In the development of the equilibrium theory the absence of friction and sufficiency of depth were assumed. Under these conditions each term of the result represented a simple harmonic wave. When a wave runs into shallow water, the trough is retarded more than its crest, so that the duration of rise of the tide becomes somewhat less than the duration of fall and the wave loses its simple harmonic form. We may, however, represent this modified form of the wave by the introduction of a series of components whose speeds are simple multiples of the speed of the fundamental astronomical tides. These are called overtides because of their analogy to overtones in musical sounds. The only overtides usually considered in the analysis are those for the principal lunar and solar components M_2 and S_2 [Terms $(A)_1$ and $(B)_1$ of formulas (100) and (215), and are designated by M_4, M_6, M_8, and S_4 and S_6, the subscript indicating the number of periods in a component day.

The arguments of the overtides are taken as exact multiples of the argument of the fundamental tide. There is no theoretical expression for the coefficients of these tides, but it is probable that the amplitudes as determined from observations will be subject to variations due to changes in the longitude of the moon's node analogous to the variations in the fundamental tide. It is assumed that the variability of the overtides may be represented by the square, cube, fourth power, etc., of the fundamental tides, and the factors of reduction are taken accordingly.

Thus,

$$F \text{ of } M_4 = (F \text{ of } M_2)^2 \tag{242}$$

$$F \text{ of } M_6 = (F \text{ of } M_2)^3 \tag{243}$$

$$F \text{ of } M_8 = (F \text{ of } M_2)^4 \tag{244}$$

The F of S_4 and F of S_6 are taken as unity.

19. COMPOUND TIDES.

Compound tides are components whose speeds are the sums or differences of the speeds of the elementary components. They were suggested by Helmholtz's theory of sound waves, and, like the overtides, are due to shallow water.

The arguments of the compound tides are taken as the sums and differences of the elementary tides.

Thus,

$$\text{Arg. } (MS)_4 = \text{Arg. } M_2 + \text{Arg. } S_2 \tag{245}$$

$$\text{Arg. } (MN)_4 = \text{Arg. } M_2 + \text{Arg. } N_2 \tag{246}$$

$$\text{Arg. } (MK)_3 = \text{Arg. } M_2 + \text{Arg. } K_1 \tag{247}$$

$$\text{Arg. } (2MK)_3 = \text{Arg. } M_4 - \text{Arg. } K_1 \tag{248}$$

$$\text{Arg. } (2SM)_2 = \text{Arg. } S_4 - \text{Arg. } M_2 \tag{249}$$

Also,

$$\text{Arg. } (2MS)_2 = \text{Arg. } M_4 - \text{Arg. } S_2 = \text{Equilibrium Arg. } \mu_2 + (2\xi - 2\nu) \tag{250}$$

$$\text{Arg. MSf} = \text{Arg. } S_2 - \text{Arg. } M_2 = \text{Equilibrium Arg. MSf} - (2\xi - 2\nu) \tag{251}$$

The mean period of the compound tide 2MS is identical with that of the equilibrium tide μ_2 of (100) and the mean period of the compound tide MSf is the same as that of the equilibrium tide MSf of (100). The arguments, however, differ by small quantities which are functions of the longitude of the moon's node and do not affect the mean periods. In the analysis the compound and equilibrium tides of equal period can not be separated from each other, and there is no known theoretical relation in their magnitudes. For convenience in reduction such tides are considered as arising from a single source. Following the past practice of the Coast and Geodetic Survey, the component μ_2 or 2MS will be treated as though it were entirely the variational equilibrium tide represented by the term $(A)_7$ of (100) and the component MSf will be considered only as a compound tide. According to the system of Sir George H. Darwin, both of these components appear to be considered as compound tides. The differences resulting from the two methods of treatment are negligible compared with the probable errors in the final results.

For the factor F for the reduction of the compound tides the products of the corresponding factors for the elementary tides are taken.

Thus,

$$F \text{ of } (\mathrm{MS})_4 = F \text{ of } \mathrm{M}_2 \tag{252}$$

$$F \text{ of } (\mathrm{MN})_4 = (F \text{ of } \mathrm{M}_2) \times (F \text{ of } \mathrm{N}_2) = (F \text{ of } \mathrm{M}_2)^2 \tag{253}$$

$$F \text{ of } (\mathrm{MK})_3 = (F \text{ of } \mathrm{M}_2) \times (F \text{ of } \mathrm{K}_1) \tag{254}$$

$$F \text{ of } (2\mathrm{MK})_3 = (F \text{ of } \mathrm{M}_4) \times (F \text{ of } \mathrm{K}_1) \tag{255}$$

$$F \text{ of } (2\mathrm{SM})_2 = F \text{ of } \mathrm{M}_2 \tag{256}$$

$$F \text{ of } \mathrm{MSf} = F \text{ of } \mathrm{M}_2 \tag{257}$$

The component μ_2 or 2MS being treated as an equilibrium tide, the factor F of this component is given by formula (165).

20. METEOROLOGICAL TIDES.

Meteorological conditions have a considerable influence upon the tides, but, in general, the effects are very irregular and do not admit of being represented by harmonic terms. There are, however, some conditions that occur with a rough periodicity which may be so represented. The land and sea breezes and the daily variation in the atmospheric pressure may give rise to a tide whose period is a solar day and the changes in the seasons to a tide with a period of a tropical year. The former is designated as the S_1 component and has a speed just one-half that of the principal solar components S_2 $[(B)_1$ of (215)]. The latter is the Sa component, and, although it may be accompanied by a number of overtides, the only one generally sought in the analysis is the semiannual component Ssa, which is also a component of the equilibrium tide $[(B)_{51}$ of (215)]. Although the determination of meteorological tides from long series of observations is valuable for some purposes, their recurrence is not generally certain enough to make them of much value in the tidal predictions.

The argument of component S_1 is taken as one-half that of the component S_2, and the argument of component Sa is one-half that of the component Ssa. The factor F for the reduction of each of the meteorological components is taken as unity, since the magnitudes of these components appear to be unaffected by changes in the longitude of the moon's node.

ANALYSIS AND PREDICTION.

21. HARMONIC CONSTANTS.

In the preceding chapter there were found from a consideration of the tidal forces the principal components that may be expected to exist in the tide. Each component is represented by the product of a coefficient, which may include a variable function of I, depending upon the longitude of the moon's node and the cosine of an argument which defines the component and determines its period. The period, being independent of conditions upon the earth's surface, is the same for every locality and gives to each component its identity.

The coefficients and phases of the components of the true tide do not, however, agree with the corresponding coefficients and phases of the equilibrium tide, but vary in different localities. It is therefore necessary, in order to represent the true tide at any place, to substitute for the coefficients of the equilibrium tide the amplitudes of the true components determined from actual observations, and also to find corrections for the phases of the equilibrium components which will make them conform to the true phases. These phase corrections are called the epochs of the components and are constants for any locality.

The amplitudes (H) and the epochs (κ) comprise the harmonic constants which are to be determined by the harmonic analysis of the tidal observations taken at the place for which the results are sought. The principal use of these constants is in the prediction of the tides.

22. OBSERVATIONS.

The most satisfactory observational data for the harmonic analysis are from the record of an automatic tide gauge, which traces a continuous curve from which the height of the tide above any adopted datum plane may be readily obtained for any hour. This record is usually tabulated to give the height of the tide at each solar hour of the series, the kind of time used being that which is customarily used at the place. Where an automatic tide gauge is not available, hourly heights as observed directly upon a plain tide staff may be used for the analysis. The record should be complete with each hour of the series represented. If a part of the record has been lost, the hiatus may be filled by interpolated values; or if the gap is very extensive, the record may be broken up into shorter series which do not include the defective portion.

If the hourly heights have not been observed, but a record of the high and low waters is available, an approximate determination of the larger components may be obtained by a special treatment. The results, however, are not nearly as satisfactory as those obtained from the hourly heights.

An interval greater or less than the solar hour might be used for the record of tabulated heights. A shorter interval would cause a considerable increase in the work of the reduction without materially increasing the accuracy of the results for the components usually sought. However, if an attempt were made to analyze the short period seiches, a closer interval would be necessary. An interval greater than one hour would lessen the work of the analysis but would not be sufficient for the satisfactory development of the overtides. The hour interval appears to be the most convenient and practicable for the usual analysis.

The summations are most effective in separating a disturbing component from the component sought when the length of the series of observations is an exact multiple of the synodic period of those components. The synodic period of two components is the time required for the difference in their phases to complete a cycle of 360°. If the speeds of two components in degrees per solar hour be represented by a and b the synodic period will be $360°/(a \sim b)$ hours. If there were only two components in the tide, the best length of series would be easily fixed; but in the actual tide there are many components and a length of series most effective in the elimination of one disturbing component may not be best adapted to the elimination of another. It is therefore necessary to adopt a length that is a compromise of the synodic periods involved, weight being given according to the theoretical relative magnitudes of the components.

Fortunately, the exact length of series to be used is not of essential importance, and for convenience all series may be taken to include an integral number of solar days. Theoretically, different lengths should be used for the different components sought, but practically it is more convenient to use the same length for all of the components. An exception to this is found desirable for the very short series which is taken as 14 days for components chiefly diurnal and 15 days for components chiefly semidiurnal. The longer the series the less important is the exact length, and the greater the number of synodic periods of two components included the more nearly complete will be the separation of those two components from each other. Two components like S_2 and K_2, which have a very small difference in speed and a synodic period of about six months, can not be satisfactorily separated by the summation of a series of less than six months. On the other hand, two components with a large difference in speeds like a diurnal and a semidiurnal component may have a synodic period that will not greatly exceed a day, and a moderately short series of observations will include a relatively large number of synodic periods. For this reason, in selecting the length of series, no special consideration need be given to the effect of a diurnal and a semidiurnal component upon each other. The length of series adopted for the harmonic analysis of the tides in the office of the U. S. Coast and Geodetic Survey are as follows: 14–15, 29, 58, 87, 105, 134, 163, 192, 221, 250, 279, 297, 326, 355, and 369 days.

For the 14–15-day series—14 for diurnal and 15 for semidiurnal components—the length conforms to the synodic periods of the principal diurnal components K_1 and O_1, and the principal semidiurnal components M_2 and S_2, and also to the synodic periods involving a few of the less important components. This is the shortest series for which the harmonic analysis is made. It can not be considered as a very satisfactory length but will serve for obtaining the approximate constants for the principal components at a place where a longer series of observations is not available.

The 29-day series conforms approximately in length to the multiples of the synodic periods of nearly all the principal components. This may be considered as a standard length for short series, and whenever it is necessary to limit the observations to a short period of time, the minimum requirement should be 29 days.

The 369-day series may be considered as the standard long series, and whenever there are sufficient observations available it should be used for the analysis. This length conforms very closely with the multiples of the synodic periods of practically all of the short-period components. The length is also well adapted for the elimination of the irregular meteorological effects. If tidal observations have been continued at a place for a number of years, it is desirable to have an independent analysis for each year in order that the results from the different years may be compared, and thus serve as a check on the work. Although not essential, there are certain conveniences in having such series commence on January 1 of each year. If observations for several successive years are analyzed, each may be made to begin on the first day of the calendar year without regard to the fact that the last few days of a 369-day series will thus extend into the following year and become the first days of the next series.

If the observations are for a period of less than 369 days, the standard length selected will usually be the greatest one that is entirely covered by the observations, extra days of the observations being rejected; but if the period of observations lacks only a few hours of being equal to the next larger standard length, it may be advantageous to extrapolate additional hourly heights in order to complete the larger series.

23. SUMMATIONS.

The first approximate separation of the components of the observed tide is accomplished by a system of summations. For each component of independent speed that is sought a separate summation is required, but the overtides will be combined with their fundamental components, and these will not require a separate summation. A single summation will serve for any group of components with commensurate periods.

Let us assume that the entire series of observations is divided into periods, each equal to the mean period of the component sought, which, for convenience, may be designated as component A. Each such division will include exactly one complete period of this component, but all the other components with incommensurate periods will be represented in each division by more or less than a whole period. Each division will include also certain irregularities due to meteorological conditions. Starting with the same phase at the beginning of each division, component A will be exactly reproduced in each successive division throughout the entire series, but the other components and the meteorological irregularities will occur differently in each division.

Now, suppose that each of these divisions which corresponds to the period of component A be subdivided into any number of convenient parts, and that the initial instants of the subdivisions of each original division be numbered consecutively, beginning with zero at the initial instant of each original division. Because of the exact reproduction of the period of component A in each division, it is evident that the instants with like numbers in the different divisions will correspond to the same phase of component A but to unlike phases of each of the other components. At each such instant the height of the observed tide will equal the height of component A for the phase corresponding to that instant, plus the heights of all of the other components, together with any variations due to meteorological causes.

Assuming, for convenience, mean sea level as a datum and adding the heights of the tide corresponding to the instants of like numbers in each division it is evident that there will be included in the sum a certain number of equal heights corresponding to a particular phase of component A, together with the unequal heights corresponding to various phases of the other components and also the meteorological fluctuations. In a series of sufficient length the sum of the unequal heights of each of the disturbing components and of the meteorological fluctuations will become zero, since the positive heights will be offset by the negative heights, while the equal heights corresponding to the particular phase of component A will accumulate as the summing proceeds. The average height of the tide obtained from such a sum when a limited series of observations has been used will be equal to the height of component A corresponding to a particular phase, plus a small residual due to the imperfect elimination of the disturbing components and meteorological effects. If the average height corresponding to each subdividing instant of the division is obtained and plotted as an ordinate with the time subdivisions as abscissæ, a curve may be drawn which will approximately represent the component A throughout its entire period. If the heights of the original tabulation are referred to any arbitrary datum having a definite relation to mean sea level, the summation will be equally effective in eliminating the disturbing elements, and the resulting heights for component A will be referred to that datum.

If, instead of making each division of the series equal to a single period of the component sought, we let it include any exact integral number of periods, the same principles will apply for the elimination of the other components. In this case the resulting average heights when plotted will represent the corresponding number of periods of the component sought. As a matter of convenience in the harmonic analysis of the short period components it is customary to include in each division such multiples of the component period as will most nearly conform to the solar day. Such a division is a component day. If the component is diurnal, its component day will include exactly one period; if semidiurnal, exactly two periods; if terdiurnal, exactly three periods, etc. Each component day is subdivided into 24 equal parts, each part being designated as a component hour. The initial instants of the component hours of each component day are numbered consecutively from 0 to 23. For the long-period components the original divisions are taken as the component month or the component year, and these are subdivided into 24 equal parts. As the long-period components require a different treatment than the short-period components, they will be given special consideration in a later section.

If the summations for the short-period components were made strictly in accord with the principles outlined above, it would be necessary to have a separate tabulation for each component sought, in which the heights would strictly apply to the beginning of each component hour. The labor involved in such separate tabulations would be too great to be considered. Instead of making independent tabulations for each component a single tabulation with the heights of the tide taken to correspond to each solar hour of the series is used. These solar hourly heights are then assigned to the component hours with which they most nearly coincide and the summations made as though the heights applied exactly to those component hours. Corrections are later applied to take account of any systematic error in this approximation.

Two systems of distribution of the solar hourly heights differing only slightly in detail will be considered: In the system ordinarily adopted each solar hourly height is assigned to the nearest component hour. In the second system there is selected for each component hour the nearest solar hourly height. By the first system each solar hourly height is used once, and once only, in the summation for each component, but each component hour may not be equally represented by the solar hourly heights. If the component day is shorter than the solar day, some of the individual component hours will be unrepresented; but if the component day is the longer, some of the individual component hours may have two solar hourly heights assigned to them. By the second system the component hours are equally represented, but it will be necessary to reject some solar hourly heights or to use some of them twice in order to accomplish this purpose. The difference in the final results obtained by using the two systems will be practically negligible, and as the first system affords a quicker method of checking the summations it is the one generally adopted.

The distribution of the solar hourly heights was at first accomplished by making separate copies of the heights for each component, using tables that had been prepared to show the assignment of each hour. The making of these separate copies involves much labor which has since been eliminated by various devices. The U. S. Coast and Geodetic Survey has adopted a system of stencils devised by L. P. Shidy, which will be described in the next section.

The British have been using a set of movable strips devised by Sir George Darwin. These are made of xylonite, an artificial ivory, and each strip is 9 inches long and one-fifth of an inch wide and is divided by black lines into 24 equal spaces to provide for the 24 hourly heights of the day. The set used by Darwin consists of 74 strips on which are to be written the hourly heights for 74 consecutive days. By the aid of printed forms these strips are arranged so that the heights corresponding to any particular component hour which are to be summed together will be found in a vertical column. By rearranging the strips summations can be made successively for the different components. After the summation of the first 74 days of the series for all of the components has been completed the strips are cleaned off with a damp cloth and entries made for the next 74 days of the series, and these are then summed for all the components. These operations are repeated until the entire series has been summed. A more detailed description of this apparatus will be found in Scientific Papers by Sir George Darwin, volume 1, pages 216 to 220.

Another device to accomplish the distribution of the hourly heights is a set of tracing-paper sheets designed by Doctor Borgen, of Germany. These sheets are prepared with lines so arranged that when the sheets are laid on the hourly heights that have been copied in a standard form the heights which are to be grouped under any particular component hour will appear between a pair of lines. A separate set of sheets is necessary for each component. In principle and in use these sheets are essentially the same as the stencils of the Coast and Geodetic Survey.

24. STENCILS.

A system of stencils was devised and prepared by L. P. Shidy, of the U. S. Coast and Geodetic Survey, early in the year 1885, for the purpose of effecting the distribution of tabulated solar hourly heights according to the component hours to be represented by the sums.[3] Since that time these stencils have resulted in a very great saving of labor.

For the use of the stencils it is necessary that a standard form be used for the original tabulations of the observed hourly heights (fig. 22). The standard form adopted by the Coast and Geodetic Survey is a sheet 8 by 10½ inches, with spaces arranged for the tabulation of the 24 hourly heights of each day in a vertical column, with 7 days of record on each page. The hours of the day are numbered consecutively from 0^h at midnight to 23^h at 11 p. m. Each day is indicated by its calendar date and also by a serial number commencing with 1 as the first day of series. The stencils (fig. 23) are prepared from the same standard forms, with days numbered serially to correspond to the serial numbers of the tabulations. They are thus applicable to any series of observations without regard to the calendar dates. A separate set of stencils is required for each component for which sums are to be obtained. For convenience in construction each set of stencils is prepared with two stencil sheets for each page of tabulated heights, one sheet taking account of the odd component hours and the other sheet of the even component hours. To provide for the summation of series up to 369 days in length, each set consists of 106 stencils for use on 53 pages of tabulations. When a shorter series is summed, only a portion of the stencils need be used.

The openings in the stencils are numbered according to the component hours that correspond most closely with the times of the height values that show through the openings when the stencil is applied to the sheet of tabulations. Openings applying to the same component hour are connected by ruled lines which clearly indicate to the eye the heights which are to be summed together.

These stencils are adapted to tabulations made in any kind of time, either local or standard, civil or astronomical, provided the time is uniform throughout the series of observations. In the tidal analysis made by the British authorities the records have generally been referred to astronomical time with the day beginning at noon; but for convenience the tabulations made by the Coast and Geodetic Survey generally conform to the mean civil time ordinarily used at the place of observations. The series to be reduced must, however, commence with the zero hour of the day. If the actual series of observations commences at any other time of day, the heights for

[3] Report of U. S. Coast and Geodetic Survey, 1893, Vol. I, p. 108.

that day may be rejected and the following day adopted as the first day of series, or the heights for the earlier hours on the original first day may be estimated. The zero solar hour of the first day of the series is also adopted as the zero component hour of the first component day for each component. Successive solar hours will fall either earlier or later than the corresponding component hours according to whether the component day is longer or shorter than the solar day.

For the construction of the stencils it is necessary to calculate the component hour that most nearly coincides with each solar hour of the series.

Let a = speed or rate of change in argument of component sought in degrees per solar hour.

p = number of component periods in component day; 1 for diurnal tides, 2 for semidiurnal tides, etc.

sh = number of solar hour reckoned from 0 at beginning of each solar day.

shs = number of solar hour reckoned from 0 at beginning of series.

dos = day of series counting from 1 as the first day.

ch = number of component hour reckoned from 0 at beginning of each component day.

chs = number of component hour reckoned from 0 at beginning of series.

Then

$$1 \text{ component period} = \frac{360}{a} \text{ solar hours.} \tag{258}$$

$$1 \text{ component day} = \frac{360p}{a} \text{ solar hours.} \tag{259}$$

$$1 \text{ component hour} = \frac{15p}{a} \text{ solar hours.} \tag{260}$$

$$1 \text{ solar hour} = \frac{a}{15p} \text{ component hours.} \tag{261}$$

Therefore,

$$(chs) = \frac{a}{15p}(shs) = \frac{a}{15p}[24\{(dos)-1\}+(sh)] \tag{262}$$

The above formula gives the component hour of the series (chs) corresponding to any solar hour of the series (shs). The observed heights of the tide being tabulated for the exact solar hours of the day, the (shs) with which we are concerned will represent successive integers counting from 0 at the beginning of the series. The (chs) as derived from the formula will generally be a mixed number. As it is desired to obtain the integral component hour corresponding most nearly with each solar hour, the (chs) should be taken to the nearest integer by rejecting a fraction less than 0.5, or counting as an extra hour a fraction greater than 0.5, or adopting the usual rule for computations if the fraction is exactly 0.5. The component hour of the component day (ch) required for the construction of the stencils may be obtained by rejecting multiples of 24 from the (chs).

In the application of the above formula it will be found that the integral component hour will differ from the corresponding solar hour by a constant for a succession of solar hours, and then, with the difference changed by one, it will continue as a constant for another group of solar hours, etc. This fact is an aid in the preparation of a table of component hours corresponding to the solar hours of the series, as it renders it unnecessary to make an independent calculation for each hour. Instead of using the above formula for each value the times when the difference between the solar and component hours changes may be determined. The application of the differences to the solar hours will then give the desired component hours.

Formula (262) is true for any value of (shs), whether integral or fractional. It represents the component time of any instant in the series of observations in terms of the solar time of that same instant, both kinds of time being reckoned from the beginning of the series as the zero hour. The difference between the component and the solar time of any instant may therefore be expressed by the following formula:

$$\text{Difference} = \frac{a}{15p}(shs) \sim (shs) = \frac{a \sim 15p}{15p}\,(shs) \tag{263}$$

If the component day is shorter than the solar day, the speed a will be greater than $15p$, and the component hour as reckoned from the beginning of the series will be greater than the solar hour of the same instant. If the component day is longer than the solar day the component hour at any instant will be less than the solar hour of the same instant. At the beginning of the series the difference between the component and solar time will be zero, but the difference will increase uniformly with the time of the series. As long as the difference does not exceed 0.5 of an hour the integral component hours will be designated by the same ordinals as the integral solar hours with which they most nearly coincide. Differences between 0.5 and 1.5 will be represented by the integer 1, differences between 1.5 and 2.5 by the integer 2, etc. If we let d represent the integral difference, the time when the difference changes from $(d-1)$ to d, will be the time when the difference derived from formula (263) equals $(d-0.5)$. Substituting this in the formula, we may obtain

$$(shs) = \frac{15p}{a \sim 15p}(d-0.5) \tag{264}$$

in which (shs) represents the solar time when the integral difference between the component and solar time will change by one hour from $(d-1)$ to d. By substituting successively the integers 1, 2, 3, etc., for d in the formula (264) the time of each change throughout the series may be obtained. The value of (shs) thus obtained will generally be a mixed number; that is to say, the times of the changes will usually come between integral solar hours. The first integral solar hour after the change will be the one to which the new difference will apply if the usual system of distribution is to be adopted. In this case we are not concerned with the exact value of the fractional part of (*shs*) but need note only the integral hours between which this value falls.

If, however, the second system of distribution should be desired, it should be noted whether the fractional part of (*shs*) is greater or less than 0.5 hour. With a component day shorter than the solar day and the differences of formula (263) increasing positively, the application of the differences to the consecutive solar hours will result in the jumping or omission of a component hour at each change of difference. Under the second system of distribution each component must be represented, and it will therefore be necessary in this case to apply two consecutive differences to the same solar hour to represent two consecutive component hours. The solar hour selected for this double use will be the one occurring nearest to the time of change of differences. If the fractional part of the (*shs*) in (264) is less than 0.5 hour, the old and new differences will both be applied to the preceding integral solar hour; but if the fraction is greater than 0.5 hour the old and new difference will be applied to the integral solar hour following the change.

With a component day longer than the solar day and the differences of formula (263) increasing negatively, the application of the differences to the consecutive solar hours will result in two solar hours being assigned to the same component hour at each change of differences. Under the second system of distribution this must be avoided by the rejection of one of the solar hours. In this case the integral solar hour nearest the time of change will be rejected, since at the time of change the difference between the integral and the true difference is a maximum. Thus, if the fractional part of the (*shs*), is less than 0.5 hour, the preceding solar hour will be rejected; but if the fraction is greater than 0.5 hour the next following solar hour will be rejected.

Table 31, computed from formula (264), gives the first solar hour of the group to which each difference applies when the usual system of distribution is adopted. Multiples of 24 have been rejected from the differences, since we are concerned only with the component hour of the component day rather than with the component hour of the series, and these differences may be applied directly to the solar hours of the day. For convenience equivalent positive and negative differences are given. By using the negative difference when it does not exceed the solar hour to which it is to be applied, and at other times using the positive difference, the necessity for adding or rejecting multiples of 24 hours from the results is avoided.

The tabulated solar hour is the integer hour that immediately follows the value for the (*shs*) in formula (264). An asterisk (*) indicates that the fractional part of the (*shs*) exceeds 0.5, and that the tabular hour is therefore the one nearest the exact value of (*shs*). If the second system for the distribution of the hourly heights is adopted, the solar hours marked with the asterisk will be used with both old and new difference to represent two component hours, or will be rejected altogether according to whether the component day is shorter or longer than the solar day. If the tabular hour is unmarked, the same rule of double use or rejection will apply to the untabulated solar hour immediately preceding the tabular unmarked hour. For the ordinary stencils no attention need be given to the asterisks. By the formula components with commensurable periods will have the same tabular values, and no distinction is made in the construction of the stencils. Thus, stencils for component M serve not only for component M_2 but also for M_3, M_4, M_6, etc.

For the construction of a set of stencils the standard forms designed for the tabulation of the hourly heights may be used. A preliminary set of such forms is prepared with the days of series entered consecutively, beginning with 1, and with each hourly height space designated by the number of the component hour to which the height is to be assigned. The component hours are readily derived by the application of the differences given in Table 31. Each difference applies to a group of solar hours, the first hour of each group being indicated by the table. Under the usual system of distribution each hourly space will be represented by a single component hour number.

After the preliminary set of forms has been filled out as indicated the odd and even competent hours on each page will be transferred to separate sheets of the form and the spaces marked cut out. In the Coast and Geodetic Survey this cutting is done by a machine with a punch operated by a small hand lever. The openings corresponding to the same component hour are as far as practicable connected by ruled lines, which are numbered to accord with the component hours represented. Black ruling with red numbering is usually adopted. The use of the red numbers to indicate the component hours has the advantage that it emphasizes the distinction between these numbers and the figures representing the hourly heights which are to be summed. Figure 23 illustrates one of the stencils used for the summations for component M.

In using the stencils they are placed one at a time on the forms containing the tabulated heights of the observed tides, and all the heights on a page corresponding to each component hour are summed separately, the grouping of the heights being indicated by the ruling on the stencil.

For component S no stencils are required, since the component hours are identical with the solar hours in accordance with which the observed hourly heights have been tabulated.

For components like K, P, R, and T, whose speeds differ little from the speed of component S, the lines joining the openings in the stencils will frequently become horizontal. Since the sum of the values in such a horizontal line will have previously been obtained and entered in the margin of the form, the resuming will be saved by having a corresponding opening in the margin of the stencil which will expose this sum.

25. SECONDARY STENCILS.

After the sums for certain principal components have been obtained by the stencils described in the preceding section, which for convenience will be called the primary stencils, the summations for other components may be abbreviated by the use of secondary stencils which are designed to regroup the hourly page sums already obtained for one component into new combinations conforming to the periods of other components. Certain irregularities are introduced by the process, but in a long series, such as 369 days, these are for the most part eliminated, and the resulting values for the harmonic constants compare favorably with those obtained by use of the primary stencils directly, the differences in the results obtained by the two methods being negligible. For short series the irregularities are less likely to be eliminated, and since the labor of summing for such a series is relatively small, the abbreviated form of summing is not recommended. As the length of series increases the saving in labor by the use of the secondary stencils increases, while the irregularities due to the short process tend to disappear. It is believed that the use of the secondary stencils will be found advantageous for all series more than six months in length.

In the primary summations there are obtained 24 sums for each page of tabulations, representing the 24 component hours of a component day. In general each sum will include 7 hourly heights, and the average interval between the first and last heights will be 6 component days. A few of the sums may, however, include a greater or less number of hourly heights within limits which may be a day greater or less than 6 component days.

Let the component for which summations have been made by use of the primary stencils be designated as component A and the component which is to be obtained by use of the secondary stencils as component B. For convenience let it be first assumed that the heights included in the sums for component A refer to the exact component A hours. This assumption is true for component S but only approximately true for the other components. It is now proposed to assign each hourly page sum obtained for component A to the integral component B hour with which it most nearly coincides. Component A and component B hours separate at a uniform rate, and the proposed assignment will depend upon the relation of the hours on the middle day of each page of tabulations. The tabulated hourly heights on each full page of record run from zero (0) solar hour on the first day to the 23d solar hour on the seventh or last day of the page. The middle of the record on each such page is therefore at 11.5 solar hour on the fourth day, or 83.5 solar hours from the beginning of the page of record.

Let a and b represent the hourly speeds of the components A and B, respectively, and p and p_1 their respective subscripts, and let n equal the number of the page of tabulation under consideration, beginning with number one as the first page.

The middle of page n will then be

$$[168\ (n-1)+83.5] \text{ or } (168\,n-84.5) \text{ solar hours} \tag{265}$$

from the beginning of the series.

Since one solar hour equals $a/15p$ component A hours (formula 261), the middle of page n will also correspond to

$$(168\,n-84.5)\,\frac{a}{15p} \text{ component } A \text{ hours} \tag{266}$$

from the beginning of the series.

As there are 24 component hours in each component day, the middle component A day of each page will commence 12 component A hours earlier than the time represented by the middle of the page, or at

$$\left[(168\,n-84.5)\,\frac{a}{15p}-12\right] \text{ component } A \text{ hours} \tag{267}$$

from the beginning of the series.

The 24 integral component A hours of the middle component day of the page will therefore be the integral component A hours which immediately follow the time indicated by the last formula. The numerical value of this formula will usually be a mixed number. Let f equal the fractional part, and let m be an integer representing the number of any integral component hour according to its order in the middle component day of each page. For each page m will have successive values from 1 to 24. The integral component A hours falling within the middle component day of each page of tabulations will then be represented by the general formula

$$[(168\ n-84.5)\ \frac{a}{15p}-12-f+m]\ \text{component } A \text{ hours} \qquad (268)$$

from the beginning of the series.

The relation of the lengths of the component A and component B hours is given by the formula

$$1 \text{ component } A \text{ hour}=\frac{pb}{p_1a} \text{ component } B \text{ hours}. \qquad (269)$$

The component B hour corresponding to the integral component A hour of formula (268) is therefore

$$[(168\ n-84.5)\ \frac{a}{15p}-12-f+m]\ \frac{pb}{p_1a}\ \text{component } B \text{ hours} \qquad (270)$$

from the beginning of the series.

The last formula will, in general, represent a mixed number. The integral component B hour to which the sum for the component A hour is to be assigned will be the nearest integral number represented by this formula. Let g be a fraction not greater than 0.5, which, applied either positively or negatively to the formula, will render it an integer.

The assignment of the hourly page sums for component A hours to the component B hours may now be represented as follows, multiples of 24 hours being rejected:

$$[(168\ n-84.5)\ \frac{a}{15p}-12-f+m-\text{multiple of } 24]\ \text{component } A \text{ hour} \qquad (271)$$

sum to be assigned to

$$[\{(168\ n-84.5)\ \frac{a}{15p}-12-f+m\}\frac{pb}{p_1a}\pm g-\text{multiple of } 24]\ \text{component } B \text{ hour}. \qquad (272)$$

The difference between the component A hour and the component B hour to which the A hour sum is to be assigned is

$$[\{(168\,n-84.5)\,\frac{a}{15p}-12-f+m\}\{\frac{pb}{p_1a}-1\}\pm g-\text{multiple of } 24] \qquad (273)$$

By means of the above formula Table 33 has been prepared, giving the differences to be applied to the component A hours of each page to obtain the component B hours with which they most nearly coincide.

For the construction of secondary stencils the forms designated for the compilation of the stencil sums from the primary summations may be used. Because of the practical difficulties of constructing stencils with openings in adjacent line spaces it is desirable that the original compilation of the primary sums should be made so that each alternate line in the form for stencil sums is left vacant. As with the primary stencils, it will generally be found convenient to use two stencils for each page of the compiled primary sums, although in some cases it may be found desirable to use more than two stencils in order to separate more clearly the groups to be summed. The actual construction of the secondary stencils is similar to that of the primary stencils. A preliminary set of forms is filled out with component B hours as derived by differences from Table 33 applied to the component A hours. The odd and even component B hours are then transferred to separate forms and the spaces indicated cut out. The openings corresponding to the same component B hour are connected with ruled lines and numbered to accord with the component hour represented. The page numbering corresponding to the page numbering on the compiled primary sums and referring to the pages of the original tabulated hourly heights is to be entered in the column provided near the left margin of the stencil.

In using the stencils each sheet is to be applied to the page of compiled primary sums having the same page numbering in the left-hand column as is given on the stencil. The primary sums applying to the same component B hour are added and the results brought together in a stencil sum form, where the totals and means are obtained. A table of divisors for obtaining the means may be readily derived as follows: In a set of stencil sum forms corresponding to those used for the compilation of component A primary sums the number of hourly heights included in each primary sum is entered in the space corresponding to that used for such primary sum. The secondary stencils for component B are then applied and the sums of the numbers obtained and compiled in the same manner as that in which the component B height sums are obtained. The divisors having been once obtained are applicable for all series of the same length.

In the analysis the means obtained by use of the secondary stencils may be treated as though obtained directly by the primary summations except that a special augmenting factor, to be discussed later, must be applied.

The closeness of the agreement between the hourly means obtained by use of the secondary stencils and those obtained directly by use of primary stencils will depend to a large extent upon the relation of the speeds of components A and B. The smaller the difference in the speeds the closer will be the agreement.

To determine the extreme difference in the time of an individual hourly height and of the component B hour to which it is assigned by the secondary stencils, let an assumed case be first considered in which the tabulated heights coincide exactly with the integral component A hours, and that on the middle day of the page of tabulated hourly heights one of the integral component B hours coincides exactly with a component A hour. At the corresponding component A hour, one component A day later, the component B hour will have increased by $24\,\frac{pb}{p_1a}$ component B hours. Rejecting a multiple of 24 hours, this becomes $24\left(\frac{pb}{p_1a}-1\right)$, so that at the end of one component A day after the coincidence of integral hours of components A and B the component A hourly height will differ in time from the integral component B hour to which it is to be assigned by 24 $\left(\frac{pb}{p_1a}-1\right)$ component B hours. At the end of the third component A day this difference becomes 72 $\left(\frac{pb}{p_1a}-1\right)$ component B hours. The same difference with opposite sign will apply to the third component day before the middle day of the page. Now, taking account of the fact that the component B hour on the middle day of the page may differ by an amount as great 0.5 of a component B hour from the integral component A hour, and that the integral component A hour may differ as much as 0.5 of a component A, or 0.5 pb/p_1a of a component B hour from the time of the actual observation of the solar hourly height, the extreme difference between the time of observation of an hourly height and the time represented by the component B hour with which this height is grouped by the secondary stencils may be represented by the formula.

$$\pm[72\left(\frac{pb}{p_1a}\sim 1\right)+0.5\left(\frac{pb}{p_1a}+1\right)] \text{ component } B \text{ hours.} \qquad (274$$

The differences may be either positive or negative, and in a long series it may reasonably be expected that the number of positive and negative values will be approximately equal.

The above formula for the extreme difference furnishes a criterion by which to judge, to some extent, the reliability of the method. Testing the following schedule of components for which it is proposed to use the secondary stencils, the extreme differences as indicated are obtained. The differences are expressed in component B hours and also in component B degrees. It will be noted that one component hour is equivalent to a change of 15° in the phase of a diurnal component, 30° in the phase of a semidiurnal component, etc.

Component A	J		S				
Component B	OO	2SM	K_1	K_2	R_2	T_2	P_1
Difference in hours	3.58	1.36	1.20	1.20	1.10	1.10	1.20
Difference in degrees	54	41	18	36	33	33	18

Component A	L			2MK		
Component B	MS	λ_2	MK	MN	ν_2	N_2
Difference in hours	1.09	1.18	1.43	1.24	1.26	1.45
Difference in degrees	65	35	64	74	38	44

Component A	O				
Component B	μ_2	2N	ρ_1	Q	2Q
Difference in hours	1.21	1.02	3.42	3.79	6.58
Difference in degrees	36	31	51	57	99

In the ordinary primary summation the extreme difference between the time of the observation of a solar hourly height and the intregal component hour to which it is assigned is one-half of a component hour and, represented by component degrees, it is 7.5° for diurnal, 15° for semidiurnal, 22.5° for terdiurnal, 30° for quarter diurnal, 45° for sixth-diurnal, and 60° for eighth-diurnal components. By the above schedule it will be noted that the extreme difference exceeds 60° in only a few cases. The largest difference is 99° for component $2Q$ when based upon the primary summations for O. This is a small and unimportant component, and heretofore no analysis has been made for it, the value of its harmonic constants being inferred from those of component O. Although theoretically too small to justify a primary summation in general practice, the lesser work involved in the secondary summations may produce constants for this component which will be more satisfactory than the inferred constants.

Although the general use of secondary stencils for series of observations less than six months in length is not at present recommended, it is possible that future tests may indicate that these stencils may be used to advantage with shorter series.

26. THE FOURIER SERIES.

A series involving only sines and cosines of whole multiples of a varying angle is generally known as the Fourier series. Such a series is of the form

$$\begin{aligned} h = H_0 + C_1 \cos \theta + C_2 \cos 2\theta + C_3 \cos 3\theta + \cdots \\ + S_1 \sin \theta + S_2 \sin 2\theta + S_3 \sin 3\theta + \cdots \end{aligned} \qquad (275)$$

It can be shown that by taking a sufficient number of terms the Fourier series may be made to represent any periodic function of θ.

This series may be written also in the following form:

$$h = H_0 + A_1 \cos (\theta + \alpha_1) + A_2 \cos (2\theta + \alpha_2) + A_3 \cos (3\theta + \alpha_3) + \cdots \qquad (276)$$

in which

$$A_m = [C_m^2 + S_m^2]^{\frac{1}{2}} \text{ and } \alpha_m = -\tan^{-1}\frac{S_m}{C_m}$$

m being the subscript of any term.

From the summations for any component 24 component hourly means are obtained, these means being the approximate heights of the component tide at given intervals of time. These mean component hourly heights, together with the intermediate heights, may be represented by the Fourier series, in which

H_0 = mean value of the function corresponding to the height of mean sea level above the adopted datum.

θ = an angle that changes uniformly with time and completes a cycle of 360° in one component day. The values of θ corresponding to the 24 hourly means will be 0°, 15°, 30°, $\cdots$ 330°, and 345°.

Formula (275), or its equivalent (276), is the equation of a curve with the values of θ as the abscissæ and the corresponding values of h as the ordinates. If the 24 component hourly means are plotted as ordinates corresponding to the values of 0°, 15°, 30°, $\cdots$ for θ, it is possible to find values for H_o, C_m, and S_m, which when substituted in (276) will give the equation of a curve that will pass exactly through each of the 24 points representing the component means.

In order to make the following discussion more general, let it be assumed that the period of θ has been divided into n equal parts, and that the ordinate or value of h pertaining to the beginning of each of those parts is known. Let u equal the interval between these ordinates, then

$$n\,u=2\pi, \text{ or } 360° \qquad (277)$$

Let the given ordinates be $h_0, h_1, h_2 \cdot \cdot \cdot \cdot h_{(n-1)}$ corresponding to the abscissae $o, u, 2u \cdot \cdot \cdot \cdot (n-1)\,u$, respectively.

It is now proposed to show that the curve represented by the following Fourier series will pass through the n points of which the ordinates are given.

$$\begin{aligned} h &= H_0 + C_1 \cos\theta + C_2 \cos 2\theta + \ . \ . \ . \ . \ C_k \cos k\,\theta \\ &\quad + S_1 \sin\theta + S_2 \sin 2\theta + \ . \ . \ . \ . \ S_l \sin l\,\theta \\ &= H_0 + \sum_{m=1}^{m=k} C_m \cos m\,\theta + \sum_{m=1}^{m=l} S_m \sin m\theta \end{aligned} \qquad (278)$$

in which the limit $k=\frac{n}{2}$ if n is an even number, or $k=\frac{n-1}{2}$ if n is an odd number; and the limit $l=\frac{n}{2}-1$ if n is even, or $\frac{n-1}{2}$ if n is odd.

By substituting successively the coordinates of the n given points in (278) we may obtain n equations of the form

$$h_a = H_o + \sum_{m=1}^{m=k} C_m \cos mau + \sum_{m=1}^{m=l} S_m \sin mau \qquad (279)$$

in which a represents successively the integers 0 to $(n-1)$.

By the solution of these n equations the values of n unknown quantities may be obtained, including H_o and the $(n-1)$ values for C_m and S_m. It will be noted that the sum of the limits k and l of (278) or (279) equals $(n-1)$ for both even and odd values of n

The reason for these limits is as follows:

A continued series $\Sigma\ C_m \cos m\,a\,u$ may be written

$$\begin{aligned} &C_1 \cos a\,u + C_2 \cos 2\,a\,u + \cdot \cdot \cdot \cdot + C_n \cos n\,a\,u \\ &\quad + C_{(n+1)} \cos (n+1)\,a\,u + C_{(n+2)} \cos (n+2)\,a\,u + \cdot \cdot \cdot \cdot + C_{2n} \cos 2\,n\,a\,u \\ &\quad + C_{(2n+1)} \cos (2n+1)\,a\,u + C_{(2n+2)} \cos (2n+2)\,a\,u + \cdot \cdot \cdot \cdot \\ &\quad\quad + C_{3n} \cos 3\,n\,a\,u \\ &\quad\quad + \text{---} \end{aligned} \qquad (280)$$

Since $n\,u\ = 2\pi$ and a is an integer, the above may be written

$$\begin{aligned} &[C_1 + C_{(n+1)} + C_{(2n+1)} + \cdot \cdot \cdot \cdot\,] \cos a\,u \\ &+ [C_2 + C_{(n+2)} + C_{(2n+2)} + \cdot \cdot \cdot \cdot\,] \cos 2\,a\,u \\ &+ \text{---} \\ &+ [C_{(n-1)} + C_{(2n-1)} + C_{(3n-1)} + \cdot \cdot \cdot \cdot\,] \cos (n-1)\,a\,u \\ &+ [C_n + C_{2n} + C_{3n} + \cdot \cdot \cdot \cdot\,] \cos n\,a\,u \end{aligned} \qquad (281)$$

Since $\cos n\, a\, u = \cos 2a\,\pi = 1$; $\cos (n-1)\, a\, u = \cos (2a\,\pi - a\,u) = \cos a\,u$; $\cos (n-2)\, a\, u = \cos 2\, a\, u$; etc., (281) may be written

$$
\begin{aligned}
&[C_n + C_{2n} + C_{3n} + \cdots\cdot]\cos 0\\
&+[C_1 + C_{(n+1)} + C_{(2n+1)} + \cdots\\
&+ C_{(n-1)} + C_{(2n-1)} + C_{(3n-1)} + \cdots\cdot]\cos a\,u\\
&+[C_2 + C_{(n+2)} + C_{(2n+2)} + \cdots\cdot\\
&+ C_{(n-2)} + C_{(2n-2)} + C_{(3n-2)} + \cdots\cdot]\cos 2\,a\,u\\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\\
&+[C_k + C_{(n+k)} + C_{(2n+k)} + \cdots\cdot\\
&+ C_{(n-k)} + C_{(2n-k)} + C_{(3n-k)} + \cdots\cdot]\cos k\,a\,u
\end{aligned}
\tag{282}
$$

The first term of the above is a constant which will be included with the H_0 in the solution of (279). From an examination of (282) it is evident that the cosine terms will be completely represented when $k=\frac{n}{2}$, or $\frac{n-1}{2}$, according to whether n is even or odd.

Similarly, the continued series $\sum S_m \sin m\,a\,u$ may be written

$$
\begin{aligned}
&[S_n + S_{2n} + S_{3n} + \cdots\cdot]\sin 0\\
&+[S_1 + S_{(n+1)} + S_{(2n+1)} + \cdots\cdot\\
&- S_{(n-1)} - S_{(2n-1)} - S_{(3n-1)} - \cdots\cdot]\sin a\,u\\
&+[S_2 + S_{(n+2)} + S_{(2n+2)} + \cdots\cdot\\
&- S_{(n-2)} - S_{(2n-2)} - S_{(3n-2)} - \cdots\cdot]\sin 2\,a\,u\\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\\
&+[S_l + S_{(n+l)} + S_{(2n+l)} + \cdots\cdot\\
&- S_{(n-l)} - S_{(2n-l)} - S_{(3n-l)} - \cdots\cdot]\sin l\,a\,u
\end{aligned}
\tag{283}
$$

The first term in the above equals zero. The remaining terms will take complete account of the series $\sum S_m \sin m\,a\,u$, if $l=\frac{n}{2}-1$ when n is even, or $\frac{n-1}{2}$ when n is odd.

From the foregoing it is evident that the limit of m will not exceed $\frac{n}{2}$.

If we let u and α represent any angles with fixed values, m and p any integers with fixed values, and a an integer having successive values from 0 to $(n-1)$, it may be shown that

$$\sum_{a=0}^{a=(n-1)} \sin (a\,m\,u+\alpha) = \frac{\sin\frac{1}{2}\,n\,m\,u}{\sin\frac{1}{2}\,m\,u}\sin\left[\tfrac{1}{2}\,(n-1)\,m\,u+\alpha\right] \tag{284}$$

$$\sum_{a=0}^{a=(n-1)} \cos (a\,m\,u+\alpha) = \frac{\sin\frac{1}{2}\,n\,m\,u}{\sin\frac{1}{2}\,m\,u}\cos\left[\tfrac{1}{2}\,(n-1)\,m\,u+\alpha\right] \tag{285}$$

$$
\begin{aligned}
\sum_{a=0}^{a=(n-1)} \sin a\,p\,u\,\sin a\,m\,u &= \tfrac{1}{2}\,\frac{\sin\frac{1}{2}\,n\,(p-m)\,u\,\cos\frac{1}{2}\,(n-1)\,(p-m)\,u}{\sin\frac{1}{2}\,(p-m)\,u}\\
&-\tfrac{1}{2}\,\frac{\sin\frac{1}{2}\,n\,(p+m)\,u\,\cos\frac{1}{2}\,(n-1)\,(p+m)\,u}{\sin\frac{1}{2}\,(p+m)\,u}
\end{aligned}
\tag{286}
$$

$$
\begin{aligned}
\sum_{a=0}^{a=(n-1)} \cos a\,p\,u\,\cos a\,m\,u &= \tfrac{1}{2}\,\frac{\sin\frac{1}{2}\,n\,(p-m)\,u\,\cos\frac{1}{2}(n-1)\,(p-m)\,u}{\sin\frac{1}{2}\,(p-m)\,u}\\
&+\tfrac{1}{2}\,\frac{\sin\frac{1}{2}\,n\,(p+m)\,u\,\cos\frac{1}{2}\,(n-1)(p+m)\,u}{\sin\frac{1}{2}\,(p+m)\,u}
\end{aligned}
\tag{287}
$$

$$
\begin{aligned}
\sum_{a=0}^{a=(n-1)} \sin a\,p\,u\,\cos a\,m\,u &= \tfrac{1}{2}\,\frac{\sin\frac{1}{2}\,n\,(p-m)\,u\,\sin\frac{1}{2}\,(n-1)\,(p-m)\,u}{\sin\frac{1}{2}\,(p-m)\,u}\\
&+\tfrac{1}{2}\,\frac{\sin\frac{1}{2}\,n\,(p+m)\,u\,\sin\frac{1}{2}\,(n-1)\,(p+m)\,u}{\sin\frac{1}{2}\,(p+m)\,u}
\end{aligned}
\tag{288}
$$

If we let $\alpha=0$ and $u=\frac{2\pi}{n}$, or $n\,u=2\pi$, then formulas (284) to (288) may be written as follows:

$$\sum_{a=0}^{a=(n-1)} \sin a\,m\,u=\frac{\sin m\,\pi \sin\left(m\,\pi-\frac{m}{n}\,\pi\right)}{\sin \frac{m}{n}\,\pi} \tag{289}$$

$$\sum_{a=0}^{a=(n-1)} \cos a\,m\,u=\frac{\sin m\,\pi \cos\left(m\,\pi-\frac{m}{n}\,\pi\right)}{\sin \frac{m}{n}\,\pi} \tag{290}$$

$$\sum_{a=0}^{a=(n-1)} \sin a\,p\,u \sin a\,m\,u=\tfrac{1}{2}\,\frac{\sin (p-m)\,\pi \cos\left[(p-m)\,\pi-\frac{p-m}{n}\,\pi\right]}{\sin \frac{(p-m)}{n}\,\pi} -\tfrac{1}{2}\,\frac{\sin (p-m)\,\pi \cos\left[(p+m)\,\pi-\frac{p+m}{m}\,\pi\right]}{\sin \frac{p+m}{n}\,\pi} \tag{291}$$

$$\sum_{a=0}^{a=(n-1)} \cos a\,p\,u \cos a\,m\,u=\tfrac{1}{2}\,\frac{\sin (p-m)\,\pi \cos\left[(p-m)\,\pi-\frac{p-m}{n}\,\pi\right]}{\sin \frac{p-m}{n}\,\pi} +\tfrac{1}{2}\,\frac{\sin (p+m)\,\pi \cos\left[(p+m)\,\pi-\frac{p+m}{n}\,\pi\right]}{\sin \frac{p+m}{n}\,\pi} \tag{292}$$

$$\sum_{a=0}^{a=(n-1)} \sin a\,p\,u \cos a\,m\,u=\tfrac{1}{2}\,\frac{\sin (p-m)\,\pi \sin\left[(p-m)\,\pi-\frac{p-m}{n}\,\pi\right]}{\sin \frac{p-m}{n}\,\pi} +\tfrac{1}{2}\,\frac{\sin (p+m)\,\pi \sin\left[(p+m)\,\pi-\frac{p+m}{n}\,\pi\right]}{\sin \frac{p+m}{m}\,\pi} \tag{293}$$

If p and m are unequal integers and neither exceeds $\frac{n}{2}$, the above (289) to (293) become equal to zero. Thus,

$$\left.\begin{aligned}
&\sum_{a=0}^{a=(n-1)} \sin a\,m\,u=0\\
&\sum_{a=0}^{a=(n-1)} \cos a\,m\,u=0\\
&\sum_{a=0}^{a=(n-1)} \sin a\,p\,u \sin a\,m\,u=0\\
&\sum_{a=0}^{a=(n-1)} \cos a\,p\,u \cos a\,m\,u=0\\
&\sum_{a=0}^{a=(n-1)} \sin a\,p\,u \cos a\,m\,u=0
\end{aligned}\right\} \tag{294}$$

If p and m are equal integers and do not exceed $\frac{n}{2}$, formulas (291), (292), and (293) will contain the indeterminate quantity $\frac{\sin (p-m)\pi}{\sin \frac{p-m}{n}\pi} = \frac{0}{0}$, and also when p and m each equal $\frac{n}{2}$, the indeterminate quantity $\frac{\sin (p+m)\pi}{\sin \frac{(p+m)}{n}\pi} = \frac{0}{0}$.

Evaluating these quantities we have

$$\left.\frac{\sin (p-m)\pi}{\sin \frac{p-m}{n}\pi}\right]_{(p-m)=o} = \left.\frac{\pi \cos (p-m)\pi}{\frac{\pi}{n} \cos \frac{p-m}{n}\pi}\right]_{(p-m)=o} = n \quad (295)$$

and

$$\left.\frac{\sin (p+m)\pi}{\sin \frac{p+m}{n}\pi}\right]_{(p+m)=n} = \left.\frac{\pi \cos (p+m)\pi}{\frac{\pi}{n} \cos \frac{p+m}{n}\pi}\right]_{(p+m)=n} = -n \quad (296)$$

In (296) it will be noted that when the integers p and m each equal $\frac{n}{2}$, n must be an even number, and therefore $\cos n\pi$ is positive, while $\cos \pi$ is negative.

Assuming the condition that p and m are equal integers, each less than $\frac{n}{2}$, we have by substituting (295) in (291), (292), and (293),

$$\sum_{a=0}^{a=(n-1)} \sin a\,p\,u \sin a\,m\,u = \sum_{a=0}^{a=(n-1)} \sin^2 a\,m\,u = \tfrac{1}{2}\,n \quad (297)$$

$$\sum_{a=0}^{a=(n-1)} \cos a\,p\,u \cos a\,m\,u = \sum_{a=0}^{a=(n-1)} \cos^2 a\,m\,u = \tfrac{1}{2}\,n \quad (298)$$

$$\sum_{a=0}^{a=(n-1)} \sin a\,p\,u \cos a\,m\,u = \sum_{a=0}^{a=(n-1)} \sin a\,m\,u \cos a\,m\,u = 0 \quad (299)$$

Assuming the condition that p and m are each equal to $\frac{n}{2}$, we have by substituting (295) and (296) in (291), (292), and (293),

$$\sum_{a=0}^{a=(n-1)} \sin^2 a\,m\,u = \tfrac{1}{2}n + \tfrac{1}{2}\,n \cos \pi = 0 \quad (300)$$

$$\sum_{a=0}^{a=(n-1)} \cos^2 a\,m\,u = \tfrac{1}{2}\,n - \tfrac{1}{2}\,n \cos \pi = n \quad (301)$$

$$\sum_{a=0}^{a=(n-1)} \sin a\,m\,u \cos a\,m\,u = 0 \quad (302)$$

Returning now to the solution of (279), by substituting the successive values of a from 0 to $(n-1)$, we have

$$\left.\begin{aligned}
h_0 &= H_0 + C_1 \cos 0 + C_2 \cos 0 + \dots + C_k \cos 0 \\
&\quad + S_1 \sin 0 + S_2 \sin 0 + \dots + S_l \sin 0 \\
h_1 &= H_0 + C_1 \cos u + C_2 \cos 2u + \dots + C_k \cos ku \\
&\quad + S_1 \sin u + S_2 \sin 2u + \dots + S_l \sin lu \\
h_2 &= H_0 + C_1 \cos 2u + C_2 \cos 4u + \dots + C_k \cos 2ku \\
&\quad + S_1 \sin 2u + S_2 \sin 4u + \dots + S_l \sin 2lu \\
&\text{-----------------------------------} \\
h_{(n-1)} &= H_0 + C_1 \cos (n-1)u + C_2 \cos 2(n-1)u + \dots \\
&\quad + C_k \cos (n-1)ku \\
&\quad + S_1 \sin (n-1)u + S_2 \sin 2(n-1)u + \dots \\
&\quad + S_l \sin (n-1)lu
\end{aligned}\right\} \tag{303}$$

To obtain value of H_0, add above equations

$$\sum_{a=0}^{a=(n-1)} h_a = n\,H_0$$

$$+ C_1 \sum_{a=0}^{a=(n-1)} \cos a\,u + C_2 \sum_{a=0}^{a=(n-1)} \cos 2\,a\,u + \dots + C_k \sum_{a=0}^{a=(n-1)} \cos a\,k\,u$$

$$+ S_1 \sum_{a=0}^{a=(n-1)} \sin a\,u + S_2 \sum_{a=0}^{a=(n-1)} \sin 2\,a\,u + \dots + S_l \sum_{a=0}^{a=(n-1)} \sin a\,l\,u$$

$$= n\,H_0 + \sum_{m=1}^{m=k} C_m \sum_{a=0}^{a=(n-1)} \cos a\,m\,u + \sum_{m=1}^{m=l} S_m \sum_{a=0}^{a=(n-1)} \sin a\,m\,u \tag{304}$$

From (294), $\sum_{a=0}^{a=(n-1)} \cos a\,m\,u$ and $\sum_{a=0}^{a=(n-1)} \sin a\,m\,u$ each equals zero, since neither k nor l, the maximum values of m exceeds $\frac{n}{2}$

Therefore

$$\sum_{a=0}^{a=(n-1)} h_a = n\,H_0 \tag{305}$$

and

$$H_0 = \frac{1}{n} \sum_{a=0}^{a=(n-1)} h_a \tag{306}$$

To obtain the value of any coefficient C, such as C_p, multiply each equation of (303) by $\cos a\,p\,u$. Then

$$\begin{aligned}
h_0 \cos 0 &= H_0 \cos 0 \\
&\quad + C_1 \cos 0 + C_2 \cos 0 + \dots + C_k \cos 0 \\
&\quad + S_1 \sin 0 + S_2 \sin 0 + \dots + S_l \sin 0 \\
h_1 \cos p\,u &= H_0 \cos p\,u \\
&\quad + C_1 \cos u \cos p\,u + C_2 \cos 2u \cos p\,u + \dots + C_k \cos k\,u \cos p\,u \\
&\quad + S_1 \sin u \cos p\,u + S_2 \sin 2u \cos p\,u + \dots + S_l \sin l\,u \cos p\,u \\
h_2 \cos 2p\,u &= H_0 \cos 2p\,u \\
&\quad + C_1 \cos 2u \cos 2p\,u + C_2 \cos 4u \cos 2p\,u + \dots \\
&\quad\quad + C_k \cos 2k\,u \cos 2p\,u \\
&\quad + S_1 \sin 2u \cos 2p\,u + S_2 \sin 4u \cos 2p\,u + \dots \\
&\quad\quad + S_l \sin 2l\,u \cos 2p\,u
\end{aligned}$$

$$h_{(n-1)} \cos (n-1)\, p\, u = H_0 \cos (n-1)\, p\, u$$
$$+ C_1 \cos (n-1)\, u \cos (n-1)\, p u + C_2 \cos 2\,(n-1)\, u \cos (n-1)\, p u + \ldots.$$
$$+ C_k \cos (n-1)\, k\, u \cos (n-1)\, p\, u$$
$$+ S_1 \sin (n-1)\, u \cos (n-1)\, p u + S_2 \sin 2\,(n-1)\, u \cos (n-1)\, p u + \ldots.$$
$$+ S_l \sin (n-1)\, l\, u \cos (n-1)\, p\, u \qquad (307)$$

Summing the above equations

$$\sum_{a=0}^{a=(n-1)} h_a \cos a\, p\, u = H_0 \sum_{a=0}^{a=(n-1)} \cos a\, p\, u$$
$$+ C_1 \sum_{a=0}^{a=(n-1)} \cos a\, u \cos a\, p\, u + S_1 \sum_{a=0}^{a=(n-1)} \sin a\, u \cos a\, p\, u$$
$$+ C_2 \sum_{a=0}^{a=(n-1)} \cos 2a\, u \cos a\, p\, u + S_2 \sum_{a=0}^{a=(n-1)} \sin 2a\, u \cos a\, p\, u$$

$$+ C_k \sum_{a=0}^{a=(n-1)} \cos a\, k\, u \cos a\, p\, u + S_l \sum_{a=0}^{a=(n-1)} \sin a\, l\, u \cos a\, p\, u$$
$$= H_0 \sum_{a=0}^{a=(n-1)} \cos a\, p\, u + \sum_{m=1}^{m=k} C_m \sum_{a=0}^{a=(n-1)} \cos a\, m\, u \cos a\, p\, u$$
$$+ \sum_{m=1}^{m=l} S_m \sum_{a=0}^{a=(n-1)} \sin a\, m\, u \cos a\, p\, u \qquad (308)$$

Examining the limits of (308), it will be noted by a reference to page 77 that k, the maximum value of m for the C terms is $\frac{n}{2}$ when n is even and $\frac{n-1}{2}$ when n is odd; also, that l has a value of $\frac{n}{2}-1$ when n is even and $\frac{n-1}{2}$ when n is odd. The limits of p, which is a particular value of m, will, of course, be the same as those of m.

By (294) the quantity $\sum_{a=0}^{a=(n-1)} \cos a\, p\, u$ becomes zero for all the values of p, and the quantity $\sum_{a=0}^{a=(n-1)} \cos a\, m\, u \cos a\, p\, u$ becomes zero for all values of m and p except when p equals m. By (294), (299), and (302) the quantity $\sum_{a=0}^{a=(n-1)} \sin a\, m\, u \cos a\, p\, u$ becomes zero for all values of m and p.

Formula (308) may therefore be reduced to the form

$$\sum_{a=0}^{a=(n-1)} h_a \cos a\, p\, u = C_p \sum_{a=0}^{a=(n-1)} \cos^2 a\, p\, u \qquad (309)$$

For any value of p less than $\frac{n}{2}$

$$\sum_{a=0}^{a=(n-1)} \cos^2 a\, p\, u = \tfrac{1}{2}\, n \ (298)$$

but when $p=\frac{n}{2}$, this quantity becomes equal to n (301).

Therefore for all values of p less than $\frac{n}{2}$

$$C_p=\frac{2}{n}\sum_{a=0}^{a=(n-1)} h_a \cos a\,p\,u \tag{310}$$

but when p is exactly $\frac{n}{2}$

$$C_p=\frac{1}{n}\sum_{a=0}^{a=(n-1)} h_a \cos a\,p\,u \tag{311}$$

Since in tidal work p is always taken less than $\frac{n}{2}$, we are not especially concerned with the latter formula.

To obtain the value of any coefficient S, such as S_p, multiply each equation of (303) by sin $a\ p\ u$. Sum the resulting equations and obtain

$$\begin{aligned}\sum_{a=0}^{a=(n-1)} h_a \sin a\,p\,u =& Ho\sum_{a=0}^{a=(n-1)} \sin a\,p\,u\\ &+\sum_{m=1}^{m=k} C_m \sum_{a=0}^{a=(n-1)} \cos a\,m\,u \sin a\,p\,u\\ &+\sum_{m=1}^{m=l} S_m \sum_{a=0}^{a=(n-1)} \sin a\,m\,u \sin a\,p\,u \end{aligned}\tag{312}$$

By (294), (299), and (302) the quantities $\sum_{a=0}^{a=(n-1)} \sin a\,p\,u$ and $\sum_{a=0}^{a=(n-1)} \cos a\,m\,u \sin a\,p\,u$ are zero for all the values of m and p; and $\sum_{a=0}^{a=(n-1)} \sin a\,m\,u \sin a\,p\,u$ becomes zero for all the values of m and p except when m and p are equal. In this case the limit of l for m and p is less than $\frac{n}{2}$ and by (297), the quantity $\sum_{a=0}^{a=(n-1)} \sin^2 a\,p\,u$ $=\frac{1}{2}\,n$.

Therefore, formula (312) reduces to the form

$$\sum_{a=0}^{a=(n-1)} h_a \sin a\,p\,u=\tfrac{1}{2}\,n\,S_p \tag{313}$$

and

$$S_p=\frac{2}{n}\sum_{a=0}^{a=(n-1)} h_a \sin a\,p\,u \tag{314}$$

By substituting (306), (310), (311), and (314) in (278), the following equation of a curve, which will pass through the n given points, will be obtained

$$
\begin{aligned}
h = \frac{1}{n} \sum_{a=0}^{a=(n-1)} h_a &+ \left[\frac{2}{n} \sum_{a=0}^{a=(n-1)} h_a \cos a\,u\right] \cos\theta \\
&+ \left[\frac{2}{n} \sum_{a=0}^{a=(n-1)} h_a \sin a\,u\right] \sin\theta \\
&+ \left[\frac{2}{n} \sum_{a=0}^{a=(n-1)} h_a \cos 2\,a\,u\right] \cos 2\,\theta \\
&+ \left[\frac{2}{n} \sum_{a=0}^{a=(n-1)} h_a \sin 2\,a\,u\right] \sin 2\,\theta \\
&- \\
&+ \left[\frac{2}{n}^{*} \sum_{a=0}^{a=(n-1)} h_a \cos k\,a\,u\right] \cos k\,\theta \\
&+ \left[\frac{2}{n} \sum_{a=0}^{a=(n-1)} h_a \sin l\,a\,u\right] \sin l\,\theta
\end{aligned}
\qquad (315)
$$

Although by taking a sufficient number of terms the Fourier series may thus be made to represent a curve which will be exactly satisfied by the n given ordinates, this is, in general, neither necessary nor desirable in tidal work, since it is known that the mean ordinates obtained from the summations of the hourly heights of the tide include many irregularities due to the imperfect elimination of the meteorological effects and also residual effects of components having periods incommensurable with that of the component sought. It is desirable to include only the terms of the series which represent the true periodic elements of the component. With series of observations of sufficient length, the coefficient of the other terms, if sought, will be found to approximate to zero.

By a reference to formula (100), page 35, it will be noted that the short-period components as derived from the equilibrium theory are, in general, either diurnal or semidiurnal. If the period of θ in formula (278), page 76, is taken to correspond to the component day, the diurnal components will be represented by the terms with coefficient C_1 and S_1, and the semidiurnal components by the terms with coefficients C_2 and S_2. For the long-period components, the period of θ may be taken to correspond to the component month or to the component year, in which case the coefficients C_1 and S_1 will refer to the monthly or annual components and the coefficients C_2 and S_2 to the semimonthly or semiannual components.

For most of the components the coefficients C_1, S_1, C_2, and S_2 will be the only ones required, but for the tides depending upon the fourth power of the moon's parallax (sec. 15) for the overtides (sec. 18), and the compound tides (sec. 19), other coefficients will be required. Terms beyond those with coefficients C_8 and S_8, for the overtides of the principal lunar component, are not generally used in tidal work.

When it is known that certain periodic elements exist in a component tide and that the mean ordinates obtained from observations include

* If n is even and $k=\frac{n}{2}$, this fraction is $\frac{1}{n}$ instead of $\frac{2}{n}$.

accidental errors that are not periodic, it may be readily shown by the method known as the least square adjustment, using the observational equations represented by (279), that the most probable values of the constant H_0 and the coefficient C_p and S_p are the same as those given by formulas (306), (310), and (314), respectively.

Since in tidal work the value of H_0, which is the elevation of mean sea level above the datum of observations, is generally determined directly from the original tabulation of hourly heights, formula (306) is unnecessary except for checking purposes. Formulas (310) and (314) are used for obtaining the most probable values of the coefficients C_p and S_p from the component hourly means obtained from the summations.

When 24 hourly means are used $n=24$, and $u=15°$, and the formulas may be written

$$C_p = \frac{1}{12} \sum_{a=0}^{a=23} h_a \cos 15\, a\, p \tag{316}$$

$$S_p = \frac{1}{12} \sum_{a=0}^{a=23} h_a \sin 15\, a\, p \tag{317}$$

in which the angles are expressed in degrees.

If only 12 means are used, the formulas become

$$C_p = \frac{1}{6} \sum_{a=0}^{a=11} h_a \cos 30\, a\, p \tag{318}$$

$$S_p = \frac{1}{6} \sum_{a=0}^{a=11} h_a \sin 30\, a\, p \tag{319}$$

The upper part of Form 194 (fig. 29) is designed for the computation of the coefficients C_p and S_p in accordance with formulas (316) and (317) to take account of the 24 component hourly means.

It is now desired to express each component in the form

$$y = A \cos (p\,\theta + \alpha) \tag{320}$$

or using a more specialized notation by

$$y = A \cos (p\,\theta - \zeta) \tag{321}$$

By trigonometry

$$\begin{aligned} A \cos (p\,\theta - \zeta) &= A \cos \zeta \cos p\,\theta + A \sin \zeta \sin p\,\theta \\ &= C_p \cos p\,\theta + S_p \sin p\,\theta \end{aligned} \tag{322}$$

in which $C_p = A \cos \zeta$ and $S_p = A \sin \zeta$ (323)

Therefore,

$$\tan \zeta = \frac{S_p}{C_p} \tag{324}$$

and

$$A = \frac{C_p}{\cos \zeta} = \frac{S_p}{\sin \zeta} = \sqrt{C_p^2 + S_p^2} \tag{325}$$

By substituting the values obtained for C_p and S_p by formulas (316) and (317) in formulas (324) and (325), the corresponding values of A and ζ for formula (321) may be obtained.

In (321) we now have an harmonic expression, which, with its constants A and ζ determined by the methods already described, is an approximate representation of one of the tidal components sought. These constants must, however, be modified and reduced in order to be adapted to practical use.

27. AUGMENTING FACTORS.

In the usual summations with the primary stencils for all the short period components, except component S, the hourly ordinates which are summed in any single group are scattered more or less uniformly over a period from one-half of a component hour before to one-half of a component hour after the exact component hour which the group represents. Because of this the resulting mean will differ a little from the true mean ordinate that would be obtained if all the ordinates included were read on the exact component hour, as with component S, and the amplitude obtained will be less than the true amplitude of the component. The factor necessary to take account of this fact is called the augmenting factor.

Let any component be represented by the curve

$$y = A \cos (at + \alpha) \tag{326}$$

in which

A = the true amplitude of the component
a = the speed of the component (degrees per solar hours)
t = variable time (expressed in solar hours)
α = any constant.

The mean value of y for a group of consecutive ordinates from $\tau/2$ hours before to $\tau/2$ hours after any given time t, τ being the number of solar hours covered by the group, is

$$\frac{A}{\tau}\int_{t-\tau/2}^{t+\tau/2} \cos (at+\alpha)\, dt = \frac{180}{\pi}\frac{A}{a\tau} \sin (at+\alpha)\Big]_{t-\tau/2}^{t+\tau/2}$$

$$= \frac{180}{\pi}\frac{A}{a\tau} \sin \left(at+\alpha+\frac{a\tau}{2}\right) - \sin \left(at+\alpha-\frac{a\tau}{2}\right)$$

$$= \frac{360}{\pi}\frac{A}{a\tau} \cos (at+\alpha) \sin \frac{a\tau}{2} = \frac{360}{\pi a\tau} \sin \frac{a\tau}{2}\, A \cos (at+\alpha) \tag{327}$$

Since the true value of y at any time t, is equal to $A \cos (at+\alpha)$ by (326), it is evident that the relation of this true value to the mean value (327) for the group τ hours in length is

$$\frac{A \cos (at+\alpha)}{\frac{360}{\pi a\tau} \sin \frac{a\tau}{2} A \cos (at+\alpha)} = \frac{\pi a\tau}{360 \sin \frac{a\tau}{2}} \tag{328}$$

The quantity $\dfrac{\pi a\tau}{360 \sin \frac{a\tau}{2}}$ is the augmenting factor which is to be applied to the mean ordinate to obtain the true ordinate. In the use of this factor it is assumed that all the consecutive ordinates within the time $\tau/2$ hours before to $\tau/2$ hours after the given time have been used in obtaining the mean. This assumption is, of course, only approximately realized in the summation for any component, but the larger the series of observations the more nearly to the truth it approaches.

According to the usual summations with the primary stencils, the hourly heights included in a single group may be distributed over an interval from one-half of a component hour before to one-half of a component hour after the hour to be represented. In this case τ equals one component hour, or $\frac{15p}{a}$ solar hours.

Substituting this in (328), the

$$\text{augmenting factor} = \frac{\pi p}{24 \sin \frac{15p}{2}} \tag{329}$$

which is the formula generally adopted and is the one upon which the augmenting factor of Form 194 is based.

If the second system of distribution of the hourly heights as described on page 65 is adopted, τ equals one solar hour and formula (328) becomes

$$\text{augmenting factor} = \frac{\pi a}{360 \sin \frac{a}{2}} \tag{330}$$

It will be noted that formula (329) depends upon the value of p and therefore will be the same for all short period components (S excepted) with like subscripts. Formula (330) depends upon the speed a of the component and will therefore be different for each component.

When the secondary stencils (described in sec. 25) are used, the grouping of the ordinates is less simple than that provided by the primary stencils only. Let it be assumed that the series is of sufficient length so that the distribution of the ordinates is more or less uniform in accordance with the system adopted.

Suppose the original primary summations have been made for component A with speed a and that the secondary stencils have been used for component B with speed b. Then let p and p^1 represent the subscripts of components A and B, respectively.

The equation for component B may be written

$$y = B \cos (bt + \beta) \tag{331}$$

In the primary summation for component A, the group of ordinates included in a single sum covers a period of one component A hour or $\frac{15p}{a}$ solar hours. Expressed in time t, midway of this interval and representing the exact integral component A hour to which the group applied, the average value of the B ordinates included in such a group may be written

$$\begin{aligned}
&\frac{a}{15p} B \int_{t-\frac{15p}{a}}^{t+\frac{15p}{a}} \cos (bt + \beta)\, dt \\
&= \frac{180}{\pi} \frac{a}{15pb} B \left[\sin \left(bt + \beta + \frac{15pb}{2a} \right) - \sin \left(bt + \beta - \frac{15pb}{2a} \right) \right] \\
&= \left(\frac{24}{\pi} \frac{a}{pb} \sin \frac{15pb}{2a} \right) B \cos (bt + \beta) \\
&= F_1 B \cos (bt + \beta) \qquad (332)
\end{aligned}$$

In which F_1, for brevity, is substituted for the coefficient $\frac{24}{\pi}\frac{a}{pb}\sin\frac{15pb}{2a}$ and gives the relation of the average B ordinate included in the A grouping to the true B ordinate for the time t represented by that group. The reciprocal of this coefficient will be that part of the augmenting factor necessary to take account of this primary grouping. If the primary summing has been for the component S, this coefficient may be taken as unity since the original S sums refer to the exact S hour.

When the secondary stencils are applied to the component A group sums, the groups applying to an exact component A hour at any time t and represented by that time, will be distributed over an interval of a component B hour, or $\frac{15p^1}{b}$ solar hours.

For an integral component B hour at any time t within the middle day represented by a seven-day page of original tabulations the limits of this interval will be $\left(t-\frac{15p^1}{2b}\right)$ and $\left(t+\frac{15p^1}{2b}\right)$. For the same page of tabulations, letting t represent the same time in the middle day, the limits of the group interval for the day following the middle one, are $\left(t+\frac{360p}{a}-\frac{15p^1}{2b}\right)$ and $\left(t+\frac{360p}{a}+\frac{15p^1}{2b}\right)$. If we let $n=-3, -2, -1, 0, +1, +2, +3$, respectively, for the seven successive days represented by a single page of original tabulations, the limits of the group interval for any day of the page may be represented by

$$\left(t+\frac{360pn}{a}-\frac{15p^1}{2b}\right) \text{ and } \left(t+\frac{360pn}{a}+\frac{15p^1}{2b}\right)$$

Formula (332) gives the mean value of the B ordinate for grouping of the A summations. The mean value of (332) obtained by combining the groups falling in any particular day of page of tabulations in the limits indicated above is

$$\frac{b}{15p^1}F_1B\int_{t+\frac{360pn}{a}-\frac{15p^1}{2b}}^{t+\frac{360pn}{a}+\frac{15p^1}{2b}}\cos\,(bt+\beta)\,dt$$

$$=\frac{180}{\pi}\frac{1}{15p^1}F_1B\left[\sin\left(bt+\beta+\frac{360bpn}{a}+\frac{15p^1}{2}\right)\right.$$

$$\left.-\sin\left(bt+\beta+\frac{360bpn}{a}-\frac{15p^1}{2}\right)\right]$$

$$=\left(\frac{24}{\pi}\frac{1}{p^1}\sin\frac{15p^1}{2}\right)F_1B\cos\left(bt+\beta+\frac{360pn}{a}\right)$$

$$=F_1F_2B\cos\left(bt+\beta+\frac{360bpn}{a}\right) \qquad (333)$$

if we put $F_2=\frac{24}{\pi}\frac{1}{p^1}\sin\frac{15p^1}{2}$ for brevity.

Formula (333) represents the mean value of the B ordinate for a particular day of the page record. The average value for the 7 days may be written

$$\tfrac{1}{7}\, F_1F_2B \sum_{n=-3}^{n=+3} \cos\left(t+\beta+\frac{360bpn}{a}\right)$$

$$=\tfrac{1}{7}\, F_1F_2B \left[\cos (bt+\beta) \cos\left(-3\,\frac{360bp}{a}\right) - \sin (bt+\beta) \sin\left(-3\,\frac{360bp}{a}\right)\right.$$

$$+\cos (bt+\beta) \cos\left(-2\,\frac{360bp}{a}\right) - \sin (bp+\beta) \sin\left(-2\,\frac{360bp}{a}\right)$$

$$+\cos (bt+\beta) \cos\left(-1\,\frac{360bp}{a}\right) - \sin (bt+\beta) \sin\left(-1\,\frac{360bp}{a}\right)$$

$$+\cos (bt+\beta) \cos 0 - \sin (bt+\beta) \sin 0$$

$$+\cos (bt+\beta) \cos\left(\frac{360bp}{a}\right) - \sin (bt+\beta) \sin\left(\frac{360bp}{a}\right)$$

$$+\cos (bt+\beta) \cos\left(2\,\frac{360bp}{a}\right) - \sin (bt+\beta) \sin\left(2\,\frac{360bp}{a}\right)$$

$$\left.+\cos (bt+\beta) \cos\left(3\,\frac{360bp}{a}\right) - \sin (bt+\beta) \sin\left(3\,\frac{360bp}{a}\right)\right]$$

$$=\tfrac{1}{7}\, F_1F_2B \left[1+2 \cos\frac{360bp}{a}+2 \cos 2\,\frac{360bp}{a}+2 \cos 3\,\frac{360bp}{a}\right] \cos (bt+\beta)$$

$$=\tfrac{1}{7}\, F_1F_2B \left[2\,\frac{\sin 2\,\frac{360bp}{a} \cos \frac{3}{2}\,\frac{360bp}{a}}{\sin \frac{1}{2}\,\frac{360bp}{a}} - 1 \right] \cos (bt+\beta)$$

$$=\tfrac{1}{7}\, F_1F_2B \left[\frac{\sin \frac{1260bp}{a}}{\sin \frac{180bp}{a}} \right] \cos (bt+\beta). \tag{334}$$

Replacing the equivalents of F_1 and F_2 in (334), the average value of the B ordinate as obtained by the secondary summations may be written

$$\left(\frac{24a}{\pi pb} \sin \frac{15bp}{2a}\right)\left(\frac{24}{\pi p^1} \sin \frac{15p^1}{2}\right)\left(\frac{\sin \frac{1260bp}{a}}{7 \sin \frac{180bp}{a}}\right) B \cos (bt+\beta) \tag{335}$$

Since the true ordinate of component B at any time t is equal to $B \cos (bt+\beta)$, the reciprocal of the bracketed coefficient will be the augmenting factor necessary to reduce the B ordinate as obtained from the summations to their true values.

This augmenting factor may be written

$$\left[\frac{\pi bp}{24a\sin\frac{15bp}{2a}}\right]\left[\frac{\pi p^1}{24\sin\frac{15p^1}{2}}\right]\left[\frac{7\sin\frac{180bp}{a}}{\sin\frac{1260bp}{a}}\right] \qquad (336)$$

The first factor of the above is to be omitted if the primary summations are for component S. It will be noted that the middle factor is the same as the augmenting factor that would be used if component B had been subjected to the primary summations.

28. REDUCTION OF EPOCHS AND AMPLITUDES TO MEAN VALUES.

In equation (321), page 84,

$$y = A\cos(p\,\theta - \zeta)$$

the quantity $(-\zeta)$ is the phase of the component at the time θ equals zero—that is, at the beginning of the series—and $p\,\theta$ is equal to ζ at the time y is a maximum; that is, at the time of the component high water. The value of ζ will therefore depend upon the time of the beginning of the series, which is more or less arbitrary, and the ζ's of any component determined from different series of observations are not directly comparable. Expressions for the theoretical phases, or arguments, of the principal lunar components are represented in formula (100), page 35, and a general expression for this argument as modified by a constant κ for a particular locality is given by formula (101), page 39. The last formula is an equivalent of the angle of (321) and may be written

$$(at + V_0 + u - \kappa) = p\,\theta - \zeta \qquad (337)$$

In the above the variable angle $p\ \theta = at$, the angle θ having its zero value at the beginning of the series when t equals zero.

Then

$$V_0 + u - \kappa = -\zeta$$

or $$\kappa = \zeta + V_0 + u \qquad (338)$$

The significance of the expression $(V_0 + u)$ was discussed in section 10.

In (338) κ is a constant that is independent of the beginning of the series, and it is called the opoch of the component. The κ's as determined from different series of observations for the same locality are comparable.

The angle κ may be graphically represented by Figures 1 and 11. In Figure 1, we have a simple representation of a single component. In this figure changes in the phase or angle are measured along the horizontal line, positive change toward the right and negative change toward the left. The full vertical line indicates the beginning of the series, at which time the angle $p\ \theta$, or at, equals 0. At the left of this vertical line, the symbol of a moon (M) indicates the zero value of the equilibrium argument that precedes the beginning of the series. For the principal lunar or solar component, this will be simultaneous with a transit of the mean moon (modified by longitude of moon's node) or of the mean sun, and for other short-period components with the transit of a fictitious star representing such component (p. 38). At the point represented by this moon, the angle $(V+u)$ has a value of zero. This angle increases to the right, and at the beginning of the series has a value represented by (V_0+u), which may be readily computed for the beginning of any series. This interval from M to the time of occurrence of the first following component high water is the epoch κ. This represents the lag or difference between the actual component high water at any place and the theoretical time as determined by the equilibrium theory. The distance from the beginning of the series to the following high water is the ζ of formula (321), which is determined directly from the analysis of the observations. From the figure it is evident that the κ is the sum of (V_0+u) and ζ, and also that it is independent of the time of the beginning of the series.

Figure 11 gives a more detailed representation of the epoch of a component. In this figure the horizontal line represents changes in time. Distances along this line will be proportional to the changes in the angle of any single component, but since each component has a different speed equal distances along this line will not represent equal angles for different components. The time between the events may be converted into an equivalent component angle by multiplying by the speed of the component. The figure is to some extent self-explanatory. The word "transit" signifies the transit of the fictitious moon representing any component and also the time when the equilibrium argument of that component has a zero value. For all short-period components the time of such zero value will depend upon the longitude of the place of observation as well as upon absolute time. For long-period components the zero values are independent of the longitude of the place of observation, and the "transits" over the several meridians may be considered as occurring simultaneously, which is equivalent to taking the coefficient p equal to zero. The figure illustrates the relation between the Greenwich (V_0+u) calculated for the meridian of Greenwich and referring to standard Greenwich time and local (V_0+u) referring to the meridian of observation and the actual time of the beginning of the observations.

Referring to formulas (100), (208), (215), etc., it will be noted that the element of each component argument involving the longitude of the place of observation may be represented by $p\ T$, or $p \times$ (hour angle of mean sun), in which p equals the subscript for the short-period components and zero for the long-period components. The hour angle of the mean sun at any instant is different for each meridian of the earth, the difference being the same as the difference between the longitudes of the places considered. The longitude of Greenwich being zero, the local $(V+u)$ has its origin or zero value at a later time if reckoned toward the west, or at an earlier time if reckoned toward the east, than the Greenwich $(V+u)$. The relation between the local and Greenwich $(V+u)$ may be expressed

$$\text{local } (V+u) = \text{Greenwich } (V+u) - p\,L \tag{339}$$

in which L = longitude of local meridian, positive if west and negative if east.

The (V_0+u) is the value of $(V+u)$ for a certain specific time. In the reduction of any particular series of observations the local

(V_0+u) properly refers to the actual time of the beginning of such series. In the usual analysis where the stencils, or similar devices, are used for the summations it is of great convenience to have all series commence at the zero (0) hour of some day. The absolute time of occurrence of this (0) hour will depend upon the kind of time used at the place of observation, which may be either civil or astronomical, local or standard.

In order to provide convenient tables of (V_0+u) which may be easily adapted to any place or kind of time, the Greenwich (V_0+u) referring to the Greenwich standard time may be used. In this work the reference is to Greenwich mean civil time, but the tables might with equal propriety have been referred to astronomical time had the latter been considered equally convenient.

The rate of change in the $(V+u)$ of any component is the same as the speed of the component. Let c be its ratio to speed of mean sun. The difference between the Greenwich (V_0+u) and the local (V_0+u), due to the difference in the reference to the Greenwich zero hour and zero hour of the kind of time used for the observations, may therefore be expressed by cS in which S is the longitude of time meridian used for the observations, positive for west longitude, negative for east longitude. Combining the last correction with formula (339), the relation between the local and Greenwich (V_0+u) may be expressed,

$$\text{local } (V_0+u) = \text{Greenwich } (V_0+u) - p\,L + c\,S \tag{340}$$

In section 10 attention was called to the distinction between the V_0 and the u. The V_0 is independent of the length of series and is determined entirely by the beginning of the series. The u, which is treated as constant for the entire length of series, takes its value as of the middle of the series and depends, therefore, both upon the beginning and length of series. In the table of Greenwich (V_0+u)'s, the series is taken as one calendar year in length, as the table is designed primarily for preparing constants for the prediction of tides. For the analysis, however, an independent calculation of the local (V_0+u)'s for each series is made in Form 244, Figure 27, which is based upon the formulas of Table 3. Applying these to the ζ's in accordance with formula (338) gives the corrected κ's of the components

The amplitude A as determined from formula (325) must be modified by the argumenting factor, section 27, and Table 20. The resulting amplitude usually designated by R will pertain to the particular time covered by the observations and must be reduced to its mean value H in accordance with section 12. The reduced values of the amplitude H and the epoch κ of the component formula

$$y = H \cos\,(at + V_0 + u - \kappa) \tag{341}$$

are thus determined, but before final acceptance must be subjected to an elimination process to be discussed in the following sections.

29. INFERENCE OF CONSTANTS.

Under the conditions assumed for the equilibrium theory the amplitudes of the components could be computed directly by means of the coefficient formulas without the necessity of securing tidal observations, and the phases would correspond with the equilibrium arguments of the components. Under the conditions that actually exist it has been found from observations that the amplitudes of the components of a similar type at any place, although differing greatly from their theoretical values, have a relation that, in general, agrees fairly closely with the relations of their theoretical coefficients. It has also been ascertained from the results obtained from observations that the difference in the epochs or lags of the components have a relation conforming, in general, with the relation of the differences in the speeds of the components. This last relation is based upon an assumption that the ages of the inequalities in any component due to the disturbing influence of other components of a similar type are equal when expressed in time.

If the mean amplitudes, epochs, and speeds of several components A, B, C, are represented by $H(A)$, $H(B)$, $H(C)$, $\kappa(A)$, $\kappa(B)$, $\kappa(C)$, and a, b, c, respectively, the above relations may be expressed by the following formulas:

$$H(B)=\frac{\text{mean coefficient component } B}{\text{mean coefficient component } A}H(A) \tag{342}$$

$$\kappa(C)-\kappa(A)=\frac{c-a}{b-a}\left[\kappa(B)-\kappa(A)\right] \tag{343}$$

or,

$$\kappa(C)=\kappa(A)+\frac{c-a}{b-a}\left[\kappa(B)-\kappa(A)\right] \tag{344}$$

By formula (342) the amplitude of a component (B) may be inferred from the known amplitude of a component (A), and by formula (344) the epoch of a component (C) may be inferred from the known epochs of components (A) and (B).

These formulas have, however, certain limitations. They are not applicable to shallow water and meteorological components, nor are they adapted to the determination of a diurnal component from a semidurnal component or of a semidiurnal component from a diurnal component. The results obtained by the application of the formulas to tides of similar type may be considered only as rough approximations to the truth. They may, however, be preferable to the values obtained for certain components when the series of observations is short.

By substituting the mean values of the coefficients and the speeds from Table 3 the following special formulas may be derived from the general formulas (342) and (344)

Diurnal components.

$$H\,(J_1)=0.079\,H\,(O_1);\ \kappa\,(J_1)=\kappa\,(K_1)+0.496\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{345}$$
$$H\,(M_1)=0.071\,H\,(O_1);\ \kappa\,(M_1)=\kappa\,(K_1)-0.500\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{346}$$
$$H\,(OO)=0.043\,H\,(O_1);\ \kappa\,(OO)=\kappa\,(K_1)+1.000\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{347}$$
$$H\,(P_1)=0.331\,H\,(K_1);\ \kappa\,(P_1)=\kappa\,(K_1)-0.075\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{348}$$
$$H\,(Q_1)=0.194\,H\,(O_1);\ \kappa\,(Q_1)=\kappa\,(K_1)-1.496\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{349}$$
$$H\,(2Q)=0.026\,H\,(O_1);\ \kappa\,(2Q)=\kappa\,(K_1)-1.992\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{350}$$
$$H\,(\rho_1)=0.038\,H\,(O_1);\ \kappa\,(\rho_1)=\kappa\,(K_1)-1.429\,[\kappa\,(K_1)-\kappa\,(O_1)] \tag{351}$$

Semidiurnal components.

$$H\ (K_2) = 0.272\ H\ (S_2)\ ;\ \kappa\ (K_2) = \kappa\ (S_2)\ + 0.081\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (352)$$
$$H\ (L_2)\ = 0.028\ H\ (M_2)\ ;\ \kappa\ (L_2)\ = \kappa\ (S_2)\ - 0.464\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (353)$$
$$= 0.143\ H\ (N_2)\ ;\qquad = \kappa\ (M_2) + 1.000\ [\kappa\ (M_2) - \kappa\ (N_2)]\quad (354)$$
$$H\ (N_2) = 0.194\ H\ (M_2)\ ;\ \kappa\ (N_2) = \kappa\ (S_2)\ - 1.536\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (355)$$
$$H\ (2N) = 0.026\ H\ (M_2)\ ;\ \kappa\ (2N) = \kappa\ (S_2)\ - 2.072\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (356)$$
$$= 0.133\ H\ (N_2)\ ;\qquad = \kappa\ (M_2) - 2.000\ [\kappa\ (M_2) - \kappa\ (N_2)]\quad (357)$$
$$H\ (R_2) = 0.008\ H\ (S_2)\ ;\ \kappa\ (R_2) = \kappa\ (S_2)\ + 0.040\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (358)$$
$$H\ (T_2)\ = 0.059\ H\ (S_2)\ ;\ \kappa\ (T_2)\ = \kappa\ (S_2)\ - 0.040\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (359)$$
$$H\ (\lambda_2)\ = 0.007\ H\ (M_2)\ ;\ \kappa\ (\lambda_2)\ = \kappa\ (S_2)\ - 0.536\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (360)$$
$$H\ (\mu_2)\ = 0.024\ H\ (M_2)\ ;\ \kappa\ (\mu_2)\ = \kappa\ (S_2)\ - 2.000\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (361)$$
$$H\ (\nu_2)\ = 0.038\ H\ (M_2)\ ;\ \kappa\ (\nu_2)\ = \kappa\ (S_2)\ - 1.464\ [\kappa\ (S_2)\ - \kappa\ (M_2)]\quad (362)$$
$$= 0.194\ H\ (N_2)\ ;\qquad = \kappa\ (M_2) - 0.866\ [\kappa\ (M_2) - \kappa\ (N_2)]\quad (363)$$

In order to test the reliability of the results obtained by inference as above, 60 stations, representing various types of tide in different parts of the world, where the harmonic constants had been determined from observations, were selected, and a comparison was made between the values for certain constants as obtained by inference and by observations. The tests were applied to the diurnal components M_1, P_1, and Q_1, and to the semidiurnal components K_2, L_2, and ν_2, and formulas (346), (348), (349), (352), (353), and (362) were used for the purpose. The following results were obtained for the differences between values as obtained from inference and from observations. The average gross difference is the average difference without regard to the signs of the individual items, and the average net difference takes into account these signs so that a positive difference may offset a negative difference in the mean. The last two lines in the table show the percentage of cases in which the differences were less than 0.05 and 0.10 foot, respectively, for the amplitudes, and less than 10° and 20°, respectively, for the epochs.

	M_1 amplitude.	M_1 Epoch.	P_1 amplitude.	P_1 Epoch.	Q_1 amplitude.	Q_1 Epoch.
	Ft.	*Deg.*	*Ft.*	*Deg.*	*Ft.*	*Deg.*
Maximum difference	0.05	149	0.27	49	0.05	105
Average gross difference	.02	31	.03	8	.01	14
Average net difference	.01	1	.01	3	.00	0
	%	%	%	%	%	%
Differences less than 0.05 foot or 10°	93	37	85	76	96	58
Differences less than 0.10 foot or 20°	100	57	92	92	100	82

	K_2 amplitude.	K_2 Epoch.	L_2 amplitude.	L_2 Epoch.	ν_2 amplitude.	ν_2 Epoch.
	Ft.	*Deg.*	*Ft.*	*Deg.*	*Ft.*	*Deg.*
Maximum difference	0.28	51	1.09	104	0.28	53
Average gross difference	.02	9	.09	25	.04	14
Average net difference	.00	5	.08	4	.02	4
	%	%	%	%	%	%
Differences less than 0.05 foot or 10°	87	65	58	20	71	48
Differences less than 0.10 foot or 20°	97	93	78	44	88	83

By using formulas (354) and (363) for L_2 and ν_2 the results are slightly improved, the average net differences for the amplitude and epoch of L_2 becoming 0.07 foot and 3°, respectively, the difference for the epoch of ν_2 becoming 2°, while the average net difference for the amplitude of ν_2 remains unchanged.

Although there is a fairly good agreement indicated by the average differences, it is evident that the inferred constants, especially the epochs, can not, in general, be depended upon for any high degree of refinement. It may be stated, however, that for components with very small amplitudes the epochs as determined from actual observations may be equally unreliable. A comparison of the epochs of several of these small components as determined from series a year in length, with the mean epochs as determined from many years, indicated as much uncertainty as was found among the inferred results. Fortunately, these large probable errors in the epochs are found only in the components with very small amplitudes and are therefore of little real practical importance.

Form 452 (figs. 30–31) is designed for inference of certain constants in accordance with formulas (345) to (363). The numerical coefficients for the epochs are taken in convenient rounded numbers, since the large uncertainty in the results renders useless any effort to a high degree of refinement.

Form 452 provides not only for the computation of certain inferred constants in accordance with the given formulas, but also for the compilation of the best-known preliminary values of all the constants that are to be used in the elimination process described in the following section. Of the principal components, the values for M_2, N_2, and O_1 are taken directly as obtained from Form 194, but the values for components S_2 and K_1 may be improved by an approximate elimination of the effects of the components K_2 and T_2 from the former and P_1 from the latter. In a short series the effect of the components upon each other is considerable on account of the small difference in their speeds.

Let

$$y_1 = A \cos (at + \alpha) \tag{364}$$

and

$$y_2 = B \cos (bt + \beta) \tag{365}$$

represent two components, the first being the principal or predominating component and the latter a secondary component whose effect is to modify the amplitude and epoch of the principal component. The resultant tide will then be represented by

$$y = y_1 + y_2 = A \cos (at + \alpha) + B \cos (bt + \beta) \tag{366}$$

Values of t which will render (364) a maximum must satisfy the derived equation

$$Aa \sin (at + \alpha) = 0 \tag{367}$$

and the values of t which will render (366) a maximum must satisfy the equation

$$Aa \sin (at + \alpha) + Bb \sin (bt + \beta) = 0 \tag{368}$$

For a maximum of (364)

$$t = \frac{2n\pi - \alpha}{a} \tag{369}$$

in which n is any integer.

Let $\frac{\theta}{a}$ = the acceleration in the principal component A due to the disturbing component B. Then for a maximum of (366),

$$t=\frac{2n\pi-\alpha-\theta}{a} \tag{370}$$

This value of t must satisfy equation (368), therefore we have

$$Aa\sin(2n\pi-\theta)+Bb\sin\left[\frac{b}{a}(2n\pi-\theta-\alpha)+\beta\right]$$
$$=-Aa\sin\theta+Bb\sin\left[\frac{b-a}{a}(2n\pi-\theta-\alpha)+\beta-\alpha-\theta\right]=0 \tag{371}$$

At the time of this maximum, when

$$t=\frac{2n\pi-\alpha-\theta}{a},$$

the phase of component A will equal

$$(2n\pi-\alpha-\theta)+\alpha$$

and the phase of component B will equal

$$\frac{b}{a}(2n\pi-\alpha-\theta)+\beta$$

Let ϕ = phase of component B − phase of component A at this time.

Then

$$\phi=\frac{b-a}{a}(2n\pi-\alpha-\theta)+\beta-\alpha \tag{372}$$

Substituting the above in (371)

$$\begin{aligned}&-Aa\sin\theta+Bb\sin(\phi-\theta)\\&=-Aa\sin\theta+Bb\sin\phi\cos\theta-Bb\cos\phi\sin\theta\\&=-(Aa+Bb\cos\phi)\sin\theta+Bb\sin\phi\cos\theta=0\end{aligned} \tag{373}$$

Then

$$\tan\theta=\frac{Bb\sin\phi}{Aa+Bb\cos\phi} \tag{374}$$

For the resultant amplitude at the time of this maximum substitute the values of t from (370), in (366), and we have

$$\begin{aligned}y&=A\cos(2n\pi-\theta)+\mathrm{B}\cos\left[\frac{b}{a}(2n\pi-\theta-\alpha)+\beta\right]\\&=A\cos\theta+B\cos\left[\frac{b-a}{a}(2n\pi-\theta-\alpha)+\beta-\alpha-\theta\right]\\&=A\cos\theta+B\cos(\phi-\theta)\\&=A\cos\theta+B\cos\phi\cos\theta+B\sin\phi\sin\theta\\&=(A+B\cos\phi)\cos\theta+B\sin\phi\sin\theta\\&=\sqrt{A^2+B^2+2AB\cos\phi}\cos\left(\theta-\tan^{-1}\frac{B\sin\phi}{A+B\cos\phi}\right)\end{aligned} \tag{375}$$

From (374)

$$\theta=\tan^{-1}\frac{B\sin\phi}{A\frac{a}{b}+B\cos\phi}=\tan^{-1}\frac{\sin\phi}{\frac{Aa}{Bb}+\cos\phi} \tag{376}$$

In the special cases under consideration the ratio $\frac{a}{b}$ is near unity, and the difference between θ and $\tan^{-1}\frac{B\sin\phi}{A+B\cos\phi}$ is therefore very small, so that the cosine may be taken as unity.

The resultant amplitude may therefore be expressed by

$$\sqrt{A^2+B^2+2AB\cos\phi}=A\sqrt{1+\frac{B^2}{A^2}+2\frac{B}{A}\cos\phi} \tag{377}$$

The true amplitude of the component sought being A, the resultant amplitude must be divided by the factor

$$\sqrt{1+\frac{B^2}{A^2}+2\frac{B}{A}\cos\phi} \tag{378}$$

in order to correct for the influence of the disturbing component.

The corrections for acceleration and amplitudes as indicated by formulas (374) and (378) may to advantage be applied to the constants for component K_1 for an approximate elimination of the effects of component P_1 and to the constants for S_2 for an approximate elimination of the effects of components K_2 and T_2. By taking the relations of the theoretical coefficients for the ratios $\frac{B}{A}$ and the differences in the equilibrium arguments as the approximate equivalents of the phase differences represented by ϕ, tables may be prepared giving the acceleration and resultant amplitudes with the arguments referring to certain solar elements.

Thus, from Table 3, the following values may be obtained.

	$\frac{B}{A}$	$\frac{Aa}{Bb}$	ϕ
Effect of P_1 on K_1	0.33086	3.03904	$-2h+\nu'-180°$.
Effect of K_2 on S_2	0.27213	3.66469	$2h-2\nu''$.
Effect of T_2 on S_2	0.05881	17.02813	$-h+p_1$.

Substituting the above in (344) and (378) we have

Effect of P_1 on K_1

$$\text{Acceleration}=\tan^{-1}\frac{\sin(2h-\nu')}{3.0390-\cos(2h-\nu')} \tag{379}$$

$$\text{Resultant amplitude}=0.813\sqrt{1.6767-\cos(2h-\nu')} \tag{380}$$

Effect of K_2 on S_2

$$\text{Acceleration}=\tan^{-1}\frac{\sin(2h-2\nu'')}{3.6647+\cos(2h-2\nu'')} \tag{381}$$

$$\text{Resultant amplitude}=0.738\sqrt{1.9734+\cos(2h-2\nu'')} \tag{382}$$

Effect of T_2 on S_2

$$\text{Acceleration} = \tan^{-1} \frac{-\sin (h-p_1)}{17.0281 + \cos (h-p_1)} \tag{383}$$

$$\text{Resultant amplitude} = 0.343 \sqrt{8.5318 + \cos(h-p_1)} \tag{384}$$

The above formulas give the accelerations and resulting amplitudes for any individual high water. For the correction of the constants derived from a series covering many high waters it is necessary to take averages covering the period of observations. Tables 21 to 26 give such average values for different lengths of series, the argument in each case referring to the beginning of the series.

In the preceding formulas the mean values of the coefficients were taken to obtain the ratios $\frac{A}{B}$. To take account of the longitude of the moon's node, the factor of reduction from section 12 should be introduced. If the mean coefficients are indicated by the subscript o, formulas (376) and (378) may be written

$$\text{Acceleration} = \tan^{-1} \frac{\sin \phi}{\frac{f(A)A_oa}{f(B)B_ob} + \cos \phi} \tag{385}$$

$$\text{Resultant amplitude} = \sqrt{1 + \left(\frac{f(B)B_o}{f(A)A_o}\right)^2 + 2\frac{f(B)B_o}{f(A)A_o} \cos \phi} \tag{386}$$

In the cases under consideration the ratio $\frac{f(A)}{f(B)}$ will not differ greatly from unity, the ratio $\frac{A_oa}{B_ob}$ will be rather large compared with $\cos \phi$, which can never exceed unity, and the acceleration itself is relatively small. Because of these conditions the following may be taken as the approximate equivalent of (385).

$$\text{Acceleration} = \frac{f(B)}{f(A)} \tan^{-1} \frac{\sin \phi}{\frac{A_oa}{B_ob} + \cos \phi} \tag{387}$$

Also because $\frac{B_o}{A_o}$ in these cases is small compared with unity, the following may be taken as the approximate equivalent of (386):

$$\text{Resulting amplitude} = 1 + \frac{f(B)}{f(A)}\left[\sqrt{1 + \left(\frac{B_o}{A_o}\right)^2 + 2\,\frac{B_o}{A_o} \cos \phi} - 1\right] \tag{388}$$

To allow for the effects of the longitude of the moon's node, the tabular value of the acceleration should, therefore, be multiplied by the ratio $\frac{f(B)}{f(A)}$ and the amount by which the resultant amplitude differs from unity by the same factor. In the particular cases under consideration the factor f, for components P_1, S_2, and T_2, is unity for each. Therefore, for the effect of P_1 on K_1, the ratio $\frac{f(B)}{f(A)} = \frac{1}{f(K_1)} = F(K_1)$, and for the effect of K_2 upon S_2, this ratio is $f(K_2)$. For the effect of T_2 upon S_2 the ratio is unity.

30. ELIMINATION.

Because of the limited length of a series of observations analyzed the amplitudes and epochs of the components as obtained by the processes described in the preceeding sections are only approximately freed from the effects of each other. The separation of two components from each other might be satisfactorily accomplished by having the length of series equal to a multiple of the synodic period of the two components. To completely effect the separation of all the components from each other by the same process would require a series of such a length that it would contain an exact multiple of the period of each component. The length of such a series would be too great to be given practical consideration. In general, it is therefore desirable to apply certain corrections to the constants as directly obtained from the analysis in order to eliminate the residual effects of the components upon each other.

Let A be the designation of a component for which the true constants are sought and let B be the general designation for each of the other components in the tide, the effects of which are to be eliminated from component A.

Let the original tide curve which has been analyzed be represented by the formula

$$y = A\cos(at+\alpha) + \Sigma B\cos(bt+\beta) \tag{389}$$

in which

y = the height of the tide above mean sea level at any time t.

t = time reckoned in mean solar hours from the beginning of the series as the origin.

$A = R(A)$ = true amplitude of the component A for the time covered by series of observations.

$B = R(B)$ = true amplitude of component B for the time covered by series of observations.

$\alpha = -\zeta(A)$ = true initial phase of component A at beginning of series.

$\beta = -\zeta(B)$ = true initial phase of component B at beginning of series.

a = speeds of component A.

b = speed of component B.

Formula (389) may be written

$$\begin{aligned} y &= A\cos\alpha\cos at + \Sigma\, B\cos\{(b-a)t+\beta\}\cos at \\ &\quad - A\sin\alpha\sin at - \Sigma\, B\sin\{(b-a)t+\beta\}\sin at \\ &= [A\cos\alpha + \Sigma\, B\cos\{(b-a)t+\beta\}]\cos at \\ &\quad - [A\sin\alpha + \Sigma\, B\sin\{(b-a)t+\beta\}]\sin at \end{aligned} \tag{390}$$

The mean values of the coefficients of $\cos at$ and $\sin at$ of formula (390) correspond to the coefficients C_p and S_p of formulas (316) and (317) which are obtained from the summations for component A.

Let A^1 and α^1 = the uneliminated amplitude and initial phase, respectively, of component A, as obtained directly from the analysis.

The equation of the uneliminated component A tide may be written

$$y = A^1\cos(at+\alpha^1) = A^1\cos\alpha^1\cos at - A^1\sin\alpha^1\sin at \tag{391}$$

Comparing (390) and (391), it will be found that

$$A^1 \cos \alpha^1 = \text{mean value of } [A \cos \alpha + \Sigma B \cos \{(b-a)t+\beta\}] \quad (392)$$

$$A^1 \sin \alpha^1 = \text{mean value of } [A \sin \alpha + \Sigma B \sin \{(b-a)t+\beta\}] \quad (393)$$

Let τ = length of series in mean solar hours. Then the mean value of $B \cos\{(b-a)t+\beta\}$ within the limits $t=0$ and $t=\tau$, is

$$\frac{1}{\tau}\int_0^\tau B \cos\{(b-a)t+\beta\}dt = \frac{180}{\pi} \frac{B}{(b-a)\tau} [\sin\{(b-a)\tau+\beta\} - \sin \beta]$$

$$= \frac{180}{\pi} \frac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\pi} B \cos\{\tfrac{1}{2}(b-a)\tau+\beta\} \quad (394)$$

The mean value of $B \sin\{(b-a)t+\beta\}$ within the same limits is

$$\frac{1}{\tau}\int_0^\tau B \sin\{(b-a)t+\beta\}dt = \frac{180}{\pi} \frac{B}{(b-a)\tau} [\cos\{(b-a)\tau+\beta\} - \cos \beta]$$

$$= \frac{180}{\pi} \frac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau} B \sin\{\tfrac{1}{2}(b-a)\tau+\beta\} \quad (395)$$

Substituting (394) and (395) in (392) and (393), and for brevity letting

$$F_b = \frac{180}{\pi} \frac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau} B \quad (396)$$

we have

$$A^1 \cos \alpha^1 = A \cos \alpha + \Sigma F_b \cos\{\tfrac{1}{2}(b-a)\tau+\beta\} \quad (397)$$

$$A^1 \sin \alpha^1 = A \sin \alpha + \Sigma F_b \sin\{\tfrac{1}{2}(b-a)\tau+\beta\} \quad (398)$$

Transposing,

$$A \cos \alpha = A^1 \cos \alpha^1 - \Sigma F_b \cos\{\tfrac{1}{2}(b-a)\tau+\beta\} \quad (399)$$

$$A \sin \alpha = A^1 \sin \alpha^1 - \Sigma F_b \sin\{\tfrac{1}{2}(b-a)\tau+\beta\} \quad (400)$$

Multiplying (399) and (400) by $\sin \alpha^1$ and $\cos \alpha^1$, respectively,

$$A \sin \alpha^1 \cos \alpha = A^1 \sin \alpha^1 \cos \alpha^1 - \Sigma F_b \cos\{\tfrac{1}{2}(b-a)\tau+\beta\} \sin \alpha^1 \quad (401)$$

$$A \cos \alpha^1 \sin \alpha = A^1 \sin \alpha^1 \cos \alpha^1 - \Sigma F_b \sin\{\tfrac{1}{2}(b-a)\tau+\beta\} \cos \alpha^1 \quad (402)$$

Subtracting (402) from (401)

$$A \sin(\alpha^1-\alpha) = \Sigma F_b \sin\{\tfrac{1}{2}(b-a)\tau+\beta-\alpha^1\} \quad (403)$$

Multiplying (399) and (400) by $\cos \alpha^1$ and $\sin \alpha^1$, respectively,

$$A \cos \alpha^1 \cos \alpha = A^1 \cos^2 \alpha^1 - \Sigma F_b \cos\{\tfrac{1}{2}(b-a)\tau+\beta\} \cos \alpha^1 \quad (404)$$

$$A \sin \alpha^1 \sin \alpha = A^1 \sin^2 \alpha^1 - \Sigma F_b \sin\{\tfrac{1}{2}(b-a)\tau+\beta\} \sin \alpha^1 \quad (405)$$

Taking the sum of (404) and (405)

$$A \cos(\alpha^1-\alpha) = A^1 - \Sigma F_b \cos\{\tfrac{1}{2}(b-a)\tau+\beta-\alpha^1\} \quad (406)$$

Dividing (403) by (406)

$$\tan(\alpha^1-\alpha) = \frac{\Sigma F_b \sin\{\frac{1}{2}(b-a)\tau+\beta-\alpha^1\}}{A^1 - \Sigma F_b \cos\{\frac{1}{2}(b-a)\tau+\beta-\alpha^1\}} \quad (407)$$

From (406)

$$A = \frac{A^1 - \Sigma\ F_b \cos\ \{\tfrac{1}{2}(b-a)\tau + \beta - \alpha^1\}}{\cos\ (\alpha^1 - \alpha)} \tag{408}$$

Substituting the value F_p from (396) and the equivalents $R^1(A)$, $R(A)$, $R(B)$, $-\zeta^1(A)$ $-\zeta(A)$, and $-\zeta(B)$ for A^1, A, B, α^1, α, and β, respectively, we have by (407) and (408)

$$\tan\ [\zeta(A) - \zeta^1(A)]$$

$$= \frac{\Sigma\ \dfrac{180}{\pi}\ \dfrac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\ \tau}\ R(B)\ \sin\ \{\tfrac{1}{2}(b-a)\tau - \zeta(B) + \zeta^1(A)\}}{R^1(A) - \Sigma\ \dfrac{180}{\pi}\ \dfrac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau}\ R(B)\ \cos\ \{\tfrac{1}{2}(b-a)\tau - \zeta(B) + \zeta^1\ (A)\}} \tag{409}$$

$$R(A) = \frac{R^1(A) - \Sigma\ \dfrac{180}{\pi}\ \dfrac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau}\ R(B)\ \cos\ \{\tfrac{1}{2}(b-a)\tau - \zeta(B) + \zeta^1(A)\}}{\cos\ [\zeta(A) - \zeta^1(A)]} \tag{410}$$

Formula (409) gives an expression for obtaining the difference to be applied to the uneliminated $\zeta^1(A)$ in order to obtain the true $\zeta(A)$, and formula (410) gives an expression for obtaining the true amplitude $R(A)$. These formulas can not, however, be rigorously applied, because the true values of $R(B)$ and $\zeta(B)$ of the disturbing components are, in general, not known, but very satisfactory results may be obtained by using the approximate values of $R(B)$ and $\zeta(B)$ derived from the analysis or by inference.

By a series of successive approximations, using each time in the formulas, the newly eliminated values for the disturbing components, any desired degree of refinement may be obtained; but the first approximation is usually sufficient, and all that is justified because of the greater irregularities existing from other causes.

Form 245 (fig. 32) provides for the computations necessary in applying formulas (409) and (410).

In these formulas the factors represented by $\dfrac{180}{\pi}\ \dfrac{\sin \frac{1}{2}(b-a)}{\frac{1}{2}(b-a)\tau}$, and the angles represented by $\frac{1}{2}(b-a)\tau$ will depend upon the length of series; but for any given length of series they will be constant for all times and places. Table 29 has been computed to give these quantities for different lengths of series. The factor as directly obtained may be either positive or negative, but for convenience the tabular values are all given as positive, and when the factor as directly obtained is negative the angle has been modified by $\pm 180°$ in order to compensate for the change of sign in the factor and permit the tabular values to be used directly in formulas (409) and (410).

An examination of formulas (409) and (410) will show that the disturbing effect of one component upon another will depend largely upon the magnitude of the fraction $\dfrac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau}$. Assuming that b is not equal to a, this fraction and the disturbing effect it represents will approach zero as the length of series τ approaches in value $\dfrac{360°}{(b-a)}$, or any multiple thereof, or, in other words, as τ approaches in length any multiple of the synodic period of components A and B. Also, since the numerator of the fraction can never exceed unity, while the denominator may be increased indefinitely, the value of the fraction will, in general, be diminished by increasing the length of series and will approach zero as τ approaches infinity. The greater the difference $(b-a)$ between the speeds of the two components the less will be their disturbing effects upon each other. For this reason the effects upon each other of the diurnal and semidiurnal components or of any components of different subscripts is usually considered as negligible, and in the application of formulas (409) and (410) only components with like subscripts are taken into account.

The quantities $R(B)$ and $\zeta(B)$ of formulas (409) and (410) refer to the true amplitudes and epochs of the disturbing components. These true values being in general unknown when the elimination process is to be applied, it is desirable that there should be used in the formulas the closest approximation to such values as are obtainable. If the series of observations cover a period of a year or more, the amplitudes and epochs as directly obtained from the analysis may be considered sufficiently close approximations for use in the formulas. For short series of observations, however, the values as directly obtained for the amplitudes and epochs of some of the components may be so far from the true values that they are entirely unserviceable for use in the formulas. In such cases inferred values for the disturbing components should be used.

31. LONG-PERIOD COMPONENTS.

The preceding discussions have been especially applicable to the reduction of the short-period components—those having a period of a component day or less. They are the components that determine the daily or semidaily rise and fall of the tide. Consideration will now be given to the long-period tides which affect the mean level of the water from day to day, but which have practically little or no effect upon the times of the high and low waters. There are five such long-period components that are usually treated in works on harmonic analysis—the lunar fortnightly Mf, the lunisolar synodic fortnightly MSf, the lunar monthly Mm, the solar semiannual Ssa, and the solar annual Sa. The first three are usually too small to be of practical importance, but the last two, depending largely upon meteorological conditions, often have an appreciable effect upon the mean daily level of the water.

To obtain the long-period components, methods similar to those adopted for the short-period components with certain modifications may be used. For the fortnightly and monthly components the component month may be divided into 24 equal parts, analogous to the 24 component hours of the day. Similarly, for the semiannual and annual components the component year may be divided into 24 equal parts, although it will often be found more convenient to divide the year into 12 parts to correspond approximately with the 12 calendar months.

Instead of distributing the individual hourly heights, as for the short-period components, a considerable amount of labor can be saved by using the daily sums of these heights. The mean of each sum is to be considered as applying to the middle instant of the period from 0 hour to 23d hour; that is, at the 11.5 hour of the day. If the component month or component year is divided into 24 equal parts, the instants separating the groups may be numbered consecutively, like the component hours, from 0 to 23, with the 0 instant of the first groups taken at the exact beginning of the series. A table may now be prepared (Table 34) which will show to which division each daily sum, or mean, of the series must be assigned.

Letting

a = the hourly speed of any component, in degrees.
p = 1 when applied to a monthly or an annual component, and
p = 2 when applied to a fortnightly or a semiannual component.
d = day of series.
s = solar hour of day.

Then

$$1 \text{ component period} = \frac{360}{a} \text{ solar hours} \tag{411}$$

and

$$1 \text{ component month} = \frac{360p}{a} \text{ solar hours} \tag{412}$$

also

$$1 \text{ component year} = \frac{360p}{a} \text{ solar hours} \tag{413}$$

Dividing the component month or component year into 24 equal parts, the length of

$$1 \text{ component division} = \frac{15p}{a} \text{ solar hours} \tag{414}$$

Therefore, to express the time of any solar hour in units of the component divisions to which the solar hourly heights are to be assigned, the solar hour should be multiplied by the factor $a/15p$.

Thus,

$$\begin{aligned} \text{Component division} &= \frac{a}{15p} \text{ (solar hour of series)} \\ &= \frac{a}{15p}\,[24(d-1)+s] \\ &= \frac{a}{15p}\,[24(d-1)+11.5] \end{aligned} \tag{415}$$

since in using the daily sums, the solar hour of the day to which each such sum applies will always be 11.5 hour.

By substituting the speeds of the components from Table 3 the following numerical values are obtained for the coefficient $\frac{a}{15p}$:

Mf . . . 0.036,601,10; MSf . . . 0.033,863,19; Mm. . . 0.036,291,65;
Sa. and Ssa . . . 0.002,737,91.

By using the appropriate coefficient and substituting successively the numerals corresponding to the day of series (d), the corresponding value of the component division to which each daily sum is to be assigned may be readily obtained. The value of such division as obtained directly from the formula will usually be a mixed number. For Table 34 the nearest integral number, less any multiple of 24, is used.

The distribution of the daily sums for the analysis of the long-period components may be conveniently accomplished by copying such sums in Form 142 (fig. 25), taking the component divisions as the equivalents of the component hours and using Table 34 to determine the division or hour to which each sum should be assigned. The total sum and mean for each division may then be readily obtained. These means can then be treated as the hourly means of the short-period tides according to the processes outlined in Form 194 (fig. 29) with such modifications as will now be described.

In using the daily means as ordinates of a long-period component consideration must be given to the residual effects of any of the short-period components upon such means and steps taken to clear the means of these effects when necessary. Component S_2 with a period commensurate with the solar day, may be considered as being completely eliminated from each daily mean. Components K_1 and K_2 are very nearly eliminated, because the component K day is very nearly equal to the solar day. Other short-period components may affect the daily means to a greater or less extent, depending largely upon their amplitudes. Of these the principal ones are components M_2, N_2, and O_1. In the distribution and grouping of the daily means for the analysis of the several long-period components the disturbing effects of the short-period components just enumerated, excepting the effect of M_2 upon MSf, will be greatly reduced, and in a series covering several years may be practically eliminated.

Because the period of MSf is the same as the synodic period of M_2 and S_2 there will always remain a residual effect of the component M_2 in the component MSf sums of the daily means, no matter how long the series, which must be removed by a special process.

Let the equation of one of the short-period components be

$$y = A \cos (at + \alpha) \tag{416}$$

Letting d = day of series, the values of t for the hours 0 to 23 of d day will be

$$24(d-1),\ 24(d-1)+1,\ 24(d-1)+2,\ .\ .\ .\ .\ 24(d-1)+23.$$

Substituting these values for t in (416) and designating the corresponding values of the ordinate y as y_0, y_1, y_2 . . . . y_{23} the following are obtained:

$$\left.\begin{aligned} y_0 &= A \cos [24(d-1)a+\alpha] \\ y_1 &= A \cos [24(d-1)a+\alpha+a] \\ y_2 &= A \cos [24(d-1)a+\alpha+2a] \\ &\text{-------------------------} \\ y_{23} &= A \cos [24(d-1)a+\alpha+23a] \end{aligned}\right\} \tag{417}$$

Representing the mean of these 24 ordinates for d day by y_d, we have

$$y_d = \frac{1}{24} A \cos\{24(d-1)a+\alpha\} [1+\cos a+\cos 2a+\cdots+\cos 23a]$$

$$-\frac{1}{24} A \sin\{24(d-1)a+\alpha\} [\sin a+\sin 2a+\cdots+\sin 23a]$$

$$=\frac{1}{24} A \frac{\sin 12a}{\sin \frac{1}{2}a} \left[\cos\{24(d-1)a+\alpha\} \cos\frac{23}{2}a \right.$$

$$\left. -\sin\{24(d-1)a+\alpha\} \sin\frac{23}{2}a\right]$$

$$=\frac{1}{24} A \frac{\sin 12a}{\sin \frac{1}{2}a} \cos\{24(d-1)a+\alpha+11.5a\} \tag{418}$$

Formula (418), representing the average value of the component A ordinates contained in the daily mean for d day, is the correction or clearance that must be subtracted from the mean for that day in order to eliminate the effects of component A. It will be noted that if we let A represent any of the solar components, S_1, S_2, S_3, S_4, etc., the factor sin $12a$, and consequently the entire formula, becomes zero for all values of d.

By formula (418) clearances for each of the disturbing short-period components for each day of series may be computed and these clearances then applied individually to the daily means, or, if first multiplied by the factor 24, to the daily sums.

The labor involved in making independent calculations for the clearance of the effect of each short-period component for each day of series would be considerable, but this may be avoided to a large extent by means of a tide-computing machine.

If we let t = time reckoned in mean solar hours from the beginning of the series, then for any value of y_d, which must apply to the 11.5 hour of d day,

$$t = 24(d-1)+11.5$$

and

$$at = 24(d-1)a+11.5a \tag{419}$$

If the above equivalent is substituted in (418) and y_d replaced by y_a, we have

$$y_a = \frac{1}{24} A \frac{\sin 12a}{\sin \frac{1}{2}a} \cos(at+\alpha) \tag{420}$$

which represents a continuous function of t; and for any value of t corresponding to the 11.5 hour of d day the corresponding value of y_a will be y_d. This formula is the same as that for the short-period component A, except that it includes the factor $\frac{1}{24}\frac{\sin 12a}{\sin \frac{1}{2}a}$ in the coefficient. The speed a is, of course, a known constant, and the values of A and α are presumed to have already been determined from the harmonic analysis of the short-period components. Similarly, the disturbing effects of other short-period components may be represented by

$$y_{\mathrm{b}}=\frac{1}{24}B\frac{\sin 12b}{\sin \frac{1}{2}b}\cos(bt+\beta)$$

$$y_{\mathrm{c}}=\frac{1}{24}C\frac{\sin 12c}{\sin \frac{1}{2}c}\cos(ct+\gamma) \qquad (421)$$

etc.

The combined disturbing effect of all the short-period components may, therefore, be represented by the equation

$$y=y_{\mathrm{a}}+y_{\mathrm{b}}+\text{etc.}=\frac{1}{24}A\frac{\sin 12a}{\sin \frac{1}{2}a}\cos(at+\alpha)$$

$$+\frac{1}{24}B\frac{\sin 12b}{\sin \frac{1}{2}b}\cos(bt+\beta)+\text{etc.} \qquad (422)$$

This formula is adapted to use on the tide-computing machine. With the component cranks set in accordance with the coefficients and initial epochs of the above formula, the machine will indicate the values of y corresponding to successive values of t. The values of y desired for the clearances are those which correspond to t at the 11.5 hour on each day. Thus, the clearance for each successive day of series may be read directly from the dials of the machine. In practice, it may be found more convenient to use the daily sums rather than the daily means for the analysis. In this case the coefficients of the terms of (422) should be multiplied by the factor 24 before being used in the tide-computing machine.

Assuming that all the daily sums are used in the analysis, the augmenting factor represented by formula (329) which is used for the short-period component is also applicable to the long-period components, with p representing the number of component periods in a component month or a component year. Thus, for components Mm and Sa, p equals 1, and for Mf, MSf, and Ssa, p equals 2. For the long-period components a further correction or augmenting factor is necessary, because the mean or sum of the 24 hourly heights of the day is used to represent the single ordinate at the 11.5 hour of the day.

If we let formula (416) be the equation of the long-period component sought, formula (420) will give the mean value of the 24 ordinates of the day which, in the grouping for the analysis, is taken as representing the 11.5 hour of the day or the t_{d} hour of the series. Since the true component ordinate for this hour should be $A\cos(at_{\mathrm{d}}+\alpha)$, it is evident that an augmenting factor of $24\frac{\sin \frac{1}{2}a}{\sin 12a}$ must be applied to the mean ordinates as derived from the sum of the 24 hourly heights of the day in order to reduce the means to the 11.5 hour of each day.

The complete augmenting factor for the long-period components will therefore be obtained by combining the above with (329) to obtain

$$\frac{\pi p}{24\sin\dfrac{15p}{2}}\times\frac{24\sin \frac{1}{2}a}{\sin 12a} \qquad (423)$$

Values obtained from formula (423) are given in Table 20.

The following method of reducing the long-period tides, which conforms to the system outlined by Sir George H. Darwin, differs to some extent from that just described. In this discussion it is assumed that a series of 365 days is used.

Let the entire tide due to the five long-period components already named be represented by the equation

$$y = A\cos(at+\alpha) + B\cos(bt+\beta) + C\cos(at+\gamma) \\ + D\cos(dt+\delta) + E\cos(et+\epsilon) \tag{424}$$

For convenience in this discussion let t be reckoned from the 11.5th solar hour of the first day of series instead of the midnight beginning that day. Every value of t to which the daily means refer will then be either 0 or a multiple of 24.

Let A', B', C', D', and E', equal
$A\cos\alpha$, $B\cos\beta$, $C\cos\gamma$, $D\cos\delta$, and $E\cos\epsilon$, respectively, and
A'', B'', C'', D'', and E'', equal
$-A\sin\alpha$, $-B\sin\beta$, $-C\sin\gamma$, $-D\sin\delta$, and $-E\sin\epsilon$, respectively. (425)

Then formula (424) may be written

$$y = A'\cos at + B'\cos bt + C'\cos ct + D'\cos dt + E'\cos et \\ + A''\sin at + B''\sin bt + C''\sin ct + D''\sin dt + E''\sin et \tag{426}$$

In the above equation there are 10 unknown quantities, A', A'', B', B'', etc., for which values are sought in order to obtain from them the amplitudes and epochs of the five long-period components. The most probable values of these quantities may be found by the least square adjustment.

Let $y_1, y_2, \ldots y_{365}$ represent the daily means for a 365 day series, as obtained from observations. If we let n be any day of the series, the value of t to which that mean applies will be $24(n-1)$. By substituting in formula (426) the successive values of y and the values of t to which they correspond, 365 observational equations are formed as follows:

$$\left.\begin{aligned} y_1 &= A'\cos 0 + B'\cos 0 + \ldots \\ &\quad + A''\sin 0 + B''\sin 0 + \ldots \\ y_2 &= A'\cos 24a + B'\cos 24b + \ldots \\ &\quad + A''\sin 24a + B''\sin 24b + \ldots \\ &\text{-------------------------} \\ y_{365} &= A'\cos 24\times 364a + B'\cos 24\times 364b + \ldots \\ &\quad + A''\sin 24\times 364a + B''\sin 24\times 364b + \ldots \end{aligned}\right\} \tag{427}$$

A normal equation is now formed for each unknown quantity by multiplying each observational equation by the coefficient of the unknown quantity in that equation and adding the results. Thus, for the unknown quantity A', we have

$$\left.\begin{aligned} y_1\cos 0 &= A'\cos^2 0 + B'\cos 0\cos 0 + \cdots \\ &\quad + A''\sin 0\cos 0 + B''\sin 0\cos 0 + \cdots \\ y_2\cos 24a &= A'\cos^2 24a + B'\cos 24b\cos 24a + \cdots \\ &\quad + A''\sin 24a\cos 24a + B''\sin 24b\cos 24a + \cdots \\ &\text{-------------------------} \\ y_{365}\cos(24\times 364a) &= A'\cos^2(24\times 364a) \\ &\quad + B'\cos(24\times 364b)\cos(24\times 364a) + \cdots \\ &\quad + A''\sin(24\times 364a)\cos(24\times 364a) \\ &\quad + B''\sin(24\times 364b)\cos(24\times 364a) + \cdots \end{aligned}\right\} \tag{428}$$

Summing

$$\sum_{n=1}^{n=365} y_n \cos 24(n-1)a = A' \sum_{n=1}^{n=365} \cos^2 24(n-1)a$$

$$+A'' \sum_{n=1}^{n=365} \sin 24(n-1)a \cos 24(n-1)a$$

$$+B' \sum_{n=1}^{n=365} \cos 24(n-1)b \cos 24(n-1)a$$

$$+B'' \sum_{n=1}^{n=365} \sin 24(n-1)b \cos 24(n-1)a$$

$$+C' \sum_{n=1}^{n=365} \cos 24(n-1)c \cos 24(n-1)a$$

$$+C'' \sum_{n=1}^{n=365} \sin 24(n-1)c \cos 24(n-1)a$$

$$+D' \sum_{n=1}^{n=365} \cos 24(n-1)d \cos 24(n-1)a$$

$$+D'' \sum_{n=1}^{n=365} \sin 24(n-1)d \cos 24(n-1)a$$

$$+E' \sum_{n=1}^{n=365} \cos 24(n-1)e \cos 24(n-1)a$$

$$+E'' \sum_{n=1}^{n=365} \sin 24(n-1)e \cos 24(n-1)a \qquad (429)$$

which is the normal equation for the unknown quantity A'.

In a similar manner we have for the normal equation for the quantity A''

$$\Sigma\, y_n \sin 24(n-1)a$$

$$= A' \,\Sigma \cos 24(n-1)a \sin 24(n-1)a + A'' \,\Sigma \sin^2 24(n-1)a$$

$$+ B' \,\Sigma \cos 24(n-1)b \sin 24(n-1)a + B'' \,\Sigma \sin 24(n-1)b \sin 24(n-1)a$$

$$+ C' \,\Sigma \cos 24(n-1)c \sin 24(n-1)a + C'' \,\Sigma \sin 24(n-1)c \sin 24(n-1)a$$

$$+ D' \,\Sigma \cos 24(n-1)d \sin 24(n-1)a + D'' \,\Sigma \sin 24(n-1)d \sin 24(n-1)a$$

$$+ E' \,\Sigma \cos 24(n-1)e \sin 24(n-1)a + E'' \,\Sigma \sin 24(n-1)e \sin 24(n-1)a \qquad (430)$$

the limits of n being the same as before.

Normal equations of forms similar to (429) and (430) are easily obtained for the other unknown quantities.

By changing the notation of formulas (286) to (288) the following relations may be derived:

$$\sum_{n=1}^{n=365} \cos^2 24(n-1)a = \tfrac{1}{2}n + \tfrac{1}{2}\frac{\sin 24na \cos 24(n-1)a}{\sin 24a}$$

$$= 182\tfrac{1}{2} + \tfrac{1}{2}\,\frac{\sin 8760a \cos 8736a}{\sin 24a} \qquad (431)$$

$$\sum_{n=1}^{n=365} \sin^2 24(n-1)a = \tfrac{1}{2}n - \tfrac{1}{2}\frac{\sin 24na \cos 24(n-1)a}{\sin 24a}$$

$$= 182\tfrac{1}{2} - \tfrac{1}{2}\,\frac{\sin 8760a \cos 8736a}{\sin 24a} \qquad (432)$$

$$\sum_{n=1}^{n=365} \cos 24(n-1)b \cos 24(n-1)a$$

$$= \tfrac{1}{2}\,\frac{\sin 12n(b-a) \cos 12(n-1)(b-a)}{\sin 12(b-a)}$$

$$+ \tfrac{1}{2}\,\frac{\sin 12n(b+a) \cos 12(n-1)(b+a)}{\sin 12(b+a)}$$

$$= \tfrac{1}{2}\,\frac{\sin 4380(b-a) \cos 4368(b-a)}{\sin 12(b-a)}$$

$$+ \tfrac{1}{2}\,\frac{\sin 4380(b+a) \cos 4368(b+a)}{\sin 12(b+a)} \qquad (433)$$

$$\sum_{n=1}^{n=365} \sin 24(n-1)b \sin 24(n-1)a$$

$$= \tfrac{1}{2}\,\frac{\sin 12n(b-a) \cos 12(n-1)(b-a)}{\sin 12(b-a)}$$

$$- \tfrac{1}{2}\,\frac{\sin 12n(b+a) \cos 12(n-1)(b+a)}{\sin 12(b+a)}$$

$$= \tfrac{1}{2}\,\frac{\sin 4380(b-a) \cos 4368(b-a)}{\sin 12(b-a)}$$

$$- \tfrac{1}{2}\,\frac{\sin 4380(b+a) \cos 4368(b+a)}{\sin 12(b+a)} \qquad (434)$$

$$\sum_{n=1}^{n=365} \sin 24(n-1)b \cos 24(n-1)a$$

$$= \tfrac{1}{2}\,\frac{\sin 12n(b-a) \sin 12(n-1)(b-a)}{\sin 12(b-a)}$$

$$+ \tfrac{1}{2}\,\frac{\sin 12n(b+a) \sin 12(n-1)(b+a)}{\sin 12(b+a)}$$

$$= \tfrac{1}{2}\,\frac{\sin 4380(b-a) \sin 4368(b-a)}{\sin 12(b-a)}$$

$$+ \tfrac{1}{2}\,\frac{\sin 4380(b+a) \sin 4368(b+a)}{\sin 12(b+a)} \qquad (435)$$

By substituting in (431) to (435) the numerical values of a, b, etc., from Table 3, the corresponding equivalents for these expressions are obtained. These, in turn, may be substituted in (429), (430), and similar equations for the other unknown quantities to obtain the 10 normal equations given below. In preparing these equations the symbols a, b, c, d, and e are taken, respectively, as the speeds of components Mm, Mf, MSf, Sa, and Ssa.

$$\begin{aligned}
\sum_{n=1}^{n=365} y_n \cos 24(n-1)a \\
&= 183.05A' + 0.72B' + 0.76C' + 4.88D' + 4.96E' \\
&\quad + 2.14A'' + 4.29B'' + 5.04C'' - 0.34D'' - 0.70E'' \\
\sum_{n=1}^{n=365} y_n \sin 24(n-1)a \\
&= 2.14A' - 4.15B' - 4.90C' + 3.80D' + 3.88E' \\
&\quad + 181.95A'' + 1.01B'' + 1.06C'' + 0.34D'' + 0.68E'' \\
\sum_{n=1}^{n=365} y_n \cos 24(n-1)b \\
&= 0.72A' + 183.17B' + 0.56C' - 1.50D' - 1.51E' \\
&\quad - 4.15A'' + 0.88B'' + 0.92C'' - 0.09D'' - 0.18E'' \\
\sum_{n=1}^{n=365} y_n \sin 24(n-1)b \\
&= 4.29A' + 0.88B' + 0.92C' + 3.05D' + 3.06E' \\
&\quad + 1.01A'' + 181.83B'' - 0.80C'' - 0.08D'' - 0.17E'' \\
\sum_{n=1}^{n=365} y_n \cos 24(n-1)c \\
&= 0.76A' + 0.56B' + 183.19C' - 1.68D' - 1.70E' \\
&\quad - 4.90A'' + 0.92B'' + 0.97C'' - 0.11D'' - 0.21E'' \\
\sum_{n=1}^{n=365} y_n \sin 24(n-1)c \\
&= 5.04A' + 0.92B' + 0.97C' + 3.24D' + 3.25E' \\
&\quad + 1.06A'' - 0.80B'' + 181.81C'' - 0.10D'' - 0.20E'' \\
\sum_{n=1}^{n=365} y_n \cos 24(n-1)d \\
&= 4.88A' - 1.50B' - 1.68C' + 182.38D' - 0.24E' \\
&\quad + 3.80A'' + 3.05B'' + 3.24C'' + 0.00D'' + 0.01E'' \qquad (436) \\
\sum_{n=1}^{n=365} y_n \sin 24(n-1)d \\
&= -0.34A' - 0.09B' - 0.11C' + 0.00D' + 0.00E' \\
&\quad + 0.34A'' - 0.08B'' - 0.10C'' + 182.62D'' + 0.00E'' \\
\sum_{n=1}^{n=365} y_n \cos 24(n-1)e \\
&= 4.96A' - 1.51B' - 1.70C' - 0.24D' + 182.38E' \\
&\quad + 3.88A'' + 3.06B'' + 3.25C'' + 0.00D'' + 0.00E'' \\
\sum_{n=1}^{n=365} y_n \sin 24(n-1)e \\
&= -0.70A' - 0.18B' - 0.21C' + 0.01D' + 0.00E' \\
&\quad + 0.68A'' - 0.17B'' - 0.20C'' + 0.00D'' + 182.62E''
\end{aligned}$$

The numerical value of the first member of each of the above normal equations is obtained from the observations by taking the sum of the product of each daily mean by the cosine or sine of the angle indicated.

The solution of the equations give the values of A', A'', B', B'', etc., from which the corresponding values of amplitudes A and α, B and β, etc., of formula (424) are readily obtained, since

$$A=\sqrt{(A')^2+(A'')^2} \text{ and } \alpha=\tan^{-1}\frac{-A''}{A'}.$$

In calculating the corrected epoch, it must be kept in mind that the t in this reduction is referred to the 11.5 hour of the first day of series instead of the preceding midnight.

Before solving equations (436), if the daily means have not already been cleared of the effects of the short-period components, it will be necessary to apply corrections to the first member of each of these equations in order to make the clearances.

The disturbance in a single daily mean due to the presence of a short-period component is represented by equation (418). Introducing the subscript s to distinguish the symbols pertaining to the short-period component, the disturbance in the daily mean of the n^{th} day of series due to the presence of the short-period component A_s may be written

$$[y_s]_n=\frac{1}{24}A_s\frac{\sin 12a_s}{\sin \frac{1}{2}a_s}\cos\{24(n-1)a_s+11.5\,a_s+\alpha_s\} \qquad (437)$$

The disturbances in the products of the daily means by

$$\cos 24(n-1)a \text{ and } \sin 24(n-1)a$$

may therefore be written

$$\begin{aligned}[y_s]_n \cos 24(n-1)a &= \frac{1}{24}A_s\frac{\sin 12a_s}{\sin \frac{1}{2}a_s}\cos\{24(n-1)a_s+11.5a_s+\alpha_s\}\\ &=\frac{1}{24}A_s\frac{\sin 12a_s}{\sin \frac{1}{2}a_s}\tfrac{1}{2}[\cos\{24(n-1)\ (a_s+a)+11.5\,a_s+\alpha_s\}\\ &\qquad+\cos\{24(n-1)\ (a_s-a)+11.5\,a_s+\alpha_s\}] \qquad (438)\end{aligned}$$

and

$$\begin{aligned}&[y_s]_n \sin 24(n-1)a\\ &=\frac{1}{24}A_s\frac{\sin 12a_s}{\sin \frac{1}{2}a_s}\tfrac{1}{2}[\sin\{24(n-1)\ (a_s+a)+11.5\,a_s+\alpha_s\}\\ &\qquad \sin\{24(n-1)\ (a_s-a)+11.5\,a_s+\alpha_s\}] \qquad (439)\end{aligned}$$

Then, referring to formulas (284) and (285)

$$\sum_{n=1}^{n=365}[y_s]_n\cos 24(n-1)a=$$

$$\frac{1}{48}A_s\frac{\sin 12a_s}{\sin \frac{1}{2}a_s}\left[\frac{\sin 12\times 365(a_s+a)}{\sin 12(a_s+a)}\cos\{12\times 364(a_s+a)+11.5a_s+\alpha_s\}\right.$$
$$\left.+\frac{\sin 12\times 365(a_s-a)}{\sin 12(a_s-a)}\cos\{12\times 364(a_s-a)+11.5a_s+\alpha_s\}\right] \qquad (440)$$

and

$$\sum_{n=1}^{n=365} [y_s]_n \sin 24(n-1)a =$$

$$\frac{1}{48} A_s \frac{\sin 12a_s}{\sin \frac{1}{2}a_s} \left[\frac{\sin 12\times 365(a_s+a)}{\sin 12(a_s+a)} \sin \{12\times 364\,(a_s+a) + 11.5a_s + \alpha_s\} \right.$$

$$\left. - \frac{\sin 12\times 365(a_s-a)}{\sin 12(a_s-a)} \sin \{12\times 364(a_s-a) + 11.5a_s + \alpha_s\} \right] \quad (441)$$

Now let

$$A'_s = A_s \cos \alpha_s$$

and

$$A''_s = -A_s \sin \alpha_s \quad (442)$$

then (440) and (441) may be reduced as follows:

$$\sum_{n=1}^{n=365} [y_s]_n \cos 24(n-1)a$$

$$= \frac{1}{48} \frac{\sin 12a_s}{\sin \frac{1}{2}a_s} \left[\frac{\sin 12\times 365(a_s+a)}{\sin 12(a_s+a)} \cos \{12\times 364(a_s+a) + 11.5a_s\} \right.$$

$$\left. + \frac{\sin 12\times 365(a_s-a)}{\sin 12(a_s-a)} \cos \{12\times 364(a_s-a) + 11.5a_s\} \right] A'_s$$

$$+ \frac{1}{48} \frac{\sin 12a_s}{\sin \frac{1}{2}a_s} \left[\frac{\sin 12\times 365(a_s+a)}{\sin 12(a_s+a)} \sin \{12\times 364(a_s+a) + 11.5a_s\} \right.$$

$$\left. + \frac{\sin 12\times 365\,(a_s-a)}{\sin 12(a_s-a)} \sin \{12\times 364(a_s-a) + 11.5\,a_s\} \right] A''_s \quad (443)$$

and

$$\sum_{n=1}^{n=365} [y_s]_n \sin 24(n-1)a$$

$$= \frac{1}{48} \frac{\sin 12a_s}{\sin \frac{1}{2}a_s} \left[\frac{\sin 12\times 365(a_s+a)}{\sin 12(a_s+a)} \sin \{12\times 364(a_s+a) + 11.5a_s\} \right.$$

$$\left. - \frac{\sin 12\times 365(a_s-a)}{\sin 12(a_s-a)} \sin \{12\times 364(a_s-a) + 11.5a_s\} \right] A'_s$$

$$- \frac{1}{48} \frac{\sin 12a_s}{\sin \frac{1}{2}a_s} \left[\frac{\sin 12\times 365(a_s+a)}{\sin 12(a_s+a)} \cos \{12\times 364(a_s+a) + 11.5a_s\} \right.$$

$$\left. - \frac{\sin 12\times 365(a_s-a)}{\sin 12(a_s-a)} \cos \{12\times 364(a_s-a) + 11.5a_s\} \right] A''_s \quad (444)$$

Formulas (443) and (444) represent the clearances for any long-period component A due to any short-period component A_s. The first must be subtracted from terms corresponding to $\Sigma y_n \cos 24\ (n-1)a$ and the latter from terms corresponding to $\Sigma y_n \sin 24\ (n-1)a$ of formula (436) before solving the latter.

In (443) and (444) the coefficients of A'_s and A''_s, which for brevity we may designate as C', C'', S', and S'', respectively, contain only values that are constant for all series and may therefore be computed once for all. Separate sets of such coefficients must, however, be computed for the effect of each short-period component upon each long-period component. In the usual reductions in which the effects of 3 short-period components upon 5 long-period components are considered, 15 sets of 4 coefficients each, or 60 coefficients in all, are required.

The coefficients are given in the following table:[4]

	Long-period components.				
	Mm.	Mf.	MSf.	Sa.	Ssa.
M_2 (C')	−0.0556	+0.0030	+5.739	−0.1041	−0.1046
(C'')	−0.1704	−0.0377	−2.923	−0.0752	−0.0755
(S')	−0.1708	+0.0417	−2.840	−0.0018	−0.0035
(S'')	+0.0441	+0.0105	−5.727	+0.0048	+0.0096
N_2 (C')	−0.0588	+0.0368	+0.0294	−0.0176	−0.0176
(C'')	−0.0776	−0.2236	−0.1938	+0.0025	+0.0025
(S')	−0.0206	−0.1526	−0.1221	+0.0002	+0.0004
(S'')	+0.1138	−0.0854	−0.0808	+0.0001	+0.0002
O_1 (C')	−0.0648	+0.0166	+0.0157	−0.1924	−0.1934
(C'')	−0.3476	−0.0778	−0.0816	−0.1826	−0.1831
(S')	−0.3452	+0.0841	+0.0875	−0.0046	−0.0093
(S'')	+0.0405	+0.0338	+0.0331	+0.0090	+0.0180

In the above table the sign is so taken that the values are to be applied to the sums directly as indicated.

After the clearances have been applied and the normal equations (436) solved and the resulting amplitude and epoch obtained for each of the long-period components, the reductions will be completed in accordance with the processes already outlined, but it must be kept in mind that in this reduction the initial value of t is taken to correspond to 11.30 a. m. on the first day of series.

In obtaining the numerical values of such quantities as $\Sigma y_n \cos 24(n-1)a$ and $\Sigma y_n \sin 24(n-1)a$, in order to avoid the labor of separate multiplication for each day, the following abbreviations have been proposed by the British authorities.

The values of $\cos 24(n-1)a$ and of $\sin 24(n-1)a$ are divided into 11 groups according as they fall nearest 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, or 1.0. The daily values are then distributed into 11 corresponding groups, so that all values in one group will be multiplied by 0, another group by 0.1, etc. The $\cos 24(n-1)a$ and $\sin 24\,(n-1)a$ include negative as well as positive values. The former are taken into account by changing the sign of the daily mean to which the negative cosines apply.

As a part of the routine reductions of the tidal records from the principal tide stations it is the practice of the office to obtain the mean sea level for each calendar month, using for the purpose the hourly heights for 29 consecutive days, beginning with the first day day of each month. It is therefore desirable to have a method of using these means directly in the analysis for the annual and semiannual components, thus avoiding any special summation for the purpose.

The period of the annual component is approximately the length of the Julian year; that is, 365.25 days. If this period were divided

[4] From Scientific Papers by Sir George H. Darwin, Vol. I, p. 64.

into 12 equal groups and the mean of the hourly heights for each group taken, these means would represent the approximate height of the combined annual and semiannual components for the middle of each group, and the middle of the first group would be the initial point from which the zeta (ζ) as obtained by the usual process would be referred. As each group would represent 30° of motion for the annual component, or 60° for the semiannual component, to refer this ζ to the actual beginning of the series of observations it would be necessary to apply a correction of 15° for the annual component or 30° for the semiannual component.

In obtaining the monthly means by the usual process of including 29 days only, the year is divided only approximately into 12 equal groups. The following table shows the comparison of the middle of each group actually used in the summation and the middle of each corresponding group obtained by dividing a Julian year beginning January 1, 0 hour, into 12 equal parts. In the summing for mean sea level each group extends from 0 hour on the 1st day of the month to the 23d hour on the 29th day, making the group from first to last observation exactly 28 days and 23 hours long. The middle of each group will therefore be 14.48 days later than the first observation of the group.

Month.	Middle of each group reckoned from beginning of year.			Middle of actual group earlier than middle of same division of Julian year.	
	Julian year.	Common year.	Leap year.	Common year.	Leap year.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*
January	15.22	14.48	14.48	0.74	0.74
February	45.66	45.48	45.48	0.18	0.18
March	76.09	73.48	74.48	2.61	1.61
April	106.53	104.48	105.48	2.05	1.05
May	136.97	134.48	135.48	2.49	1.49
June	167.41	165.48	166.48	1.93	0.93
July	197.84	195.48	196.48	2.36	1.36
August	228.28	226.48	227.48	1.80	0.80
September	258.72	257.48	258.48	1.24	0.24
October	289.16	287.48	288.48	1.68	0.68
November	319.59	318.48	319.48	1.11	0.11
December	350.03	348.48	349.48	1.55	0.55
Sums	2,191.50	2,171.76	2,181.76	19.74	9.74
Means				1.64	0.81
Speed of Sa component per day=0.9856°.				°	°
Means reduced to degrees of Sa				1.62	0.80
Correction to ζ of Sa				13.38	14.20
Correction to ζ of Ssa				26.76	28.40

From the above table it is evident that in the summation for the monthly means for a calendar year the middle of each group of a common year is on an average 1.62° earlier than the middle of the corresponding group when the Julian year is equally subdivided, and the middle of each group of a leap year is on an average 0.80° earlier. Subtracting these values from 15°, the interval between the beginning of the observations and the middle of the first group of an equal subdivision, we have 13.38° and 14.20°, for common and leap years, respectively, as a correction to be applied to the ζ of Sa as directly obtained, in order to refer the ζ to the 0 hour of the 1st day of January, for the component Ssa the corrections will be twice as great.

If the year commences on the first day of any month other than January, the corrections will differ a little from the above. Calculated in a manner similar to that above, the following table gives the correction to be applied to the ζ to refer to the first day of any month at which the series commences. The correction to the ζ of Ssa will be twice the tabular value for Sa.

Observations commence—	Correction to ζ of Sa to refer to beginning of month.		Observations commence—	Correction to ζ of Sa to refer to beginning of month.	
	Common year.	Leap year.		Common year.	Leap year.
	°	°		°	°
Jan. 1	13.38	14.20	July 1	14.86	15.19
Feb. 1	12.80	13.71	Aug. 1	14.28	14.69
Mar. 1	15.19	15.19	Sept. 1	13.71	14.20
Apr. 1	14.61	14.69	Oct. 1	14.12	14.69
May 1	15.02	15.19	Nov. 1	13.54	14.20
June 1	14.45	14.69	Dec. 1	13.95	14.69

As the group summed covers approximately one-twelfth of the period of the component Sa, or one-sixth of the period of Ssa, the augmenting factors will be as follows:

Sa 1.0115, logarithm 0.00497.
Ssa 1.0472, logarithm 0.02005.

If the monthly means extend over many calendar years, it may be convenient to combine them for a single analysis. In this case the (V_0+u) for January 1 may be taken as the average of the values for the beginning of each year included in the observations, and the correction to the ζ to refer to the beginning of the year will be a mean of the values given above for common and leap years, weighted in accordance with the number of each kind of year included. If only a few years of observations are available, it is better to analyze each year separately in order that the results may serve as a check on each other.

32. ANALYSIS OF HIGH AND LOW WATERS.

The automatic tide gauge, which furnishes a continuous record of the rise and fall of the tide, now being in general use, it is seldom necessary to rely only upon the high and low waters for an analysis. It may happen, however, that a record of high and low water observations is available for a more or less isolated locality where it has been impractical to secure continuous records. Such records, if they include all the high and low waters for a month or more may be utilized in determining approximate values of the principal harmonic constants, but the results are not as satisfactory as those obtained from an analysis of the hourly heights.

An elaborate mode of analysis of the high and low waters is contained in volume 1 of Scientific Papers, by Sir George H. Darwin. Other methods are given by Dr. R. A. Harris in his Manual of Tides.

The process outlined below follows to some extent one of the methods of Doctor Harris, extending his treatment for the components K and O to other components.

The lengths of series may be taken the same as the lengths used as the analysis of the hourly heights, which are 29, 58, 87, 105, 134, 163, 192, 221, 250, 279, 297, 326, 355, and 369 days. It is sometimes convenient to divide a series, whatever its length, into periods of 29 days each. This permits a uniform method of procedure, and a comparison of the results from different series affords a check on the reliableness of the work.

The first process in this analysis consists in making the usual high and low water reductions, including the computation of the lunitidal intervals. Form 138 provides for this reduction. The times and heights of the high and low waters, together with the times of the moon's transits are tabulated. For convenience the standard time of the place of observations may be used for the times of the high and low waters, and the Greenwich mean civil time of the moon's transits over the meridian of Greenwich may be used for the moon's transits. The interval between each transit and the following high and low water is then found, and the mean of all the high water intervals and the mean of all the low water intervals are then obtained separately. The true mean intervals between the time of the moon's transit over the local meridian and the time of the following high and low waters being desired, the means as directly obtained must be corrected to allow for any difference in the kind of time used for the transit of the moon and the time of the tides and also for the difference in time between the transit of the moon over the local meridian and the transit over the meridian to which the tabular values refer.

A convenient table for the correction of the lunitidal intervals, when the high and low waters have been given in standard time and the moon's transits over the meridian of Greenwich are given in Greenwich mean civil time, will be found in Special Publication No. 26 of the U. S. Coast and Geodetic Survey.

If the tide is of the semidiurnal type, the approximate amplitude and epoch for component M_2 may be obtained directly from this high and low water reduction. On account of the presence of the other components the mean range from the high and low waters will always be a little larger than twice the amplitude of M_2. If the data are available for some other station in the general locality, the ratio of the M_2 amplitude to the mean range of tide at that station may be used in finding the M_2 amplitude from the mean range of tide at the station for which the results are sought. If this ratio can not be obtained for any station in the general locality, the empirical ratio of 0.47 may be used with fairly satisfactory results. After the amplitude of M_2 has been thus obtained, it should be corrected for the longitude of the moon's node by factor F from Table 12.

The epoch of M_2 may be obtained from the corrected high and low water lunitidal intervals $H\,WI$, $L\,WI$ by the following formula—

$$M°_2 = \tfrac{1}{2}(H\,WI + L\,WI) \times 28.984 + 90° \qquad (445)$$

In the above formula $H\,WI$ must be greater than $L\,WI$, 12.42 hours being added, if necessary, to the $H\,WI$ as directly obtained from the high and low water reductions.

The difference between the average duration of rise and fall of the tide at any place, where the tide is of the semidiurnal type, depends largely upon the component M_4. It is possible to obtain from the high and low waters a component with the speed of M_4 which, when used in the harmonic prediction of the tides, will cause the mean duration of rise and fall to be the same as that at the station. The effect of component M_4 upon the mean duration of rise will depend chiefly upon the relation of its amplitude and epoch to the amplitude and epoch of the principal component M_2. By assuming an M_4 component with epoch such as to make the component symmetrically situated in regard to the maxima and minima of the M_2 component, the amplitude necessary to account for the mean duration of rise of the tide may be readily calculated as follows:

Let DR = duration of rise of tide in hours as obtained from the lunitidal intervals.

a = Hourly speed of component M_2. = 28.°984.
M_2 = Amplitude of M_2 component.
$M_2°$ = Epoch of M_2 component.
M_4 = Amplitude of M_4 component.
$M_4°$ = Epoch of M_4 component.

Then, for component M_4 to be symmetrically situated with respect to the maxima and minima of component M_2

$$M_4° = 2\ M_2° \pm 90° \tag{446}$$

in which the upper or lower sign is to be used according to whether $a(DR)$ is greater or less, respectively, than 180°. Multiples of 360° may be added or rejected to obtain the result as a positive angle less than 360°.

The equations of the components M_2 and M_4 may be written

$$y_1 = M_2 \cos\ (at + \alpha) \tag{447}$$

$$y_2 = M_4 \cos\ (2at + \beta) \tag{448}$$

and the resultant curve

$$y = M_2 \cos\ (at + \alpha) + M_4 \cos\ (2at + \beta) \tag{449}$$

Values of t which will render (447) a maximum must satisfy the derived equation.

$$aM_2 \sin\ (at + \alpha) = 0 \tag{450}$$

and for a maximum of (449) t must satisfy the derived equation

$$aM_2 \sin\ (at + \alpha) + 2aM_4 \sin\ (2at + \beta) = 0 \tag{451}$$

For a maximum of (447)

$$t = \frac{2n\pi - \alpha}{a} \tag{452}$$

in which n is any integer.

Let $\frac{\theta}{a}$ = the acceleration in the high waters of component M_2 due to the presence of component M_4. With the M_4 wave symmetrically situated with respect to the M_2 wave, $\frac{\theta}{a}$ will also equal the retardation in the low water of component M_2, due to the presence of component M_4, and $\frac{2\theta}{a}$ will equal the total amount by which the duration of rise of the tide has been diminished by M_4. If the duration of rise has been increased, θ will be negative.

Then, for a maximum of (449)

$$t=\frac{2n\pi-\alpha-\theta}{a} \tag{453}$$

and this value of t must satisfy equation (451).

Substituting in (451), we have

$$\begin{aligned} aM_2 \sin(2n\pi-\theta)+2aM_4 \sin(4n\pi-2\alpha+\beta-2\theta) &= \\ -aM_2 \sin\theta-2aM_4 \sin(2\theta+2\alpha-\beta) &= 0 \end{aligned} \tag{454}$$

But

$$2\alpha-\beta=-2M_2{}^\circ+M_4{}^\circ \tag{455}$$

From (446),

$$-2M_2{}^\circ+M_4{}^\circ=\pm 90^\circ$$

according to whether the duration of rise is greater or less than $\frac{180^\circ}{a}$, or whether θ is negative or positive.

Then

$$2\alpha-\beta=\mp 90^\circ \tag{456}$$

according to whether θ is positive or negative.

Substituting this in (454)

$$-aM_2 \sin\theta \pm 2aM_4 \cos 2\theta=0 \tag{457}$$

and

$$\frac{M_4}{M_2}=\pm\tfrac{1}{2}\,\frac{\sin\theta}{\cos 2\theta} \tag{458}$$

the upper or lower sign being used according to whether θ is positive or negative. As under the assumed conditions θ must come within the limits $\pm 45^\circ$, the ratio of $\frac{M_4}{M_2}$ as derived from (458) will always be positive.

The duration of rise of tide due solely to the component M_2 is $\frac{180^\circ}{a}$.

The duration of rise as modified by the presence of the assumed M_4 is

$$DR=\frac{180^\circ}{a}-\frac{2\theta}{a} \tag{459}$$

Therefore

$$\theta=\tfrac{1}{2}(180^\circ-aDR) \tag{460}$$

Substituting the above in (458) we have

$$\frac{M_4}{M_2}=\pm\tfrac{1}{2}\frac{\sin\ (90°-\tfrac{1}{2}aDR)}{\cos\ (180°-aDR)}=\mp\tfrac{1}{2}\frac{\cos\ \tfrac{1}{2}aDR}{\cos\ aDR} \tag{461}$$

and

$$M_4=\mp\tfrac{1}{2}\frac{\cos\ \tfrac{1}{2}aDR}{\cos\ aDR}M_2 \tag{462}$$

M_4 must be positive, and the sign of the above coefficient will depend upon whether aDR is less or greater than 180°.

The approximate constants for components S_2, N_2, K_1, and O_1 may be obtained from the observed high and low waters as follows:

Add to each low-water height the mean range of tide. Copy the high and modified low water heights into the form for hourly heights (Form 362), always putting the values upon the nearest solar hour. Sum for the desired components, using the same stencils as are used for the regular analysis of the hourly heights. Account should be taken of the number of items entering into each sum and the mean for each component hour obtained. The 24 hourly means for each component are then to be analyzed in the usual manner.

The results obtained by this process are, of course, not as dependable as those obtained from a continuous record of hourly heights. The approximate results first obtained can, however, be improved by the following treatment if a tide-computing machine is available.

Using the approximate constants as determined above for the principal components and inferred values for smaller components, set the machine for the beginning of the period of observations and find the predicted heights corresponding to the observed times of the high and low waters. Tabulate the differences between the observed and predicted heights for these times, using the hourly height form and entering the values according to the nearest solar hour. These differences are then to be summed and analyzed the same as the original observed heights. In this analysis of the residuals the component M_2 should be included. The results from the analysis of the residuals are then combined with the constants used for the setting of the predicting machine.

In making the combinations the following formulas may be used:

Let A' and κ' represent the first approximate values of the constants of any component.

A'' and κ'', the constants as obtained from the residuals.

A and κ, the resultant constants sought.

Then

$$A=\sqrt{(A'\cos\kappa'+A''\cos\kappa'')^2+(A'\sin\kappa'+A''\sin\kappa'')^2} \tag{463}$$

and

$$\kappa=\tan^{-1}\frac{A'\sin\kappa'+A''\sin\kappa''}{A'\cos\kappa'+A''\cos\kappa''} \tag{464}$$

33. HARMONIC PREDICTION OF TIDES.

The methods for the prediction of the tides may be classified as harmonic and nonharmonic. By the harmonic methods the elementary component tides, represented by harmonic constants, are combined into a composite tide. By the nonharmonic methods the predictions are made by applying to the times of the moon's transits and to the mean height of the tide systems of differences to take account of average conditions and various inequalities due to changes in the phase of the moon and in the declination and parallax of the moon and sun.

Without the use of a predicting machine the harmonic method would involve too much labor to be of practical service, but with such a machine the harmonic method has many advantages over the nonharmonic systems and is now used exclusively by the U. S. Coast and Geodetic Survey in making predictions for the standard ports of this country.

The height of the tide at any time may be represented harmonically by the formula

$$h = H_0 + \Sigma f H \cos [at + (V_0 + u) - \kappa] \tag{465}$$

in which

h = height of tide at any time t.
H_0 = mean height of water level above datum used for prediction.
H = mean amplitude of any component A.
f = factor for reducing mean amplitude H to year of prediction.
a = speed of component A.
t = time reckoned from some initial epoch such as beginning of year of predictions.
$(V_0 + u)$ = value of equilibrium argument of component A when $t = 0$.
κ = epoch of component A.

In the above formula all quantities except h and t may be considered as constants for any particular year and place, and when these constants are known the value of h, or the predicted height of the tide, may be computed for any value of t, or time. By comparing successive values of h the heights of the high and low waters, together with the times of their occurrence, may be approximately determined. The harmonic method of predicting tides, therefore, consists essentially of the application of the above formula.

The exact value of t for the times of high and low waters will be roots of the first derivative of formula (465), equated to zero, which may be written—

$$\frac{dh}{dt} = -\Sigma a f H \sin [at + (V_0 + u) - \kappa] = 0 \tag{466}$$

Although formula (466) can not, in general, be solved by rigorous methods, it may be mechanically solved by a tide-predicting machine of the type used in the office of the U. S. Coast and Geodetic Survey.

The constant H_0 of formula (465) is the depression of the adopted datum below the mean level of the water at the place of prediction. For places on the open coast the mean water level is identical with mean sea level, but in the upper portions of tidal rivers that have an appreciable slope the mean water level may be somewhat higher than the mean sea level. The datum for the predictions may be more or less arbitrarily chosen, but it is customary to use the low-water plane that has been adopted as the reference for the soundings on the hydrographic charts of the locality. For all places on the Atlantic and Gulf coasts of the United States, including Porto Rico and the Atlantic coast of the Panama Canal Zone, this datum is mean low water. For the Pacific coast of the United States, Alaska, Hawaii, and the Philippines, the datum is in general mean lower low water. For the rest of the world, the datum is in general mean low water springs, although there are many localities where somewhat lower planes are used. After the datum for any particular place has been adopted its relation to the mean water level may be readily obtained from simple nonharmonic reductions of the tides as observed in the locality. The value of H_0 thus determined is a constant that is available for future predictions at the stations.

The amplitude H and the epoch κ for each component tide to be included in the predictions are the harmonic constants determined by the analysis discussed in the preceding chapters. Each place will have its own set of harmonic constants, and when once determined will be available for all times, except as they may be slightly modified by a more accurate determination from a better series of observations, or by changes in the physical conditions at the locality such as may occur from dredging, by the depositing of sediment, or by other causes.

The factor f is the reciprocal of factor F, discussed in section 12. It is introduced in order to reduce the mean amplitude to the true amplitude depending upon the longitude of the moon's node. The factor f for any single component, therefore, passes through a cycle of values. The change being slow, it is customary to take the value as of the middle of the year for which the predictions are being made and assume this as a constant for the entire year. The error resulting from this assumption is practically negligible. Each component has its own set of values for f, but these values are the same for all localities and have been compiled for convenient use in Table 14 for the middle of each year from 1850 to 1999.

The quantity a represents the angular speed of any component per unit of time. In the application of formulas (465) and (466) to the prediction of tides this is usually given in degrees per mean solar hour, the unit of t being taken as the mean solar hour. The values of the speeds of the different components have been calculated from astronomical data by formulas derived from the development of the equilibrium theory which has already been discussed. These speeds have been compiled in Table 3 and are essentially constant for all times and places. The quantity (V_0+u), which was discussed in section 10, is the value of the equilibrium argument of a component at the initial instant from which the value of t is reckoned; that is, when t equals zero. In the prediction of tides this initial epoch is usually taken at the midnight beginning the year for which the predictions are to be made. In strictness the V, or uniformily varying portion of the argument alone, refers to the initial epoch, while the u, or slow variation due to changes in the longitude of the moon's node, is taken as of the middle of the period of prediction and assumed to have this value as a constant for the entire period. The quantity (V_0+u) is different for each component and is also different for each initial epoch and for different longitudes on the earth. In Table 15 there have been compiled the values of this quantity for the beginning of each year from 1850 to 2000 for the longitude of Greenwich.

The values may be readily modified to adapt them to other initial epochs and other longitudes.

Let

L = west longitude in degrees of station for which predictions are desired.

S = west longitude in degrees of time meridian used at this station.

For east longitude, L and S will have negative values.

Now let

$p = 0$ when referring to the long-period components.
1 when referring to the diurnal components.
2 when referring to the semidiurnal components, etc.

then p will be the coefficient of the quantity T in the equilibrium arguments represented in (100), (215), and other formulas. Now, T is the hour angle of the mean sun and is the only quantity in these arguments that is a function of the longitude of the place of observation or of prediction. At any given instant of time the difference between the values of the hour angle T at two stations will be equal to the difference in longitude of the stations. If, therefore, the value of the argument (V_0+u) for any component at any given instant has been computed for the meridian of Greenwich, the correction to refer this argument for the same instant to a place in longitude $L°$ west of Greenwich will be $-pL$, the negative sign being necessary as the value of T decreases as the west longitude increases.

The instant of time to which each of the tabular values of the Greenwich (V_0+u)'s of Table 15 refers is the 0 hour of the Greenwich mean civil time at the beginning of a calendar year. In the predictions of the tides at any station it is desirable to take as the initial epoch the 0 hour of the standard or local time customarily used at that station. If, therefore, the longitude of the time meridian used is $S°$ west of Greenwich, the initial epoch of the predictions will usually be $S/15$ mean solar hours later than the instant to which the tabular Greenwich (V_0+u)'s are referred.

In formulas (465) and (466) the symbol a is the general designation of the speed of any component; that is to say, it is the hourly rate of change in the argument. The difference in the argument due to a difference of $S/15$ hours in the initial epoch is therefore $aS/15$ degrees. The total correction to the tabular Greenwich (V_0+u) of any year in order to obtain the local (V_0+u) for a place in longitude $L°$ west at an initial epoch of 0 hours of time meridian $S°$ west at the beginning of the same calendar year is

$$\frac{aS}{15}-pL. \tag{467}$$

The general expression for the angles of (465) and (466) may now be written

$$[at+(V_0+u)-\kappa]=[at+\text{Greenwich }(V_0+u)+\frac{aS}{15}-pL-\kappa] \tag{468}$$

In order to avoid the necessity of applying the corrections for longitude and initial epoch to the Greenwich (V_0+u)'s for each year, these corrections may be applied once for all to the κ's

Let

$$\left(\frac{aS}{15}15-pL-\kappa\right)=-\kappa' \tag{469}$$

Then (468) may be written

$$at+(V_0+u)-\kappa=at+\text{Greenwich }(V_0+u)-\kappa' \tag{470}$$

Thus, by applying the corrections indicated in (469) to the κ's for any station, a modified set of epochs is obtained. These will remain the same year after year and permit the direct use of the tabular Greenwich (V_0+u)'s in determining the actual component phases at the beginning of each calendar year.

Let

$$\text{Greenwich }(V_0+u)-\kappa'=\alpha \tag{471}$$

then formulas (465) and (466) may be written

$$h=H_0+\sum fH\cos(at+\alpha) \tag{472}$$

for height of tide at any time, and

$$\sum afH\sin(at+\alpha)=0 \tag{473}$$

for times of high and low waters.

Formula (472) may be easily solved for any single value of t, but for many values of t as are necessary in the predictions of the tides for a year at any station the labor involved by an ordinary solution would be very great. Formula (473) can not, in general, be solved by rigorous methods.

The invention of tide-predicting machines has rendered the solution of both formulas a comparatively simple matter.

The first tide-predicting machine was designed by Sir William Thomson (afterwards Lord Kelvin) and was made in 1873 under the auspices of the British Association for the Advancement of Science. This was an integrating machine designed to compute the height of the tide in accordance with formula (472). It provided for the summation of 10 of the principal components, and the resulting predicted heights were registered by a curve automatically traced by the machine. This machine is described in Part I of Thomson and Tait's Natural Philosophy, edition of 1879. Several other tide-predicting machines designed upon the same general principles, but providing for an increased number of components were afterwards constructed.

The first tide-predicting machine used in the United States was designed by William Ferrel, of the U. S. Coast and Geodetic Survey. This machine, which was completed in 1882, was based upon modified formulas and differed somewhat in design from any other machine that has ever been constructed. No curve was traced, but both the times and heights of the high and low waters were indicated directly by scales on the machine. The intermediate heights of the tide could be obtained only indirectly. A description of this machine is given in the report of the U. S. Coast and Geodetic Survey for the year 1883.

The first machine designed to solve simultaneously formulas (472) and (473) is the U. S. Coast and Geodetic Survey tide-predicting machine No. 2, which is described in the following section. A description of the machine is also given in Special Publication No. 32 of the U. S. Coast and Geodetic Survey.

34. U. S. COAST AND GEODETIC SURVEY TIDE-PREDICTING MACHINE NO. 2.

The Coast and Geodetic Survey tide-predicting machine No. 2 was designed to sum simultaneously the terms of formulas (472) and (473) and to register the successive heights of the tide (h) by a dial and pointer as well as graphically by a curve, and also to indicate the time or values of (t) which satisfy equation (473) for the high and low waters. This machine was designed and constructed in the office of the U. S. Coast and Geodetic Survey. Designed in 1895, its construction was begun the following year, and after some interruptions it was completed in 1910. It was first used in making predictions for the U. S. Coast and Geodetic Survey Tide Tables for the year 1912 and has been used for all editions of the Tide Tables since that time.

The general appearance of the machine is illustrated by Figures 12, 13, and 14. It is about 11 feet long, 2 feet wide, and 6 feet high, and weighs approximately 2,500 pounds. The principal features are: First, the supporting framework; second, a system of gearing by means of which shafts representing the different components are made to rotate with angular speeds proportional to the actual speeds of the components; third, a system of cranks and sliding frames for obtaining harmonic motion; fourth, summation chains connecting the individual component elements, by means of which the sums of the harmonic terms of formulas (472) and (473) are transmitted to the recording devices; fifth, a system of dials and pointers for indicating in a convenient manner the height of the tide for successive instants of time and also the time of the high and low waters; sixth, a tide curve or graphic representation of the tide automatically constructed by the machine. The machine is designed to take account of the 37 components listed in Table 3, including 32 short-period and 5 long-period components.

The heavy cast-iron base of the machine, which includes the operator's desk, has an extreme length of 11 feet and is 2 feet wide. This forms a very substantial foundation for the superstructure, increasing its stability and thereby diminishing errors that might result from a lack of rigidity in the fixed parts. On the left side of the desk is located the hand crank for applying the power (*1*, fig. 12), and under the desk are the primary gears for setting in motion the various parts of the machine.

The superstructure is in three sections, each consisting of parallel hard-rolled brass plates held from 6 to 7 inches apart by brass bolts. Between these plates are located the shafts and gears that govern the motion of the different parts of the machine.

The front section, or dial case, rests upon the desk facing the operator and contains the apparatus for indicating and registering the results obtained by the machine. The middle section rests upon a depression in the base and contains the mechanism for the harmonic motions for the principal components M_2, S_2, K_1, O_1, N_2, and M_4. The rear section contains the mechanism for the harmonic motions for the remaining 31 components for which the machine provides.

The angular motions of the individual components, as indicated by the quantity *at* in formulas (472) and (473), are represented in the machine by the rotation of short horizontal shafts having their bearings in the parallel plates of the component frames. All of these component shafts are connected by a system of gearing with the hand crank at the left of the dial case and also with the time-registering dials, so that when the machine is in operation the motion of each of these shafts will be proportional to the speed *a* of the corresponding component, and for any interval of time or increment in *t* as indicated by the time dials the amount of angular motion in any component shaft will be equal the increment in the product *at* corresponding to that component.

Since the corresponding angles in formulas (472) and (473) are identical for all values of *t*, the motion provided by the gearing will be applicable alike to the solution of both the formulas. The mechanism for the summation of the terms of formula (472) is situated on the side of the machine at the left of the operator, and for convenience this side of the machine is called the "height side" (fig. 12), and the mechanism for the summation of the terms of formula (473) is on the right-hand side of the machine, which is designated as the "time side" (fig. 13).

In Table 37 are given the details of the general gearing from the hand-operating crank to the main vertical component shafts, together with the details of all the gearing in the front section or dial case.

It will be noted that *S–6* (fig. 16) is the main vertical shaft of the dial case and is connected through the releasable gears to the hour hand, the minute hand, and the day dial, respectively. The releasable gears permit the adjustment of these indicators to any time desired. After an original adjustment is made so that the hour and minute hand will each read 0 at the same instant that the day dial indicates the beginning of a day, further adjustment will, in general, be unnecessary, as the gearing itself will cause the indicators to maintain a consistent relation throughout the year, and by use of the hand-operating crank the entire system may be made to indicate any time desired. The period of the hour-hand shaft is 24 dial hours, and the hand moves over a dial graduated accordingly (*3*, fig. 12). The minute-hand shaft, with a period of 1 dial hour, moves over a dial graduated into 60 minutes (*2*, fig. 12).

The day dial, which is about 10 inches in diameter, is graduated into 366 parts to represent the 366 days in a leap year. The names of the months and numerals to indicate every fifth day of each month are inscribed on the face of the dial. This dial is located just back of the front plate or face of the machine, in which there is an arc-shaped opening through which the graduations representing nearly two months are visible at any one time (*4*, fig. 12). The progress of the days as the machine is operated is indicated by the rotation of this dial past an index or pointer just below the opening (*6*, fig. 12). This pointer is secured to a short shaft which carries at its inner end a lever arm with a pin reaching under the lower edge of the day dial, against which it is pressed by a light spring. A portion of the edge of the dial equal to the angular distance from January 1 to February 28 is of a slightly larger radius, so that the pin pressing against it rises and throws the day pointer to the right one day when this portion has passed by. On the last day of December this pointer will move back one day to its original position.

On the same center with the day pointer there is a smaller index (*7*, fig. 12) which may be turned either to the right toward a plate inscribed "Common year," or to the left to a plate inscribed "Leap year." When this smaller index is turned toward the right, the day pointer is free to move in accordance with the change in radius of the edge of the dial. If the smaller index is turned toward the left, the day pointer is locked and must hold a fixed position throughout the year. For the prediction of the tides for two or more common years in succession the day dial must be set forward one day at the close of the year, in order that the days of the succeeding year may be correctly registered. The day dial can be released for setting by the nut (*5*, fig. 12) immediately above the large dial ring. A slower movement of the day dial is provided by a releasable gear on the vertical shaft *S–6* (fig. 16).

There are three main vertical component shafts *S–13* (fig. 18), *S–14* (fig. 19), and *S–16* (fig. 14), to which are connected the gearing for the individual components. The period of rotation of each is 12 dial hours, and all move clockwise when viewed from above the machine. The connections between these main component shafts and the individual component crank shafts are, in general, made by two pair of bevel gears and an intermediate horizontal shaft, except that for the slow moving components Sa, Ssa, Mm, Mf, and Msf, a worm screw and wheel and a pair of spur gears are in each case substituted for a pair of bevel gears. In each case the gear on the main vertical shaft is releasable so that each component crank shaft can be set independently.

Main component shaft *S–13* in the front component section drives 9 individual component crank shafts representing 6 components, 3 of the components being provided with two crank shafts each. These 6 components are M_2, S_2, K_1, N_2, M_4, and O_1, the first three having the double crank shafts. Main component shaft *S–14* at the front of the rear component section drives 16 component crank shafts representing one component each. These are M_6, MK, S_4, MN, ν_2, S_6, μ_2, and 2N in the upper range, and MS, M_8, K_2, 2MK, L_2, M_3, 2SM, and P_1 in the lower range. Main component shaft *S–16* at the back of the rear component section drives 15 component crank shafts. The components represented are OO, λ_2, S_1, M_1, J_1, Mm, and Ssa, in the upper range, and 2Q, R_2, T_2, Q_1, ρ_1, Mf, MSf, and Sa in the lower range.

For each of the five long-period components motion is communicated from the intermediate shaft by a worm screw and wheel to a small shaft on which is mounted a sliding spur gear. The latter engages a spur gear on the component crank shaft, but may be easily disconnected by drawing out a pin on the time side of the machine, thus permitting the component crank shaft to be turned freely when setting the machine.

Gear speeds.—The relative angular motion of each individual component shaft must correspond as near as possible to the theoretical speed of the component represented. The period of rotation of each of the three main vertical shafts being 12 dial hours, the angular motion of each of these shafts is 30° per dial hour. Table 38 contains the details of the gearing from the main vertical component shafts to the individual component cranks, the number of teeth in the different gears for each component being given in columns I, II, III, and IV. In designing the predicting machine it was necessary to find such values for these columns as would give gear speeds approximating as closely as possible with the theoretical speeds of the components. By comparing the gear speeds as obtained with the corresponding theoretical speeds it will be noted that the accumulated errors of the gears for an entire dial year for all the components are negligible in the prediction of the tides.

Releasable gears.—Releasable gears (*52*, fig. 19) on the main vertical shafts of the dial case and component frames permit the independent adjustment of the time indicators and individual component shafts. The details of these gears are illustrated in Figure 20. A collar *C*, with a thread at its upper end and a flange at the bottom, is fastened to the shaft by means of three steel screws. The gear wheel *A* fits closely upon this collar and rests upon the flange. It has sunk into its upper surface a recess *a*, which is filled by the flange of collar *B*. When in place, the latter is prevented from turning by a small steel screw reaching into a vertical groove *c* in the collar *C*. The lower surface of collar *B* is slightly dished, and the collar is split twice at right angles nearly to the top. When the milled nut *D* is screwed down with a small pin wrench, the edge of the collar *B* is pressed against the edge of the recess *a* with such force as to make slipping practically impossible. When the nut is loosened, the gear may be turned independently of the main driving shaft. A small wrench (*56*, fig. 19) is used for setting these gears.

Each of the three main driving shafts is provided with a clamp (*55*, fig. 19) to secure the shaft from turning when the nut of the releasable gear is being loosened or tightened.

Component cranks.—Secured to the ends of the individual component shafts, which project through the brass plates on both sides of the machine, are brass cranks (*40*, fig. 16) which are provided for the component amplitudes. Those on the left or height side of the machine are designated as the component height cranks and are used for the coefficients of the cosine terms of formula (472), and those on the right or time side of the machine are designated as the component time cranks and are used for the coefficients of the sine terms of formula (473). The time crank on each component shaft is attached 90° in advance (in the direction of rotation) of the height crank on the same shaft. For the components Sa and Ssa no time cranks are provided, as the coefficients of the sine terms corresponding to these components are too small to be taken into account. The direction of rotation of each component shaft with its component cranks is clockwise when viewed from the time side of the machine and counterclockwise when viewed from the height side. The details of a component crank are shown in Figure 21. The pointer *a* is rigidly attached to the crank as an index for reading its position on a dial. In each crank there is a longitudinal groove *b* with flanges in which a crank pin *d* may be clamped in any desired position. The crank pin has a small rectangular block as a base which is designed to fit the groove in the crank, and through the center of the crank pin there is a threaded hole for the clamp screw *f*. Attached to the under side of the crank-pin block is a small spring *c* that presses the block outward against the flanges of the groove, keeping it from slipping out of place when unclamped and at the same time permitting it to be moved along the groove when setting the machine. The crank pin may be securely fastened in

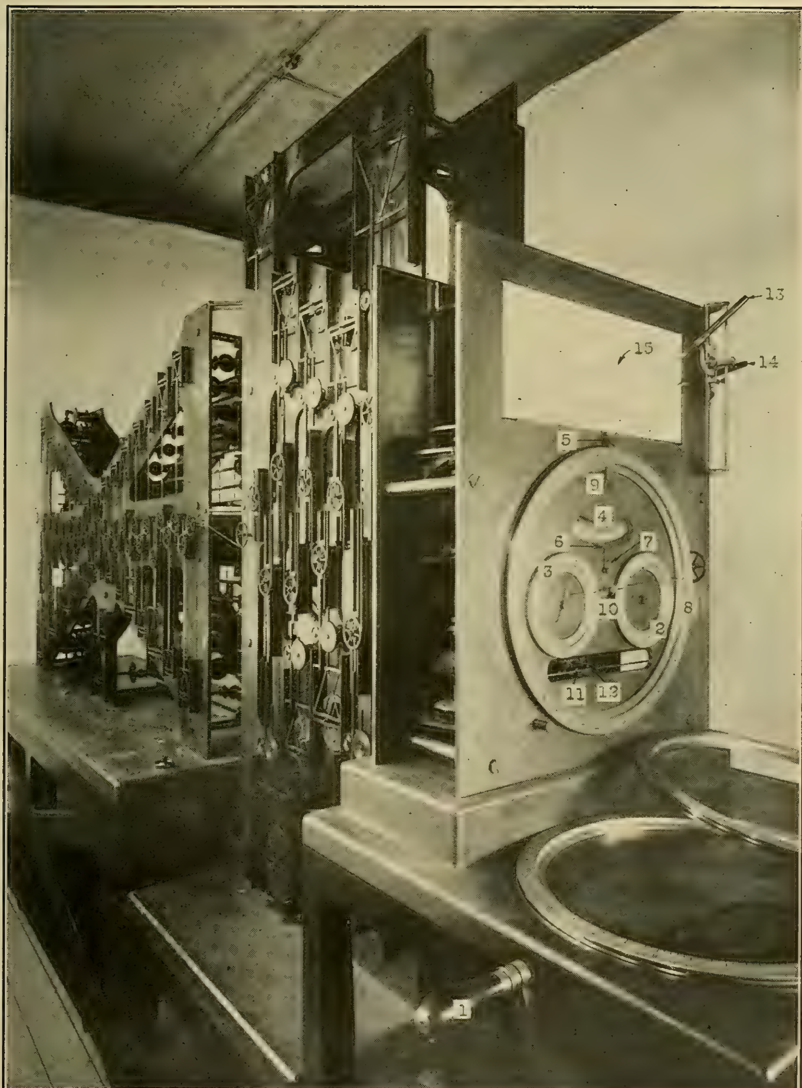


Fig. 12.—DIAL CASE AND HEIGHT SIDE, TIDE-PREDICTING MACHINE.

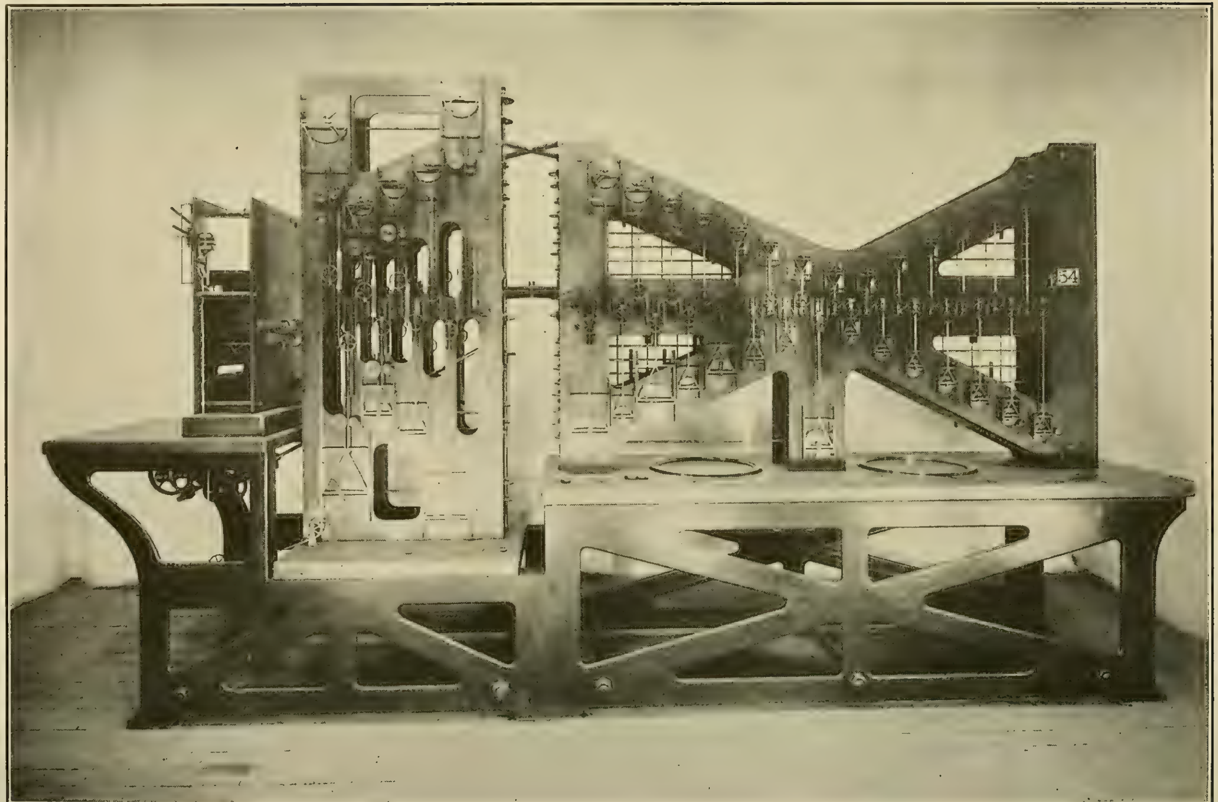


Fig. 13.—TIME SIDE, TIDE-PREDICTING MACHINE.

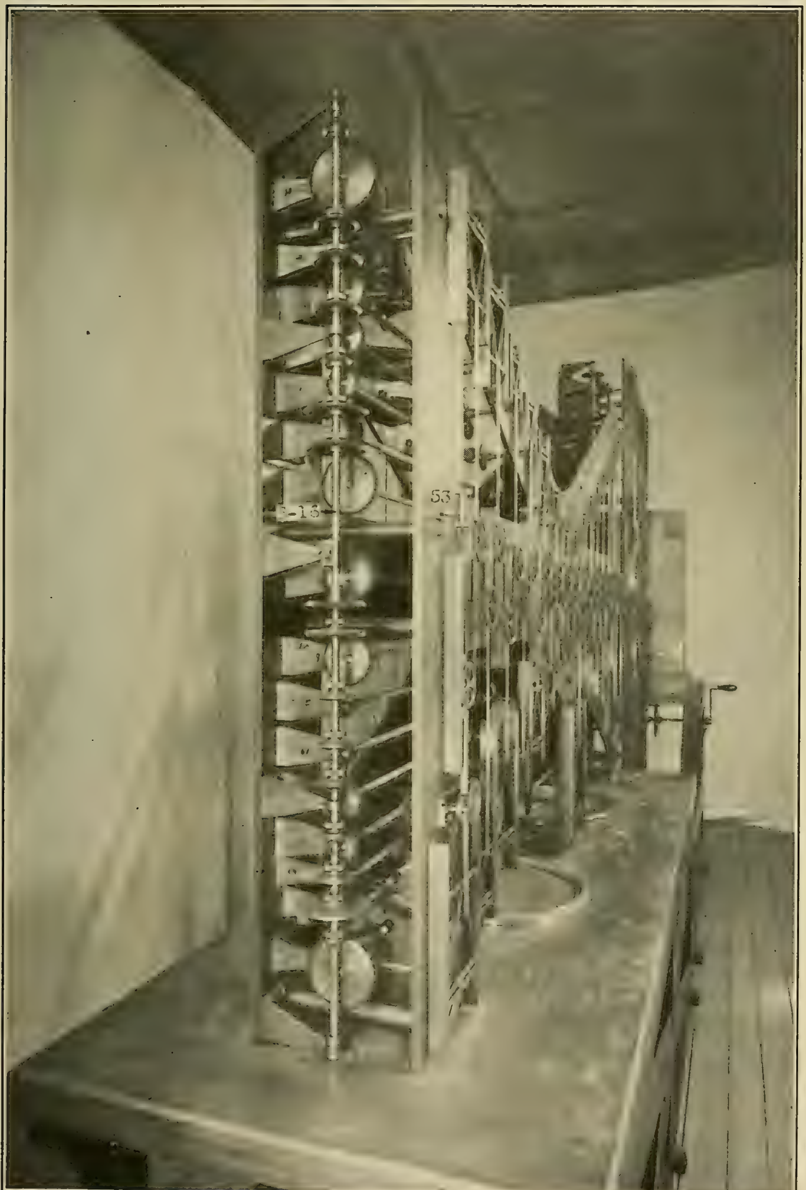


Fig. 14.—REAR END AND HEIGHT SIDE, TIDE-PREDICTING MACHINE.

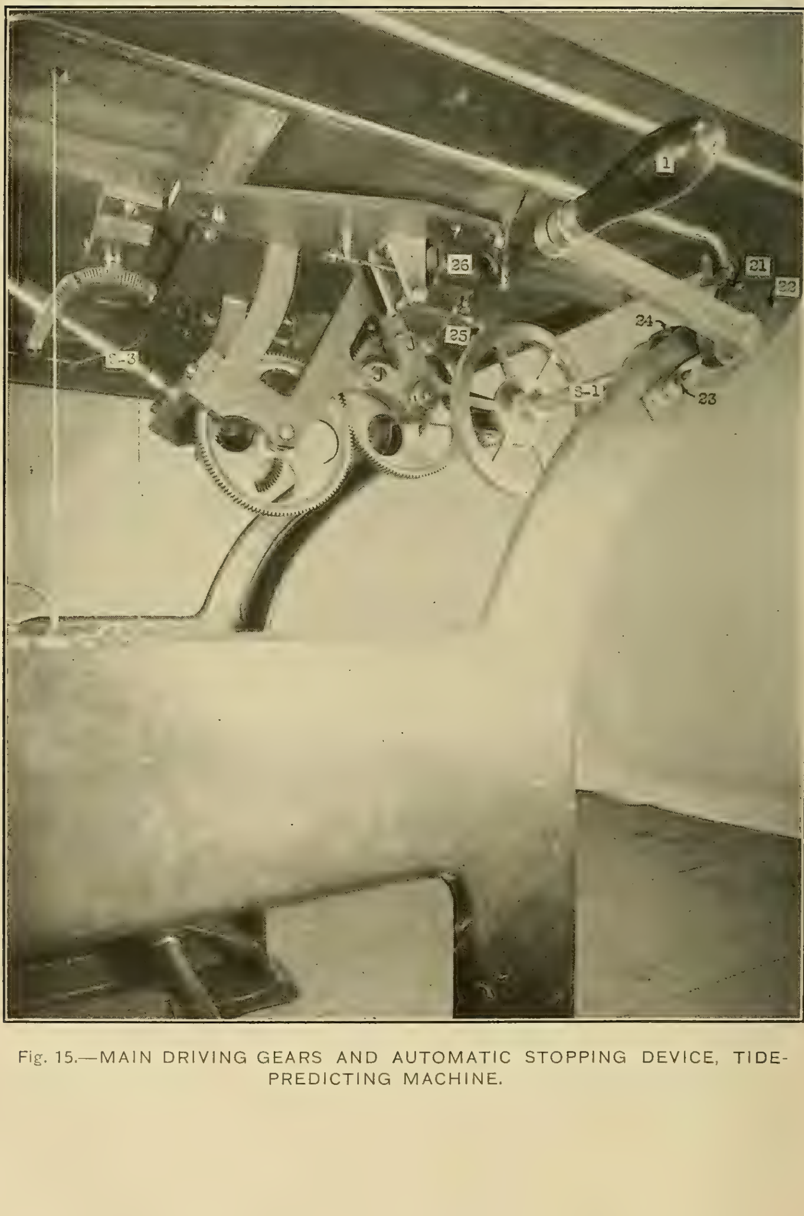


Fig. 15.—MAIN DRIVING GEARS AND AUTOMATIC STOPPING DEVICE, TIDE-PREDICTING MACHINE.

any desired position by tightening up on the clamp screw, which, pressing against the small spring at the back, forces the crank-pin block outward against the flanges of the groove with sufficient pressure to prevent any slipping. A milled head wrench B is used for tightening the clamp screw. A small rectangular block e of hardened steel is fitted to turn freely upon the finely polished axle of the crank pin. This block is designed to fit into and slide along the slot of the component frame.

Positive and negative direction.—All the component shafts and cranks may be grouped into two ranges—those above the medial horizontal plane of the framework being in the upper range and those below this plane in the lower range. In the following discussion direction toward this medial plane is to be considered as negative and direction away from the plane as positive; that is to say, for all components in the upper range the positive direction will be upward and the negative direction downward, while for the components in the lower range the positive direction will be downward and the negative direction upward.

Component dials.—To indicate the angular positions of the component shafts, the pointer (a, fig. 21) moves around a dial (*41*, fig. 16) which is graduated in degrees. These dials are fastened to the frame of the machine back of the component cranks on both sides of the machine, those on the time side being graduated clockwise and those on the height side counterclockwise. These dials and pointers are so arranged that the angular position of a component shaft at any time will be the same whether read from the dial on the height side or from the dial on the time side of the machine, and at the zero reading for any component the height crank will be in a positive vertical position and the corresponding time crank in a horizontal position. At a reading of 90° the height crank will be horizontal and the time crank in a negative vertical position.

With the face of the machine registering the initial epoch, such as January 1, 0 hour, of any year, the value of t then being taken as zero, each component shaft may be set, by means of its releasable gear, so that the dial readings will be equal to the α of the corresponding component as represented in formulas (472) and (473). If the machine is then put in operation, the dial readings will, for successive values of t, continuously correspond to the angles $(at+\alpha)$ of the formulas, as the gearing already described will provide for the increment at.

Component sliding frames.—For each component crank there is a light steel frame (*42*, fig. 16) fitted to slide vertically in grooves in a pair of angle pieces attached to the side plates of the machine. At the top of the component frame there is a horizontal slot in which the crank pin slides. As the machine is operated the rotation of the component shafts with their cranks cause each crank pin to move in the circumference of a circle, the radius of which depends upon the setting of the pin on the crank. This motion of the pin, acting in the horizontal slot of the component frame, imparts a vertical harmonic motion to that frame. The frame is in its zero position when the center horizontal line of the slot intersects the axis of the component shaft; positive motion is the direction away from the medial horizontal plane of the machine and negative motion is toward the medial plane. The displacement of each component height frame from its zero position will always equal the product of the amplitude setting of the crank pin by the cosine of the component dial reading, and the displacement of each component time frame will always equal the product of the amplitude setting by minus the sine of the component dial reading.

Component pulleys.—Each component frame is connected with a small movable pulley (*43*, fig. 16). For all components except M_2, S_2, N_2, K_1, O_1, and Sa on the height side and components M_2, S_2, N_2, and M_4 on the time side this connection is by a single steel strip, so that the pulley has the same vertical motion as the corresponding component frame.

Doubling gears.—Because of the very large amplitudes of some of the components two methods were used in order to keep the lengths of the cranks within practical limits. For the components M_2, S_2, and K_1 two sets of shafts and cranks were provided, so that the amplitudes of these components may be divided when necessary and a portion set on each. A further reduction in the length of the cranks for these and the other components named in the paragraph above is accomplished by the use of doubling gears between the component frame and movable pulley. Two spur gears with the ratio of 1:2 (*48*, fig. 16) are arranged to turn together on the same axis. The smaller gear engages a rack (*46*) attached to the component frame and the larger gear engages a rack (*47*) attached to the component pulley. Each rack is held against its gear by a flange roller (*49*), and counterpoise weights are provided to take up the backlash in the gears. Through the action of these doubling gears any motion in the component frame causes a motion twice as great in the component pulley. Doubling gears are provided on the height side of the machine for components M_2, S_2, N_2, K_1, O_1, and Sa and on the time side for components M_2, S_2, N_2, and M_4.

Scales for amplitude settings.—The scales for setting the component amplitudes are attached to the frame of the machine and are, in general, graduated into units and tenths (*44*, fig. 16). The scales are arranged to read in a negative direction; that is, downward for the components of the upper range and upward for the components in the lower range. On a small adjustable plate (*45*) attached to each component pulley there is an index line which is set to read zero on the scale when the component frame is in its zero position. For setting the crank pins for the component amplitudes the cranks to be set are first turned to a negative vertical position. For the cranks on the height side of the machine this position corresponds to a dial reading of 180° and for the cranks on the time side to a reading of 90°.

The scales on the height side of the machine, which are used in setting the coefficients of formula (472), are graduated uniformly one-half inch to the unit. On the time side of the machine the scales are modified in order to automatically take account of the additional factor involving the speed of the component which appears in each of the coefficients of formula (473). Dividing the members of this formula by m, the speed of component M_2, it becomes

$$-\Sigma \frac{a}{m} fH \sin (at+\alpha)=0 \tag{474}$$

The modified scales are graduated 0.5 a/m inch to the unit. The use of the modified scales on the time side of the machine permits both the height and time crank for any component to be set in accord with the factor fH which is common to the coefficients of both formulas (472) and (473). There are also provided for special use on the time side of the machine unmodified scales graduated uniformly to read in a positive direction.

Summation chains.—The summations of the several cosine terms in formula (472) and of the several sine terms in formula (473) are carried on simultaneously by two chains, one (*27*, fig. 16) on the height side and the other (*28*, fig. 17) on the time side of the machine. The chains are of the chronometer fuse type, of tempered steel, and have 125 links per foot. The total length of the height chain is 27.6 feet and of the time chain 30.6 feet. A platinum point is attached to one of the links of the time chain 3.5 feet from its free end for an index.

Each of these chains is fastened at one end near the back part of the machine by a pair of adjusting screws (*53*, fig. 14, and *54*, fig. 13). From these adjusting screws each chain passes alternately downward under a component pulley of the lower range and upward over a component pulley of the upper range, spanning the space between the rear and front component frames by two idler pulleys and continuing until every component pulley on each side of the machine is included in the system. The movable pulleys are so arranged that the direction of the chain in passing from one to another is always vertical and parallel to the direction of the motion of the component sliding frames.

Summation wheels.—The free or movable end of each of the chains is attached to a threaded grooved wheel (*29*, *30*, fig. 16), 12 inches in circumference and threaded to hold more than seven turns of the chain, or about 90 inches in all. These are called the height and time summation wheels. Each is mounted on a shaft that admits a small lateral motion, and by means of a fixed tooth attached to the framework of the machine and reaching into the threads of a screw fastened to the shaft the latter when rotating is forced into a screw motion with a pitch equal to that of the thread groove of the summation wheel; so that the path of the chain as it is wound or unwound from the summation wheel remains unchanged.

The height summation wheel (*29*, fig. 16) is located near the front edge of the front component section, where it receives the height summation chain directly from the nearest component pulley. The time summation pulley (*30*) is located inside the dial case near the lower left side, and three fixed pulleys are used to carry the time chain from the end component pulley to the summation wheel. Counterpoise weights are connected with the shafts containing the summation wheels in order to keep the summation chains taut.

When all of the component frames on either side of the machine are in their zero positions, the corresponding summation wheel is approximately half filled by turns of the summation chain. Any motion of a component frame in a positive direction will tend to unwind the chain from the wheel, and any motion in the negative direction will tend to slacken the chain so that it will be wound up by the counterpoise weight. With several of the component frames on either side of the machine moving simultaneously, the resultant motion, which is the algebraic sum of all, will be communicated to the summation wheel. The motion of the component frame being transmitted to the chain through a movable pulley, the motion of the free end of the chain must be twice as great as that in the pulley. The scale of the pulley motion is one-half inch to the unit, and therefore the scale of the chain motion is 1 inch to the unit, and one complete rotation of the summation wheel represents a change of 12 units.

The zero position of the height summation wheel is indicated by the conjunction of an index line (*50,* fig.16) on the arm attached to the wheel and an index line (*51,* fig. 16) on a bracket attached to the framework of the machine just below the summation wheel, the wheel itself being approximately one-half filled with the summation chain. The length of the chain is adjusted so that the summation wheel will be in its zero position when all the component frames are in their zero positions. It will be noted that the conjunction of the index lines will not alone determine the zero position of the wheel, since such conjunctions will occur at each turn of the wheel, while there is only one zero position, which is that taken when the component frames are set at zero.

The zero position of the time summation wheel is indicated by the conjunction of an index point (*11,* fig. 12) attached to the time summation chain and a fixed index (*12,* fig. 12) in the middle of the horizontal opening near the bottom of the dial case, and the length of the time summation chain is so adjusted that this conjunction will occur when all of time component frames are in their zero positions.

Predicted heights of the tide.—When the machine is in operation, the sum of all the cosine terms of formula (472) included in the settings for a station will be transmitted through the height summation wheel to the face of the machine and there indicated in two ways—first by a pointer moving over a circular height scale (*8,* fig. 12) and second by the ordinates of a tide curve that is automatically traced on a roll of paper (*15,* fig. 12). The motion of the height summation wheel is transmitted by a gear ratio of 30 : 100 to a horizontal shaft which is located just back of the dial case. One complete rotation of this shaft represents 40 units in the height of the tide. From this shaft the motion is carried by two separate systems of gearing to the height pointer on the face of the machine and to the pen that traces the tide curve.

Height scale.—The height pointer is geared to make one complete revolution for a change of 40 units in the height of the tide. A height scale, with its circumference divided into 40 equal parts and each of these unit parts subdivided into tenths, provides for the direct registering of the sum of the cosine terms of formula (472) as communicated through the summation wheel. This scale has its zero graduation at the top and is graduated positively to the right and negatively to the left. The height pointer can easily be adjusted to any position by means of a small milled nut (*10,* fig. 12) at the end of its shaft. If it should be desired to refer the predicted heights to mean sea level, this pointer must be adjusted to read zero at the same time that the summation wheel is in its zero position; but if it is desired to refer to some other datum, the pointer will be adjusted according to the elevation of mean sea level above this datum. For the value of h in formula (472) the pointer will be adjusted to a reading corresponding to the adopted value of H_0 at the time the summation wheel is in its zero position, then this value of H_0 will be automatically included with the sum of the cosine terms of that formula. As the

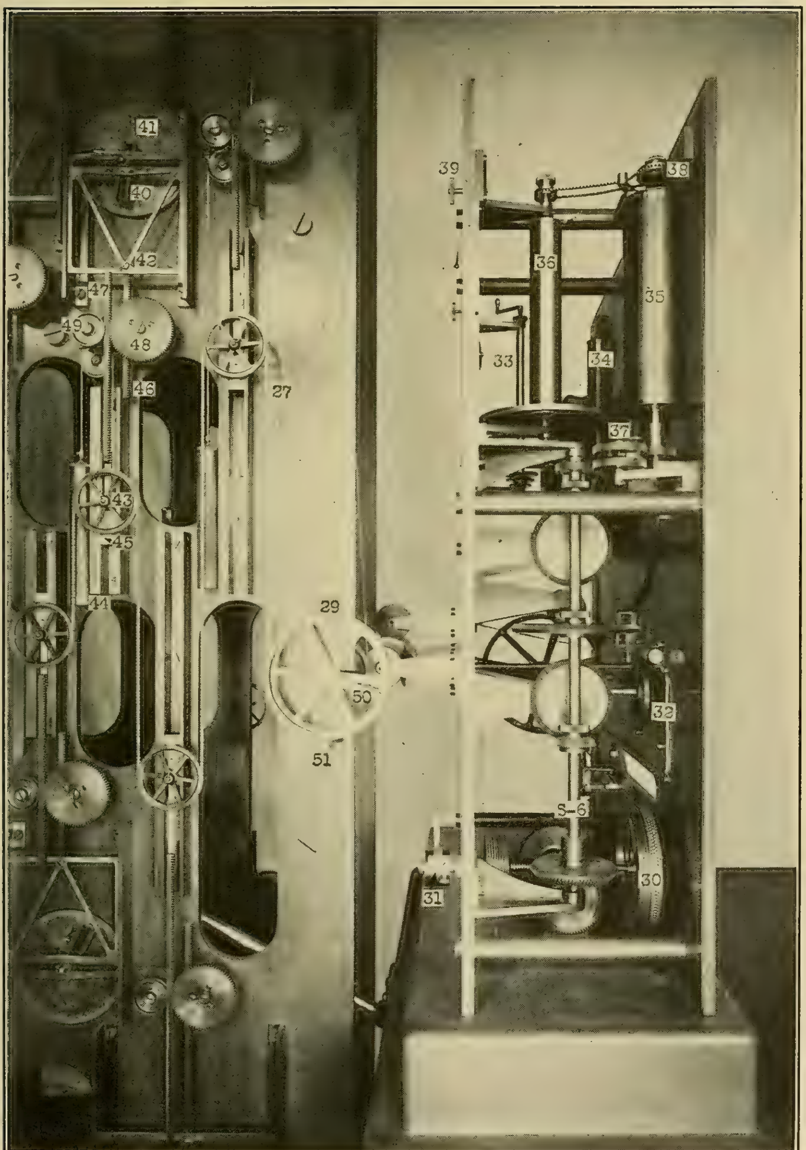


Fig. 16.—DIAL CASE, TIDE-PREDICTING MACHINE.

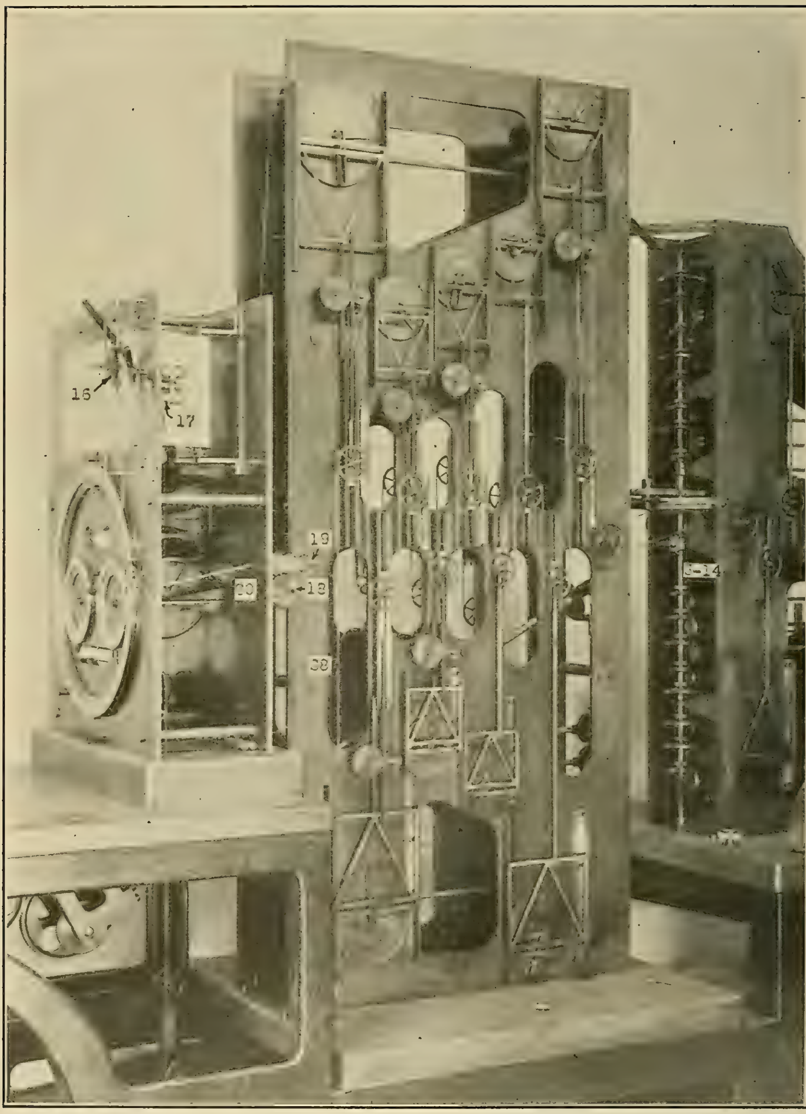


Fig. 17.—DIAL CASE AND FRONT COMPONENT SECTION, TIME SIDE, TIDE-PREDICTING MACHINE.

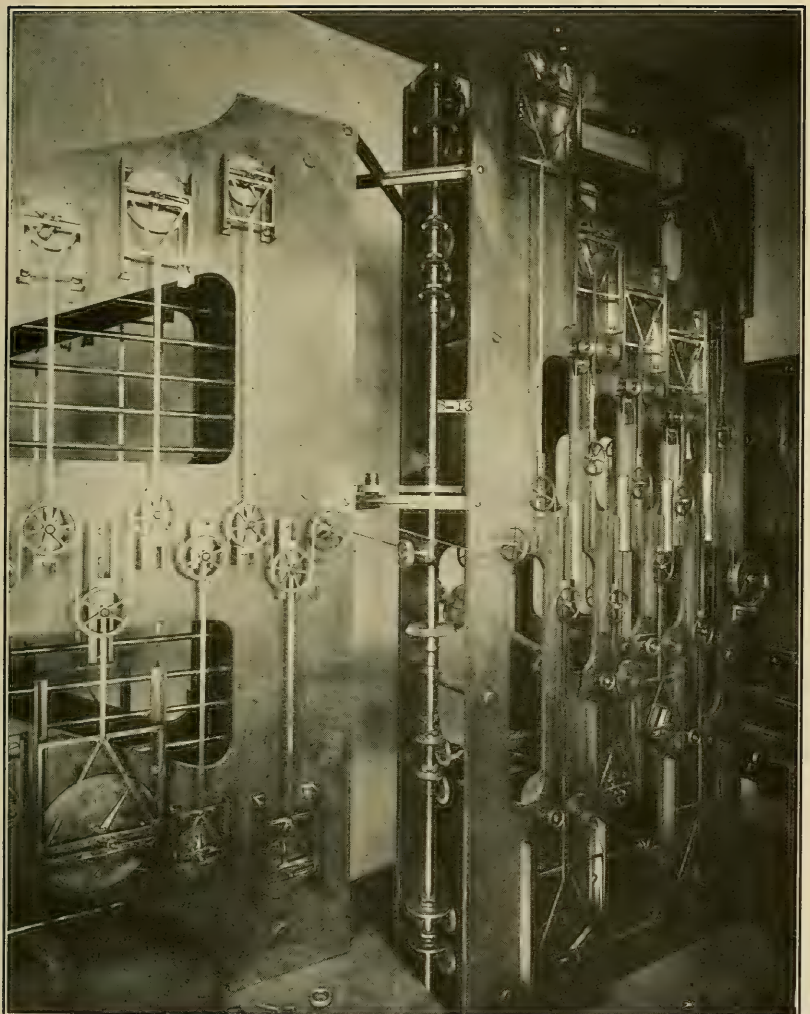


Fig. 18.—VERTICAL DRIVING SHAFT, FRONT COMPONENT SECTION, TIDE-PREDICTING MACHINE.

Fig. 19.—FORWARD DRIVING SHAFT, REAR COMPONENT SECTION, TIDE-PREDICTING MACHINE.

machine is operated the height pointer will indicate the predicted height of the tide corresponding to the time shown on the time dials.

In order to increase the working scale of the machine when predicting tides with smaller ranges, two additional circular height scales are provided, one with the circle divided into 20 units and the other into 10 units, with the units subdivided into tenths. These scales may be easily removed or replaced on the machine, the scale in use being secured in place by a small button at the top (*9*, fig. 12). The 20-unit scale may be conveniently used when the extreme range of the predicted tide at any place is between 10 and 20 feet, and the 10-unit scale when the extreme range is less than 10 feet. If the 20-unit scale is to be used, the value of each coefficient of both the cosine and the sine terms must be doubled before setting the component cranks, and if the 10-unit scale is used these original coefficients must first be multiplied by 4 before setting the values in the machine. If the extreme tide is less than 4 feet, the 40-unit dial may be readily used as a 4-unit scale by considering the original unit graduations as tenths of units in the larger scale. In this case the coefficients of the cosine and sine terms of the formula must be multiplied by 10 before entering in the machine. The factor used for multiplying the coefficients to adapt them to the different height scales is called the working scale of the machine. Working scales of 1, 2, 4, and 10 are now in general use to take account of the different ranges of tide at the places for which predictions are made.

Predicted times of the tide.—Simultaneously with the summation of the cosine terms of formula (472) on the height side of the machine the summation of the sine terms of formula (474), which was derived from formula (473), is being effected on the time side. Being concerned only with the time at which the sum of the sine terms is zero, no provision is made for registering the sum except at this time, which is indicated on the machine by the conjunction of the index point on the time chain and the fixed platinum index in the dial case. Near the time of a high water the index on the chain moves from right to left and near the time of a low water from left to right. The conjunction of the movable and fixed index is visible to the operator of the machine and he may note the corresponding dial readings for the time and height of the high or low water.

Automatic stopping device.—This device provides for automatically stopping the machine at each high and low water. Secured to the hand-crank shaft is a ratchet wheel and just above the ratchet wheel is a steel pawl (*25*, fig. 15) operated by an electromagnet (*26*) mounted under the desk top. The electric circuit for the electromagnet is closed by a contact spring that rests upon a hard-rubber cylinder (*31*, fig. 16) on the rear end of the shaft on which the time summation wheel is mounted. A small platinum plug in this rubber cylinder comes in contact with the spring, which is fitted with a fine motion adjustment, when the time summation chain registers zero. This closes the circuit and draws the pawl against the ratchet wheel, thereby automatically stopping the machine. The lateral screw motion of the shaft on which the rubber cylinder is mounted prevents the platinum plug from coming in contact with the spring on any revolution other than the one which brings the time chain to its zero position. The circuit is led through an insulated ring on the hub of the hand crank where a contact is kept closed by a spring. After the operator has noted the time and height readings of the high or low water he may easily break the circuit at the crank hub by a slight inward pressure against the crank handle, thus releasing the armature and pawl and permitting the machine to be turned forward to the next stop. By means of a small switch (23, fig. 15) just below the crank the circuit may be held open to prevent the automatic device from operating when so desired.

Nonreversing ratchet.—Upon the crank shaft, close to the bearing in the desk frame, there is a small ratchet wheel and above this there is a pawl (24, fig. 15) that is lifted away from the wheel by friction springs when the machine is being turned forward but which is instantly thrown into engagement when the crank is accidentally turned backward. By pushing in one of the small buttons (*22*, fig. 15) just above the crank the pawl is locked so that it can not engage the ratchet, thus permitting the machine to be turned backward when desired. Pressure on another button releases the pawl.

Tide curve.—The tide curve which graphically represents the rise and fall of the predicted tide is automatically traced on a roll of paper by the machine at the same time that the results are being indicated on the dials. The curve is the resultant of a horizontal movement of the paper, corresponding to the passing of time, and a vertical movement of a fountain pen (*13*, fig .12), corresponding to the rise and fall of the tide. The paper is 6 inches wide with about 380 feet to the roll, which is sufficient to include a little more than a full year of record of the predicted tides at a station. The paper should be about 0.0024 inch thick in order that the complete roll may be of a suitable size for use in the machine.

Within the dial case, near the upper right-hand corner, is a mandrel (*33*, fig. 16), which can be quickly removed and replaced. It is designed to hold the blank roll of paper, the latter being wound upon a wooden core especially designed to fit on the mandrel. At the bottom of the mandrel is an adjustable friction device to provide tension on the paper. From the blank roll the paper is led over an idler roller (*34*, fig. 16), mounted in the front plate of the dial case, then across the face of the machine for a distance of about 13 inches to a feed roller (*35*, fig. 16), then over the feed roller to the receiving roller (*36*, fig. 16), upon which it is wound.

The feed roller governs the motion of the paper across the face of the machine and is provided near each end with 12 fine needle points to prevent the paper from slipping. The feed roller is controlled by the main vertical shaft of the dial case through gearing of such ratio that the feed roller will turn at the same rate as the main vertical shaft; that is to say, one complete turn of the feed roller will represent 12 dial hours in time. The feed roller being 6 inches in circumference the paper will be moved forward at the rate of one-half inch to the dial hour. A ratchet and pawl (*37*, fig. 16) are so placed as to leave the paper at rest when the machine is turned backward. If desired, the paper feed can be thrown out of action altogether by turning a small milled head on the ratchet gear.

To provide for the winding up of the paper on the receiving roller there is a sprocket wheel (*38*, fig. 16) held by adjustable friction to the upper end of the feed roller. Fitted to the top of the receiving roller is a smaller sprocket which is driven by a chain from the feed-roller sprocket. The ratio of the sprockets is such as to force the receiving roller to wind up all the paper delivered by the feed roller, the tension on the paper being kept uniform by the friction device. To remove a completed roll of record the smaller sprocket is lifted from the receiving roller and a pin (*39*, fig. 16) at the back of the dial case is drawn out, releasing the upper bearing bracket. The bracket can then be raised and the receiving roller with its record removed. A similar bracket secured by a pin is provided for the removal of the mandrel on which the blank roll of paper is placed.

Marigram gears.—The pen that traces the tide curve is mounted in a carriage which is arranged to slide vertically on a pair of guiding rods and is controlled from a horizontal shaft at the back of the dial case. On this shaft there is mounted a set of three sliding change gears (*18*, fig. 17), which are designed to mesh, respectively, with three fixed gears mounted on a shaft just above. By sliding the change gears in different positions any one of them may be brought into mesh with its corresponding fixed gear. These gears provide for ratios of 1 : 1, 2 : 1, and 3 : 2, according to whether the innermost, the middle, or the outer gears are in mesh. At the outer end of the shaft containing the fixed gears is a thread-grooved wheel 4 inches in circumference (*19*, fig. 17), to which is attached one end of the pen-carriage chain (*20*, fig. 17). The chain is partly wound upon the wheel and from it passes through the dial case to the front of the machine, then upward over a pulley near the top to a counterpoise weight within the dial case. The pen carriage is secured to this chain by means of a clamp and can be adjusted to any desired position.

Scale of tide curve.—With a working scale of unity the arrangement is such that the motion of the height summation wheel as transmitted to the curve-line pen through the marigram gears with ratio of 1 : 1 causes the pen to move vertically 0.1 inch for each unit change in the predicted height of the tide. If the marigram gears with ratio 3 : 2 or 2 : 1 are used the unit of height will be represented by a vertical movement of the pen of 0.15 or 0.2 inch, respectively. For any working scale other than unity the above unit equivalents must be multiplied by the number representing that scale.

The scale ratio of the tide curve will depend upon the unit of height used for the predictions. Taking the foot as the unit, the following scale ratios are obtained:

	Marigram gears 1 : 1.	Marigram gears 3 : 2.	Marigram gears 2 : 1.
Working scale 1	1 : 120	1 : 80	1 : 60
Working scale 2	1 : 60	1 : 40	1 : 30
Working scale 4	1 : 30	1 : 20	1 : 15
Working scale 10	1 : 12	1 : 8	1 : 6

Pens.—The curve-line pen (*13*, fig. 12) and the datum-line pen (*14*) are each of the ordinary fountain type. Each is fitted with a metal lock joint, so that it may be quickly removed and replaced in the same position, and is pressed against the paper by a light coil spring when in use. The curve-line pen is mounted in a swivel arm on a light carriage which slides vertically along two rods. The datum-line pen is mounted in a swivel arm that may be adjusted so that the mean sea-level line will be traced midway between the upper and lower edges of the paper.

Hour-marking device.—The arm for the datum-line pen is secured to the outer end of a shaft which carries two armatures, one for the upper and the other for the lower of two electromagnets (*17*, fig. 17). A spring keeps the armatures at equal distances from their respective electromagnets. The upper electromagnet is designed for indicating the hours on the datum line and is in a circuit that is opened and closed by a platinum-tipped contact spring resting upon the edge of an ivory disk in which are embedded, equally spaced, 24 narrow strips of platinum (*32*, fig. 16). The ivory disk is mounted on the shaft of the hour pointer, and as this rotates the platinum strips successively make an electric contact that throws the datum-line pen downward for an instant, making a corresponding jog in the datum line, the downward stroke of the pen indicating the exact hour. An extra strip of platinum placed close to the one representing the midnight hour causes a double jog for the beginning of each day, the downward stroke of the second jog indicating the zero hour.

High and low water marking device.—The lower electromagnet is in a circuit that is closed when the platinum index on the time chain (*11*, fig. 12) is in contact with the fixed platinum index (*12*); that is to say, at the times of high and low waters. When this contact is made, the electromagnet attracts the armature, which throws the datum-line pen upward, causing a corresponding upward jog in the datum line, and thus automatically marking the time of the high or low water.

A small switch (*21*, fig. 15) just above the hand-crank shaft permits the cutting out of the current from the two electromagnets.

Adjustment of machine.—The adjustment of the machine should be tested at least once each year and at any other time when there is any reason for believing that a change may have taken place. The following adjustments are required.

Height-chain adjustment.—All amplitudes should be set at zero, so that the turning of each component crank shaft will produce no motion in the height chain. This should bring the summation wheel to its zero position, but on account of a certain amount of backlash and flexures in the machine this wheel may not be in an exact zero position even when the chain is in adjustment. Now, set a single component with a very small amplitude and operating the machine with the hand crank, note whether the index of the summation wheel oscillates equal distances on both sides of its zero position. If not, the chain should be adjusted by the adjusting nut at its fixed end at the back part of the machine.

Time-chain adjustment.—The adjustment of the time chain is similar to that of the height chain. The zero position is indicated by the conjunction of a small triangular-shaped index on the chain and a fixed platinum index in the middle of the horizontal opening in the dial face. A small amplitude being set on one of the component time cranks and the machine operated by the hand crank, the chain index should oscillate equal distances on both sides of the platinum point. If it does not, the necessary adjustment may be made at the fixed end of the chain.

Hour-hand adjustment.—This must be so adjusted that it will register the exact hour at the same instant the circuit for the electromagnet is closed for the hour mark on the marigram, which is indicated by a downward stroke of the datum-line pen. It is also neces-

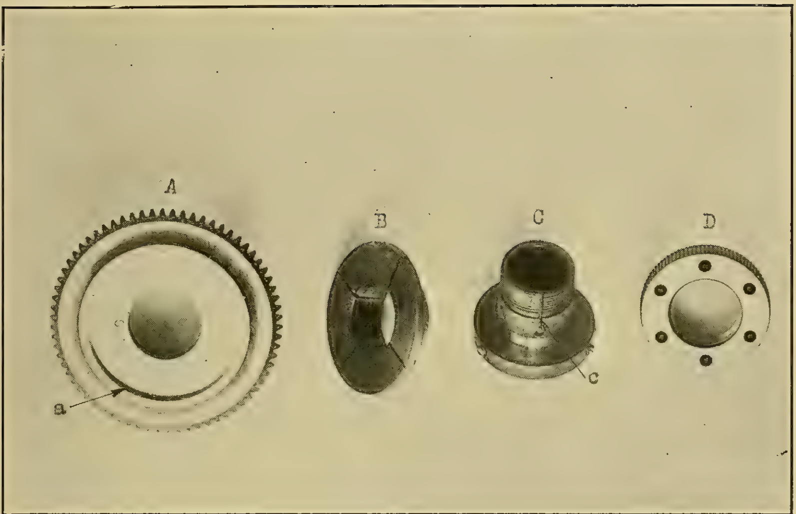


Fig. 20.—DETAILS OF RELEASABLE GEARS, TIDE-PREDICTING MACHINE.

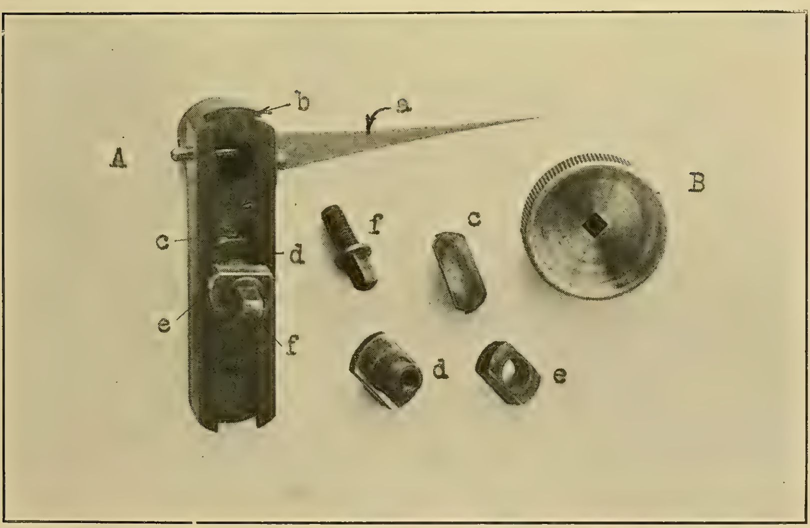


Fig. 21.—DETAILS OF COMPONENT CRANKS, TIDE-PREDICTING MACHINE.

sary that the zero hour or beginning of the day shall correspond to the double hour mark on the marigram. This adjustment may be accomplished by moving the hour hand on its shaft after releasing its set screw. A finer adjustment may be effected by changing the position of the contact spring back of the dial face.

Minute-hand adjustment.—This is to be adjusted to read zero on the exact hour indicated by the hour hand and the closing of the electric circuit for the hour mark. The adjustment may be accomplished either by moving the minute hand on its shaft after releasing its set screw or by means of the releasable gears on the main vertical shaft of the dial case. The adjustments just described are those which need be made only occasionally. Other adjustments are taken into account each time the machine is set for a station.

Setting predicting machine.—The time indicators on the face of the machine are first set to represent the exact beginning of the period for which predictions are to be made, which will ususally be 0 hour of January 1 of some year. The hour and minute hands should always be brought into place by the turning of the operating crank in order that the adjustment of these hands relative to the electromagnet circuit may not be affected. The date dial may, however, if desired, be set independently, using the binding nut just above the large dial ring for releasing and clamping. If only a small motion of the date dial is necessary, it is generally preferable to set it by the operating crank. The year index should be set to indicate the kind of year.

In the usual operation of the machine a ratchet prevents the operating crank from being turned backwards, but this ratchet may be released when desired by pressing on a button in the side of the machine just above the crank. After the face of the machine has been thus set to register the beginning of the predictions the three main vertical shafts of the two component frames should be clamped to prevent them from turning.

To set the height amplitudes.—All the component cranks on the left or height side of the machine are first turned, by means of the releasable gears on the main vertical shafts, to a vertical position, the cranks of the upper range of components pointing downward and those in the lower range upward, in which position all angles will read 180°. For the long-period components the cranks can be more quickly brought to the vertical position by drawing out small knobs on the time side of the machine, thus disconnecting the gearing. The cranks are then turned by hand to the desired position and the knobs pushed back into place. The amplitudes may now be set according to the scales attached to the sides of the machine. The crank pin is unclamped by a small milled head wrench and is then moved along its groove until the index at the scale registers the amplitude setting given in Form 445, when it is clamped in this position. If no amplitude is given for any component, the corresponding crank must be set at zero.

To set time amplitudes.—The process is similar to that for the height amplitudes, the cranks on the time side of the machine being first turned to a vertical position with all angles reading 90°. The cranks are to be set with the same amplitudes as were used for the height side, the modified scales automatically taking account of the true differences in the amplitudes. For the components Sa and Ssa the amplitudes are set on the height side only.

To set component angles.—After the amplitudes have been set and checked on both sides of the machine the angles are set for the beginning of the period of predictions, these settings being given in Form 445. The angles may be set from either side of the machine, except for components Sa and Ssa, for which there are no dials on the time side, as the readings are the same for both sides. As each component angle is set its releasable gear is clamped to the main vertical shaft. After all the angles have been thus set the three main vertical shafts must be unclamped to permit them to turn.

Changing height scale.—There are three interchangeable height scales, known as the 40-foot, the 20-foot, and the 10-foot scale: The 40-foot ring may also be conveniently used as a 4-foot scale. The scale to be used for any station is indicated in Form 445. In removing a scale from the machine a small button at the top is turned to release the ring, which is then lifted slightly as it is being removed. The desired scale is then placed on the machine and secured in place by a button. Before removing or replacing the height scale it is desirable that the height pointer be set approximately 45° to the left of its zero position in order to interfere least with the removal or replacement of the scale.

The datum or plane of reference.—The hand-operating crank should be turned forward or backward until the index of the summation wheel on the height side of the machine indicates mean sea level. It must be kept in mind, however, that as the index lines may come in conjunction at each complete rotation of the summation wheel there is a possibility of being misled in regard to the mean sea-level position. When in doubt, the operating crank should be turned forward to obtain a number of conjunctions, the corresponding height dial reading for each being noted. The conjunction that corresponds most closely with the average of such height readings will be the one that applies to the true zero position. Each complete turn of the height summation wheel will cause a change to the height reading of 12 units, 6 units, or 3 units, respectively, according to whether the 40-unit, 20-unit, or 10-unit dial is used.

The height hand, which can be released by the milled nut on the face of the machine, may now be set to the scale reading that corresponds to the height of mean sea level above the datum which has been adopted for the predictions, this value being given in Form 445.

The marigram gear.—There are three gear combinations, designated as the 1:1, 3:2, and 2:1 ratios. The gear ratio to be used for any station is indicated in Form 445. When it is necessary to change the gear ratio, the machine should be first turned to its mean sea-level position. The change is then effected by sliding the lower set of gears horizontally, being careful to hold the upper set with one hand to prevent it from turning when the gears are released. Before engaging the gears in their new ratios the counterpoise for the pen carriage should be brought to a position approximately midway between the limits of its range of motion. The 1:1 ratio is obtained by sliding the lower set of gears as far as possible toward the height side of the machine, thus engaging the innermost gears; the 3:2 ratio by moving these gears toward the time side until the outer gears are engaged, and the 2:1 ratio by engaging the middle gear of each set.

In setting up the machine for successive stations there is a mechanical advantage in making the necessary gear changes before setting the new amplitudes if the gear changes are in the order of 2:1, 3:2, 1:1, and after setting the amplitudes if the gear changes are in the reverse order. This precaution will lessen the chances of jambing the curve pen carriage and throwing the height chain off its pulleys when setting the amplitudes.

Inserting paper roll.—To place the paper on the machine, remove the mandril that is mounted within the dial case near the upper right-hand corner and slip the roll of paper over the mandril, the roll being so placed that the winding is clockwise when viewed from above and when on the machine the paper unwinds from the outer side of the roll. In placing the roll on the mandril care should be taken to see that the small projection on the base of the latter enters the cavity in the wooden core, so that the roll will fit flat against the base. After the mandril with the roll of paper has been returned to the machine and secured in place the end of the paper is passed around a roller to the face of the machine, across the face, and over the feed roller at the left of the machine. The end is then inserted into the slit in the receiving roller, which is given a few turns to take up the slack paper and make it secure. Before passing the paper over the feeding roller and on the receiving roller these rollers should be released to permit them to turn independently, the release being effected by turning the small milled head on a ratchet stud gear near the base of the feeding roller and by lifting off from the top of the receiving roller the small knob holding the connecting chain. After the paper has been secured to the receiving roller these connections should be restored.

Curve pen adjustment.—With the machine in its mean sea-level position, the curve pen must be adjusted to bring the pen point on the mean sea-level line as drawn by the base-line pen. This adjustment may be effected by releasing the pen carriage from the operating chain and moving it to the desired position, where it is clamped in place by the binding screw.

Verification of machine settings.—Each step in the adjustment and setting of the machine should be carefully checked before proceeding with the next step. After the setting of the machine for any station has been completed an excellent check on the work is afforded, if the predictions for the same station for the preceding year are available, by turning the machine backward several days and then comparing the predicted tides with those previously obtained.

Predicting.—The datum and curve fountain pens are filled and put in place, the electric cut-out switch under the base of the machine closed, and the ratchet of the operating crank set to prevent the machine from being turned backward.

If the predicted height of the tide for any given time is desired, the machine may be turned forward until the required time is registered on the time dials and the corresponding height read off of the height dial.

If the predicted high and low waters for the year are desired, the operating crank is turned forward until the machine is automatically stopped by the brake at a high or low water. To avoid the strain on the machine due to sudden stops, the operator should watch the small index on the time chain, and as this approaches the fixed index in the center of the opening on the face of the machine, turn the crank more slowly until the machine is stopped as the indexes come in contact with each other. The time and height may then be read directly from the dials on the face of the machine. The movement of the height pointer before the stopping of the machine and also the tide curve will clearly indicate whether the tide is a high or low water. After the tide has been recorded an inward pressure on the crank handle will release the brake and the machine can be turned forward to the next tide, the process being repeated until all the tides of the year have been predicted and recorded.

35. TIDAL CURRENTS.

Tidal currents are the periodic horizontal movements of the waters of the earth's surface. As they are caused by the same periodic forces that produce the vertical rise and fall of the tide, it is possible to represent these currents by harmonic expressions similar to those used for the tides. Components with the same periods as those contained in the tides are involved, but the current velocities take the place of the tidal heights. There are two general types of tidal currents, known as the reversing type and the rotary type.

In the reversing type the current flows alternately in opposite directions, the velocity increasing from zero at the time of turning to a maximum about three hours later and then diminishes to zero again, when it begins to flow in the opposite direction. By considering the velocities as positive in one direction and negative in the opposite direction, such a current may be expressed by a single harmonic series, such as

$$V=A \cos (at+\alpha)+B \cos (at+\beta)+C \cos (ct+\gamma)+\text{etc.} \tag{475}$$

in which V = velocity of the current in the positive direction at any time t.

A, B, C, etc. = maximum velocities of current components.
a, b, c, etc. = speeds of components.
α, β, γ, etc. = initial phases of components.

In the rotary type the direction of the current changes through all points of the compass, and the velocity, although varying in strength, seldom becomes zero. In the analysis of this type of current it is necessary to resolve the observed velocities in two directions at right angles to each other. For convenience the north and east directions are selected for this purpose, velocities toward the south and west being considered as negatives of these. For the harmonic representation of such currents it is therefore necessary to have two series—one for the north and the other for the east component.

For the analysis of either type of current the original hourly velocities or the resolved hourly velocities are tabulated in the same form used for the hourly heights of the tide. To avoid the inconvenience of negative readings in this tabulation, a constant, such as 3 knots, is added to all velocities.

These hourly velocities are then summed with the same stencils that are used for the tides, and the hourly mean velocities are analyzed in the same manner as the hourly heights of the tide. The same forms are used for the currents, with the necessary modifications in the headings. The rotary currents will be represented by a double set of constants, one for the north components and the other for the east components.

Although the predicting machine was designed, primarily, for the prediction of the tides, it is adapted also to the prediction of tidal currents. The currents involve both direction and velocity, while the tides involve height only. The predicting machine can not be used directly for the determination of direction, but it is used for the summation of component velocities in the same manner as for the summation of component heights in the prediction of the tides.

It is therefore directly applicable for the reversing type of current, in which only a single direction need be considered, the velocities being taken as positive or negative according to the direction in which it is flowing.

For the rotary type of current all velocities might be resolved into two directions at right angles to each other, such as the north and east, and velocity predictions made for each of these directions independently. The labor, however, of recombining the north and east components into the resultant velocities would be practically prohibitive without a machine especially designed for this purpose.

For the predictions of the reversing current two methods are employed. The first is of general application and requires that the harmonic constants of the current components be obtained from an analysis of the current velocities. The machine settings are then computed in the same manner as for the prediction of the tides and using the same forms with slight modifications in the headings, the amplitudes being expressed in knots instead of feet. The approximate extreme range will be taken as twice the maximum current in one direction. The height dial unit will be taken as the knot instead of the foot, and zero velocity will be taken to correspond to mean sea level.

If the machine is now set up and operated in the same manner as for the prediction of tides, the current velocities may be read directly from the face of the machine for any desired time, the positive values being for the velocities in the direction originally adopted as positive, preferably the flood current, and the negative values for the velocities in the opposite direction. The machine will be automatically stopped at each maximum flood and ebb current, and slack water will be indicated by the zero position of the recording hand. The velocity of the current for any desired time and the times of maximum velocities and of slack water may be also obtained from the predicted curve.

A second method of predicting the reversing current, which is more indirect than that just described, is applicable to a hydraulic current in a strait. Such a current is caused by the difference in the head of the tidal waters at the two ends of the strait. Except for the lag due to the inertia or momentum of the water, slack would occur at the time the water is at the same level at both ends and the maximum velocities at the times of greatest difference in the head. For this method of predicting it is necessary that tidal harmonic constants should be available for both ends of the strait.

Let these ends be designated by M and N, and let the single subscript refer to the tidal constants at M and the double subscript to those at N, and for convenience call the direction of flow from M to N as flood or positive and the reverse direction as ebb or negative.

Excepting for the lag, therefore, the flow will be positive when the elevation of the water at M is higher than at N and negative when the water at N is the higher.

Let

$H_{,}$ = amplitude of any component A for station M.
$H_{,,}$ = amplitude of same component A for station N.
$\kappa_{,}$ = epoch of same component A for station M.
$\kappa_{,,}$ = epoch of same component A for station N.
$L_{,}$ = longitude of station M (positive if west, negative if east).
$L_{,,}$ = longitude of station N (positive if west, negative if east).
p = subscript of component A.
$(V_0+u)_{,}$ = local V_0+u for component A at station M.
$(V_0+u)_{,,}$ = local V_0+u for component A at station N.

Then $(V_0+u)_{,,}=(V_0+u)_{,}+p\,(L_{,}-L_{,,})$ (476)

The equations of the heights of the tide due to component A at stations M and N, respectively, may be written

$$\begin{aligned} y_{,} &= fH_{,} \cos\,[at+(V_0+u)_{,}-\kappa_{,}] \\ &= fH_{,} \cos\,[at+(V_0+u)_{,}] \cos \kappa_{,} + fH_{,} \sin\,[at+(V_0+u)_{,}] \sin \kappa_{,} \end{aligned} \tag{477}$$

$$\begin{aligned} y_{,,} &= fH_{,,} \cos\,[at+(V_0+u)_{,,}-\kappa_{,,}] \\ &= fH_{,,} \cos\,[at+(V_0+u)_{,}+p(L_{,}-L_{,,})-\kappa_{,,}] \\ &= fH_{,,} \cos\,[at+(V_0+u)_{,}] \cos\,[\kappa_{,,}-p(L_{,}-L_{,,})] \\ &\quad + fH_{,,} \sin\,[at+(V_0-u)_{,}] \sin\,[\kappa_{,,}-p(L_{,}-L_{,,})] \end{aligned} \tag{478}$$

The difference in the height due to component A, positive when the tide at M is the higher and negative when the tide at N is the higher, may now be written

$$\begin{aligned} y = y_{,}-y_{,,} &= f\{H_{,} \cos \kappa_{,} - H_{,,} \cos\,[\kappa_{,,}-p(L_{,}-L_{,,})]\} \cos\,[at+(V_0+u)_{,}] \\ &\quad + f\{H_{,} \sin \kappa_{,} - H_{,,} \sin\,[\kappa_{,,}-p(L_{,}-L_{,,})]\} \sin\,[at+(V_0+u)_{,}] \\ &= f\sqrt{H_{,}^2+H_{,,}^2-2H_{,}H_{,,} \cos\,[\kappa_{,}-\kappa_{,,}+p(L_{,}-L_{,,})]}\,\times \\ &\cos\left[at+(V_0+u)_{,}-\tan^{-1} \frac{H_{,} \sin \kappa_{,} - H_{,,} \sin\,[\kappa_{,,}-p(L_{,}-L_{,,})]}{H_{,} \cos \kappa_{,} - H_{,,} \cos\,[\kappa_{,,}-p(L_{,}-L_{,,})]}\right] \end{aligned} \tag{479}$$

If we let

$$H=\sqrt{H_{,}^2+H_{,,}^2-2H_{,}H_{,,} \cos\,[\kappa_{,}-\kappa_{,,}+p(L_{,}-L_{,,})]} \tag{480}$$

and

$$\kappa=\tan^{-1} \frac{H_{,} \sin \kappa_{,} - H_{,,} \sin\,[\kappa_{,,}-p(L_{,}-L_{,,})]}{H_{,} \cos \kappa_{,} - H_{,,} \cos\,[\kappa_{,,}-p(L_{,}-L_{,,})]} \tag{481}$$

and substitute in (479), we have

$$y=fH \cos\,[at+(V_0-u)_{,}-\kappa] \tag{482}$$

In (481) the quadrant of κ is determined by the signs of the numerator and denominator, which correspond, respectively, to the signs of the sine and cosine of the angle.

Similar formulas will represent the height difference due to the other components, and the sum of all will give the resulting difference in the head of water at station M and station N.

This sum for successive values of t is readily obtained by use of the tide-predicting machine, which will give the times of the maximum and minimum and zero differences and also the difference in the head of the water for any desired time.

In general, the current will flow from M to N when the value of y is positive and in the reverse direction when y is negative, but on account of the inertia of the water there will be a lag which will cause the maximum strength of flood and ebb to occur some minutes after the time of greatest head, and also the slack water to be some time later than the time of zero difference in head. The amount of this lag may be determined from actual observations.

In the prediction of the slack waters by the use of the predicting machine the necessity of taking account of the lag for each individual slack is avoided by modifying once for all the epochs determined from Formula (481).

Let t_0 = lag or average difference between time of zero difference in head and time of following slack water, and let

$$t' = t + t_0 \text{ or } t = t' - t_0 \tag{483}$$

Then, when t represents the time of zero head, t' will represent the time of the corresponding slack water.

Substituting in (482) we have

$$y = fH \cos\,[at' + (V_0 + u)_{\prime} - (\kappa + at_0)] \tag{484}$$

in which t' will represent the time of slack water when y equals zero.

To adapt the above to the use of the Greenwich $(V_0 + u)$, we have from (467)

$$(V_0 + u)_{\prime} = \text{Greenwich } (V_0 + u) + a\,S/15 - pL_{\prime} \tag{485}$$

Substituting in (484) and letting

$$\kappa' = \kappa + at_0 - a\,S/15 + pL_{\prime} = \kappa + pL_{\prime} - a\,(S/15 - t_0) \tag{486}$$

we have

$$y = fH \cos\,[at' + \text{Greenwich } (V_0 + u) - \kappa'] \tag{487}$$

In formulas (481) to (486) it will be noted that the κ has for convenience been taken as referring to the longitude of station M and the corresponding values for the local $(V_0 + u)$ and L are therefore used. The S refers to the meridian of the standard time used in the calculation.

The κ' is adapted to the meridian of Greenwich and also takes account of the lag in the current.

The elements such as represented by formula (487) may be readily summed by the tide-predicting machine. While the resulting differences in head will refer to time t, the face of the machine will indicate time t', and when the difference in head registers zero, t' will indicate the time of the corresponding slack water.

Formula (487) may also be used for the prediction of the strength of the current, but if the lag in the strength differs from the lag in the slack waters a separate set of κ's must be computed. The strength of flood current will correspond to the maximum positive differences in the head and the strength of ebb to the greatest negative differences.

36. FORMS USED FOR ANALYSIS AND PREDICTIONS.

The forms used by the U. S. Coast and Geodetic Survey to facilitate the work of the harmonic analysis and predictions of the tides, together with an example of their use, are shown in Figures 22 to 34. A series of tidal observations at Morro, Calif., for February 13 to July 25, 1919, is taken as the example to illustrate the analysis and the computation of the settings for the predicting machine.

Form 362, hourly heights (fig. 22).—The hourly heights of the tide are first tabulated in Form 362. Although the zero of the tide staff is usually taken as the height datum, any other fixed plane will serve this purpose. For practical convenience it is desirable that the datum be low enough to avoid negative tabulations, but not so low as to cause the readings to be inconveniently large for summing.

The hours refer to mean solar time, which may be either local or standard, astronomical or civil, but standard civil time will generally be the most convenient to use. The series must commence with the zero (0) hour of the adopted time, and all vacancies in the record should be filled by interpolated values in order that each hour of the series may be represented by a tabulated height. It is the general practice to use red ink for the interpolated values to distinguish them from the observed heights. The record for successive days of the series must be entered in successive columns of the form, and these columns are to be numbered consecutively, beginning with one (1) for the first day of the series.

The series analyzed should be one of the following lengths: 15 (14 days for diurnal components), 29, 58, 87, 105, 134, 163, 192, 221, 250, 279, 297, 326, 355, or 369 days. Series of observations very nearly equal to one of these standard lengths may be completed by the use of extrapolated hourly heights. If the observations cover a period of several years, the analysis for each year may be made separately, a comparison of the results affording an excellent check on the work.

The hourly heights on each page of Form 362 are first summed horizontally and vertically. The total of the vertical sums must equal the total of the horizontal sums, and this page sum is entered in the lower right-hand corner of the page.

Stencils (figs. 23 and 24).—The first figure is a copy of the component M stencil for the even hours of the first seven days of the series, and the latter illustrates the use of the same. This stencil being laid over the page of hourly heights shown in Figure 22, the heights applying to each of the even component hours for this page show through the openings in the stencil, where they appear connected by diagonal lines, thus indicating each group to be summed.

For each component summation, excepting for S, there are provided two stencils for each page of tabulated hourly heights, one for the even component hours and the other for the odd component hours. The stencils are numbered with the days of series to which they apply, and special care must be taken to see that the days of series on each stencil correspond with the days of series on the page of tabulations with which it is used.

For component S no stencils are necessary, as the component hours correspond to the solar hours of the tabulations, and the horizontal sums from Form 362 may be taken directly as the component hour sums.

Form 142, stencil sums (figs. 25 and 26).—The sums for each component hour are entered in Form 142, one line of the form being used for each page of the original tabulations. The total of the hour sums in each line of the form must equal the corresponding page sum of

Form 362
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: HOURLY HEIGHTS

Station: Morro, California. Year: 1919.
Chief of Party: E. B. Latham. Lat. 35° 22' N. Long. 120° 51' W.
Time Meridian: 120 W. Tide Gauge No. 107 Scale 1:9 Reduced to Staff.
11—792

Month and Day.	mo. Feb. d. 13	d. 14	d. 15	d. 16	d. 17	d. 18	d. 19	Horizontal Sum.
Day of Series.	1	2	3	4	5	6	7	
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	3 9	4.2	4.6	4.5	4.4	4.7	4.6	30.9
1	3.4	3.8	4.2	4.2	4.2	4.9	4.8	29.5
2	3.0	3.3	3.5	3.7	3.8	4.6	4.9	26.8
3	2.8	3.0	3.0	3.1	3.3	4.1	4.5	23.8
4	3.0	2.8	2.6	2.5	2.7	3.5	3.8	20.9
5	3.6	3.1	2.5	2.2	2.2	3.0	3.2	19.8
6	4.4	3.6	2.8	2.2	1.9	2.6	2.7	20.2
7	5.1	4.5	3.5	2.6	2.0	2.5	2.3	22.5
8	5.7	5.3	4.3	3.3	2.4	2.7	2.2	25.9
9	6.0	6.0	4.9	4.1	3.1	3.1	2.4	29.6
10	5.6	6.2	5.4	4.6	3.9	3.6	2.8	32.1
11	4.8	5.8	5.5	4.9	4.3	4.1	3.2	32.6
Noon.	3.9	5.1	5.1	4.8	4.4	4.5	3.6	31.4
13	3.4	4.3	4.4	4.3	4.2	4.5	3.8	28.9
14	2.6	3.4	3.5	3.6	3.7	4.3	3.8	24.9
15	1.9	2.6	2.8	2.9	3.1	3.8	3.6	20.7
16	1.2	2.0	2.2	2.2	2.6	3.2	3.2	16.6
17	1.0	1.6	1.7	1.6	2.1	2.7	2.8	13.5
18	1.3	1.6	1.5	1.3	1.9	2.4	2.5	12.5
19	2.3	2.2	1.8	1.4	1.9	2.3	2.3	14.2
20	3.2	3.1	2.6	2.0	2.3	2.5	2.4	18.1
21	4.0	3.9	3.4	2.8	3.0	3.0	2.9	23.0
22	4.3	4.5	4.1	3.6	3.8	3.6	3.7	27.6
23	4.5	4.7	4.5	4.1	4.4	4.2	4.2	30.6
Sum.	84.9	90.6	84.4	76.5	75.6	84.4	80.2	576.6

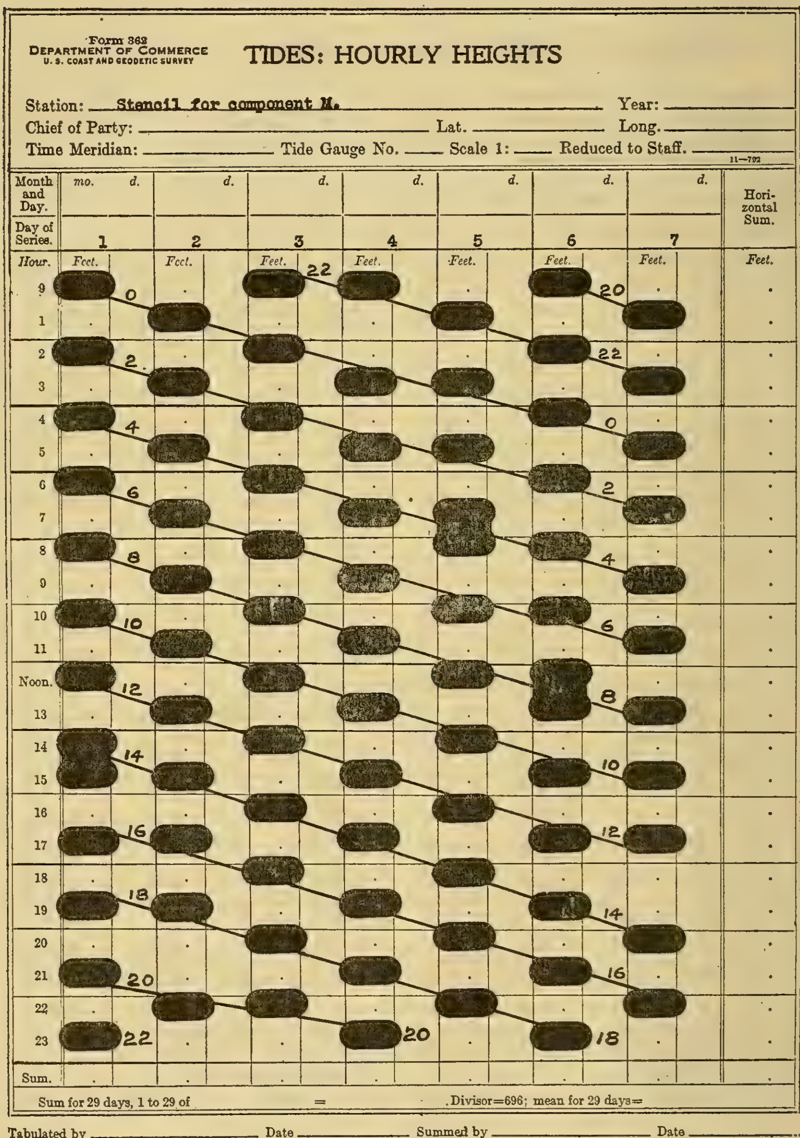
Sum for 29 days, 1 to 29 of = Divisor=696; mean for 29 days=

Tabulated by M.L.S. Date Apr. 22, '19. Summed by F.A.K. Date Nov. 22, 1920.

FIG. 22.

the hourly heights in Form 362, this serving as a check on the summation. After the summing of all the pages of the series has been completed for any component the totals for each component hour are obtained, the divisors from Table 32 entered, and the component hourly means computed (fig. 26). These means should be carefully checked before proceding with the analysis. Large errors can usually be detected by plotting the means.

Form 244, computation of (V_0+u) (fig. 27).—This form provides for the computation of the equilibrium arguments for the beginning of



Form 362
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: HOURLY HEIGHTS

Station: Stencil for component M. Year:
Chief of Party: Lat. Long.
Time Meridian: Tide Gauge No. Scale 1: Reduced to Staff.

11—792

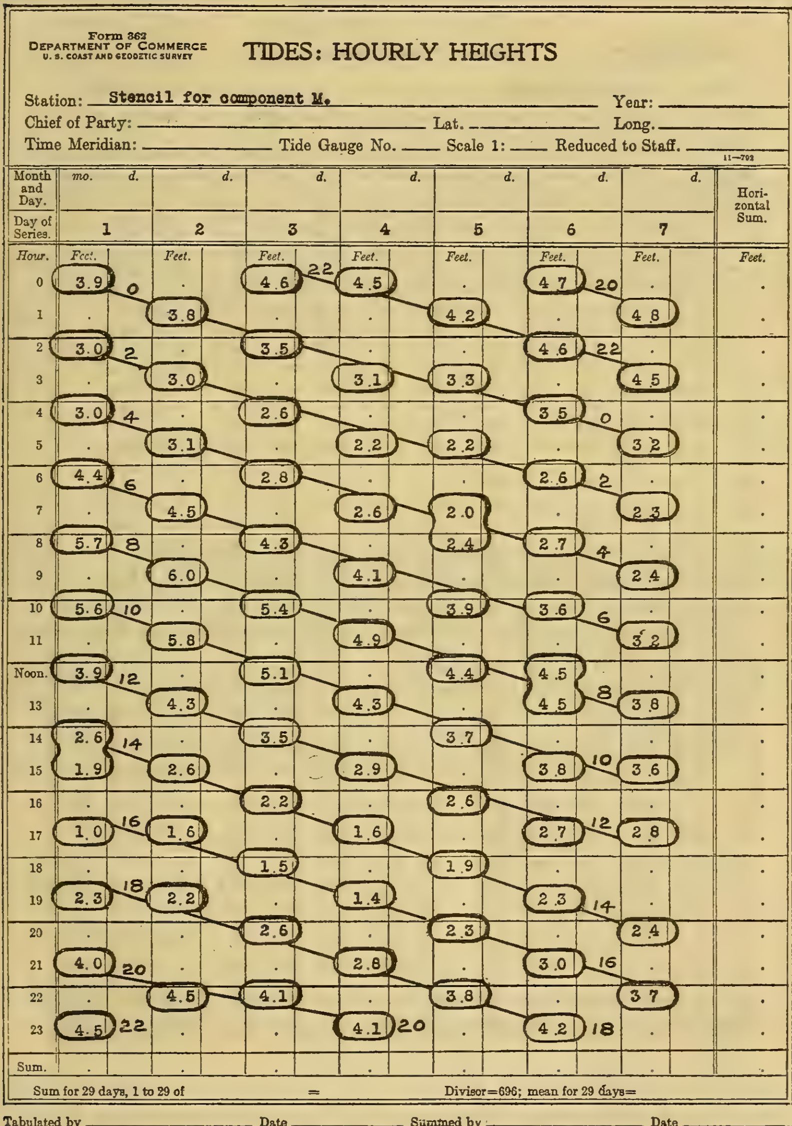
Month and Day. mo. d. | d. | d. | d. | d. | d. | d. | Horizontal Sum.
Day of Series. 1 | 2 | 3 | 4 | 5 | 6 | 7
Hour. Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet.
9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, Noon, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23
Sum.

Sum for 29 days, 1 to 29 of = . Divisor=696; mean for 29 days=

Tabulated by Date Summed by Date

FIG. 23.

the series of observations, the computation being in accordance with formulas given in Table 3. For the most part the form is self-explanatory. The values of the mean longitude of the moon (s), of the lunar perigee (p), of the sun (h), of the solar perigee (p_1), and of the moon's ascending node (N), may be obtained from Table 4 for the beginning of any year between 1800 and 2000. The values for any year beyond these limits may be readily obtained by taking into account the rate of change in these elements as given in Table 2. The corrections necessary in order to refer the elements to any desired



Form 362
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: HOURLY HEIGHTS

Station: Stencil for component M_2 Year: ______
Chief of Party: ______ Lat. ______ Long. ______
Time Meridian: ______ Tide Gauge No. ______ Scale 1: ______ Reduced to Staff. ______

11—792

Month and Day.	mo. d.		d.		d.		d.		d.		d.		d.		Horizontal Sum.
Day of Series.	1		2		3		4		5		6		7		
Hour.	Feet.		Feet.		Feet.		Feet.		Feet.		Feet.		Feet.		Feet.
0	3.9	0	.		4.6	22	4.5		.		4.7	20	.		.
1	.		3.8		.		.		4.2		.		4.8		.
2	3.0	2	.		3.5		.		.		4.6	22	.		.
3	.		3.0		.		3.1		3.3		.		4.5		.
4	3.0	4	.		2.6		.		.		3.5	0	.		.
5	.		3.1		.		2.2		2.2		.		3.2		.
6	4.4	6	.		2.8		.		.		2.6	2	.		.
7	.		4.5		.		2.6		2.0		.		2.3		.
8	5.7	8	.		4.3		.		2.4		2.7	4	.		.
9	.		6.0		.		4.1		.		.		2.4		.
10	5.6	10	.		5.4		.		3.9		3.6	6	.		.
11	.		5.8		.		4.9		.		.		3.2		.
Noon.	3.9	12	.		5.1		.		4.4		4.5		.		.
13	.		4.3		.		4.3		.		4.5	8	3.8		.
14	2.6	14	.		3.5		.		3.7		.		.		.
15	1.9		2.6		.		2.9		.		3.8	10	3.6		.
16	.		.		2.2		.		2.6		.		.		.
17	1.0	16	1.6		.		1.6		.		2.7	12	2.8		.
18	.		.		1.5		.		1.9		.		.		.
19	2.3	18	2.2		.		1.4		.		2.3	14	.		.
20	.		.		2.6		.		2.3		.		2.4		.
21	4.0	20	.		.		2.8		.		3.0	16	.		.
22	.		4.5		4.1		.		3.8		.		3.7		.
23	4.5	22	.		.		4.1	20	.		4.2	18	.		.
Sum.	.		.		.		.		.		.		.		.

Sum for 29 days, 1 to 29 of = Divisor=696; mean for 29 days=

Tabulated by ______ Date ______ Summed by ______ Date ______

FIG. 24.

month, day, and hour are given in Table 5. As the tables refer to Greenwich mean civil time, the argument used in entering them should refer also to this kind of time, and in the lines for the beginning and middle of the series at the head of the form space is therefore provided for entering the equivalent Greenwich hour. Any change in the day may be avoided by using a negative Greenwich hour when necessary. For example, 1922, January 1, 0 hour, in the standard time of the meridian 15° east of Greenwich, may be written as 1922, January 1, −1 hour in Greenwich time, instead of 1921, December 31, 23 hour, as would otherwise be necessary. If a negative argument

Form 142
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: STENCIL SUMS.

Station: Morro, California. Lat.: 35° 22' N.

Component: "M" Length of series: 163 Days. Series begins: 1919-Feb.-13-0 (Yr. Mo. Da. Hr.) Long.: 120° 51' W.

Kind of time used: 120° W. Computed by Fred. A. Kummell, Dec. 9, 1920. (Date.)

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Page.	0h	1	2	3	4	5	6	7	8	9	10	11
1	24.3	20.6	17.9	16.9	21.0	23.0	28.0	31.9	39.2	34.8	31.9	27.4
2	21.8	17.5	14.4	13.6	11.2	12.3	14.6	20.5	21.7	23.9	24.7	24.3
3	19.7	16.9	11.0	9.6	12.2	17.7	28.1	24.9	27.4	27.6	29.8	21.1
4	26.4	18.0	17.3	17.3	22.7	22.6	26.0	34.3	36.5	41.2	33.3	28.5
5	21.5	21.4	17.9	18.2	16.3	19.9	24.9	29.9	37.7	34.8	33.2	29.6
6	20.3	16.8	15.8	12.1	12.5	15.1	21.0	21.4	23.6	24.8	25.0	28.1
7	23.1	16.1	13.3	13.1	15.6	23.7	28.6	33.9	30.1	34.9	27.6	23.6
8	25.5	23.0	21.4	21.6	20.8	23.5	27.2	29.7	43.5	36.4	32.6	27.5
9	20.9	18.5	15.2	12.1	11.3	13.8	18.1	26.3	26.8	28.6	28.0	29.6
10	16.9	13.2	10.2	8.7	11.5	15.5	18.3	21.5	24.4	25.3	28.7	24.3
11	18.6	15.0	12.5	15.7	17.2	23.2	29.5	41.1	36.7	34.4	27.8	24.0
12	24.5	25.5	20.4	20.7	21.0	24.6	32.1	31.7	32.7	36.5	31.6	25.6
13	25.7	17.3	13.2	10.0	11.9	12.5	16.2	20.3	24.3	30.2	30.3	24.4
14	16.7	12.6	8.3	8.7	9.5	14.3	19.0	23.4	30.2	27.4	27.2	26.2
15	19.0	16.1	16.3	15.7	20.1	26.5	37.7	37.7	40.2	39.3	35.6	29.6
16	29.6	22.8	21.6	22.5	25.7	31.7	31.9	34.9	35.8	38.1	28.3	27.3
17	22.9	18.6	14.5	11.1	10.5	12.3	15.3	19.0	25.4	24.5	24.9	23.6
18	15.4	10.0	6.2	3.2	4.9	10.2	16.0	24.2	24.5	25.1	25.4	27.6
19	16.7	15.4	13.1	15.3	19.8	29.4	31.8	35.8	38.3	37.9	38.7	28.3
20	27.6	21.0	19.8	20.4	28.1	29.9	31.5	36.1	36.4	39.9	28.9	22.8
Sums.	437.1	356.3	300.3	286.5	323.8	401.7	495.8	578.5	635.4	645.6	593.5	523.4

Page.	12	13	14	15	16	17	18	19	20	21	22	23	
1	22.7	21.1	17.5	13.5	14.5	17.5	17.9	26.2	26.2	27.7	26.9	28.0	576.6
2	25.8	17.6	17.4	18.9	21.5	28.8	32.1	35.1	36.5	35.9	35.8	26.6	552.5
3	17.5	17.5	14.7	15.4	21.1	23.5	29.2	33.3	35.3	39.5	30.0	24.8	547.8
4	23.2	20.8	12.9	9.0	7.1	7.9	14.0	20.8	22.2	24.9	25.8	25.3	538.0
5	27.5	20.2	16.9	15.5	16.4	23.8	25.3	30.3	27.9	29.0	34.0	25.4	597.5
6	23.8	23.0	20.0	24.2	23.1	25.2	27.5	28.8	39.4	38.2	28.7	24.4	562.8
7	19.5	15.5	17.8	14.6	15.5	20.2	29.8	31.4	33.7	33.1	30.6	29.0	574.3
8	22.4	19.4	12.3	8.8	7.4	10.7	14.9	19.5	24.1	26.6	32.0	27.3	558.1
9	22.1	18.1	15.4	14.0	17.1	19.1	24.3	29.3	38.0	29.0	28.0	24.6	528.2
10	23.2	22.6	26.3	22.0	24.4	26.9	28.7	33.8	28.1	30.7	26.4	24.5	536.1
11	19.4	18.2	11.8	12.5	13.1	16.8	25.3	26.6	29.1	29.0	30.4	22.9	550.8
12	21.5	13.3	8.4	4.6	4.4	8.7	15.0	21.0	25.5	31.9	28.1	27.0	536.3
13	21.7	18.8	16.5	17.6	17.6	21.6	26.9	36.1	35.5	36.4	30.2	27.0	542.2
14	28.6	23.6	27.4	26.4	26.0	28.8	36.8	32.5	31.5	28.2	28.0	25.0	566.3
15	20.3	16.4	12.9	10.5	14.6	21.5	22.0	25.7	27.8	31.1	25.4	22.6	584.6
16	20.9	14.9	10.9	6.1	4.8	9.9	16.9	23.2	32.1	30.8	30.6	28.9	580.2
17	21.3	22.2	17.1	16.8	17.9	26.7	27.6	36.0	33.5	36.5	35.4	32.1	545.7
18	22.2	21.1	21.5	23.6	31.2	31.8	30.4	31.7	31.3	28.2	27.6	21.1	514.4
19	19.6	15.5	12.5	11.3	10.0	12.2	19.9	26.1	28.6	24.1	22.5	19.7	542.5
20	20.4	15.2	7.8	3.6	3.0	7.2	17.1	22.2	27.4	29.8	34.3	27.7	558.1
Sums.	443.6	375.0	318.0	288.9	310.7	388.8	481.6	569.6	613.7	620.6	590.7	513.9	11093.0

FIG. 25.

is used in Table 5, the corresponding tabular value must be taken with its sign reversed. For the middle of the series the nearest integral hour is sufficient.

The values of I, ν, ξ, ν', and $2\nu''$ are obtained for the middle of the series from Table 6, using N as the argument. If N is between 180 and 360°, each of the last four quantities will be negative, but I is always positive. Although Table 6 is computed for the epoch, January 1, 1900, it is applicable without material error for any series of observations.

The values of u of L_2 and u of M_1 may be obtained from Table 13 for any date between 1900 and 2000, inclusive, using the value of N

Form 142
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: STENCIL SUMS.

Station: Morro, California. Lat.: 35° 22' N.

Component: "M" Length of series: 163 Days. Series begins: 1919 - Feb.-13-0 (Yr. Mo. Da. Hr.) Long.: 120° 51' W.

Kind of time used: 120°W. Computed by Fred A.Kummell, Dec.9,1920. (Date.)

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	Page.	0h	1	2	3	4	5	6	7	8	9	10	11
	21	25.9	18.1	14.8	14.5	10.6	11.1	17.3	23.8	23.1	24.4	24.1	22.6
	22	16.8	14.8	7.7	5.7	6.6	11.1	19.5	23.2	26.5	27.6	30.8	24.9
	23	17.8	15.7	15.1	20.1	21.6	30.7	33.3	37.3	39.0	42.8	33.9	28.4
	24	7.2	6.8	6.2	6.1	6.5	8.0	9.7	10.9	18.3	12.1	11.0	9.4
Sums-	21-24	67.7	55.4	43.8	46.4	45.3	60.9	79.8	95.2	106.9	106.9	99.8	85.3
"	1-20	437.1	356.3	300.3	286.5	323.8	401.7	495.8	578.5	635.4	645.6	593.5	523.4
Sums.-		504.8	411.7	344.1	332.9	369.1	462.6	575.6	673.7	742.3	752.5	693.3	608.7
Divisors.-		164	163	162	165	164	163	163	163	164	165	163	162
Means.-		3.08	2.53	2.12	2.02	2.25	2.84	3.53	4.13	4.53	4.56	4.25	3.76

Sums.

	Page.	12h	13	14	15	16	17	18	19	20	21	22	23	
	21	23.3	18.2	17.0	17.3	23.3	24.0	28.7	32.9	35.9	42.1	34.7	31.1	558.8
	22	22.5	20.7	20.2	26.0	26.9	31.7	36.2	34.0	40.0	31.3	26.2	20.5	551.4
	23	23.1	16.3	15.5	11.6	11.9	13.7	19.6	25.1	26.6	26.2	24.0	24.5	573.8
	24	3.3	4.7	3.0	1.7	0.9	0.9	1.7	3.4	5.5	7.0	7.7	7.8	159.8
Sums	21-24	72.2	59.9	55.7	56.6	63.0	70.3	86.2	95.4	108.0	106.6	92.6	83.9	1843.8
"	1-20	443.6	375.0	318.0	288.9	310.7	388.8	481.6	569.6	613.7	620.6	590.7	513.9	11093.0
Sums.-		515.8	434.9	373.7	345.5	373.7	459.1	567.8	665.0	721.7	727.2	683.3	597.8	12936.8
Divisors.-		162	163	163	163	162	162	163	163	162	162	163	163	
Means.-		3.18	2.67	2.29	2.12	2.31	2.83	3.48	4.08	4.45	4.49	4.19	3.67	

Sums.

FIG. 26.

for interpolation. If the series falls beyond the limits of this table, the following formulas may be used:

$$u \text{ of } L_2 = 2\xi - 2\nu - R \quad \text{(p. 48)} \tag{488}$$

$$u \text{ of } M_1 = \xi - \nu + Q \quad \text{(p. 51)} \tag{489}$$

The values of ξ and ν may be taken from Form 244, the values of R and Q from Tables 8 and 10, respectively, using the arguments I and P for the middle of the series.

In finding the difference between the longitude of the time meridian (S) and the longitude of the place (L) consider west longitude as positive and east longitude as negative.

In the ordinary use of Form 244 it is assumed that civil time has been used in the tabulations of the observations. If, however, the

Form 244.
DEPARTMENT OF COMMERCE,
U. S. COAST AND GEODETIC SURVEY.

TIDES: Computation of V_0+u.

Station Morro, California. Lat. 32° 22' N. Long. 120° 51' W 120.85 W = L

Beginning of series yr. 1919 mo. Feb. d. 13 hr. 0 († Greenwich hr. 8) Length of series d. 163 Time mer. 120°.00W = S

Middle of series yr. 1919 mo. May d. 5 hr. 12 († Greenwich hr. 20)

Compute all values to two decimal places. Tables in Harmonic Analysis and Prediction of the Tide.

	For the beginning of series.				For the middle of series.	
	(1)=s	(2)=p	(3)=h	(4)=p_1	(5)=p	(6)=N.
Table 4, for January 1 of year	268.04	27.41	279.60	281.55	27.41	251.71
Table 5, correction to 1st of month	48.47	3.45	30.56	0.00	13.37	-6.35
Table 5, correction to day of month	158.12	1.34	11.83	0.00	0.45	-0.21
Table 5, correction to Greenwich hr.	4.39	0.04	0.33	0.00	0.09	-0.04
Sum=	(1)= 119.02	(2)= 32.24	(3)= 322.32	(4)= 281.55	(5)= 41.32	(6)= 245.11

(7)= I (Table 6) = 21.76 (8)= ν (Table 6) = -12.68 (9)= ξ (Table 6) = -11.71 (10)= ν' (Table 6) = -8.53 (11)= 2ν'' (Table 6) = -16.63	J_1 + (19) = 138.25 − (8) = 12.68 V_0+u = 150.93 = .	M_6 V_0+u=2 (M_3)= 140.52 M_8 V_0+u=2 (M_4)= 187.36	R_2 (32)±180° = 220.77 + (33) = -1.70 V_0+u = 219.07 = .	$(MK)_3$ + M_2 = 46.84 + K_1 = 60.00 V_0+u = 106.84 = .
(12)= P=(5)−(9) = 53.03 (13)= u of L_2±180° = 170.6 (Table 13) (14)= u of M_1+90° = 123.6 (Table 13)	K_1 + (17) = 51.47 − (10) = 8.53 V_0+u = 60.00 = .	N_2 + M_2 = 46.84 − (18) = -86.78 V_0+u = -39.94 = 320.06	S_1 V_0+u=(15)±180° = 179.15 S_2 V_0+u=(33) = 358.30	$(2MK)_3$ + M_4 = 93.68 − K_1 = -60.00 V_0+u = 33.68 = .
(15)= S^*-L^* = -0.85 (16)= (3)+(15) = 321.47 (17)= (16)+90° = 51.47	K_2 + (20) = 282.94 − (11) = 16.63 V_0+u = 299.57 = .	$(2N)_2$ + N_2 = 320.06 − (18) = -86.78 V_0+u = 233.28 = .	S_4 V_0+u=2(33)= 356.60 S_6 V_0+u=3(33)= 354.90	$(MN)_4$ + M_2 = 46.84 + N_2 = 320.06 V_0+u = 366.90 = 6.90
(18)= (1)−(2) = 86.78 (19)= (17)+(18) = 138.25 (20)= 2 (16) = 282.94 (21)= (1)+(2) = 151.26 (22)= (20)−(21) = 131.68	L_2 + (22) = 131.68 + (13) = 170.6 V_0+u = 302.28 = .	O_1 + (31) = 334.15 − (30) = -351.46 V_0+u = -17.31 = 342.69	T_2 + (33) = 358.30 − (32) = -40.77 V_0+u = 317.53 = .	$(MS)_4$ + M_2 = 46.84 + S_2 = 358.30 V_0+u = 405.14 = 45.14
(23)= (16)−(1) = 202.45 (24)= (9)−(8) = 0.97 (25)= (23)+(24) = 203.42 (26)= 2 (25) = 46.84 (27)= (25)+(26) = 250.26	M_1 + (23) = 202.45 + (14) = 123.6 V_0+u = 326.05 = .	$(OO)_1$ + (31) = 334.15 + (30) = 351.46 V_0+u = 685.61 = 325.61	λ_2 (36)±180° = 180.24 − (18) = -86.78 V_0+u = 93.46 = .	$(2SM)_2$ + S_2 = 356.60 − M_2 = -46.84 V_0+u = 309.76 = .
(28)= (1)−(9) = 130.73 (29)= 2 (28) = 261.46 (30)= (29)+90° = 351.46	M_2 V_0+u=+(26) = 46.84 = .	P_1 (15)+270° = 269.15 − (3) = -322.32 V_0+u = -53.17 = 306.83	μ_2 + M_2 = 46.84 + (35) = 46.60 V_0+u = 93.44 = .	Mf V_0+u=+(29) = 261.46 MSf + S_2 = 358.30 − M_2 = -46.84 V_0+u = 311.46 = .
(31)= (16)−(8) = 334.15 (32)= (3)−(4) = 40.77 (33)= 2 (15) = -1.70	M_3 V_0+u=(27)±180° = 70.26	Q_1 + O_1 = 342.69 − (18) = -86.78 V_0+u = 255.91 = .	ν_2 μ_2 = 93.44 + (18) = 86.78 V_0+u = 180.22 = .	Mm V_0+u=+(16) = 86.78
(34)= (3)−(1) = 203.30 (35)= 2 (34) = 46.60 (36)= (26)−(35) = 0.24 (37)= (3)−(2) = 290.08 (38)= 2 (37) = 220.16	M_4 V_0+u=2 (M_2) = 93.68 = .	$(2Q)_1$ + Q_1 = 255.91 − (18) = -86.78 V_0+u = 169.13 = .	ρ_1 + Q_1 = 255.91 + (38) = 220.16 V_0+u = 476.07 = 116.07	Sa V_0+u=+(3)= 322.32 Ssa V_0+u=+2 (3) = 284.64

† Greenwich hour=original hour+(S^*÷15). * Positive for West longitude; negative for East longitude.

Computed by I. A. Alpert, Feb. 25, 1921. (Date.) Duplicated by L. P. Disney. Feb. 25, 1921. (Date.)

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FIG. 27.

original hourly heights as tabulated in Form 362 are in accordance with astronomical time in which the 0 hour represents the noon of the corresponding civil day and the 12th hour the following midnight, Form 244 will still be applicable if the longitude of the time meridian (S) is taken equal to the civil time meridian plus 180°. For example, if tabulations have been made in astronomical time for a locality where the civil time is based upon the meridian 15° E., the value for S should be taken as $-15+180$, or 165°. If tabulations have been in Greenwich astronomical time, S should be taken as 180°.

Form 244a, log F and arguments for elimination (fig. 28).—Items (1) to (11) are compiled here for convenience of reference for this and Form 452. Items (1) to (6) are obtained from values given in Form 244. Item (7) is obtained from Table 7, using items (2) and (3) as arguments, and item (8) is obtained from Table 9, using item (3) as

Form 244a

TIDES: Log F and Arguments for Elimination.

Station Morro, California.

Length of series 163 days. Series begins 1919, Feb. 13, 0 (yr. m. d. h.)

Component	Log F.	Component	Log F.	Component	Log F.
J_1	0.0201	M_8	9.9726	MK	0.0091
K_1	0.0160	N_2, 2N	9.9932	2MK	0.0023
K_2	0.0472	O_1	0.0264	MN	9.9863
L_2	9.9569	OO	0.0929	MS, 2SM	9.9932
M_1	9.8856	P_1	0.0000	Mf	0.0596
M_2	9.9932	Q_1, 2Q	0.0264	MSf	9.9932
M_3	9.9897	R_2, S_1, S_2, S_4, S_6, T_2	0.0000	Mm	9.9772
M_4	9.9863	λ_2, μ_2, ν_2	9.9932	Sa, Ssa	0.0000
M_6	9.9794	ρ_1	0.0264		

(1) = N = item (6) from Form 244 = 245°.11
(2) = I = item (7) from Form 244 = 21.76
(3) = P = item (12) from Form 244 = 53.03

(4) = $(h-\frac{1}{2}\nu')$ = item (3) − $\frac{1}{2}$ item (10), from Form 244 = 327°
(5) = $(h-\nu'')$ = item (3) − $\frac{1}{2}$ item (11), from Form 244 = 331
(6) = $(h-P_1)$ = item (3) − item (4), from Form 244 = 41

(7) = Log R_a from Table 7 = 9.9657
(8) = Log Q_a from Table 9 = 9.8592

(9) = Natural number from Log $F(K_1)$ = 1.038
(10) = Log $f(K_2)$ = 10 − Log $F(K_2)$ = 9.9528
(11) = Natural number $f(K_2)$ from (10) = 0.897

FIG. 28.

argument. Items (9) to (11) are obtained after the rest of the form has been filled out.

The log F for each of the listed components, except L_2 and M_1 and those for which the logarithm is given as zero, may be obtained from Table 12, using item (2) as the argument. For components L_2 and M_1

$$\text{Log } F(L_2) = \log F(M_2) + \text{item (7)} \tag{490}$$

$$\text{Log } F(M_1) = \log F(O_1) + \text{item (8)} \tag{491}$$

If the tidal series analyzed was observed between the years 1900 and 2000, the log $F(L_2)$ and log $F(M_1)$ may be taken directly from

Table 13, using the year of observations, together with item (1), as argument.

Form 194, harmonic analysis (*fig. 29*).—This form is based, primarily, upon formulas (316), (317), (324), and (325) and is designed for the computations of the first approximate values of the epochs (κ) and the amplitudes (H) of the harmonic constants.

Form 194
DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

TIDES: HARMONIC ANALYSIS.

Station Morro, California. Lat. 35° 22'N Long. 120° 51'W

Component M Series begins (yr.) 1919 (m.) Feb. (d.) 13 (h.) 0 Length of series 163 (Days) Time Mer. 120° W

Hourly Means from Form 142.

(1) Hours 0 to 11	3.08	2.53	2.12	2.02	2.25	2.84	3.53	4.13	4.53	4.56	4.25	3.76
(2) Hours 12 to 23	3.18	2.67	2.29	2.12	2.31	2.83	3.48	4.08	4.45	4.49	4.19	3.67
(3)=(1)−(2)	-0.10	-0.14	-0.17	-0.10	-0.06	0.01	0.05	0.05	0.08	0.07	0.06	0.09
(4)=Last 5 values of (3) reversed	0.00	0.09	0.06	0.07	0.08	0.05	0.00					
(5)=(1)+(2)	6.26	5.20	4.41	4.14	4.56	5.67	7.01	8.21	8.98	9.05	8.44	7.43
(6)=Last half of (5)	7.01	8.21	8.98	9.05	8.44	7.43						

(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Sin. $n\times15°$	(3)+(4)	(7)×(8) $12s_1$	Cos. $n\times15°$	(3)−(4)	(10)×(11) $12c_1$	Sin. $n\times45°$	(8)×(13) $12s_3$	Cos. $n\times45°$	(11)×(15) $12c_3$	Sin. $n\times30°$	(5)−(6)	(17)×(18) $12s_2$	Cos. $n\times30°$	(18)×(20) $12c_2$
.000	-0.10	0.000	1.000	-0.10	-0.100	.000	0.000	1.000	-0.100	.000	-0.75	0.000	1.000	-0.750
.259	-0.05	-0.013	.966	-0.23	-0.222	.707	-0.035	.707	-0.163	.500	-3.01	-1.505	.866	-2.607
.500	-0.11	-0.055	.866	-0.23	-0.199	1.000	-0.110	.000	0.000	.866	-4.57	-3.958	.500	-2.285
.707	-0.03	-0.021	.707	-0.17	-0.120	.707	-0.021	-.707	-0.120	1.000	-4.91	-4.910	.000	0.000
.866	0.02	0.017	.500	-0.14	-0.070	.000	0.000	-1.000	-0.140	.866	-3.88	-3.360	-.500	-1.940
.966	0.06	0.058	.259	-0.04	-0.010	-.707	-0.042	-.707	-0.028	.500	-1.76	-0.880	-.866	-1.524
1.000	0.05	0.050	.000	0.05	0.000	-1.000	-0.050	.000	0.000		$12s_2$=	-14.613	$12c_2$=	-2.178
	$12s_1$=	-0.036		$12c_1$=	-0.721	$12s_3$=	-0.258	$12c_3$=	-0.025					

(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)
Sin. $n\times90°$	(18)×(22) $12s_6$	Cos. $n\times90°$	(18)×(24) $12c_6$	(5)+(6) 1st half.	(5)+(6) 2d half.	(26)−(27)	Sin. $n\times60°$	(28)×(29) $12s_4$	Cos. $n\times60°$	(28)×(31) $12c_4$	(26)+(27)	Sin. $n\times120°$	(33)×(34) $12s_8$	Cos. $n\times120°$	(33)×(36) $12c_8$
0	0.000	+1	-0.750	13.27	13.19	0.08	.000	0.000	1.000	0.080	26.46	.000	0.000	1.000	26460
+1	-3.010	0	0.000	13.41	13.00	0.41	.866	0.355	.500	0.205	26.41	.866	22.871	-.500	-13205
0	0.000	-1	4570	13.39	13.10	0.29	.866	0.251	-.500	-0.145	26.49	-.866	-22.940	-.500	-13245
-1	4.910	0	0.000				$12s_4$=	0606	$12c_4$=	0.140		$12s_8$=	-0069	$12c_8$=	0.010
0	0.000	+1	-3880												
+1	-1.760	0	0.000												
$12s_6$=	0.140	$12c_6$=	-0060												

ζ' is in 1st quadrant when we have $+s$ and $+c$.
ζ' is in 2d quadrant when we have $+s$ and $-c$.
ζ' is in 3d quadrant when we have $-s$ and $-c$.
ζ' is in 4th quadrant when we have $-s$ and $+c$.

Component	M_1	M_2	M_3	M_4	M_6	M_8
(38)=log. $12s$	8.55630	1.16474	9.41162	9.78247	9.14613	8.83885
(39)=log. $12c$	9.85794	0.33806	8.39794	9.14613	8.77815	8.00000
(40)=(38)−(39)=log. tan. ζ'	8.69836	0.82668	1.01368	0.63634	0.36798	0.83885
(41)=ζ', for beginning of the series	177.14	261.52	275.53	76.99	113.20	278.25
(42)=local V_0+u (From Form 244)	326.05	46.84	70.26	93.68	140.52	187.36
(43)=(41)+(42)=κ'	143.19	308.36	345.79	170.67	253.72	105.61
(44)=log. sin. ζ', or	--------	9.99523	9.99797	9.98871	9.96338	9.99548
(45)=log. cos. ζ'	9.99946	--------	--------	--------	--------	--------
(46)=(38)−(44), or (39)−(45)	9.85848	1.16951	9.41365	9.79376	9.18275	8.84337
(47)=log. (augmenting factor÷12)	8.92206	8.92579	8.93204	8.94085	8.96642	9.00332
(48)=log. (reciprocal of 12) for component S	8.92082	8.92082	8.92082	8.92082	8.92082	8.92082
(49)=(46)+(47), or ~~(46)+(48)~~=log. R'	8.78054	0.09530	8.34569	8.73461	8.14917	7.84669
(50)=log. factor F (From Form 244 a)	9.8856	9.9932	9.9897	9.9863	9.9794	9.9726
(51)=(49)+(50)=log. H'	8.66614	0.08850	8.33539	8.72091	8.12857	7.81929
(52)=natural number from (49)=R'	0.060	1.245	0.022	0.054	0.014	0.007
(53)=natural number from (51)=H'	0.046	1.226	0.022	0.053	0.013	0.007

Computed by L. P. Disney, Feb. 25, 1921. (Date.) Verified by I. A. Alpert, Feb. 25, 1921. (Date.)

FIG. 29.

Provisions are made for obtaining the diurnal, semidurnal, terdiurnal, quarter-diurnal, sixth-diurnal and eighth-diurnal components, but only such items need be computed as are necessary for the particular components sought.

For the principal lunar series M_1, M_2, M_3, M_4, M_6, and M_8, compute all items of the form.

For the principal solar series S_1, S_2, S_4, and S_6, items (14), (16), (33), (35), and (37) may be omitted.

For the lunal solar components K_1 and K_2, items (14), (16), and (23) to (37) may be omitted.

For the diurnal components J_1, O_1, OO, P_1, Q_1, 2Q, and ρ_1, items (5), (6), and (14) to (34) may be omitted.

For the semidurnal components L_2, N_2, 2N, R_2, T_2, λ_2, μ_2, ν_2, and 2SM, items (3), (4), (8) to (16), and (23) to (37) may be omitted.

For terdiurnal components MK and 2MK, items (5), (6), (9), (12), and (18) to (37) may be omitted.

For quarter-diurnal components MN and MS, items (3), (4), (8) to (25), and (35) to (37) may be omitted.

In the bottom portion of the form the symbol of the component is to be entered at the head of the column or columns indicated by the subscript corresponding to the number of component periods in a component day, the remaining columns being left blank.

The hourly means from Form 142 (fig. 26) are entered as items (1) and (2) in regular order, beginning with the mean for 0 hour. Item (4) consists of the last five values of item (3) arranged in reverse order. Item (6) consists of the last six values of item (5) in their original order. For the computations of this form the following tables will be found convenient: Table 19 of this publication for natural products, Vega's Logarithmic Tables for logarithms of linear quantities, and Bremiker's Funfstellige Logarithmen for logarithms of the trigonometrical functions. In the last table the angular arguments are given in degrees and decimals.

In choosing between items (44) and (45) the former should be used if the tabular value of (41) in the first quadrant is greater than 45° and the latter if this angle is less than 45°.

In referring (41) to the proper quadrant it must be kept in mind that the signs of the natural numbers corresponding to (38) and (39) are respectively the signs of the sine and cosine of the required angles. Therefore (41) will be in the first quadrant if both s and c are positive, in the second quadrant if s is positive and c negative, in the third quadrant if both s and c are negative, and in the fourth quadrant if s is negative and c positive.

In obtaining (49) use (46) + (47) for all components except S, and (46) + (48) for component S. The log factor F for item (50) may be obtained from Form 244a.

Form 194 is designed for use when 24 component hourly means have been obtained and all the original hourly heights have been used in the summation. If in the summation for a component each component hour of the observation period received one and only one of the hourly heights, it will be necessary to take the log-augmenting factor from Table 20 and add this to the sum of items (46) and (48) to obtain item (49), striking out item (47).

This form is also adapted for use with the long-period components. Assuming that the daily means have been cleared of the effects of the short-period components in accordance with section 31, and that these means have been assorted into 24 groups to cover the component period, the 24 group means may then be entered in Form 194 in place of the 24 hourly means used for the short-period components. Then, treating the components Mm and Sa the same as the diurnal tides and the components Mf, Msf, and Ssa as the semidiurnal tides, the form may be followed except that the log-augmenting factor must be taken from Table 20 and then combined with items (46) and (48) to obtain item (49), striking out item (47).

To obtain Sa and Ssa from the monthly means of sea level, or tide level, determined from the first 29 days of each calendar month, the following process may be used: Enter the monthly means beginning with that for January in alternate spaces provided for the hourly means on the front of Form 194, placing the value for January in the space for the 0 hour. For convenience consider all the intermediate blank spaces as being filled with zero values and make the computations indicated by (3) to (12) and (18) to (21). Correct the coefficients of s_1 and c_1 from 12 to 6, at top and foot of columns (9), (12), (19), and (21). In bottom of form enter Sa in column having subscript 2 and Ssa in column with subscript 4 in order to obtain correct augmenting factors and strike out numerals indicating subscripts. For (38) and (39) take the logarithm of twice the values of 6*s* and 6*c* as obtained above. The ζ's as obtained from (40) must have the following corrections applied in order to refer them to 0 hour of the first day of January—common years, Sa correction $= -13.38°$, Ssa correction $= -26.76°$; leap years, Sa correction $= -14.20°$, Ssa correction $= -28.40°$. For convenience in recording the results it is suggested that the ζ as directly obtained from (40) be entered (in its proper quadrant) in the space just below the logarithm from which it is obtained, and that the ζ corrected to the first day of January be entered in the same line in the vacant column just to the right. The $V+u$, computed to the first day of January, may then be entered immediately under the corrected ζ's and the κ' of (43) readily obtained. For (49) the combination $(46)+(47)$ will be used

Form 452, R, κ, and ζ from analysis and inference (figs. 30 and 31)—This form provides for certain computations preliminary to the regular elimination process. The constants for components K_1 and S_2 as obtained directly from Form 194 may be improved by the application of corrections from Tables 21 to 26; and constants for some of the smaller components, which have been poorly determined or not determined at all by the analysis, may be obtained by inference. If the series of observations is very short, the inferred values for the constants of some of the components may be better than the uneliminated values from Form 194.

Form 452 is based upon section 29. It is designed to take account of the diurnal component on one side (fig. 30) and the semidiurnal components on the other side (fig. 31). The amplitudes and epochs indicated by the accent (′) are to be taken from Form 194 and the quantities indicated by the asterisk (*) from Form 244 or 244a. If the series is less than 355 days, values for S_1 and 2SM may be omitted.

For all short series the values in columns (4) and (8) are to be computed in accordance with the equivalents and factors in columns (3) and (7), respectively. If the series is 192 days or more in length, the κ of M_1, P_1, and K_2 for column (4), and the log R of M_1, P_1, and K_2 for column (8) may be taken directly from Form 194, and if the series is 355 days or more in length the κ and log R of all the components for which analyses have been made may be taken directly from the same form. When a value is thus taken directly from the analysis, the corresponding equivalent in column (3) and factors in column (7) are to be crossed out.

The tabular values of items (12) and (13) for the diurnal components and items (14) to (18) for the semidiurnal components may be obtained from Tables 21 to 26 or from plotted curves representing these tables, but for a series of 355 days or more in length the accelerations may be taken as zero and the resultant amplitude factors as unity.

Form 452
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: R, κ, AND ζ, FROM ANALYSIS AND INFERENCE.

Station Morro, California

Length of Series 163 days. Series begins 1919, February 13.

DIURNAL COMPONENTS.

Components.	From Analysis. R' (1) Ft. (3 dec.)	From Analysis. ζ' (2) ° (2 dec.)	Components.	From Analysis and Inference. κ (3) Equivalent.	κ (4) ° (1 dec.)	V_0+u.* (5) ° (1 dec.)	$\zeta=(4)-(5)$ (6) ° (0 dec.)
J_1	.	.	J_1	$K_1^\circ+0.5\times(14)$	116.7	150.9	326
K_1	0.967	48.82	K_1	$(K_1^\circ)'$ 108.8+(12)	110.9	60.0	51
M_1	0.060	177.14	M_1	$K_1^\circ-0.5\times(14)$	105.1	326.0	139
O_1	0.569	116.61	O_1	$(O_1^\circ)'$	99.3	342.7	117
OO	.	.	OO	$K_1^\circ+(14)$	122.5	325.6	157
P_1	0.299	182.53	P_1	K_1°	110.9	306.8	164
Q_1	0.107	210.95	Q_1	$K_1^\circ-1.5\times(14)$	93.5	255.9	198
2Q	.	.	2Q	$K_1^\circ-2.0\times(14)$	87.7	169.1	279
S_1	.	.	S_1	$(S_1^\circ)'$	-	-	-
ρ_1	.	.	ρ_1	$K_1^\circ-1.43\times(14)$	94.3	116.1	338

(9)=P*= 53.03 (2 dec.); (10)=$F(K_1)$*= 1.038 (3 dec.); (11)=$(h-\frac{1}{2}\nu)$*= 327 (0 dec.)
(12)=acceleration in K_1 due to $P_1=F(K_1)\times$Table 21= 2.1 (1 dec.)
(13)=resultant amplitude, K_1 and $P_1=1+[F(K_1)\times$ (Table 22]= 1.03 (2 dec.)
(14)=$(K_1^\circ-O_1^\circ)$= 11.6 (1 dec.)

Components.	From Analysis and Inference. R (7) Factors.	(8) (4 dec.)
J_1	log. 0.079	+8.8976
	log. $R'(O_1)$	+9.7814
	log. $F(J_1)$*	−0.0201
	log. $R(J_1)$	8.6589
	$R(J_1)$	
K_1	log. $R'(K_1)$	+9.9852
	log. (13)	−0.0128
	log. $R(K_1)$	9.9724
	$R(K_1)$	
M_1	log. 0.071	+8.8513
	log. $R(O_1)$	+9.7550
	log. Q_a*	−9.8592
	log. $R(M_1)$	8.7471
	$R(M_1)$	
O_1	log. $R'(O_1)$	9.7550
	$R(O_1)=R'(O_1)$	
OO	log. 0.043	+8.6335
	log. $R'(O_1)$	+9.7814
	log. $F(OO)$*	−0.0929
	log. $R(OO)$	8.3220
	$R(OO)$	
P_1	log. 0.331	+9.5198
	log. $R(K_1)$	+9.9724
	log. $F(K_1)$*	+0.0160
	log. $R(P_1)$	9.5082
	$R(P_1)$	
Q_1	log. 0.194	+9.2878
	log. $R(O_1)$	+9.7550
	log. $R(Q_1)$	9.0428
	$R(Q_1)$	
2Q	log. 0.026	+8.4150
	log. $R(O_1)$	+9.7550
	log. $R(2Q)$	8.1700
	$R(2Q)$	
S_1	log. $R'(S_1)$	---
	$R(S_1)=R'(S_1)$	
ρ_1	log. 0.038	+8.5798
	log. $R(O_1)$	+9.7550
	log. $R(\rho_1)$	8.3348
	$R(\rho_1)$	

Date

Computed by I. A. Albert, Feb. 28, 1921

Duplicated by L. P. Disney, Feb. 28, 1921

FIG. 30.

The κ's of K_1 and S_2 are to be corrected by the accelerations as indicated before entering in column (4), and in computing item (14) for the diurnal components and (21) for the semidiurnal components the corrected κ's are to be used. If the two angles in item (14) for the diurnal components, or in items (20) or (21) for the semidiurnal components, differ by more than 180°, the smaller angle should be increased by 360° before taking the difference, which may be either positive or negative.

In computing column (8) it will be noted that the corrected log R's of K_1 and S_2 are to be used in inferring other components depending upon these.

Form 452
DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY

TIDES: R, κ, AND ζ, FROM ANALYSIS AND INFERENCE.

Station Morro, California

Length of Series 163 days. Series begins 1919, February 13.

SEMIDIURNAL COMPONENTS.

Components.	From Analysis.		Components.	From Analysis and Inference.			
	R'	ζ'		κ		V_0+u.*	$\zeta=(4)-(5)$
	(1)	(2)		(3)	(4)	(5)	(6)
	Ft. (3 dec.)	° (2 dec.)		Equivalent.	° (1 dec.)	° (1 dec.)	° (0 dec.)
K_2	0.090	20.63	K_2	S_2°	304.2	299.6	5
L_2	0.065	15.67	L_2	$M_2^\circ+(20)$	329.9	302.3	28
M_2	1.245	261.52	M_2	$(M_2^\circ)'$	308.4	46.8	262
N_2	0.263	326.84	N_2	$(N_2^\circ)'$	286.9	320.1	327
2N	.	.	2N	$N_2^\circ-(20)$	265.4	233.3	32
R_2	.	.	R_2	S_2°	304.2	219.1	85
S_2	0.314	306.49	S_2	$(S_2^\circ)'$ 304.8 + (16)	304.2	358.3	306
T_2	.	.	T_2	S_2°	304.2	317.5	347
λ_2	.	.	λ_2	$M_2^\circ+0.464\times(21)$	306.5	93.5	213
μ_2	0.015	99.20	μ_2	$M_2^\circ-(21)$	312.6	93.4	219
ν_2	0.010	118.79	ν_2	$M_2^\circ-0.866\times(20)$	289.8	180.2	110
2SM	.	.	2SM	$(2SM^\circ)'$	.	.	

(9) = I* = 21.76 (2 dec.); (10) = P* = 53.03 (2 dec.); (11) = $f(K_2)$* 0.897 (3 dec.)
(12) = $(h-\nu'')$* = 331 (0 dec.); (13) = $(h-p_1)$* = 41 (0 dec.)
(14) = acceleration in S_2 due to K_2 = Table 23 × $f(K_2)$ = 1.4 ° (1 dec.)
(15) = acceleration in S_2 due to T_2 = Table 25 = −2.0 ° (1 dec.)
(16) = (14) + (15) = −0.6 ° (1 dec.)
(17) = resultant amplitude, S_2 and K_2 = 1 + [Table 24 × $f(K_2)$] = 1.01 (2 dec.)
(18) = resultant amplitude, S_2 and T_2 = Table 26 = 0.98 (2 dec.)
(19) = log. (17) + log. (18) = 9.9955 (4 dec.)
(20) = $(M_2^\circ-N_2^\circ)$ = 21.5 (1 dec.); (21) = $(S_2^\circ-M_2^\circ)$ = −4.2 (1 dec.)

Components.	From Analysis and Inference. R (7) Factors.	(8) (4 dec.)
K_2	log. 0.272	+9.4346
	log. $R(S_2)$	+9.5017
	log. $F(K_2)$*	−0.0472
	log. $R(K_2)$	8.8891
	$R(K_2)$	
L_2	log. 0.143	+9.1553
	log. $R'(N_2)$	+9.4201
	log. R_a*	−9.9657
	log. $R(L_2)$	8.6097
	$R(L_2)$	
M_2	log. $R'(M_2)$	0.0953
	$R(M_2)=R'(M_2)$	
N_2	log. $R'(N_2)$	9.4201
	$R(N_2)=R'(N_2)$	
2N	log. 0.133	+9.1239
	log. $R'(N_2)$	+9.4201
	log. $R(2N)$	8.5440
	$R(2N)$	
R_2	log. 0.008	+7.9031
	log. $R(S_2)$	+9.5017
	log. $R(R_2)$	7.4048
	$R(R_2)$	
S_2	log. $R'(S_2)$	+9.4972
	(19)	−9.9955
	log. $R(S_2)$	9.5017
	$R(S_2)$	
T_2	log. 0.059	+8.7709
	log. $R(S_2)$	+9.5017
	log. $R(T_2)$	8.2726
	$R(T_2)$	
λ_2	log. 0.007	+7.8451
	log. $R'(M_2)$	+0.0953
	log. $R(\lambda_2)$	7.9404
	$R(\lambda_2)$	
μ_2	log. 0.024	+8.3802
	log. $R'(M_2)$	+0.0953
	log. $R(\mu_2)$	8.4755
	$R(\mu_2)$	
ν_2	log. 0.194	+9.2878
	log. $R'(N_2)$	+9.4201
	log. $R(\nu_2)$	8.7079
	$R(\nu_2)$	
2SM	log. $R'(2SM)$	
	$R(2SM)=R'(2SM)$	

Date

Computed by I. A. Alpert, Feb. 28, 1921

Duplicated by L. P. Disney, Feb. 28, 1921

FIG. 31.

Form 245, elimination of component effects (fig. 32).—This form is based upon formulas (409) and (410). One side of the form is designed for the elimination of the effects of the diurnal components upon each other and the other side for use with the semidiurnal components, the two sides being similar except for the listing of the components.

The symbol A represents the component to be cleared, and the symbol B is the general designation for the disturbing components. The symbol applying to component A is to be crossed out in column (1) and entered in column (8). The values for items (9) and (19) are to be taken from columns (1) and (2) of Form 452.

The "table" in the headings of columns (2), (3), and (4) refers to Table 29 in this publication. For column (2) it will be found convenient to copy the logarithms of the R's of B from column (8) of

Form 245
DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

TIDES: ELIMINATION OF COMPONENT EFFECTS

Station Morro, California.

Length of series 163 *days.* *Series begins* 1919, Feb. 13, 0 (*yr.* *m.* *d.* *h.*)

(1) B_1	(2) $R(B_1)\times$Table	(3) $R(B_1)\times$Table	(4) Table−$\zeta(B_1)$	(5) (4)+(19)	(6) (3)×Sin (5)	(7) (3)×Cos (5)	(8) RESULTS		
	log. (4 dec.)	ft. (3 dec.)	°(no dec.)	°(no dec.)	(3 dec.)	(3 dec.)	Use 4 dec. for logarithms, 3 dec. for amplitudes, 1 dec. for angles.		
							Component A_2 = K₂		
K_2							(9)=$R'(A_2)$ from analysis	=	0.090
L_2	6.0462						(10)=(9)−(7)	=	0.080
M_2	7.8481	0.007	290	311	−0.005	+0.005	(11)=log. (6)	=	8.6721
N_2	7.3351	.002	240	261	− .002	.000	(12)=log. (10)	=	8.9031
2N	6.5019						(13)=(11)−(12)=log. tan $\delta\zeta$	=	9.7690
R_2	7.2518	.002	195	216	− .001	− .002	*(14)=$\delta\zeta$	=	−30.4
S_2	6.5740	.037	253	274	− .037	+ .003	(15)=log. cos $\delta\zeta$	=	9.9356
T_2	7.5905	.004	312	333	− .002	+ .004	(16)=(12)−(15)=log. $R(A_2)$	=	8.9675
λ_2	6.3638						(17)=(16)+log. $F(A_2)$=log. $H(A_2)$	=	9.0147
μ_2	5.5703						(18)=$H(A_2)$	=	0.103
ν_2	6.2207						(19)=$\zeta'(A_2)$ from analysis	=	20.6
2SM							(20)=(14)+(19)=$\zeta(A_2)$	=	350.2
				Sums =	−0.047	+0.010	(21)=(20)+(V_0+u)=$\kappa(A_2)$	=	289.8
							Component A_2 = L₂		
K_2	6.3256						(9)=$R'(A_2)$ from analysis	=	0.065
L_2							(10)=(9)−(7)	=	0.054
M_2	8.2448	0.018	293	309	−0.014	+0.011	(11)=log. (6)	=	8.0000
N_2	7.5542	.004	243	259	− .004	− .001	(12)=log. (10)	=	8.7324
2N	6.6518						(13)=(11)−(12)=log. tan $\delta\zeta$	=	9.2576
R_2	6.1512						*(14)=$\delta\zeta$	=	−10.5
S_2	7.8741	.007	76	92	+.007	.000	(15)=log. cos $\delta\zeta$	=	9.9927
T_2	7.0340	.001	135	151	.000	−.001	(16)=(12)−(15)=log. $R(A_2)$	=	8.7397
λ_2	7.3292	.002	5	21	+.001	+.002	(17)=(16)+log. $F(A_2)$=log. $H(A_2)$	=	8.6986
μ_2	5.8985						(18)=$H(A_2)$	=	0.050
ν_2	6.2592						(19)=$\zeta'(A_2)$ from analysis	=	15.7
2SM							(20)=(14)+(19)=$\zeta(A_2)$	=	5.2
				Sums =	+0.010	+0.011	(21)=(20)+(V_0+u)=$\kappa(A_2)$	=	307.5
							Component A_2 = M₂		
K_2	6.6419						(9)=$R'(A_2)$ from analysis	=	1.245
L_2	6.7592	0.001	137	39	+0.001	+0.001	(10)=(9)−(7)	=	1.246
M_2							(11)=log. (6)	=	7.6021
N_2	7.5696	.004	228	130	+ .003	− .003	(12)=log. (10)	=	0.0955
2N	6.6781						(13)=(11)−(12)=log. tan $\delta\zeta$	=	7.5066
R_2	5.8470						*(14)=$\delta\zeta$	=	0.2
S_2	7.0530	.001	61	323	− .001	+ .001	(15)=log. cos $\delta\zeta$	=	0.0000
T_2	6.7316	.001	120	22	.000	+ .001	(16)=(12)−(15)=log. $R(A_2)$	=	0.0955
λ_2	6.3128						(17)=(16)+log. $F(A_2)$=log. $H(A_2)$	=	0.0887
μ_2	6.0268						(18)=$H(A_2)$	=	1.227
ν_2	7.0803	.001	228	130	+ .001	− .001	(19)=$\zeta'(A_2)$ from analysis	=	261.5
2SM							(20)=(14)+(19)=$\zeta(A_2)$	=	261.7
				Sums =	+0.004	−0.001	(21)=(20)+(V_0+u)=$\kappa(A_2)$	=	30[illegible]

* $\delta\zeta$ or (14) is in the 1st quadrant when (6) is + and (10) is +.
$\delta\zeta$ or (14) is in the 2d quadrant when (6) is + and (10) is −.
$\delta\zeta$ or (14) is in the 3d quadrant when (6) is − and (10) is −.
$\delta\zeta$ or (14) is in the 4th quadrant when (6) is − and (10) is +.

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Computed by I. A. Alpert, Feb. 28, 1921. (Date)

Verified by L. P. Disney " " " (Date)

FIG. 32.

Form 452 on a horizontal strip of paper spaced the same as Table 29. Applying this strip successively to the upper line of the tabular values for each component the logarithms of the resulting products for column (2) may be readily obtained. Similarly, for column (4), the ζ's of B from column (6) of Form 452 may be copied on a strip of paper and applied to the bottom line of the tabular values for each component and the differences obtained.

The natural numbers for column (3) corresponding to the logarithms in column (2) can usually be obtained most expeditiously from Table 27, this table giving the critical logarithm for each change of 0.001 in the corresponding natural number. If the logarithm is less than 6.6990, the natural number will be too small to appear in the third decimal place, and the effects of the corresponding com-

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form No. 444

TIDES: STANDARD HARMONIC CONSTANTS FOR PREDICTION

STATION Morro, California.

Lat. 35° 22′ N.
Long. 120° 51′ W.
Long. 120.°85 W.

COMPONENT	H AMPLITUDE	κ EPOCH	A κ′−κ	B 4×H	C 360°−κ′	D −κ′
	ft.	°	°	ft.	°	°
M_2	1.227	308.5	+ 9.8	4.91	+ 41.7	−318.3
S_2	0.320	304.3	+ 1.7	1.28	+ 54.0	−306.0
N_2	0.260	284.5	+14.2	1.04	+ 61.3	−298.7
K_1	1.001	111.2	+ 0.5	4.00	+248.3	−111.7
M_4	0.053	170.7	+19.6	0.21	+169.7	−190.3
O_1	0.608	99.1	+ 9.3	2.43	+251.6	−108.4
M_6	0.013	253.7	+29.5	0.05	+ 76.8	−283.2
$(MK)_3$					+	−
S_4	0.009	176.6	+ 3.4	0.04	+180.0	−180.0
$(MN)_4$					+	−
ν_2	0.065	285.0	+13.6	0.26	+ 61.4	−298.6
S_6	0.006	148.3	+ 5.1	0.02	+206.6	−153.4
μ_2	0.025	174.2	+18.0	0.10	+167.8	−192.2
$(2N)_2$	(0.035	260.5)	+18.5	0.14	+ 81.0	−279.0
$(OO)_1$	(0.026	123.3)	− 8.3	0.10	+245.0	−115.0
λ_2	(0.009	306.6)	+ 6.0	0.04	+ 47.4	−312.6
S_1					+	−
M_1	0.041	132.4	+ 4.9	0.16	+222.7	−137.3
J_1	(0.048	117.2)	− 3.8	0.19	+246.6	−113.4
Mm					+	−
Ssa					+	−
Sa					+	−
MSf					+	−
Mf					+	−
ρ_1	(0.023	93.9)	+13.1	0.09	+253.0	−107.0
Q_1	0.107	98.9	+13.7	0.43	+247.4	−112.6
T_2	(0.019	304.5)	+ 2.0	0.08	+ 53.5	−306.5
R_2	(0.003	304.1)	+ 1.4	0.01	+ 54.5	−305.5
$(2Q)_1$	(0.016	87.1)	+18.0	0.06	+254.9	−105.1
P_1	0.274	107.7	+ 1.2	1.10	+251.1	−108.9
$(2SM)_2$					+	−
M_3	0.022	345.8	+14.7	0.09	+359.5	− 0.5
L_2	0.050	307.5	+ 5.5	0.20	+ 47.0	−313.0
$(2MK)_3$					+	−
K_2	0.103	289.8	+ 1.0	0.41	+ 69.2	−290.8
M_8	0.007	105.6	+39.3	0.03	+215.1	−144.9
$(MS)_4$					+	−

REMARKS.

Time meridian 120° = 8.0 h.
Approximate extreme range 8.8 ft.
Height dial 10 ft.
Marigram gear 3:2
Marigram scale 1:20

The DATUM is ~~a plane ---- ft. above below~~ Mean {~~Low Water Springs~~ Lower Low Water} which is 2.40 ft. below mean sea level, and is ~~approximately~~ the datum of the {Coast and Geodetic Survey ~~Admiralty, French, German~~} charts.

Harmonic constants are from observed hourly heights for 163 days beginning February 13, 1919.

Compiled by L.P.D. March 28,1923. (Date) Verified by F.J.H. March 29,1923. (Date)

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FIG. 33.

ponent may be considered as nil. The products for columns (6) and (7) may be conveniently obtained from Table 30.

In column (8) the references to (6) and (7) are to the sums of these columns. The values of log $F(A)$ and (V_0+u) for column (8) may be obtained from Forms 244 and 244a.

In the use of this form it will be noted that the R's and ζ's referring to component B are to be the best known values whether derived from the analysis or by inference, but the R' and ζ' of component A, entered as items (9) and (19), respectively, must be the unmodified values as obtained directly by Form 194.

Form 444, standard harmonic constants for predictions (fig. 33).—This form provides for the compilation of the harmonic constants for use in the prediction of the tides and also for certain permanent preliminary computations to adapt the constants for use with the U. S. Coast and Geodetic Survey tide-predicting machine No. 2. The form is used in a loose-leaf binder.

The components are listed in an order that conforms to the arrangement of the corresponding component shafts and cranks on the predicting machine. The accepted amplitudes and epochs are to be given in the columns provided for the purpose. At the bottom of the page a space is provided for indicating the source from which the constants were derived.

The column of Remarks provides for miscellaneous information pertaining to the predictions. This includes the kind of time in which the predictions are to be given—the approximate extreme range of tide at the place for determining the proper scale to be used, the height dial, the marigram gear, the marigram scale, and the datum to which the predicted heights are to be referred.

The extreme range may be estimated from the predictions for a preceding year or may be taken approximately as twice the sum of the amplitudes of the harmonic constants. The height dial, marigram gear, and marigram scale which are recommended for use with different extreme ranges are given in the table below.

Working scale, height dial, marigram gear, and scale.

(1) Extreme range (feet).	(2) Working scale.	(3) Height dial.	(4) Marigram gear.	(5) Marigram scale.	(6) Marigram 1-inch tide.	(7) Marigram limit tide.	(8) Tide 1-foot marigram.
					Feet.	*Feet.*	*Inches.*
0.0- 2.5	10	4	2 : 1	1 : 6	0.50	3.0	2.0
2.6- 3.5	10	4	3 : 2	1 : 8	0.67	4.0	1.5
3.6- 4.5	10	4	1 : 1	1 : 12	1.00	6.0	1.0
4.6- 7.0	4	10	2 : 1	1 : 15	1.25	7.5	0.8
7.1- 9.5	4	10	3 : 2	1 : 20	1.67	10.0	0.6
9.6-10.5	4	10	1 : 1	1 : 30	2.50	15.0	0.4
10.6-14.5	2	20	2 : 1	1 : 30	2.50	15.0	0.4
14.6-19.5	2	20	3 : 2	1 : 40	3.33	20.0	0.3
19.6-20.5	2	20	1 : 1	1 : 60	5.00	30.0	0.2
20.6-29.5	1	40	2 : 1	1 : 60	5.00	30.0	0.2
29.6-39.5	1	40	3 : 2	1 : 80	6.67	40.0	0.15
39.6-	1	40	1 : 1	1 : 120	10.00	60.0	0.1

Column (1), or extreme range, is the argument for determining the working scale and marigram gear for each station.
Column (2) contains the factor to reduce the amplitudes of the harmonic constants to the working scale.
Columns (3) and (4) contain the height dial and marigram gear that should be used for ranges of tide within the limits indicated in column (1).
Column (5) gives the height scale of the tide curve.
Column (6) shows the amount of rise or fall of the tide represented by each inch, vertical measure, on the marigram.
Column (7) gives the extreme range of tide that can be represented on the marigram, which is 6 inches wide, with the different marigram scales.
Column (8) shows the amount of rise and fall on the marigram for each foot of actual tide.

The principal hydrographic datums in general use are as follows: Mean low water for the Atlantic and Gulf coasts of the United States and Porto Rico. Mean lower low water for the Pacific coast of the United States, Canada, and Alaska, and the Hawaiian and Philippine Islands. Approximate low water springs for the rest of the world, with a few exceptions.

For use on the predicting machine the datum must be defined by its relation to the mean sea level, and this relation is usually determined from a reduction of the high and low waters.

Column A of Form 444 is designed for the differences by which the epochs of the components are adapted once for all for use with the unmodified Greenwich (V_0+u)'s of each year. These differences take account of the longitude of the station and also of the time meridian used for the predictions, and are computed by the formula

$$\kappa'-\kappa=pL-\frac{aS}{15} \tag{492}$$

in which

$\kappa'-\kappa$ = adapted epoch − true epoch.
p = subscript of component, which indicates number of periods in one component day. For the long-period components Mm, Ssa, Sa, Msf, and Mf, p should be taken as zero.
L = longitude of station in degrees; + if west, − if east.
a = speed of component in degrees per solar hours.
S = longitude of time meridian in degrees; + if west, − if east.

The values of the products $\frac{aS}{15}$ for the principal time meridians may be taken from Table 35. For any time meridian not given in the table the products may be obtained by direct multiplication, taking the values for the component speeds (a) from Table 3.

Column B is designed for the reduction of the amplitudes to the working scale of the machine. The scale is unity when the 40-foot height dial is used, 2 for the 20-foot height dial, 4 for the 10-foot height dial, and 10 for a 4-foot height dial. The working scale should be entered at the head of the column and used as a factor with the amplitudes in order to obtain the values for this column.

Columns C and D are designed to contain the adapted epochs in positive and negative forms which may be used additively with the Greenwich (V_0+u)'s. It will be found most convenient to compute column D, first, by applying the difference in column A to the κ in the preceding column and entering the result with the negative sign. If the direct application of the difference should give a negative result, this must be subtracted from 360° before entering in column D. The values for column C may then be obtained by applying 360° to the negative values in column D.

Form 445, settings for tide-computing machine (fig. 34).—This form is designed for the computations of the settings for the predicting machine for the beginning of each year of predictions. The forms are bound in books, a separate book being used for each year of predictions. This form is used in connection with Form 444, and for convenience the order of arrangement of the components is identical in the two forms. The name of the station, the time meridian, the height dial, marigram gear, marigram scale, and datum plane are copied directly from Form 444.

For the amplitude settings the amplitudes of column *B* of Form 444 are multiplied by the factors *f* from Table 14 for the year for which the predictions are to be made. A convenient way to apply

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form No. 445

TIDES: SETTINGS FOR TIDE COMPUTING MACHINE

STATION Morro, California. YEAR 1923.

COMPONENT	AMPLITUDE SETTING	DIAL SETTING JAN. 1, 0^h	FEB. 1, 0^h	DEC. 31, 24^h		
	ft.	°	°	°		
M_2	5.10	82.9	47.1	183.7		
S_2	1.30	54	54	54		
N_2	1.10	214	133	226		
K_1	3.55	255	286	255		
M_4	0.20	252	180	94		
O_1	2.00	287	221	28		
M_6	0.05	200	93	142		
$(MK)_3$	----	----	----	----		
S_4	0.05	180	180	180		
$(MN)_4$	----	----	----	----		
ν_2	0.25	33	6	323		
S_6	----	----	----	----		
μ_2	0.10	251	179	93		
$(2N)_2$	0.15	345	219	268		
$(OO)_1$	0.05	40	167	298		
λ_2	0.05	338	293	249		
S_1	----	----	----	----		
M_1	0.25	347	329	217		
J_1	0.15	140	216	228		
Mm	----	----	----	----		
Ssa	----	----	----	----		
Sa	----	----	----	----		
MSf	----	----	----	----		
Mf	----	----	----	----		
ρ_1	0.05	219	162	150		
Q_1	0.35	35	284	47		
T_2	0.10	56	25	56		
R_2	----	----	----	----		
$(2Q)_1$	0.05	154	358	78		
P_1	1.10	242	211	242		
$(2SM)_2$	----	----	----	----		
M_3	0.10	61	7	32		
L_2	0.20	149	158	338		
$(2MK)_3$	----	----	----	----		
K_2	0.30	264	325	264		
M_8	0.05	20	237	63		
$(MS)_4$	----	----	----	----		

REMARKS

Time Meridian 120° W.
Height dial 10 ft.
Marigram gear 3:2
Marigram scale 1:20

The datum is ~~a plane~~ ~~feet above~~ ~~below~~ mean ~~Low Water Springs~~ Lower Low Water which is 2.40 feet below mean sea level, and is ~~approximately~~ the datum of the Coast and Geodetic Survey ~~Admiralty — French — German~~ charts.

Machine settings computed by L.P.D. March 28, 1923. Verified by F.J.H. March 29, 1923.

Tides predicted by

Date

FIG. 34.

these factors is to prepare a strip of paper with the same vertical spacing as the lines on Form 444 and enter the factors *f* for the required year on this strip. The strip may then be placed alongside of column *B* of Form 444 and the multiplication be performed. The same strip will serve for every station for which predictions are to be made for the given year. It has been the recent practice to enter the amplitude settings to the nearest 0.05 foot as being sufficiently close for all practical purposes.

For the dial settings for January 1, 0 hour, the Greenwich equilibrium arguments of (V_0+u)'s from Table 15 are to be applied, according to the indicated sign, to the angles of column C or D of Form 444, using the angle in column D if it is less than the argument, otherwise using the angle in column C. For the application of the (V_0+u)'s a strip similar to that used for the factors f should be prepared. The same strip will serve for all stations for the given year. For the dial settings it is customary to use whole degrees, except for component M_2, for which the setting is carried to the first decimal of a degree.

The settings for February 1 and December 31 are used for checking purposes to ascertain whether there have been any slipping of the gears during the operation of the machine. To obtain the dial settings for February 1, 0^h, and December 31, 24^h, prepare strips similar to those for the f's and (V_0+u)'s. On one enter the angular motion of the components from January 1, 0^h to February 1, 0^h; on a second and a third strip, the angular motion for February 1, 0^h to December 31, 24^h, for a common and leap year, respectively. For checking purposes a fourth and fifth strip may contain the angular changes for a complete common and a complete leap year, respectively. The values for these strips may be obtained from Table 36. These strips will be found more convenient if arranged with two columns each, one column containing the values in a positive form and the other column containing the equivalent negative value which is obtained by subtracting the first from 360. These strips are good for all years, distinction being made between the common and leap years. By applying the first strip to the dial settings for January 1 the values for February 1 are readily obtained, and by applying the second or third strip to the latter settings those for the end of the year are obtained. The values obtained by applying the fourth or fifth strips to the settings for January 1 should also give the correct setting for the end of the year, and thus serve as a check. The angular changes for computing the settings for any day of the year may be obtained from Tables 16 and 17.

PART II.—TABLES.

EXPLANATION OF TABLES.

TABLE 1. *Astronomical constants and formulas.*—There are given in this table some fundamental astronomical constants and formulas, which are used in the computation of other tables which follow, with references to the authorities from which they were obtained. The form and degree of precision is for the most part identical with that of the original source.

It will be noted that T is the time expressed in Julian centuries reckoned forward from Greenwich mean noon on December 31, 1899 (Gregorian calendar), which corresponds to December 19, 1899, by the Julian calendar. (See p. 11 for an explanation of these calendars.) By the Julian calendar the date corresponding to an integral value of T will always be December 19 of a year ending with the figures 99 A. D. or 02 B. C.; for example, by the Julian calendar, $T=-1$ on December 19, 1799; -2 on December 19, 1699, etc. The Gregorian calendar was first introduced in 1582. By this calendar, $T=-3$ on December 29, 1599; -2 on December 29, 1699; -1 on December 30, 1799; 0 on December 31, 1899; $+1$ on January 1, 2000; $+2$ on January 1, 2100; $+3$ on January 2, 2200; etc.

In the formulas for the true longitude and distance of the moon the notation has been changed in order to be in accord with the notation of the present volume, and the terms not used here have been omitted. The terms containing k^2 were for the reduction to the ecliptic and have been omitted here because it is desired to represent the position of the moon in its orbit rather than in the ecliptic. The longitude in the orbit is referred to an origin (Υ' of fig. 6) selected so that the longitude of the moon's nodes will be identical in either the ecliptic or the moon's orbit.

TABLE 2. *Astronomical quantities and relations.*—The values compiled in this table for convenience of reference are based upon Table 1.

The mean longitudes of the lunar and solar elements and also the rate of change in these elements are derived from formulas of Table 1. The rate of change, although computed for the epoch January 1, 1900, will apply without material error to all modern times, since the variations in the rates for all the elements are very small.

The inclination of the earth's orbit to the ecliptic changes about 0.013 of a degree in a century. The value computed for epoch January 1, 1900, may therefore be used without material error for all modern times. The inclination of the moon's orbit to the ecliptic is regarded as an absolute constant.

The eccentricity of the earth's orbit changes about 0.000042 per century. The value as computed for the epoch January 1, 1900, may therefore be used as a constant. The mean value of the eccentricity of the moon's orbit is also used as a constant.

The mean radius of the earth is taken as the cube root of the product of the polar radius and the square of the equatorial radius, this being the radius of a sphere having the same volume as that of the earth. In expressing this radius in feet the result is rounded off to the nearest hundred, since a greater precision is not warranted by the data from which it is obtained.

The numerical values of several other important quantities that appear in the text are also included in Table 2 for convenience of reference.

TABLE 3. *Principal harmonic components.*—This table gives a list of the principal harmonic components used in the prediction of the tides. The symbol by which each component is generally designated and a brief description suggesting the derivation of the component are given in the first and second columns, respectively.

A general discussion of the argument $(V+u)$ will be found in section 10. The formulas for these arguments are derived from formulas (100), (176), (190), (194), (208), (215), (228), and (230) in the text. References to the overtides, compound tides, and meteorological tides will be found in sections 18, 19, and 20.

The speed, or average rate of change in the argument, in general, depends entirely upon that part of the argument designated as V, the u being an inequality that does not affect the average rate of change. The speed formulas are readily derived from formulas for V by substituting for the variable elements T, h, s, p, and p_1 the corresponding hourly rates of change in these elements, represented by θ, η, σ, ϖ, and ϖ_1, respectively. The value for θ is 15°, this being the hourly rate of change in the hour angle of the mean sun. The values for the other elements may be obtained from Table 2, and by substituting in the formulas the corresponding numerical values for the speeds of the components are readily obtained. An explanation of the double expression for the argument for component M_1 will be found in section 14.

The coefficients are discussed in section 11. The coefficient formulas of Table 3 are derived from formulas (100), (176), (190), (194), (208), (215), (228), and (230) of the text. In the coefficients of the solar components the factor G has been introduced in order that the general lunar coefficient, $\frac{3}{2}\frac{M}{E}\left(\frac{a}{c}\right)^3 a \times$ (function of λ) may be used as a common coefficient factor for both the lunar and solar components. The mean values of the coefficients are obtained by mutliplying the constant factors by the mean values of the variable factors. The numerical values of the constants are given in Table 2, and the mean values of the variables, which depend upon some function of I, are given in the formulas indicated by the references. The mean value of the coefficient does not include the general coefficient.

For the evectional and variational components ν_2, λ_2, μ_2, and ρ_1, two mean values are given for each coefficient. The first is that derived from the given formula and the second is a value obtained by Prof. J. C. Adams, who was associated with Sir George H. Darwin in the investigation of the Harmonic Analysis of Tidal Observations, and who in his computations carried the development of the lunar theory to a higher order of precision than is provided for in this work. (See pp. 60–61 of Report of British Association for the Advancement of Sciences for the year 1883.) The second value may therefore be presumed to be a more precise determination of the mean coefficient for each of these components.

The factors F for reduction have been compiled from the formulas indicated in the column of references. The table includes the corrected factor for the component M_1. The factor in general use for this component is represented by formula (204) on page 52.

TABLE 4. *Mean longitude of lunar and solar elements.*—This table contains the mean longitude of the moon (s), of the lunar perigee (p), of the sun (h), of the solar perigee (p_1), and of the moon's ascending node (N), for January 1, 0 hour, Greenwich mean civil time, for each year from 1800 to 2000, the dates referring to the Gregorian calendar.

These values are readily derived from Table 2, the rate of change in the mean longitude of the elements for the epoch January 1, 1900, being applicable without material error to any time within the two centuries 1800 to 2000 covered by Table 4. The same rate of change may also be used, without introducing any errors of practical importance, to extend Table 4 to dates beyond these limits. In extending the table, care should be taken to distinguish between the common and leap years, and for the earlier dates due consideration should be given to the kind of calendar in use. (See p. 11 for discussion of calendars.) It will be noted that each Julian century contains 36,525 days, while the common Gregorian century contains only 36,524 days, with an additional day every fourth century.

TABLE 5. *Differences to adapt Table 4 to any month, day, and hour.*—These differences are derived from the daily and hourly rate of change of the elements as given in Table 2, multiples of 360° being rejected when they occur. The table is prepared especially for common years, but is applicable to leap years by increasing the given date by one day if it is between March 1 and December 31, inclusive. The correction for the hour of the day refers to the Greenwich hour, and if the hour for which the elements are desired is expressed in another kind of time the equivalent Greenwich hour must be used for the table.

TABLE 6. *Values of I, ν, ξ, ν', and $2\nu''$ for each degree of N.*—This table has been computed for epoch January 1, 1900, using the constants of Table 2, but the tabular values are applicable without material error to any series of observations within modern times.

The following formulas were used in the computations for this table:

$$\text{Cos } I = \cos i \cos \omega - \sin i \sin \omega \cos N$$

$$= 0.91369 - 0.03569 \cos N \quad \text{(103) of p. 41.}$$

$$\text{Tan } \tfrac{1}{2}(N - \xi + \nu) = \frac{\cos \tfrac{1}{2}(\omega - i)}{\cos \tfrac{1}{2}(\omega + i)} \tan \tfrac{1}{2}N \quad \text{(104) of p. 41}$$

$$\text{Tan } \tfrac{1}{2}(N - \xi - \nu) = \frac{\sin \tfrac{1}{2}(\omega - i)}{\sin \tfrac{1}{2}(\omega + i)} \tan \tfrac{1}{2}N \quad \text{(105) of p. 41}$$

$$\text{Log } \frac{\cos \tfrac{1}{2}(\omega - i)}{\cos \tfrac{1}{2}(\omega + i)} = 0.00810; \ \log \frac{\sin \tfrac{1}{2}(\omega - i)}{\sin \tfrac{1}{2}(\omega + i)} = 9.80897$$

$$\text{Tan } \nu' = \frac{\sin \nu \sin 2I}{\cos \nu \sin 2I + \frac{2 + 3e_1^2}{2 + 3e^2} \left(\frac{c}{c_1}\right)^3 \frac{S}{M} \sin 2\omega}$$

$$= \frac{\sin \nu \sin 2I}{\cos \nu \sin 2I + 0.3357} \quad \text{(229) of p. 57}$$

$$\text{Tan } 2\nu'' = \frac{\sin 2\nu \sin^2 I}{\cos 2\nu \sin^2 I + \frac{2+3e_1^2}{2+3e^2}\left(\frac{c}{c_1}\right)^3 \frac{S}{M} \sin^2 \omega}$$

$$= \frac{\sin 2\nu \sin^2 I}{\cos 2\nu \sin^2 I + 0.0728} \quad (231) \text{ of p. 57.}$$

TABLE 7. *Values of log R_a for amplitude of component* L_2.—This table has been computed by means of the following formula:

$$R_a = [1 - 12 \tan^2 \tfrac{1}{2}I \cos 2P + 36 \tan^4 \tfrac{1}{2}I]^{-\frac{1}{2}} \quad (177) \text{ of p. 48.}$$

The argument $P = p - \xi$. The value of p and N for any date between 1800 and 2000 may be taken directly from Tables 4 and 5 and the values of ξ and I as functions of N may be obtained from Table 6.

TABLE 8. *Values of R for argument of component* L_2.—This table has been computed by the following formula:

$$\text{Tan } R = \frac{6 \sin 2P}{\cot^2 \frac{1}{2}I - 6 \cos 2P}, \quad (178) \text{ of p. 48.}$$

The argument of $P = p - \xi$. The values of p and N for any date between 1800 and 2000 may be taken directly from Tables 4 and 5, and the values of ξ and I as functions of N may be obtained from Table 6.

TABLE 9. *Values of log Q_a for amplitude of component* M_1.—The formula upon which this table is based is

$$Q_a = [5/2 - 9/2 \tan^2 \tfrac{1}{2}I + 9/4 \tan^4 \tfrac{1}{2}I + 3/2(1 - \tan^2 \tfrac{1}{2}I) \cos 2P]^{-\frac{1}{2}},$$
(191) of p. 50.

Attributing to I its mean value ($\omega = 23.°452$) from Table 2, the above may be written

$$Q_a = [2.310 + 1.435 \cos 2\,P]^{-\frac{1}{2}}.$$

By means of the latter formula a single argument table of the logarithms of Q_a has been prepared, which is applicable without serious error to any series without regard to the exact value of I.

TABLE 10. *Values of Q for argument of component* M_1.—The formula for which this table is based is

$$\text{Tan } Q = \frac{2 - 3 \tan^2 \frac{1}{2}I}{4 - 3 \tan^2 \frac{1}{2}I} \tan P \quad (195) \text{ of p. 51.}$$

Attributing to I its mean value ($\omega = 23.°452$) from Table 2, the above formula may be written

$$\text{Tan } Q = 0.483 \tan P.$$

By means of the latter formula a single argument table has been prepared which is applicable without serious error to any series without regard to the exact value of I.

TABLE 11. *Values of u for equilibrium argument.*—The values for the table have been computed for each degree of N by the formulas

for this argument given in Table 3, the elements of the formulas being functions of N, which are given in Table 6. The u's of components L_2 and M_1 are functions of both N and P. The u of $L_2 = u$ of $M_2 - (R$ from Table 8) and the u of $M_1 = \frac{1}{2}$ (u of M_2) + (Q from Table 10). For any time between the years 1900 and 2000 the u's of L_2 and M_1 may be conveniently obtained from Table 13.

TABLE 12. *Log factor F for each tenth degree of I.*—This table is based upon the formulas for factor F in Table 3. The factors for L_2 and M_1 being functions of both I and P are not included directly in the table. These may be obtained from the following formulas:

$$\log F\,(L_2) = \log F\,(M_2) + (\log R_a \text{ from Table 7}) \quad \text{[See (186) p. 49.]}$$
$$\log F\,(M_1) = \log F\,(O_1) + (\log Q_a \text{ from Table 9}) \quad \text{[See (206) p. 53.]}$$

For any time between the years 1900 and 2000 the factors for L_2 and M_1 may be conveniently obtained from Table 13. It will be noted that the above formula for log F (M_1) accords with the factor generally used in practice rather than the theoretically correct factor, as indicated in Table 3 (see p. 52).

TABLE 13. *Values of u and log factor F for components* L_2 *and* M_1.—This table includes the values of u and log F for components L_2 and M_1, for each 5° of N for the years 1900 to 2000, inclusive. The values are based upon the following formulas:

$$u \text{ of } L_2 = 2\xi - 2\nu - R = (u \text{ of } M_2) - R \qquad \text{p. 48.}$$
$$u \text{ of } M_1 = \xi - \nu + Q = \tfrac{1}{2}(u \text{ of } M_2) + Q \qquad \text{p. 51.}$$
$$F\,(L_2) = F\,(M_2) \times R_a \qquad \text{(186) of p. 49.}$$
$$F\,(M_1) = F\,(O_1) \times Q_a \qquad \text{(206) of p. 53.}$$

The values of u of M_2 may be taken from Table 11, F (M_2) and F (O_1) from Table 12, R from Table 8, Q from Table 10, R_a from Table 7, and Q_a from Table 9. The factors F of M_1 represented in this table are those which have heretofore been in general use (see p. 52). For the corrected F (M_1) the tabular logarithms should be increased by 0.1523, which is the logarithm of the correcting factor 1.42.

TABLE 14. *Factor f for middle of each year 1850 to 1999.*—The factor f is the reciprocal of factor F. The values for the years 1850 to 1950 were taken directly from the Manual of Tides, by R. A. Harris, and the values for 1951 to 1999 were derived from Tables 12 and 13.

TABLE 15. *Equilibrium argument* (V_0+u) *for beginning of each year 1850 to 2000.*—The equilibrium argument is discussed in section 10. The tabular values are computed by the formulas for the argument in Table 3, the V_0 referring to the value of V on January 1, 0 hour Greenwich mean civil time, for each year, and the u referring to the middle of the same calendar year; that is, Greenwich noon on July 2 in common years and the preceding midnight in leap years. The value of the T of the formulas is 180° for each midnight, and the values of the other elements for the V may be obtained from Table 4. The u of the argument may be obtained from Tables 11 and 13 after the value of N has been determined for the middle of each year from Tables 4 and 5. In constructing Table 15 the values for the years 1850 to 1950 were taken directly from the Manual of Tides, by R. A. Harris, and the values for the years 1951 to 2000 were computed as indicated above.

TABLES 16, 17, AND 18.—These tables give the differences to adapt Table 15 to any month, day, and hour, and are computed from the hourly speeds of the components as given in Table 3. The differences refer to the uniformly varying portion V of the argument, it being assumed that for practical purposes the portion u is constant for the entire year.

The approximate Greenwich (V_0+u) for any desired Greenwich hour may be obtained by applying the appropriate differences from Tables 16, 17, and 18 to the value for the first of January of the required year, as given in Table 15. To refer this Greenwich (V_0+u) to any local meridian, it is necessary to apply a further correction equal to the product of the longitude in degrees by the subscript of the component, which represents the number of periods in a component day. West longitude is to be considered as positive and east longitude as negative, and the subscripts of the long-period components are to be taken as zero. This correction is to be subtracted.

The (V_0+u) obtained as above will, in general, differ by a small amount from the value as computed by Form 244, because in the former case the u refers to the middle of the calendar year and in the latter case to the middle of the series of observations.

TABLE 19. *Products for Form 194.*—This is a multiplication table especially adapted for use with Form 194, the multipliers being the sines of multiples of 15°.

TABLE 20. *Augmenting factors.*—A discussion of the augmenting factors is given in section 27 of the text. The tabular values for the short-period components are obtained by formulas (329) and (330). For the long-period components the augmenting factors were computed by formula (423).

TABLES 21 TO 26.—These tables represent perturbations in K_1 and S_2 due to other components. They are based upon formulas (379) to (384), inclusive.

TABLE 27. *Critical logarithms for Form 245.*—This table was designed for quickly obtaining the natural numbers to three decimal places for column (3) of Form 245 from the logarithms of column (2). The logarithms are given for every change of 0.001 in the natural number. Each logarithm given in this table is derived from the natural number that is 0.0005 less than the tabular number to which it applies. Intermediate logarithms, therefore, apply to the same natural number as the preceding tabular logarithm. For example, logarithms less than 6.6990 apply to the natural number 0.000 and logarithms from 6.6990 to 7.1760 apply to the natural number 0.001, etc.

TABLE 28. *Component speed differences.*—The component speeds as given in Table 3 were used in the computation of this table.

TABLE 29. *Elimination factors.*—These tables provide for certain constant factors in formulas (409) and (410). Separate tables for each length of series and different values for each term of the formulas are required. The tabular values are arranged in groups of three, determined as follows:

$$\text{First value} = \text{logarithm of } \frac{180 \sin \frac{1}{2}(b-a)\tau}{\pi \ \frac{1}{2}(b-a)\tau}$$

Second value = natural number $\dfrac{180}{\pi} \dfrac{\sin \frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau}$ always taken as positive.

Third value $=\frac{1}{2}(b-a)\tau$, if $\dfrac{\sin\frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau}$ is positive,

or $\frac{1}{2}(b-a)\tau\pm180$, if $\dfrac{\sin\frac{1}{2}(b-a)\tau}{\frac{1}{2}(b-a)\tau}$ is negative.

TABLE 30. *Products for Form 245.*—This table is designed for obtaining the products for columns (6) and (7) of Form 245.

TABLE 31. *For construction of primary stencils.*—This table gives the differences to be applied to the solar hours in order to obtain the component hours to which they most nearly coincide. Each difference applies to several successive solar hours, but for brevity only the first solar hour of each group to which the difference applies is given in the table.

An asterisk (*) indicates that the solar hour so marked is to be used twice or rejected according to whether the component speed is greater or less than $15p$, when in the summation it is desired to assign a single solar hour to each successive component hour. For the usual summations in which each solar hour height is assigned to the nearest component hour no attention need be given to the asterisk.

The table is computed by substituting successive integral values for d in formula (264) and reducing the resulting solar hour series (*shs*) to the corresponding day and hour. The solar hour to be tabulated is the integral hour that immediately follows the value the (*shs*) of the formula. If the fractional part of (*shs*) exceeds 0.5, the tabular solar hour is marked by an asterisk (*). The successive values of d, although used positively in formula (264), are to be considered as negative in the application of the table when the speed of the component is less than $15p$. When the component speed is greater than $15p$, the difference is to be taken as positive. All tabular differences are brought within the limits $+24$ hours and -24 hours by rejecting multiples of ±24 hours when necessary, and for convenience in use all differences are given in both positive and negative forms.

The following example will illustrate the use of the table: To find component 2Q hours corresponding to solar hours 12 to 23 on 16th day of series. By the table we see that solar hour 12 of the 16th day of series is within the group beginning on solar hour 8 of the same day with the tabular difference of $+19$ or -5 hours, and that the difference changes by -1 hour on solar hours 15 and 21, the latter being marked by an asterisk. Applying the differences indicated, we have for these solar hours on the 16th day of series:

Solar hour	12,	13,	14*,	15,	16,	17,	18,	19,	20,	21*,	22,	23
Difference	−5	−5	−5	−6	−6	−6	−6	−6	−6	−7	−7	−7
Component 2Q hour	7,	8,	9*,	9,	10,	11,	12,	13,	14,	14*,	15,	16

In the results it will be noted that the component hours 9 and 14 are each represented by two solar hours. If it should be desired to limit the representation to a single solar hour each, the hours marked with the asterisk should be rejected.

To find component OO hours corresponding to solar hours O to 18 on the 22d day of series. The O hour of the 22d day is in the group beginning on solar hour 14 of the preceding day with the tabular difference of $+14$ or -10 hours, and changes of $+1$ hour in the differences occur on solar hours 3 and 17 of the 22d day. It will be noted that the hour 3 is marked by an asterisk. Applying the differences from the table as indicated, we have for the 22d day of series:

Solar hours..	0,	1,	2,	3*,	4,	5,	6,	7,	8,	9,	10,	11,	12,	13,	14,	15,	16*,	17,	18
Differences.	+14,	+14,	+14,	+15,	+15,	+15,	+15,	+15,	+15,	−9,	−9,	−9,	−9,	−9,	−9,	−9,	−9,	−8,	−8
Component OO hours.	14,	15,	16,	18,	19,	20,	21,	22,	23,	0,	1,	2,	3,	4,	5,	6,	7,	9,	10

In the results it will be noted that component hours 17 and 8 are missing. If it is desired to have each of these hours represented also, the solar hours marked by asterisks will be used again. In this table the components have been arranged in accordance with the length of the component days.

TABLE 32.—*Divisors for primary stencil sums.*—This table contains the number of solar hourly heights included in each component hour group for each of the standard length of series when all the hourly heights have been used in the summation.

TABLE 33. *For construction of secondary stencils.*—Component *A* is the component for which the original primary summations have been made, and component *B* is the component for which the sums are to be derived by the secondary stencils. The "Page" refers to the page of the original tabulations of the hourly heights in Form 362. The differences in this table were calculated by formula (273), and the corresponding "Component *A* hours" from formula (271), *m* being assigned successive values from 1 to 24 for each page of record. Special allowance was made for page 53 of the record to take account of the fact that in a 369-day series this page includes only 5 days of record. The sign of the difference is given at the top of the column. For K-P and R-T the positive sign is to be used for components K and R and the negative sign for components P and T.

For brevity all the 24 component hours for every page of record are not directly represented in the table. The difference for the omitted hours for any page should be taken numerically one greater than the difference for the given hours on that page. For an example, take the hours for page 2 for component OO as derived from component J. According to the table the difference for the component hours 10 to 3, inclusive, is 9 hours; therefore the difference for the omitted hours 4 to 9, inclusive, should be taken as 10 hours. For component 2Q as derived from component O the three differences usually required for each page are given in full.

The use of the table may be illustrated from the example above, as follows:

Page 2—

Component J hours	0,	1,	2,	3,	4,	5	6,	7,	8,	9,	10,	11
Differences	+9,	9,	9,	9,	10,	10,	10,	10,	10,	10,	9,	9
Component OO hours	9,	10,	11,	12,	14,	15,	16,	17,	18,	19,	19,	20
Component J hours	12,	13,	14,	15,	16,	17,	18,	19,	20,	21,	22,	23,
Difference	+9,	9,	9,	9,	9,	9,	9,	9,	9,	9,	9,	9
Component OO hours	21,	22,	23,	0,	1,	2,	3,	4,	5,	6,	7,	8

The period 24 hours should be added or subtracted when necessary in order that the resulting component hours may be between 0 and 23.

TABLE 34. *For summation of long-period components.*—This table is designed to show the assignment of the daily page sums of the hourly heights to the component divisions to which they most nearly correspond. The table is based upon formula (415). The component division to which each day of series is assigned is given in the left-hand column. For components Mf, MSf, and Mm there will frequently occur two consecutive days which are to be assigned to the same component division. In such cases the day which most nearly corresponds to the component division is the only one given in the table, and this is marked by an asterisk (*). The missing day, whether it precedes or follows the one marked by the asterisk, is to be assigned to the same component division. For component Sa a number of consecutive days of series are assigned to each component division. In the table there are given the first and last days of each group.

TABLE 35. *Products* $\frac{aSf}{15}$ *for Form 444.*—This table contains the products of the speed of each component as given in Table 3 and the longitude of each of the standard time meridians. These products are for use in formula (492), which gives the value for column *A* of Form 444.

TABLE 36. *Angle differences for Form 445.*—This table gives the differences for obtaining and checking the dial settings for February 1 and December 31, as entered in Form 445. The differences are derived from Tables 16 and 17.

TABLE 37. *U. S. Coast and Geodetic Survey tide-predicting machine No. 2—General gears.*—This table gives the details of the general gearing from the hand-operating crank to the main vertical component shafts, together with the details of the gearing in the front section or dial case. In this table the gears and shafts are each numbered consecutively for convenience of reference, the gears being designated by the letter *G* and the shafts by the letter *S*. In the second column are given the face of each bevel or spur gear and the diameter of each shaft. The next two columns contain the number of teeth and pitch of each bevel and spur gear. The pitch is the number of teeth per inch of diameter of the gear. The worm screw is equivalent to a gear of one tooth, as it requires a complete revolution of the screw to move the engaged wheel one tooth forward. The period of rotation of each shaft and gear is relative and refers to the time as indicated on the face of the machine, which for convenience is called dial time.

TABLE 38. *U. S. Coast and Geodetic Survey tide-predicting machine No. 2—Component gears.*—This table contains the details of the gearing from the main vertical component shafts to the individual component cranks. Column I gives the number of teeth in the bevel gear on the main vertical component shaft; column II, the number of teeth in the gear on the intermediate shaft that meshes with the gear on the vertical component shaft; column III, the number of teeth in the gear on the intermediate shaft that meshes with the gear on the component crank shaft; and column IV, the number of teeth in the gear on the component crank shaft.

For the long-period components the worm gear is taken as the equivalent of one tooth. For each of these components there is a short secondary shaft on which sliding gears are mounted, but the extra gears do not affect the speed of any of the component crank shafts except that for component Sa in which case a ratio of 1:2 is introduced.

The component crank-shaft speed per dial hour for each component is equal to $30° \times \frac{\text{column I}}{\text{column II}} \times \frac{\text{column III}}{\text{column IV}}$. For the component Sa the product of both values appearing in each of the columns II and III is to be taken as the value for the column. The column of "Gear speed per dial hour" contains the speeds as computed by the above formula.

For comparison the table contains also the theoretical speed of each of the components and the accumulated error per year due to the difference between the theoretical and the gear speeds.

For covenience of reference the table includes also the maximum amplitude settings of the component cranks.

TABLE 39. *Synodic periods of components.*—This table is derived from Table 28, the period represented by 360° being divided by the speed difference and the results reduced to days.

TABLE 40. *Day of year corresponding to any date.*—This table is convenient for obtaining the difference between any two dates and also in finding the middle of any series.

TABLES FOR THE ANALYSIS AND PREDICTION OF TIDES

TABLE 1.—*Astronomical constants and formulas.*

[From original sources.]

Mean distance, earth to sun = 92,897,416 statute miles.*
Mean distance, earth to moon = 238,857 statute miles.*
Radius of earth, equatorial = 3,963.34 statute miles.*
Radius of earth, polar = 3,949.99 statute miles.*

Ratio of mass of moon to that of earth = 1:81.45.†
Ratio of mass of sun to that of earth = 333,432:1.†

Eccentricity of earth's orbit
$= 0.016{,}751{,}04 - 0.000{,}041{,}80\ T - 0.000{,}000{,}126\ T^2$.†
Eccentricity of moon's orbit = 0.054,899,720.‡

Inclination of earth's orbit to plane of ecliptic:
$= 23° \ 27' \ 8.26'' - 46.845''\ T - 0.005{,}9''\ T^2 + 0.001{,}81''\ T^3$.†
Inclination of moon's orbit to plane of ecliptic = 5° 08′ 43.354,6″.‡

Mean longitude of sun
$= 279° \ 41' \ 48.04'' + 129{,}602{,}768.13''\ T + 1.089''\ T^2$.†
Longitude of solar perigee
$= 281° \ 13' \ 15.0'' + 6{,}189.03''\ T + 1.63''\ T^2 + 0.012''\ T^3$.†
Mean longitude of moon
$= 270° \ 26' \ 14.72'' + (1336 \text{ rev.} + 1{,}108{,}411.20'')\ T + 9.09''\ T^2 + 0.006{,}8''\ T^3$.†
Longitude of lunar perigee
$= 334° \ 19' \ 40.87'' + (11 \text{ rev.} + 392{,}515.94'')\ T - 37.24''\ T^2 - 0.045''\ T^3$.†
Longitude of moon's node
$= 259° \ 10' \ 57.12'' - (5 \text{ rev.} + 482{,}912.63'')\ T + 7.58''\ T^2 + 0.008''\ T^3$.†

True longitude of moon in its orbit (in radians)
= mean longitude (in radians)
$+2e \sin (s-p) + \frac{5}{4} e^2 \sin 2(s-p)$ (elliptic inequality).
$+\frac{15}{4} me \sin (s-2h+p)$ (evectional inequality).
$+\frac{11}{8} m^2 \sin 2(s-h)$ (variational inequality).‖

Reciprocal of true distance of moon from earth
= reciprocal of mean distance
$+a'e \cos (s-p) + a'e^2 \cos 2(s-p)$ (elliptic inequality).
$+\frac{15}{8} a'me \cos (s-2h+p)$ (evectional inequality).
$+a'm^2 \cos 2(s-h)$ (variational inequality).‖

T = Number of Julian centuries (36525 days) from Greenwich mean noon on December 31, 1899.
e = Eccentricity of moon's orbit.
s = Mean longitude of moon.
p = Mean longitude of lunar perigee.
h = Mean longitude of sun.
m = Ratio of mean motion of the sun to that of the moon.
a' = Reciprocal of product of moon's mean distance by $(1-e^2)$.

* American Ephemeris for year 1923, p. xvi.
† Astronomical Papers for the American Ephemeris, by Simon Newcomb: Vol. VI, pp. 9–11, and Vol. IX, pt. 1, p. 224.
‡ The Solar Parallax and Related Constants, by William Harkness, p. 140.
‖ An Elementary Treatise on the Lunar Theory, by Hugh Godfrey, 4th ed., p. 53.

TABLE 2.—*Astronomical quantities and relations.*

[Derived from Table 1.]

Epoch (Gregorian calendar, Greenwich mean civil time).	Mean longitude of lunar and solar elements. Moon. s	Lunar perigee. p	Sun. h	Solar perigee. p_1	Moon's node. N
	°	°	°	°	°
1800, Jan. 1, 0 hour	342.313	225.453	280.407	279.502	33.248
1900, Jan. 1, 0 hour	277.026	334.384	280.190	281.221	259.156
2000, Jan. 1, 0 hour	211.744	83.294	279.973	282.940	125.069

	Rate of change in mean longitude (epoch, Jan. 1, 1900). Per Julian century (36525 days).	Per common year (365 days).	Per solar day.	Per solar hour.
	°	°	°	°
Moon	1336 $r.$+307.892	13 $r.$+129.384,82	13.176,396,8	σ=0.549,016,53
Lunar perigee	11 $r.$+109.032	40.662,47	0.111,404,0	ϖ=0.004,641,83
Sun	100 $r.$+ 0.769	359.761,28	0.985,647,3	η=0.041,068,64
Solar perigee	1.719	0.017,18	0.000,047,1	ϖ_1=0.000,001,96
Moon's node	−(5 $r.$+134.142)	−19.328,19	−0.052,953,9	−0.002,206,41

NOTE.—r=1 revolution or 360°.

Inclination of earth's equator to the ecliptic (ω), epoch Jan. 1, 1900 = 23°.452
Inclination of moon's orbit to the ecliptic (i) = 5.145

Eccentricity of earth's orbit (e_1), epoch Jan. 1, 1900 = 0.01675
Eccentricity of moon's orbit (e) = 0.05490

Mean radius of earth (a) = 3,958.89 statute miles = 20,902,900 feet

$$\frac{\text{Mass of moon } (M)}{\text{Mass of earth } (E)}\times\left(\frac{\text{mean radius of earth } (a)}{\text{mean distance of moon } (c)}\right)^3=0.000,000,055,900$$

$$\frac{\text{Mass of sun } (S)}{\text{Mass of earth } (E)}\times\left(\frac{\text{mean radius of earth } (a)}{\text{mean distance of sun } (c_1)}\right)^3=0.000,000,025,806$$

$$\frac{\text{Mass of sun } (S)}{\text{Mass of moon } (M)}\times\left(\frac{\text{mean distance of moon } (c)}{\text{mean distance of sun } (c_1)}\right)^3=0.46164=G$$

$$\frac{M}{E}\times\left(\frac{a}{c}\right)^4=0.000,000,000,926,51; \qquad \frac{S}{E}\times\left(\frac{a}{c_1}\right)^4=0.000,000,000,001,10$$

$$\frac{\text{rate of change in longitude of sun } (\eta)}{\text{rate of change in longitude of moon } (\sigma)}=0.074,804=m$$

$e^2_1=0.000281$ $\quad e^2=0.003014$ $\quad m^2_{\frac{3}{2}}=0.005,596$ $\quad me=0.004,107$

$\sin\omega=0.39798$ $\quad \sin^2\omega=0.15839$ $\quad \sin\frac{1}{2}\omega=0.20323$ $\quad \sin^2\frac{1}{2}\omega=0.04130$
$\cos\omega=0.91739$ $\quad \cos^2\omega=0.84161$ $\quad \cos\frac{1}{2}\omega=0.97913$ $\quad \cos^2\frac{1}{2}\omega=0.95870$

$\sin i=0.08968$ $\quad \sin^2 i=0.00804$ $\quad \sin 2\omega=0.73021$ $\quad \sin^4\frac{1}{2}\omega=0.00171$
$\cos i=0.99597$ $\quad \cos^2 i=0.99196$ $\quad \cos 2\omega=0.68322$ $\quad \cos^4\frac{1}{2}\omega=0.91910$

[illegible]

TABLE 3.—*Principal harmonic components, with arguments, speeds, coefficients, and reduction factors.*

Symbol.	Description.	Argument.		Speed per solar hour.		Coefficient formula.	Mean coefficient.		Factor F for reduction.	
		V	u	Formula.	Value.		Value.	Ref.	Formula.	Ref.
	SEMIDIURNAL COMPONENTS.				°	$3/2 \frac{M}{E} \left(\frac{a}{c}\right)^3 a \cos^2 \lambda$				
M_2	Principal lunar	$2T+2h-2s$	$+2\xi-2\nu$	$2\theta+2\eta-2\sigma$	28.984,104,2	$(\frac{1}{2}-5/4\, e^2) \cos^4 \frac{1}{2} I$	0.4543	(155)	$\frac{0.9154}{\cos^4 \frac{1}{2} I}$	(165)
N_2	Larger lunar elliptic	$2T+2h-3s+p$	$+2\xi-2\nu$	$2\theta+2\eta-3\sigma+\varpi$	28.439,729,5	$7/4\, e \cos^4 \frac{1}{2} I$	0.0880	(155)	$F(M_2)$	(165)
L_2	Smaller lunar elliptic	$2T+2h-s-p+180°$	$+2\xi-2\nu-R$	$2\theta+2\eta-\sigma-\varpi$	29.528,478,9	$1/4\, e \frac{1}{R_a} \cos^4 \frac{1}{2} I$	0.0126	(184)	$F(M_2)\times R_a$	(186)
2N	Lunar elliptic, 2d order	$2T+2h-4s+2p$	$+2\xi-2\nu$	$2\theta+2\eta-4\sigma+2\varpi$	27.895,354,8	$17/4\, e^2 \cos^4 \frac{1}{2} I$	0.0117	(155)	$F(M_2)$	(165)
ν_2	Larger lunar evectional	$2T+4h-3s-p$	$+2\xi-2\nu$	$2\theta+4\eta-3\sigma-\varpi$	28.512,583,1	$105/32\, m\, e \cos^4 \frac{1}{2} I$	0.0123	(155)	$F(M_2)$	(165)
							[1] 0.0171			
λ_2	Smaller lunar evectional	$2T-s+p+180°$	$+2\xi-2\nu$	$2\theta-\sigma+\varpi$	29.455,625,3	$15/32\, m\, e \cos^4 \frac{1}{2} I$	0.0018	(155)	$F(M_2)$	(165)
							[1] 0.0033			
μ_2	Variational	$2T+4h-4s$	$+2\xi-2\nu$	$2\theta+4\eta-4\sigma$	27.968,208,4	$23/16\, m^2 \cos^4 \frac{1}{2} I$	0.0074	(155)	$F(M_2)$	(165)
							[1] 0.0109			
S_2	Principal solar	$2T$	Zero	2θ	30.000,000,0	$(\frac{1}{2}-5/4\, e_1^2)\, G \cos^4 \frac{1}{2} \omega$	0.2120		Unity	p. 56
T_2	Larger solar elliptic	$2T-h+p_1$	do	$2\theta-\eta+\varpi_1$	29.958,933,3	$7/4\, e_1\, G \cos^4 \frac{1}{2} \omega$	0.0124		do	p. 56
R_2	Smaller solar elliptic	$2T+h-p_1+180°$	do	$2\theta+\eta-\varpi_1$	30.041,066,7	$1/4\, e_1\, G \cos^4 \frac{1}{2} \omega$	0.0018		do	p. 56
K_2	Lunisolar semidiurnal	$2T+2h$	$-2\nu''$	$2\theta+2\eta$	30.082,137,3	Note 1	0.0576	(240)	Note 2	(241)
	DIURNAL COMPONENTS.					$3/2 \frac{M}{E} \left(\frac{a}{c}\right)^3 a \sin 2\lambda$				
O_1	Principal lunar diurnal	$T+h-2s+90°$	$+2\xi-\nu$	$\theta+\eta-2\sigma$	13.943,035,6	$(\frac{1}{2}-5/4\, e^2) \sin I \cos^2 \frac{1}{2} I$	0.1886	(157)	$\frac{0.3800}{\sin I \cos^2 \frac{1}{2} I}$	(167)
OO	Lunar diurnal, 2d order	$T+h+2s-90°$	$-2\xi-\nu$	$\theta+\eta+2\sigma$	16.139,101,7	$(\frac{1}{2}-5/4\, e^2) \sin I \sin^2 \frac{1}{2} I$	0.0081	(158)	$\frac{0.0164}{\sin I \sin^2 \frac{1}{2} I}$	(168)
Q_1	Larger lunar elliptic	$T+h-3s+p+90°$	$+2\xi-\nu$	$\theta+\eta-3\sigma+\varpi$	13.398,660,9	$7/4\, e \sin I \cos^2 \frac{1}{2} I$	0.0365	(157)	$F(O_1)$	(167)
M_1	Smaller lunar elliptic	$T+h-s+p-90°$ $T+h-s-90°$	$-\nu-Q_u$ $+\xi-\nu+Q$	$\theta+\eta-\sigma+\varpi$	14.496,693,9	$\frac{1}{2}\, e \frac{1}{Q_a} \sin I \cos^2 \frac{1}{2} I$	0.0149	(202)	$\frac{0.5410\, Q_a}{\sin I \cos^2 \frac{1}{2} I}$	(203)
J_1	Small lunar elliptic	$T+h+s-p-90°$	$-\nu$	$\theta+\eta+\sigma-\varpi$	15.585,443,3	$3/8\, e \sin 2 I$	0.0149	(159)	$\frac{0.7214}{\sin 2 I}$	(169)
2Q	Lunar elliptic, 2d order	$T+h-4s+2p+90°$	$+2\xi-\nu$	$\theta+\eta-4\sigma+2\varpi$	12.854,286,2	$17/4\, e^2 \sin I \cos^2 \frac{1}{2} I$	0.0049	(157)	$F(O_1)$	(167)
ρ_1	Larger lunar evectional	$T+3h-3s-p+90°$	$+2\xi-\nu$	$\theta+3\eta-3\sigma-\varpi$	13.471,514,5	$105/32\, m\, e \sin I \cos^2 \frac{1}{2} I$	0.0051	(157)	$F(O_1)$	(167)
							[1] 0.0071			
P_1	Principal solar diurnal	$T-h+90°$	Zero	$\theta-\eta$	14.958,931,4	$(\frac{1}{2}-5/4\, e_1^2)\, G \sin \omega \times \cos^2 \frac{1}{2} \omega$.	0.0880		Unity	p. 56
K_1	Lunisolar diurnal	$T+h-90°$	$-\nu'$	$\theta+\eta$	15.041,068,6	Note 3	0.2655	(235)	Note 4	(239)
S_1	Meteorological diurnal	T	Zero	θ	15.000,000,0	Meteorological			Unity	p. 61

	TERDIURNAL COMPONENT.					$3/2 \frac{M}{E}\left(\frac{a}{c}\right)^3 a \cos^3 \lambda$				
M₃...	From fourth power of moon's parallax.	$3T+3h-3s$	$+3\xi-3\nu$	$3\theta+3\eta-3\sigma$	43.476,156,3	$5/12 \frac{a}{c} \cos^6 \frac{1}{2} I$	0.0060	(212)	$F^{3/2}(M_2)$	(214)
	OVERTIDES.									
M₄...	Lunar quarter-diurnal	$4T+4h-4s$	$+4\xi-4\nu$	$4\theta+4\eta-4\sigma$	57.968,208,4	Shallow water			$F^2(M_2)$	(242)
M₆...	Lunar sixth-diurnal	$6T+6h-6s$	$+6\xi-6\nu$	$6\theta+6\eta-6\sigma$	86.952,312,7	do			$F^3(M_2)$	(243)
M₈...	Lunar eighth-diurnal	$8T+8h-8s$	$+8\xi-8\nu$	$8\theta+8\eta-8\sigma$	115.936,416,9	do			$F^4(M_2)$	(244)
S₄....	Solar quarter-diurnal	$4T$	Zero	4θ	60.000,000,0	do			Unity	p. 59
S₆....	Solar sixth-diurnal	$6T$	do	6θ	90.000,000,0	do			do	p. 59
	COMPOUND TIDES.									
MS...	M_2+S_2	$4T+2h-2s$	$+2\xi-2\nu$	$4\theta+2\eta-2\sigma$	58.984,104,2	do			$F(M_2)$	(252)
MN..	M_2+N_2	$4T+4h-5s+p$	$+4\xi-4\nu$	$4\theta+4\eta-5\sigma+\pi$	57.423,833,7	do			$F^2(M_2)$	(253)
MK..	M_2+K_1	$3T+3h-2s-90°$	$+2\xi-2\nu-\nu'$	$3\theta+3\eta-2\sigma$	44.025,172,9	do			$F(M_2)\times F(K_1)$	(254)
2MK.	M_4-K_1	$3T+3h-4s+90°$	$+4\xi-4\nu+\nu'$	$3\theta+3\eta-4\sigma$	42.927,139,8	do			$F(M_4)\times F(K_1)$	(255)
2SM..	S_4-M_2	$2T-2h+2s$	$-2\xi+2\nu$	$2\theta-2\eta+2\sigma$	31.015,895,8	do			$F(M_2)$	(256)
	LONG-PERIOD COMPONENTS.					$3/2 \frac{M}{E}\left(\frac{a}{c}\right)^3 a(\frac{1}{2}-3/2 \sin^2 \lambda)$				
Mf...	Lunar fortnightly	$2s$	-2ξ	2σ	1.098,033,1	$(\frac{1}{2}-5/4\ e^2) \sin^2 I$	0.0783	(160)	$\frac{0.1578}{\sin^2 I}$	(170)
Mm..	Lunar monthly	$s-p$	Zero	$\sigma-\varpi$	0.544,374,7	$e\ (1-3/2 \sin^2 I)$	0.0414	(161)	$\frac{0.7532}{1-3/2 \sin^2 I}$	(171)
MSf..	Lunisolar synodic fortnightly.	$2s-2h$	$-2\xi+2\nu$	$2\sigma-2\eta$	1.015,895,8	$m^2\ (1-3/2 \sin^2 I)$	0.0042	(161)	$F(M_2)$	(257)
Sa....	Solar annual	h	Zero	η	0.041,068,6	Meteorological			Unity	p. 61
Ssa...	Solar semiannual	$2h$	do	2η	0.082,137,3	$(\frac{1}{2}-5/4\ e_1^2)\ G \sin^2 \omega$	0.0365		do	p. 56

[1] Value when coefficients in the evection and variation have their full value as derived from the lunar theory.

T=hour angle of mean sun. θ=hourly rate of change in T=15°.
For h, s, p, p_1, η, σ, ϖ, and ϖ_1, see Table 2.
For ξ, ν ν', and $2\nu''$, see Table 6.
For R and Q, see Tables 8 and 10, respectively.
For Q_u, see Formula (192).
For M, E, a, c, G, e, e_1, m, and ω, see Table 2.
For I, see Table 6.
For R_a and Q_a, see Tables 7 and 9, respectively.

NOTE 1.—Coefficient $K_2=[(1/4+3/8\ e^2)^2 \sin^4 I+(1/4+3/8\ e_1^2)^2\ G^2 \sin^4 \omega+2\ (1/4+3/8\ e^2)\ (1/4+3/8\ e_1^2)\ G \sin^2 I \sin^2 \omega \cos 2\nu]^{\frac{1}{2}}$.

NOTE 2.—$F\ (K_2)=(51.0453-63.9167 \cos I-5.8300 \cos^2 I+19.0186 \cos^4 I)^{-\frac{1}{2}}$.

NOTE 3.—Coefficient $K_1=[(1/4+3/8\ e^2)^2 \sin^2 2\ I+(1/4+3/8\ e_1^2)^2\ G^2 \sin^2 2\omega+2\ (1/4+3/8\ e^2)\ (1/4+3/8\ e_1^2)\ G \sin 2I \sin 2\omega \cos \nu]^{\frac{1}{2}}$.

NOTE 4.—$F\ (K_1)=(0.1009+3.0073 \cos I+0.8093 \cos^2 I-3.5793 \cos^4 I)^{-\frac{1}{2}}$.

TABLE 4.—*Mean longitude of lunar and solar elements at January 1, 0 hour, Greenwich mean civil time, of each year from 1800 to 2000.*

[s=mean longitude of moon; p=mean longitude lunar perigee; h=mean longitude of sun; p_1=mean longitude solar perigee; N= longitude of moon's node.]

Year.	s	p	h	p_1	N	Year.	s	p	h	p_1	N
	°	°	°	°	°		°	°	°	°	°
1800	342.31	225.45	280.41	279.50	33.25	1852	28.44	181.24	279.82	280.40	107.55
1801	111.70	266.12	280.17	279.52	13.92	1853	171.00	222.02	280.57	280.41	88.16
1802	241.08	306.78	279.93	279.54	354.59	1854	330.38	262.68	280.33	280.43	68.84
1803	10.47	347.44	279.69	279.55	335.26	1855	69.77	303.34	280.09	280.45	49.51
1804	139.85	28.10	279.45	279.57	315.93	1856	199.15	344.00	279.85	280.46	30.18
1805	282.41	68.88	280.20	279.59	296.55	1857	341.72	24.78	280.60	280.48	10.80
1806	51.80	109.54	279.96	279.61	277.23	1858	111.10	65.44	280.36	280.50	351.47
1807	181.18	150.20	279.72	279.62	257.90	1859	240,49	106.10	280.12	280.52	332.14
1808	310.57	190.86	279.48	279.64	238.57	1860	9.87	146.77	279.88	280.53	312.81
1809	93.13	231.64	280.23	279.66	219.19	1861	152.43	187.54	280.63	280.55	293.43
1810	222.51	272.30	279.99	279.67	199.86	1862	281.82	228.20	280.39	280.57	274.10
1811	351.90	312.96	279.75	279.69	180.53	1863	51.20	268.87	280.15	280.58	254.78
1812	121.28	353.63	279.51	279.71	161.20	1864	180.59	309.53	279.91	280.60	235.45
1813	263.84	34.40	280.26	279.73	141.82	1865	323.15	350.30	280.66	280.62	216.07
1814	33.23	75.06	280.02	279.74	122.49	1866	92.53	30.96	280.42	280.64	196.74
1815	162.61	115.73	279.78	279.76	103.17	1867	221.92	71.63	280.18	280.65	177.41
1816	292.00	156.39	279.54	279.78	83.84	1868	351.30	112.29	279.94	280.67	158.08
1817	74.56	197.16	280.29	279.79	64.46	1869	133.86	153.06	280.69	280.69	138.70
1818	203.94	237.82	280.05	279.81	45.13	1870	263.25	193.73	280.45	280.71	119.37
1819	333.33	278.49	279.81	279.83	25.80	1871	32.63	234.39	280.21	280.72	100.04
1820	102.71	319.15	279.57	279.85	6.47	1872	162.02	275.05	279.97	280.74	80.72
1821	245.28	359.92	280.32	279.86	347.09	1873	304.58	315.83	280.72	280.76	61.34
1822	14.66	40.59	280.08	279.88	327.76	1874	73.96	356.49	280.48	280.77	42.01
1823	144.04	81.25	279.84	279.90	308.43	1875	203.35	37.15	280.24	280.79	22.68
1824	273.43	121.91	279.61	279.91	289.11	1876	332.73	77.81	280.01	280.81	3.35
1825	55.99	162.69	280.35	279.93	269.72	1877	115.29	118.59	280.75	280.83	343.97
1826	185.38	203.35	280.11	279.95	250.40	1878	244.68	159.25	280.51	280.84	324.64
1827	314.76	244.01	279.87	279.97	231.07	1879	14.06	199.91	280.27	280.86	305.31
1828	84.15	284.67	279.64	279.98	211.74	1880	143.45	240.58	280.04	280.88	285.98
1829	226.71	325.45	280.38	280.00	192.36	1881	286.01	281.35	280.78	280.89	266.60
1830	356.09	6.11	280.14	280.02	173.03	1882	55.39	322.01	280.54	280.91	247.28
1831	125.48	46.77	279.91	280.03	153.70	1883	184.78	2.67	280.31	280.93	227.95
1832	254.86	87.43	279.67	280.05	134.37	1884	314.16	43.34	280.07	280.95	208.62
1833	37.42	128.21	280.41	280.07	114.99	1885	96.72	84.11	280.81	280.96	189.24
1834	166.81	168.87	280.18	280.09	95.66	1886	226.11	124.77	280.57	280.98	169.91
1835	296.19	209.53	279.94	280.10	76.34	1887	355.49	165.44	280.34	281.00	150.58
1836	65.58	250.20	279.70	280.12	57.01	1888	124.88	206.10	280.10	281.01	131.25
1837	208.14	290.97	280.44	280.14	37.63	1889	267.44	246.87	280.84	281.03	111.87
1838	337.52	331.63	280.21	280.16	18.30	1890	36.82	287.54	280.61	281.05	92.54
1839	106.91	12.30	279.97	280.17	358.97	1891	166.21	328.20	280.37	281.07	73.22
1840	236.29	52.96	279.73	280.19	339.64	1892	295.59	8.86	280.13	281.08	53.89
1841	18.85	93.73	280.48	280.21	320.26	1893	78.16	49.63	280.87	281.10	34.51
1842	148.24	134.39	280.24	280.22	300.93	1894	207.54	90.30	280.64	281.12	15.18
1843	277.62	175.06	280.00	280.24	281.61	1895	336.93	130.96	280.40	281.13	355.85
1844	47.01	215.72	279.76	280.26	262.28	1896	106.31	171.62	280.16	281.15	336.52
1845	189.57	256.49	280.51	280.28	242.90	1897	248.87	212.40	280.91	281.17	317.14
1846	318.95	297.16	280.27	280.29	223.57	1898	18.26	253.06	280.67	281.19	297.81
1847	88.34	337.82	280.03	280.31	204.24	1899	147.64	293.72	280.43	281.20	278.48
1848	217.72	18.48	279.79	280.33	184.91						
1849	0.28	59.26	280.54	280.34	165.53						
1850	129.67	99.92	280.30	280.36	146.20						
1851	259.05	140.58	280.06	280.38	126.87						

TABLE 4.—*Mean longitude of lunar and solar elements at January 1, 0 hour, Greenwich mean civil time, of each year from 1800 to 2000*—Continued.

Year.	s	p	h	p_1	N	Year.	s	p	h	p_1	N
	°	°	°	°	°		°	°	°	°	°
1900.....	277.03	334.38	280.19	281.22	259.16	1952.....	323.15	290.16	279.60	282.12	333.45
1901.....	46.41	15.05	279.95	281.24	239.83	1953.....	105.72	330.94	280.35	282.13	314.07
1902.....	175.80	55.71	279.71	281.26	220.50	1954.....	235.10	11.60	280.11	282.15	294.75
1903.....	305.18	96.37	279.47	281.27	201.17	1955.....	4.49	52.26	279.87	282.17	275.42
1904.....	74.57	137.03	279.23	281.29	181.84	1956.....	133.87	92.92	279.63	282.18	256.09
1905.....	217.13	177.81	279.98	281.31	162.46	1957.....	276.43	133.70	280.38	282.20	236.71
1906.....	346.51	218.47	279.74	281.32	143.13	1958.....	45.82	174.36	280.14	282.22	217.38
1907.....	115.90	259.13	279.50	281.34	123.81	1959.....	175.20	215.02	279.90	282.24	198.05
1908.....	245.28	299.79	279.27	281.36	104.48	1960.....	304.59	255.69	279.67	282.25	178.72
1909.....	27.84	340.57	280.01	281.38	85.10	1961.....	87.15	296.46	280.41	282.27	159.34
1910.....	157.23	21.23	279.77	281.39	65.77	1962.....	216.53	337.12	280.17	282.29	140.01
1911.....	286.61	61.89	279.53	281.41	46.44	1963.....	345.92	17.78	279.93	282.30	120.69
1912.....	56.00	102.55	279.30	281.43	27.11	1964.....	115.30	58.45	279.70	282.32	101.36
1913.....	198.56	143.33	280.04	281.44	7.73	1965.....	257.86	99.22	280.44	282.34	81.98
1914.....	327.94	183.99	279.80	281.46	348.40	1966.....	27.25	139.88	280.20	282.36	62.65
1915.....	97.33	224.65	279.57	281.48	329.07	1967.....	156.63	180.54	279.97	282.37	43.32
1916.....	226.71	265.32	279.33	281.50	309.75	1968.....	286.02	221.21	279.73	282.39	23.99
1917.....	9.27	306.09	280.07	281.51	290.36	1969.....	68.58	261.98	280.47	282.41	4.61
1918.....	138.66	346.75	279.84	281.53	271.04	1970.....	197.96	302.64	280.24	282.42	345.28
1919.....	268.04	27.41	279.60	281.55	251.71	1971.....	327.35	343.31	280.00	282.44	325.95
1920.....	37.43	68.08	279.36	281.56	232.38	1972.....	96.73	23.97	279.76	282.46	306.63
1921.....	179.99	108.85	280.10	281.58	213.00	1973.....	239.29	64.74	280.50	282.48	287.24
1922.....	309.37	149.51	279.87	281.60	193.67	1974.....	8.68	105.40	280.27	282.49	267.92
1923.....	78.76	190.18	279.63	281.62	174.34	1975.....	138.06	146.07	280.03	282.51	248.59
1924.....	208.14	230.84	279.39	281.63	155.01	1976.....	267.45	186.73	279.79	282.53	229.26
1925.....	350.71	271.61	280.14	281.65	135.63	1977.....	50.01	227.50	280.54	282.54	209.88
1926.....	120.09	312.27	279.90	281.67	116.31	1978.....	179.40	268.17	280.30	282.56	190.55
1927.....	249.47	352.94	279.66	281.69	96.98	1979.....	308.78	308.83	280.06	282.58	171.22
1928.....	18.86	33.60	279.42	281.70	77.65	1980.....	78.16	349.49	279.82	282.60	151.89
1929.....	161.42	74.37	280.17	281.72	58.27	1981.....	220.73	30.26	280.57	282.61	132.51
1930.....	290.81	115.03	279.93	281.74	38.94	1982.....	350.11	70.93	280.33	282.63	113.19
1931.....	60.19	155.70	279.69	281.75	19.61	1983.....	119.50	111.59	280.09	282.65	93.86
1932.....	189.58	196.36	279.45	281.77	0.28	1984.....	248.88	152.25	279.85	282.67	74.53
1933.....	332.14	237.13	280.20	281.79	340.90	1985.....	31.44	193.02	280.60	282.68	55.15
1934.....	101.52	277.80	279.96	281.81	321.57	1986.....	160.83	233.69	280.36	282.70	35.82
1935.....	230.91	318.46	279.72	281.82	302.25	1987.....	290.21	274.35	280.12	282.72	16.49
1936.....	0.29	359.12	279.48	281.84	282.92	1988.....	59.60	315.01	279.88	282.73	357.16
1937.....	142.85	39.89	280.23	281.86	263.54	1989.....	202.16	355.79	280.63	282.75	337.78
1938.....	272.24	80.56	279.99	281.87	244.21	1990.....	331.54	36.45	280.39	282.77	318.45
1939.....	41.62	121.22	279.75	281.89	224.88	1991.....	100.93	77.11	280.15	282.79	299.13
1940.....	171.01	161.88	279.51	281.91	205.55	1992.....	230.31	117.77	279.91	282.80	279.80
1941.....	313.57	202.65	280.26	281.93	186.17	1993.....	12.87	158.55	280.66	282.82	260.42
1942.....	82.95	243.32	280.02	281.94	166.84	1994.....	142.26	199.21	280.42	282.84	241.09
1943.....	212.34	283.98	279.78	281.96	147.51	1995.....	271.64	239.87	280.18	282.85	221.76
1944.....	341.72	324.64	279.54	281.98	128.19	1996.....	41.03	280.53	279.94	282.87	202.43
1945.....	124.28	5.42	280.29	281.99	108.80	1997.....	193.59	321.31	280.69	282.89	183.05
1946.....	253.67	46.08	280.05	282.01	89.48	1998.....	312.97	1.97	280.45	282.91	163.72
1947.....	23.05	86.74	279.81	282.03	70.15	1999.....	82.36	42.63	280.21	282.92	144.39
1948.....	152.44	127.40	279.57	282.05	50.82	2000.....	211.74	83.29	279.97	282.94	125.07
1949.....	295.00	168.18	280.32	282.06	31.44						
1950.....	64.38	208.04	280.08	282.08	12.11						
1951.....	193.77	249.50	279.84	282.10	352.78						

TABLE 5.—*Differences to adapt Table 4 to any month, day, and hour of Greenwich mean civil time.*

DIFFERENCES TO FIRST OF EACH CALENDAR MONTH OF COMMON YEARS.[1]

Month.	s	p	h	p_1	N	Month.	s	p	h	p_1	N
	°	°	°	°	°		°	°	°	°	°
Jan. 1	0.00	0.00	0.00	0.00	0.00	July 1	224.93	20.16	178.40	0.01	−9.58
Feb. 1	48.47	3.45	30.56	0.00	−1.64	Aug. 1	273.40	23.62	208.96	0.01	−11.23
Mar. 1	57.41	6.57	58.15	0.00	−3.12	Sept. 1	321.86	27.07	239.51	0.01	−12.87
Apr. 1	105.88	10.03	88.71	0.00	−4.77	Oct. 1	357.16	30.41	269.08	0.01	−14.46
May 1	141.17	13.37	118.28	0.01	−6.35	Nov. 1	45.62	33.87	299.64	0.01	−16.10
June 1	189.64	16.82	148.83	0.01	−8.00	Dec. 1	80.92	37.21	329.21	0.02	−17.69

DIFFERENCES TO BEGINNING OF EACH DAY OF MONTH FOR COMMON YEARS.[1]

Day.	s	p	h	p_1	N	Day.	s	p	h	p_1	N
	°	°	°	°	°		°	°	°	°	°
1	0.00	0.00	0.00	0.00	0.00	17	210.82	1.78	15.77	0.00	−0.85
2	13.18	0.11	0.99	0.00	−0.05	18	224.00	1.89	16.76	0.00	−0.90
3	26.35	0.22	1.97	0.00	−0.11	19	237.18	2.01	17.74	0.00	−0.95
4	39.53	0.33	2.96	0.00	−0.16	20	250.35	2.12	18.73	0.00	−1.01
5	52.71	0.45	3.94	0.00	−0.21	21	263.53	2.23	19.71	0.00	−1.06
6	65.88	0.56	4.93	0.00	−0.26	22	276.70	2.34	20.70	0.00	−1.11
7	79.06	0.67	5.91	0.00	−0.32	23	289.88	2.45	21.68	0.00	−1.16
8	92.23	0.78	6.90	0.00	−0.37	24	303.06	2.56	22.67	0.00	−1.22
9	105.41	0.89	7.89	0.00	−0.42	25	316.23	2.67	23.66	0.00	−1.27
10	118.59	1.00	8.87	0.00	−0.48	26	329.41	2.79	24.64	0.00	−1.32
11	131.76	1.11	9.86	0.00	−0.53	27	342.59	2.90	25.63	0.00	−1.38
12	144.94	1.23	10.84	0.00	−0.58	28	355.76	3.01	26.61	0.00	−1.43
13	158.12	1.34	11.83	0.00	−0.64	29	8.94	3.12	27.60	0.00	−1.48
14	171.29	1.45	12.81	0.00	−0.69	30	22.12	3.23	28.58	0.00	−1.54
15	184.47	1.56	13.80	0.00	−0.74	31	35.29	3.34	29.57	0.00	−1.59
16	197.65	1.67	14.78	0.00	−0.79	32	48.47	3.45	30.56	0.00	−1.64

DIFFERENCES TO BEGINNING OF EACH HOUR OF DAY, GREENWICH CIVIL TIME.

Hour.	s	p	h	p_1	N	Hour.	s	p	h	p_1	N
	°	°	°	°	°		°	°	°	°	°
0	0.00	0.00	0.00	0.00	0.00	12	6.59	0.06	0.49	0.00	−0.03
1	0.55	0.00	0.04	0.00	0.00	13	7.14	0.06	0.53	0.00	−0.03
2	1.10	0.01	0.08	0.00	0.00	14	7.69	0.06	0.57	0.00	−0.03
3	1.65	0.01	0.12	0.00	−0.01	15	8.24	0.07	0.62	0.00	−0.03
4	2.20	0.02	0.16	0.00	−0.01	16	8.78	0.07	0.66	0.00	−0.04
5	2.75	0.02	0.21	0.00	−0.01	17	9.33	0.08	0.70	0.00	−0.04
6	3.29	0.03	0.25	0.00	−0.01	18	9.88	0.08	0.74	0.00	−0.04
7	3.84	0.03	0.29	0.00	−0.02	19	10.43	0.09	0.78	0.00	−0.04
8	4.39	0.04	0.33	0.00	−0.02	20	10.98	0.09	0.82	0.00	−0.04
9	4.94	0.04	0.37	0.00	−0.02	21	11.53	0.10	0.86	0.00	−0.05
10	5.49	0.05	0.41	0.00	−0.02	22	12.08	0.10	0.90	0.00	−0.05
11	6.04	0.05	0.45	0.00	−0.02	23	12.63	0.11	0.94	0.00	−0.05

[1] The table may also be used directly for dates between Jan. 1 and Feb. 29, inclusive, of leap years; but if the required date falls between Mar. 1 and Dec. 31, inclusive, of a leap year, the day of month should be increased by one before entering the table.

TABLE 6.—*Values of I, ν, ξ, ν', and $2\nu''$ for each degree of N.*

N	Positive always.		Positive when N is between 0 and 180°; negative when N is between 180 and 360°.								N
	I		ν		ξ		ν'		$2\nu''$		
°	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°
0	28.60	0	0.00	19	0.00	17	0.00	13	0.00	28	360
1	28.60	0	0.19	19	0.17	17	0.13	14	0.28	29	359
2	28.60	1	0.38	18	0.34	17	0.27	13	0.57	28	358
3	28.59	0	0.56	19	0.51	16	0.40	14	0.85	29	357
4	28.59	1	0.75	19	0.67	17	0.54	13	1.14	28	356
5	28.58	0	0.94	18	0.84	17	0.67	13	1.42	28	355
6	28.58	1	1.12	19	1.01	17	0.80	14	1.70	29	354
7	28.57	1	1.31	19	1.18	17	0.94	13	1.99	28	353
8	28.56	1	1.50	18	1.35	16	1.07	13	2.27	28	352
9	28.55	2	1.68	19	1.51	17	1.20	14	2.55	28	351
10	28.53	1	1.87	18	1.68	17	1.34	13	2.83	28	350
11	28.52	2	2.05	19	1.85	17	1.47	13	3.11	28	349
12	28.50	1	2.24	18	2.02	16	1.60	13	3.39	28	348
13	28.49	2	2.42	19	2.18	17	1.73	13	3.67	28	347
14	28.47	2	2.61	18	2.35	16	1.86	13	3.95	28	346
15	28.45	2	2.79	19	2.51	17	1.99	13	4.23	28	345
16	28.43	2	2.98	18	2.68	16	2.12	13	4.51	27	344
17	28.41	2	3.16	18	2.84	17	2.25	13	4.78	28	343
18	28.39	3	3.34	18	3.01	16	2.38	13	5.06	27	342
19	28.36	2	3.52	18	3.17	17	2.51	13	5.33	27	341
20	28.34	3	3.70	18	3.34	16	2.64	13	5.60	27	340
21	28.31	2	3.88	18	3.50	16	2.77	13	5.87	27	339
22	28.29	3	4.06	18	3.66	16	2.90	13	6.14	27	338
23	28.26	3	4.24	18	3.82	16	3.03	12	6.41	27	337
24	28.23	3	4.42	18	3.98	16	3.15	13	6.68	26	336
25	28.20	4	4.60	18	4.14	16	3.28	12	6.94	27	335
26	28.16	3	4.78	17	4.30	16	3.40	13	7.21	26	334
27	28.13	4	4.95	18	4.46	16	3.53	12	7.47	26	333
28	28.09	3	5.13	17	4.62	16	3.65	13	7.73	26	332
29	28.06	4	5.30	18	4.78	16	3.78	12	7.99	26	331
30	28.02	4	5.48	17	4.94	16	3.90	12	8.25	25	330
31	27.98	4	5.65	17	5.10	15	4.02	12	8.50	25	329
32	27.94	4	5.82	17	5.25	16	4.14	12	8.75	25	328
33	27.90	4	5.99	17	5.41	15	4.26	12	9.00	25	327
34	27.86	4	6.16	17	5.56	15	4.38	12	9.25	25	326
35	27.82	5	6.33	17	5.71	15	4.50	12	9.50	24	325
36	27.77	4	6.50	16	5.86	15	4.62	12	9.74	24	324
37	27.73	5	6.66	17	6.01	15	4.74	11	9.98	24	323
38	27.68	5	6.83	16	6.16	15	4.85	12	10.22	24	322
39	27.63	5	6.99	16	6.31	15	4.97	11	10.46	23	321
40	27.58	5	7.15	16	6.46	15	5.08	11	10.69	24	320
41	27.53	5	7.31	16	6.61	14	5.19	11	10.93	23	319
42	27.48	5	7.47	16	6.75	15	5.30	11	11.16	22	318
43	27.43	5	7.63	16	6.90	14	5.41	11	11.38	22	317
44	27.38	6	7.79	15	7.04	14	5.52	11	11.60	22	316
45	27.32		7.94		7.18		5.63		11.82		315

TABLE 6.—*Values of I, ν, ξ, ν′, and 2ν″ for each degree of N*—Continued.

N	Positive always.		Positive when *N* is between 0 and 180°; negative when *N* is between 180 and 360°.								N
	I		*ν*		*ξ*		*ν′*		*2ν″*		
°	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°
45	27.32	5	7.94	16	7.18	14	5.63	11	11.82	22	315
46	27.27	6	8.10	15	7.32	14	5.74	10	12.04	22	314
47	27.21	6	8.25	15	7.46	14	5.84	11	12.26	21	313
48	27.15	6	8.40	15	7.60	13	5.95	10	12.47	21	312
49	27.09	6	8.55	14	7.73	14	6.05	10	12.68	20	311
50	27.03	6	8.69	15	7.87	13	6.15	10	12.88	20	310
51	26.97	6	8.84	14	8.00	14	6.25	10	13.08	20	309
52	26.91	6	8.98	14	8.14	13	6.35	10	13.28	20	308
53	26.85	7	9.12	14	8.27	13	6.45	9	13.48	19	307
54	26.78	6	9.26	14	8.40	12	6.54	10	13.67	19	306
55	26.72	7	9.40	14	8.52	13	6.64	9	13.86	19	305
56	26.65	6	9.54	13	8.65	12	6.73	9	14.05	18	304
57	26.59	7	9.67	14	8.77	13	6.82	9	14.23	17	303
58	26.52	7	9.81	13	8.90	12	6.91	9	14.40	18	302
59	26.45	7	9.94	13	9.02	12	7.00	9	14.58	17	301
60	26.38	7	10.07	12	9.14	11	7.09	8	14.75	17	300
61	26.31	7	10.19	13	9.25	12	7.17	9	14.92	16	299
62	26.24	7	10.32	12	9.37	11	7.26	8	15.08	16	298
63	26.17	7	10.44	12	9.48	11	7.34	8	15.24	15	297
64	26.10	7	10.56	12	9.59	11	7.42	7	15.39	15	296
65	26.03	8	10.68	11	9.70	11	7.49	8	15.54	15	295
66	25.95	7	10.79	11	9.81	11	7.57	7	15.69	14	294
67	25.88	8	10.90	11	9.92	10	7.64	8	15.83	13	293
68	25.80	8	11.01	11	10.02	10	7.72	7	15.96	14	292
69	25.72	7	11.12	11	10.12	10	7.79	7	16.10	13	291
70	25.65	8	11.23	10	10.22	10	7.86	6	16.23	12	290
71	25.57	8	11.33	10	10.32	9	7.92	7	16.35	12	289
72	25.49	8	11.43	10	10.41	9	7.99	6	16.47	11	288
73	25.41	8	11.53	10	10.50	9	8.05	6	16.58	11	287
74	25.33	8	11.63	9	10.59	9	8.11	6	16.69	11	286
75	25.25	8	11.72	9	10.68	9	8.17	6	16.80	10	285
76	25.17	8	11.81	8	10.77	8	8.23	5	16.90	10	284
77	25.09	8	11.89	9	10.85	8	8.28	6	17.00	9	283
78	25.01	9	11.98	8	10.93	8	8.34	5	17.09	8	282
79	24.92	8	12.06	8	11.01	7	8.39	5	17.17	8	281
80	24.84	8	12.14	7	11.08	7	8.44	4	17.25	8	280
81	24.76	9	12.21	7	11.15	7	8.48	5	17.33	7	279
82	24.67	8	12.28	7	11.22	7	8.53	4	17.40	6	278
83	24.59	9	12.35	7	11.29	7	8.57	4	17.46	6	277
84	24.50	8	12.42	6	11.36	6	8.61	3	17.52	6	276
85	24.42	9	12.48	6	11.42	5	8.64	4	17.58	5	275
86	24.33	9	12.54	6	11.47	6	8.68	3	17.63	4	274
87	24.24	8	12.60	5	11.53	5	8.71	3	17.67	4	273
88	24.16	9	12.65	5	11.58	5	8.74	2	17.71	3	272
89	24.07	9	12.70	5	11.63	5	8.76	3	17.74	3	271
90	23.98		12.75		11.68		8.79		17.77		270

TABLE 6.—*Values of I, ν, ξ, ν', and $2\nu''$ for each degree of N*—Continued.

N	Positive always. I		Positive when N is between 0 and 180°; negative when N is between 180 and 360°. ν		ξ		ν'		$2\nu''$		N
°	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°
90	23.98	9	12.75	4	11.68	4	8.79	2	17.77	2	270
91	23.89	9	12.79	4	11.72	4	8.81	2	17.79	2	269
92	23.80	8	12.83	4	11.76	4	8.83	2	17.81	1	268
93	23.72	9	12.87	3	11.80	3	8.85	1	17.82	1	267
94	23.63	9	12.90	3	11.83	3	8.86	1	17.83	0	266
95	23.54	9	12.93	2	11.86	3	8.87	1	17.83	1	265
96	23.45	9	12.95	2	11.89	3	8.88	1	17.82	1	264
97	23.36	9	12.97	2	11.92	2	8.89	1	17.81	2	263
98	23.27	9	12.99	2	11.94	1	8.90	0	17.79	2	262
99	23.18	9	13.01	1	11.95	1	8.90	1	17.77	3	261
100	23.09	9	13.02	0	11.96	1	8.89	0	17.74	3	260
101	23.00	9	13.02	0	11.97	1	8.89	1	17.71	4	259
102	22.91	9	13.02	0	11.98	0	8.88	1	17.67	5	258
103	22.82	9	13.02	1	11 98	0	8.87	1	17.62	5	257
104	22.73	9	13.01	1	11.98	1	8.86	2	17.57	6	256
105	22.64	9	13.00	1	11.97	1	8.84	2	17.51	6	255
106	22.55	9	12.99	2	11.96	1	8.82	2	17.45	7	254
107	22.46	9	12.97	2	11.95	2	8.80	2	17.38	8	253
108	22.37	9	12.95	3	11.93	2	8.78	3	17.30	8	252
109	22.28	8	12 92	3	11.91	2	8.75	3	17.22	8	251
110	22.20	9	12.89	4	11.89	3	8.72	3	17.14	9	250
111	22.11	9	12.85	4	11.86	3	8.69	4	17.05	10	249
112	22.02	9	12.81	4	11.83	4	8.65	4	16.95	11	248
113	21.93	9	12.77	5	11.79	4	8.61	4	16.84	11	247
114	21.84	9	12.72	5	11.75	5	8.57	5	16.73	11	246
115	21.75	8	12.67	6	11.70	5	8.52	4	16.62	12	245
116	21.67	9	12.61	6	11.65	5	8.48	5	16.50	13	244
117	21.58	8	12.55	7	11.60	6	8.43	6	16.37	13	243
118	21.50	9	12.48	7	11.54	6	8.37	6	16.24	14	242
119	21.41	9	12.41	8	11.48	7	8.31	6	16.10	14	241
120	21.32	8	12.33	8	11.41	7	8.25	6	15.96	15	240
121	21.24	9	12.25	8	11.34	8	8.19	6	15.81	15	239
122	21.15	8	12.17	9	11.26	8	8.13	7	15.66	16	238
123	21.07	8	12.08	10	11.18	8	8.06	7	15.50	17	237
124	20.99	8	11.98	10	11.10	9	7.99	8	15.33	17	236
125	20.91	9	11.88	10	11.01	9	7.91	8	15.16	17	235
126	20.82	8	11.78	11	10.92	10	7.83	8	14.99	18	234
127	20.74	8	11.67	12	10.82	10	7.75	8	14.81	19	233
128	20.66	8	11.55	12	10.72	11	7.67	9	14.62	19	232
129	20.58	7	11.43	12	10.61	11	7.58	9	14.43	20	231
130	20.51	8	11.31	13	10.50	12	7.49	9	14.23	20	230
131	20.43	8	11.18	13	10.38	12	7.40	10	14.03	20	229
132	20.35	7	11.05	14	10.26	13	7.30	10	13.83	21	228
133	20.28	8	10.91	14	10.13	13	7.20	10	13.62	22	227
134	20.20	7	10.77	15	10.00	13	7.10	10	13.40	22	226
135	20.13		10.62		9.87		7.00		13.18		225

TABLE 6.—*Values of I, ν, ξ, ν′, and 2ν″ for each degree of N*—Continued.

N	Positive always.		Positive when *N* is between 0 and 180°; negative when *N* is between 180 and 360°.								N
	I		*ν*		*ξ*		*ν′*		*2ν″*		
°	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°	*Diff.*	°
135	20.13	8	10.62	15	9.87	14	7.00	11	13.18	22	225
136	20.05	7	10.47	16	9.73	14	6.89	11	12.96	23	224
137	19.98	7	10.31	16	9.59	15	6.78	12	12.73	24	223
138	19.91	7	10.15	17	9.44	15	6.66	11	12.49	24	222
139	19.84	7	9.98	17	9.29	16	6.55	12	12.25	24	221
140	19.77	6	9.81	18	9.13	16	6.43	12	12.01	25	220
141	19.71	7	9.63	18	8.97	17	6.31	13	11.76	25	219
142	19.64	6	9.45	18	8.80	17	6.18	12	11.51	25	218
143	19.58	7	9.27	19	8.63	17	6.06	13	11.26	26	217
144	19.51	6	9.08	19	8.46	18	5.93	13	11.00	26	216
145	19.45	6	8.89	20	8.28	18	5.80	14	10.74	26	215
146	19.39	6	8.69	20	8.10	19	5.66	14	10.48	27	214
147	19.33	6	8.49	21	7.91	19	5.52	14	10.21	27	213
148	19.27	5	8.28	21	7.72	20	5.38	14	9.94	28	212
149	19.22	6	8.07	22	7.52	20	5.24	15	9.66	28	211
150	19.16	5	7.85	22	7.32	20	5.09	14	9.38	28	210
151	19.11	6	7.63	22	7.12	21	4.95	15	9.10	29	209
152	19.05	5	7.41	23	6.91	21	4.80	15	8.81	29	208
153	19.00	5	7.18	23	6.70	21	4.65	15	8.52	29	207
154	18.95	4	6.95	23	6.49	22	4.50	16	8.23	29	206
155	18.91	5	6.72	24	6.27	22	4.34	15	7.94	30	205
156	18.86	4	6.48	24	6.05	23	4.19	16	7.64	30	204
157	18.82	4	6.24	25	5.82	23	4.03	16	7.34	30	203
158	18.78	4	5.99	25	5.59	23	3.87	17	7.04	30	202
159	18.74	4	5.74	25	5.36	23	3.70	16	6.74	31	201
160	18.70	4	5.49	25	5.13	24	3.54	17	6.43	31	200
161	18.66	4	5.24	25	4.89	24	3.37	17	6.12	31	199
162	18.62	3	4.98	26	4.65	24	3.20	17	5.81	31	198
163	18.59	3	4.72	26	4.41	25	3.03	17	5.50	31	197
164	18.56	3	4.46	27	4.16	25	2.86	17	5.19	32	196
165	18.53	3	4.19	27	3.91	25	2.69	17	4.87	32	195
166	18.50	3	3.92	27	3.66	25	2.52	18	4.55	32	194
167	18.47	2	3.65	27	3.41	25	2.34	17	4.23	32	193
168	18.45	2	3.38	28	3.16	26	2.17	18	3.91	32	192
169	18.43	2	3.10	27	2.90	26	1.99	18	3.59	32	191
170	18.41	2	2.83	28	2.64	26	1.81	18	3.27	33	190
171	18.39	2	2.55	28	2.38	26	1.63	18	2.94	32	189
172	18.37	1	2.27	28	2.12	26	1.45	18	2.62	33	188
173	18.36	2	1.99	28	1.86	26	1.27	18	2.29	32	187
174	18.34	1	1.71	29	1.60	27	1.09	18	1.97	33	186
175	18.33	1	1.42	28	1.33	26	0.91	18	1.64	33	185
176	18.32	0	1.14	28	1.07	27	0.73	18	1.31	32	184
177	18.32	1	0.86	29	0.80	26	0.55	18	0.99	33	183
178	18.31	0	0.57	28	0.54	27	0.37	19	0.66	33	182
179	18.31	0	0.29	29	0.27	27	0.18	18	0.33	33	181
180	18.31		0.00		0.00		0.00		0.00		180

TABLE 7.—*Log R_a for amplitude of component* L_2.

P \ I		18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	I / P	
°	°													°	°
0	180	0.0708	0.0799	0.0897	0.1002	0.1117	0.1240	0.1373	0.1517	0.1674	0.1843	0.2027	0.2228	180	360
5	185	0.0695	0.0783	0.0878	0.0981	0.1092	0.1211	0.1340	0.1479	0.1628	0.1790	0.1966	0.2155	175	355
10	190	0.0654	0.0736	0.0824	0.0918	0.1019	0.1128	0.1244	0.1367	0.1500	0.1641	0.1792	0.1953	170	350
15	195	0.0590	0.0662	0.0739	0.0820	0.0906	0.0998	0.1095	0.1197	0.1305	0.1417	0.1535	0.1658	165	345
20	200	0.0506	0.0565	0.0628	0.0693	0.0762	0.0834	0.0908	0.0986	0.1065	0.1147	0.1230	0.1313	160	340
25	205	0.0407	0.0452	0.0498	0.0546	0.0596	0.0647	0.0698	0.0750	0.0802	0.0853	0.0904	0.0952	155	335
30	210	0.0297	0.0327	0.0357	0.0388	0.0418	0.0449	0.0478	0.0506	0.0533	0.0557	0.0578	0.0597	150	330
35	215	0.0182	0.0197	0.0212	0.0225	0.0238	0.0249	0.0258	0.0265	0.0269	0.0270	0.0268	0.0262	145	325
40	220	0.0065	0.0066	0.0066	0.0064	0.0060	0.0054	0.0045	0.0034	0.0019	0.0001	9.9979	9.9953	140	320
45	225	9.9951	9.9940	9.9926	9.9910	9.9891	9.9870	9.9846	9.9819	9.9789	9.9755	9.9717	9.9676	135	315
50	230	9.9843	9.9820	9.9794	9.9765	9.9734	9.9700	9.9663	9.9623	9.9580	9.9533	9.9483	9.9430	130	310
55	235	9.9743	9.9710	9.9673	9.9634	9.9592	9.9548	9.9500	9.9449	9.9395	9.9338	9.9278	9.9215	125	305
60	240	9.9653	9.9611	9.9566	9.9518	9.9467	9.9414	9.9357	9.9298	9.9235	9.9170	9.9102	9.9031	120	300
65	245	9.9575	9.9526	9.9473	9.9418	9.9360	9.9299	9.9236	9.9169	9.9100	9.9029	9.8954	9.8877	115	295
70	250	9.9510	9.9454	9.9396	9.9335	9.9271	9.9205	9.9136	9.9064	9.8990	9.8913	9.8834	9.8753	110	290
75	255	9.9458	9.9398	9.9336	9.9270	9.9202	9.9131	9.9058	9.8982	9.8904	9.8824	9.8742	9.8657	105	285
80	260	9.9421	9.9358	9.9292	9.9224	9.9152	9.9079	9.9003	9.8924	9.8844	9.8761	9.8676	9.8589	100	280
85	265	9.9399	9.9334	9.9266	9.9196	9.9123	9.9047	9.8969	9.8889	9.8807	9.8723	9.8636	9.8548	95	275
90	270	9.9391	9.9326	9.9257	9.9186	9.9113	9.9037	9.8958	9.8878	9.8795	9.8710	9.8623	9.8535	90	270

TABLE 8.—*Values of R for argument of component* L_2.

[Tabular values are positive when *P* is in first or third quadrants, negative when *P* is in second or fourth quadrants.]

P	I	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	I	P
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
0	180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	180	360
5	185	1.8	2.0	2.3	2.6	2.9	3.3	3.7	4.1	4.6	5.2	5.9	6.6	175	355
10	190	3.4	3.9	4.4	5.0	5.6	6.3	7.1	7.9	8.9	9.9	11.1	12.4	170	350
15	195	4.9	5.6	6.4	7.1	8.0	9.0	10.0	11.2	12.5	13.9	15.4	17.1	165	345
20	200	6.2	7.1	8.0	8.9	10.0	11.2	12.4	13.8	15.2	16.8	18.6	20.4	160	340
25	205	7.3	8.2	9.2	10.3	11.5	12.8	14.1	15.6	17.1	18.8	20.6	22.5	155	335
30	210	8.0	9.0	10.1	11.3	12.5	13.8	15.2	16.7	18.2	19.9	21.7	23.5	150	330
35	215	8.5	9.5	10.6	11.8	13.0	14.3	15.7	17.1	18.6	20.2	21.9	23.6	145	325
40	220	8.7	9.7	10.8	11.9	13.1	14.3	15.7	17.0	18.4	19.9	21.4	23.0	140	320
45	225	8.6	9.5	10.6	11.6	12.8	13.9	15.2	16.4	17.7	19.1	20.5	21.9	135	315
50	230	8.2	9.1	10.1	11.1	12.1	13.2	14.3	15.4	16.6	17.8	19.0	20.3	130	310
55	235	7.7	8.5	9.4	10.3	11.2	12.1	13.1	14.1	15.2	16.2	17.3	18.3	125	305
60	240	6.9	7.6	8.4	9.2	10.0	10.8	11.7	12.5	13.4	14.3	15.2	16.1	120	300
65	245	6.0	6.6	7.3	7.9	8.6	9.3	10.0	10.8	11.5	12.2	13.0	13.7	115	295
70	250	5.0	5.5	6.0	6.5	7.1	7.6	8.2	8.8	9.4	10.0	10.6	11.2	110	290
75	255	3.8	4.2	4.6	5.0	5.4	5.8	6.3	6.7	7.1	7.6	8.0	8.5	105	285
80	260	2.6	2.8	3.1	3.4	3.7	3.9	4.2	4.5	4.8	5.1	5.4	5.7	100	280
85	265	1.3	1.4	1.6	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	95	275
90	270	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90	270

TABLE 9.—*Log Q_a for amplitude of component* M_1.

P		Log Q_a.	Diff.	P		P		Log Q_a.	Diff.	P	
°	°			°	°	°	°			°	°
0	180	9.7133	0	180	360	45	225	9.8182	47	135	315
1	181	9.7133	2	179	359	46	226	9.8229	49	134	314
2	182	9.7135	2	178	358	47	227	9.8278	50	133	313
3	183	9.7137	4	177	357	48	228	9.8328	51	132	312
4	184	9.7141	4	176	356	49	229	9.8379	51	131	311
5	185	9.7145	6	175	355	50	230	9.8430	52	130	310
6	186	9.7151	7	174	354	51	231	9.8482	54	129	309
7	187	9.7158	7	173	353	52	232	9.8536	54	128	308
8	188	9.7165	9	172	352	53	233	9.8590	55	127	307
9	189	9.7174	10	171	351	54	234	9.8645	56	126	306
10	190	9.7184	10	170	350	55	235	9.8701	56	125	305
11	191	9.7194	12	169	349	56	236	9.8757	57	124	304
12	192	9.7206	13	168	348	57	237	9.8814	58	123	303
13	193	9.7219	13	167	347	58	238	9.8872	59	122	302
14	194	9.7232	15	166	346	59	239	9.8931	59	121	301
15	195	9.7247	16	165	345	60	240	9.8990	59	120	300
16	196	9.7263	17	164	344	61	241	9.9049	60	119	299
17	197	9.7280	18	163	343	62	242	9.9109	60	118	298
18	198	9.7298	19	162	342	63	243	9.9169	60	117	297
19	199	9.7317	20	161	341	64	244	9.9229	60	116	296
20	200	9.7337	21	160	340	65	245	9.9289	60	115	295
21	201	9.7358	22	159	339	66	246	9.9349	59	114	294
22	202	9.7380	23	158	338	67	247	9.9408	60	113	293
23	203	9.7403	24	157	337	68	248	9.9468	59	112	292
24	204	9.7427	25	156	336	69	249	9.9527	58	111	291
25	205	9.7452	27	155	335	70	250	9.9585	57	110	290
26	206	9.7479	27	154	334	71	251	9.9642	56	109	289
27	207	9.7506	28	153	333	72	252	9.9698	55	108	288
28	208	9.7534	30	152	332	73	253	9.9753	54	107	287
29	209	9.7564	31	151	331	74	254	9.9807	52	106	286
30	210	9.7595	31	150	330	75	255	9.9859	50	105	285
31	211	9.7626	33	149	329	76	256	9.9909	48	104	284
32	212	9.7659	34	148	328	77	257	9.9957	45	103	283
33	213	9.7693	35	147	327	78	258	0.0002	43	102	282
34	214	9.7728	36	146	326	79	259	0.0045	40	101	281
35	215	9.7764	37	145	325	80	260	0.0085	37	100	280
36	216	9.7801	38	144	324	81	261	0.0122	34	99	279
37	217	9.7839	39	143	323	82	262	0.0156	30	98	278
38	218	9.7878	40	142	322	83	263	0.0186	27	97	277
39	219	9.7918	42	141	321	84	264	0.0213	23	96	276
40	220	9.7960	42	140	320	85	265	0.0236	19	95	275
41	221	9.8002	43	139	319	86	266	0.0255	16	94	274
42	222	9.8045	45	138	318	87	267	0.0271	11	93	273
43	223	9.8090	46	137	317	88	268	0.0282	6	92	272
44	224	9.8136	46	136	316	89	269	0.0288	2	91	271
45	225	9.8182		135	315	90	270	0.0290		90	270

TABLE 10.—*Values of Q for argument of component* M_1.

P	Q	Diff.	P	Q	Diff.	P	Q	Diff.	P	Q	Diff.
°	°		°	°		°	°		°	°	
0	0.0	0.5	45	25.8	0.8	90	90.0	2.1	135	154.2	0.8
1	0.5	0.5	46	26.6	0.8	91	92.1	2.0	136	155.0	0.8
2	1.0	0.5	47	27.4	0.8	92	94.1	2.1	137	155.8	0.7
3	1.5	0.4	48	28.2	0.9	93	96.2	2.0	138	156.5	0.7
4	1.9	0.5	49	29.1	0.8	94	98.2	2.1	139	157.2	0.7
5	2.4	0.5	50	29.9	0.9	95	100.3	2.0	140	157.9	0.7
6	2.9	0.5	51	30.8	0.9	96	102.3	2.0	141	158.6	0.7
7	3.4	0.5	52	31.7	1.0	97	104.3	1.9	142	159.3	0.7
8	3.9	0.5	53	32.7	0.9	98	106.2	2.0	143	160.0	0.7
9	4.4	0.5	54	33.6	1.0	99	108.2	1.9	144	160.7	0.6
10	4.9	0.5	55	34.6	1.0	100	110.1	1.8	145	161.3	0.7
11	5.4	0.5	56	35.6	1.0	101	111.9	1.9	146	162.0	0.6
12	5.9	0.5	57	36.6	1.1	102	113.8	1.7	147	162.6	0.6
13	6.4	0.5	58	37.7	1.1	103	115.5	1.8	148	163.2	0.6
14	6.9	0.5	59	38.8	1.1	104	117.3	1.7	149	163.8	0.6
15	7.4	0.5	60	39.9	1.2	105	119.0	1.7	150	164.4	0.6
16	7.9	0.5	61	41.1	1.2	106	120.7	1.6	151	165.0	0.6
17	8.4	0.5	62	42.3	1.2	107	122.3	1.6	152	165.6	0.6
18	8.9	0.5	63	43.5	1.2	108	123.9	1.6	153	166.2	0.5
19	9.4	0.6	64	44.7	1.3	109	125.5	1.5	154	166.7	0.6
20	10.0	0.5	65	46.0	1.3	110	127.0	1.5	155	167.3	0.6
21	10.5	0.5	66	47.3	1.4	111	128.5	1.4	156	167.9	0.5
22	11.0	0.6	67	48.7	1.4	112	129.9	1.4	157	168.4	0.6
23	11.6	0.5	68	50.1	1.4	113	131.3	1.4	158	169.0	0.5
24	12.1	0.6	69	51.5	1.5	114	132.7	1.3	159	169.5	0.5
25	12.7	0.6	70	53.0	1.5	115	134.0	1.3	160	170.0	0.6
26	13.3	0.5	71	54.5	1.6	116	135.3	1.2	161	170.6	0.5
27	13.8	0.6	72	56.1	1.6	117	136.5	1.2	162	171.1	0.5
28	14.4	0.6	73	57.7	1.6	118	137.7	1.2	163	171.6	0.5
29	15.0	0.6	74	59.3	1.7	119	138.9	1.2	164	172.1	0.5
30	15.6	0.6	75	61.0	1.7	120	140.1	1.1	165	172.6	0.5
31	16.2	0.6	76	62.7	1.8	121	141.2	1.1	166	173.1	0.5
32	16.8	0.6	77	64.5	1.7	122	142.3	1.1	167	173.6	0.5
33	17.4	0.6	78	66.2	1.9	123	143.4	1.0	168	174.1	0.5
34	18.0	0.7	79	68.1	1.8	124	144.4	1.0	169	174.6	0.5
35	18.7	0.6	80	69.9	1.9	125	145.4	1.0	170	175.1	0.5
36	19.3	0.7	81	71.8	2.0	126	146.4	0.9	171	175.6	0.5
37	20.0	0.7	82	73.8	1.9	127	147.3	1.0	172	176.1	0.5
38	20.7	0.7	83	75.7	2.0	128	148.3	0.9	173	176.6	0.5
39	21.4	0.7	84	77.7	2.0	129	149.2	0.9	174	177.1	0.5
40	22.1	0.7	85	79.7	2.1	130	150.1	0.8	175	177.6	0.5
41	22.8	0.7	86	81.8	2.0	131	150.9	0.9	176	178.1	0.4
42	23.5	0.7	87	83.8	2.1	132	151.8	0.8	177	178.5	0.5
43	24.2	0.8	88	85.9	2.0	133	152.6	0.8	178	179.0	0.5
44	25.0	0.8	89	87.9	2.1	134	153.4	0.8	179	179.5	0.5
45	25.8		90	90.0		135	154.2		180	180.0	

TABLE 10.—*Values of Q for argument of component* M_1—Continued.

P	Q	Diff.	P	Q	Diff.	P	Q	Diff.	P	Q	Diff.
°	°		°	°		°	°		°	°	
180	180.0	0.5	225	205.8	0.8	270	270.0	2.1	315	334.2	0.8
181	180.5	0.5	226	206.6	0.8	271	272.1	2.0	316	335.0	0.8
182	181.0	0.5	227	207.4	0.8	272	274.1	2.1	317	335.8	0.7
183	181.5	0.4	228	208.2	0.9	273	276.2	2.0	318	336.5	0.7
184	181.9	0.5	229	209.1	0.8	274	278.2	2.1	319	337.2	0.7
185	182.4	0.5	230	209.9	0.9	275	280.3	2.0	320	337.9	0.7
186	182.9	0.5	231	210.8	0.9	276	282.3	2.0	321	338.6	0.7
187	183.4	0.5	232	211.7	1.0	277	284.3	1.9	322	339.3	0.7
188	183.9	0.5	233	212.7	0.9	278	286.2	2.0	323	340.0	0.7
189	184.4	0.5	234	213.6	1.0	279	288.2	1.9	324	340.7	0.6
190	184.9	0.5	235	214.6	1.0	280	290.1	1.8	325	341.3	0.7
191	185.4	0.5	236	215.6	1.0	281	291.9	1.9	326	342.0	0.6
192	185.9	0.5	237	216.6	1.1	282	293.8	1.7	327	342.6	0.6
193	186.4	0.5	238	217.7	1.1	283	295.5	1.8	328	343.2	0.6
194	186.9	0.5	239	218.8	1.1	284	297.3	1.7	329	343.8	0.6
195	187.4	0.5	240	219.9	1.2	285	299.0	1.7	330	344.4	0.6
196	187.9	0.5	241	221.1	1.2	286	300.7	1.6	331	345.0	0.6
197	188.4	0.5	242	222.3	1.2	287	302.3	1.6	332	345.6	0.6
198	188.9	0.5	243	223.5	1.2	288	303.9	1.6	333	346.2	0.5
199	189.4	0.6	244	224.7	1.3	289	305.5	1.5	334	346.7	0.6
200	190.0	0.5	245	226.0	1.3	290	307.0	1.5	335	347.3	0.6
201	190.5	0.5	246	227.3	1.4	291	308.5	1.4	336	347.9	0.5
202	191.0	0.6	247	228.7	1.4	292	309.9	1.4	337	348.4	0.6
203	191.6	0.5	248	230.1	1.4	293	311.3	1.4	338	349.0	0.5
204	192.1	0.6	249	231.5	1.5	294	312.7	1.3	339	349.5	0.5
205	192.7	0.6	250	233.0	1.5	295	314.0	1.3	340	350.0	0.6
206	193.3	0.5	251	234.5	1.6	296	315.3	1.2	341	350.6	0.5
207	193.8	0.6	252	236.1	1.6	297	316.5	1.2	342	351.1	0.5
208	194.4	0.6	253	237.7	1.6	298	317.7	1.2	343	351.6	0.5
209	195.0	0.6	254	239.3	1.7	299	318.9	1.2	344	352.1	0.5
210	195.6	0.6	255	241.0	1.7	300	320.1	1.1	345	352.6	0.5
211	196.2	0.6	256	242.7	1.8	301	321.2	1.1	346	353.1	0.5
212	196.8	0.6	257	244.5	1.7	302	322.3	1.1	347	353.6	0.5
213	197.4	0.6	258	246.2	1.9	303	323.4	1.0	348	354.1	0.5
214	198.0	0.7	259	248.1	1.8	304	324.4	1.0	349	354.6	0.5
215	198.7	0.6	260	249.9	1.9	305	325.4	1.0	350	355.1	0.5
216	199.3	0.7	261	251.8	2.0	306	326.4	0.9	351	355.6	0.5
217	200.0	0.7	262	253.8	1.9	307	327.3	1.0	352	356.1	0.5
218	200.7	0.7	263	255.7	2.0	308	328.3	0.9	353	356.6	0.5
219	201.4	0.7	264	257.7	2.0	309	329.2	0.9	354	357.1	0.5
220	202.1	0.7	265	259.7	2.1	310	330.1	0.8	355	357.6	0.5
221	202.8	0.7	266	261.8	2.0	311	330.9	0.9	356	358.1	0.4
222	203.5	0.7	267	263.8	2.1	312	331.8	0.8	357	358.5	0.5
223	204.2	0.8	268	265.9	2.0	313	332.6	0.8	358	359.0	0.5
224	205.0	0.8	269	267.9	2.1	314	333.4	0.8	359	359.5	0.5
225	205.8		270	270.0		315	334.2		360	360.0	

TABLE 11.—*Values of u for equilibrium arguments.*

[Use sign at head of column when N is between 0 and 180°, reverse sign when N is between 180 and 360°.]

N	J_1	K_1	K_2	M_2, N_2 $2N, MS$ λ, μ, ν	M_3	M_4MN	M_6	M_8	O_1, Q_1 $2Q, \rho$	OO	MK	2MK	Mf	N
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
	−	−	−	−	−	−	−	−	+	−	−	+	−	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	360
1	0.19	0.13	0.28	0.04	0.05	0.08	0.11	0.15	0.15	0.53	0.17	0.06	0.34	359
2	0.38	0.27	0.57	0.08	0.11	0.15	0.23	0.30	0.30	1.05	0.34	0.12	0.67	358
3	0.56	0.40	0.85	0.11	0.17	0.23	0.34	0.45	0.45	1.57	0.52	0.17	1.01	357
4	0.75	0.54	1.14	0.15	0.23	0.30	0.45	0.60	0.60	2.10	0.69	0.23	1.35	356
5	0.94	0.67	1.42	0.19	0.28	0.38	0.56	0.75	0.75	2.62	0.86	0.29	1.68	355
6	1.12	0.80	1.70	0.23	0.34	0.45	0.68	0.90	0.90	3.14	1.03	0.35	2.02	354
7	1.31	0.94	1.99	0.26	0.40	0.53	0.79	1.05	1.05	3.67	1.20	0.41	2.36	353
8	1.50	1.07	2.27	0.30	0.45	0.60	0.90	1.20	1.20	4.19	1.37	0.47	2.69	352
9	1.68	1.20	2.55	0.34	0.51	0.68	1.01	1.35	1.35	4.71	1.54	0.53	3.03	351
10	1.87	1.34	2.83	0.37	0.56	0.75	1.12	1.49	1.49	5.23	1.71	0.59	3.36	350
11	2.05	1.47	3.11	0.41	0.62	0.82	1.24	1.64	1.64	5.75	1.88	0.64	3.70	349
12	2.24	1.60	3.39	0.45	0.67	0.90	1.34	1.79	1.79	6.27	2.05	0.70	4.03	348
13	2.42	1.73	3.67	0.48	0.73	0.97	1.45	1.94	1.94	6.79	2.21	0.76	4.36	347
14	2.61	1.86	3.95	0.52	0.78	1.04	1.56	2.09	2.09	7.31	2.38	0.82	4.70	346
15	2.79	1.99	4.23	0.56	0.84	1.12	1.67	2.23	2.23	7.82	2.55	0.88	5.03	345
16	2.98	2.12	4.51	0.60	0.89	1.19	1.79	2.38	2.38	8.34	2.72	0.93	5.36	344
17	3.16	2.25	4.78	0.63	0.95	1.26	1.90	2.53	2.53	8.85	2.89	0.99	5.69	343
18	3.34	2.38	5.06	0.67	1.00	1.34	2.00	2.67	2.68	9.36	3.05	1.05	6.02	342
19	3.52	2.51	5.33	0.70	1.06	1.41	2.11	2.81	2.82	9.87	3.22	1.11	6.35	341
20	3.71	2.64	5.60	0.74	1.11	1.48	2.21	2.95	2.97	10.38	3.38	1.17	6.67	340
21	3.89	2.77	5.87	0.77	1.16	1.55	2.32	3.09	3.11	10.89	3.54	1.23	7.00	339
22	4.07	2.90	6.14	0.81	1.21	1.62	2.42	3.23	3.26	11.39	3.71	1.28	7.33	338
23	4.25	3.03	6.41	0.84	1.26	1.69	2.53	3.37	3.40	11.89	3.87	1.34	7.65	337
24	4.42	3.15	6.68	0.88	1.31	1.75	2.63	3.51	3.55	12.39	4.03	1.40	7.97	336
25	4.60	3.28	6.94	0.91	1.37	1.82	2.73	3.64	3.69	12.89	4.19	1.46	8.29	335
26	4.78	3.40	7.21	0.94	1.42	1.89	2.83	3.78	3.83	13.39	4.35	1.52	8.61	334
27	4.96	3.53	7.47	0.98	1.47	1.96	2.94	3.92	3.98	13.89	4.51	1.57	8.93	333
28	5.13	3.65	7.73	1.01	1.52	2.02	3.04	4.05	4.12	14.38	4.67	1.63	9.25	332
29	5.30	3.78	7.99	1.04	1.57	2.09	3.13	4.18	4.26	14.87	4.82	1.69	9.57	331
30	5.48	3.90	8.24	1.08	1.62	2.16	3.23	4.31	4.40	15.36	4.98	1.75	9.88	330
31	5.65	4.02	8.50	1.11	1.67	2.22	3.33	4.45	4.54	15.84	5.13	1.80	10.19	329
32	5.82	4.14	8.75	1.14	1.72	2.29	3.43	4.58	4.68	16.32	5.29	1.86	10.50	328
33	5.99	4.26	9.00	1.17	1.76	2.35	3.52	4.70	4.82	16.80	5.44	1.92	10.81	327
34	6.16	4.38	9.25	1.20	1.81	2.41	3.61	4.82	4.96	17.28	5.59	1.97	11.12	326
35	6.33	4.50	9.50	1.24	1.85	2.47	3.71	4.94	5.10	17.76	5.74	2.03	11.43	325
36	6.50	4.62	9.74	1.27	1.90	2.53	3.80	5.06	5.23	18.23	5.89	2.09	11.73	324
37	6.66	4.74	9.98	1.30	1.94	2.59	3.89	5.18	5.37	18.69	6.03	2.15	12.03	323
38	6.83	4.85	10.22	1.33	1.99	2.65	3.98	5.30	5.50	19.16	6.18	2.20	12.33	322
39	6.99	4.97	10.46	1.36	2.03	2.71	4.07	5.42	5.64	19.62	6.32	2.26	12.63	321
40	7.15	5.08	10.69	1.38	2.08	2.77	4.15	5.54	5.77	20.08	6.46	2.31	12.92	320
41	7.31	5.19	10.93	1.41	2.12	2.82	4.24	5.65	5.90	20.53	6.60	2.37	13.22	319
42	7.47	5.30	11.16	1.44	2.16	2.88	4.32	5.76	6.03	20.98	6.74	2.42	13.51	318
43	7.63	5.41	11.38	1.47	2.20	2.94	4.40	5.87	6.16	21.43	6.88	2.48	13.80	317
44	7.79	5.52	11.60	1.50	2.24	2.99	4.49	5.98	6.29	21.87	7.02	2.53	14.08	316
45	7.94	5.63	11.82	1.52	2.28	3.04	4.57	6.09	6.42	22.31	7.15	2.59	14.37	315

NOTE.—For L_2 and M_1 see Table 13; for 2SM and MSf, take u of M_2 with sign reversed; for P_1, R_2, S_1, S_2, S_3, S_4, T_2, Mm, Sa, and Ssa, take $u=0$.

TABLE 11.—*Values of u for equilibrium arguments*—Continued.

[Use sign at head of column when N is between 0 and 180°, reverse sign when N is between 180 and 360°.]

N	J_1	K_1	K_2	$M_2, N_2, 2N, MS, \lambda, \mu, \nu$	M_3	M_4, MN	M_6	M_8	$O_1, Q_1, 2Q, \rho_1$	OO	MK	2MK	Mf	N
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
	—	—	—	—	—	—	—	—	+	—	—	+	—	
45	7.94	5.63	11.82	1.52	2.28	3.04	4.57	6.09	6.42	22.31	7.15	2.59	14.37	315
46	8.10	5.74	12.04	1.55	2.32	3.10	4.64	6.19	6.55	22.75	7.28	2.64	14.65	314
47	8.25	5.84	12.26	1.57	2.36	3.15	4.72	6.30	6.68	23.18	7.41	2.69	14.93	313
48	8.40	5.95	12.47	1.60	2.40	3.20	4.80	6.40	6.80	23.60	7.54	2.75	15.20	312
49	8.55	6.05	12.68	1.62	2.44	3.25	4.87	6.50	6.92	24.02	7.67	2.80	15.47	311
50	8.70	6.15	12.88	1.65	2.47	3.30	4.94	6.59	7.05	24.44	7.80	2.85	15.74	310
51	8.84	6.25	13.08	1.67	2.51	3.34	5.01	6.68	7.17	24.85	7.92	2.91	16.01	309
52	8.99	6.35	13.28	1.69	2.54	3.39	5.08	6.78	7.29	25.26	8.04	2.96	16.28	308
53	9.13	6.45	13.48	1.72	2.58	3.44	5.15	6.87	7.41	25.66	8.17	3.01	16.54	307
54	9.27	6.54	13.67	1.74	2.61	3.48	5.22	6.96	7.53	26.06	8.28	3.06	16.80	306
55	9.41	6.64	13.86	1.76	2.64	3.52	5.28	7.04	7.65	26.46	8.40	3.12	17.05	305
56	9.54	6.73	14.05	1.78	2.67	3.56	5.34	7.12	7.76	26.85	8.51	3.17	17.30	304
57	9.68	6.82	14.23	1.80	2.70	3.60	5.40	7.20	7.88	27.23	8.62	3.22	17.55	303
58	9.81	6.91	14.40	1.82	2.73	3.64	5.46	7.28	7.99	27.61	8.73	3.27	17.80	302
59	9.94	7.00	14.58	1.84	2.76	3.68	5.52	7.36	8.10	27.98	8.84	3.32	18.04	301
60	10.07	7.09	14.75	1.86	2.79	3.72	5.58	7.44	8.21	28.34	8.95	3.37	18.28	300
61	10.19	7.17	14.92	1.88	2.82	3.76	5.63	7.51	8.32	28.70	9.05	3.42	18.51	299
62	10.32	7.26	15.08	1.90	2.84	3.79	5.69	7.58	8.42	29.06	9.15	3.46	18.74	298
63	10.44	7.34	15.24	1.91	2.87	3.82	5.74	7.65	8.53	29.41	9.25	3.51	18.97	297
64	10.56	7.42	15.39	1.93	2.89	3.86	5.78	7.71	8.63	29.75	9.35	3.56	19.19	296
65	10.68	7.49	15.54	1.94	2.92	3.89	5.83	7.78	8.73	30.09	9.44	3.61	19.41	295
66	10.79	7.57	15.69	1.96	2.94	3.92	5.88	7.84	8.83	30.42	9.53	3.65	19.63	294
67	10.91	7.64	15.83	1.98	2.96	3.95	5.93	7.90	8.93	30.74	9.62	3.69	19.84	293
68	11.02	7.72	15.96	1.99	2.98	3.98	5.97	7.96	9.03	31.06	9.71	3.74	20.04	292
69	11.12	7.79	16.10	2.00	3.00	4.00	6.01	8.01	9.12	31.37	9.79	3.78	20.25	291
70	11.23	7.86	16.23	2.02	3.02	4.03	6.05	8.06	9.22	31.68	9.87	3.83	20.45	290
71	11.33	7.92	16.35	2.03	3.04	4.06	6.08	8.11	9.31	31.98	9.95	3.87	20.64	289
72	11.43	7.99	16.47	2.04	3.06	4.08	6.11	8.15	9.40	32.27	10.03	3.91	20.83	288
73	11.53	8.05	16.58	2.05	3.08	4.10	6.15	8.20	9.48	32.55	10.10	3.95	21.01	287
74	11.63	8.11	16.69	2.06	3.09	4.12	6.18	8.24	9.57	32.82	10.17	3.99	21.20	286
75	11.72	8.17	16.80	2.07	3.10	4.14	6.21	8.28	9.65	33.09	10.24	4.03	21.37	285
76	11.81	8.23	16.90	2.08	3.12	4.16	6.24	8.32	9.73	33.35	10.31	4.07	21.54	284
77	11.90	8.28	17.00	2.09	3.13	4.18	6.26	8.35	9.81	33.60	10.37	4.11	21.71	283
78	11.98	8.34	17.09	2.10	3.14	4.19	6.29	8.38	9.88	33.85	10.43	4.15	21.87	282
79	12.06	8.39	17.17	2.10	3.15	4.20	6.31	8.41	9.96	34.09	10.49	4.18	22.02	281
80	12.14	8.44	17.25	2.11	3.16	4.22	6.32	8.43	10.03	34.31	10.54	4.22	22.17	280
81	12.22	8.48	17.33	2.11	3.17	4.23	6.34	8.46	10.10	34.53	10.60	4.25	22.32	279
82	12.29	8.53	17.40	2.12	3.18	4.24	6.36	8.48	10.17	34.74	10.65	4.29	22.46	278
83	12.36	8.57	17.46	2.12	3.19	4.25	6.37	8.50	10.23	34.95	10.69	4.32	22.59	277
84	12.42	8.61	17.52	2.13	3.19	4.26	6.38	8.51	10.30	35.14	10.73	4.35	22.72	276
85	12.49	8.64	17.58	2.13	3.20	4.26	6.39	8.52	10.36	35.33	10.77	4.38	22.84	275
86	12.55	8.68	17.63	2.13	3.20	4.27	6.40	8.53	10.41	35.50	10.81	4.41	22.96	274
87	12.60	8.71	17.67	2.14	3.20	4.27	6.41	8.54	10.47	35.67	10.84	4.44	23.07	273
88	12.65	8.74	17.71	2.14	3.20	4.27	6.41	8.54	10.52	35.83	10.87	4.47	23.17	272
89	12.70	8.76	17.74	2.14	3.20	4.27	6.41	8.54	10.57	35.98	10.90	4.49	23.27	271
90	12.75	8.79	17.77	2.14	3.20	4.27	6.41	8.54	10.62	36.12	10.93	4.52	23.37	270

NOTE.—For L_2 and M_1 see Table 13. For 2SM and MSf, take u of M_2 with sign reversed, for P_1, R_2, S_1, S_2, S_3, S_4, T_2, Mm, Sa, and Ssa, take $u=0$.

TABLE 11.—*Values of u for equilibrium arguments*—Continued.

[Use sign at head of column when N is between 0 and 180°, reverse sign when N is between 180 and 360°.]

N	J_1	K_1	K_2	M_2, N_2 2N, MS λ, μ, ν	M_3	M_4, MN	M_6	M_8	O_1, Q_1 2Q, ρ_1	OO	MK	2MK	Mf	N
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
	−	−	−	−	−	−	−	−	+	−	−	+	−	
90	12.75	8.79	17.77	2.14	3.20	4.27	6.41	8.54	10.62	36.12	10.93	4.52	23.37	270
91	12.79	8.81	17.79	2.14	3.20	4.27	6.41	8.54	10.66	36.25	10.95	4.54	23.46	269
92	12.83	8.83	17.81	2.13	3.20	4.27	6.40	8.54	10.70	36.37	10.96	4.56	23.54	268
93	12.87	8.85	17.82	2.13	3.20	4.26	6.40	8.53	10.74	36.48	10.98	4.58	23.61	267
94	12.90	8.86	17.83	2.13	3.20	4.26	6.39	8.52	10.77	36.58	10.99	4.60	23.67	266
95	12.93	8.87	17.83	2.13	3.19	4.26	6.38	8.51	10.80	36.67	11.00	4.62	23.73	265
96	12.96	8.88	17.82	2.12	3.19	4.25	6.37	8.49	10.83	36.75	11.01	4.64	23.79	264
97	12.98	8.89	17.81	2.12	3.18	4.24	6.35	8.47	10.86	36.82	11.01	4.65	23.84	263
98	13.00	8.90	17.79	2.11	3.17	4.22	6.34	8.45	10.88	36.87	11.01	4.67	23.88	262
99	13.01	8.90	17.77	2.11	3.16	4.21	6.32	8.43	10.90	36.92	11.00	4.68	23.91	261
100	13.02	8.89	17.74	2.10	3.15	4.20	6.30	8.41	10.92	36.95	11.00	4.69	23.93	260
101	13.03	8.89	17.71	2.09	3.14	4.19	6.28	8.38	10.93	36.98	10.99	4.70	23.95	259
102	13.03	8.88	17.67	2.09	3.13	4.17	6.26	8.34	10.94	36.99	10.97	4.71	23.96	258
103	13.02	8.87	17.62	2.08	3.11	4.15	6.23	8.30	10.95	37.00	10.95	4.72	23.97	257
104	13.02	8.86	17.57	2.07	3.10	4.14	6.20	8.27	10.95	36.99	10.93	4.72	23.97	256
105	13.01	8.84	17.51	2.06	3.09	4.12	6.17	8.23	10.95	36.96	10.90	4.73	23.96	255
106	12.99	8.82	17.45	2.05	3.07	4.10	6.14	8.19	10.94	36.93	10.87	4.73	23.94	254
107	12.97	8.80	17.38	2.04	3.06	4.08	6.11	8.15	10.94	36.89	10.84	4.73	23.91	253
108	12.95	8.78	17.30	2.03	3.04	4.06	6.08	8.11	10.93	36.83	10.81	4.72	23.88	252
109	12.93	8.75	17.22	2.02	3.02	4.03	6.05	8.06	10.91	36.76	10.77	4.72	23.84	251
110	12.90	8.72	17.14	2.00	3.00	4.00	6.01	8.01	10.89	36.68	10.72	4.72	23.79	250
111	12.86	8.69	17.05	1.99	2.98	3.98	5.97	7.96	10.87	36.58	10.68	4.71	23.73	249
112	12.82	8.65	16.95	1.98	2.96	3.95	5.93	7.90	10.84	36.48	10.63	4.70	23.66	248
113	12.77	8.61	16.84	1.96	2.94	3.92	5.88	7.84	10.81	36.36	10.57	4.69	23.59	247
114	12.72	8.57	16.73	1.94	2.92	3.89	5.83	7.78	10.78	36.23	10.51	4.68	23.50	246
115	12.67	8.52	16.62	1.93	2.89	3.86	5.78	7.71	10.74	36.09	10.45	4.67	23.41	245
116	12.61	8.48	16.50	1.91	2.87	3.82	5.74	7.65	10.70	35.93	10.39	4.65	23.31	244
117	12.55	8.43	16.37	1.90	2.84	3.79	5.69	7.58	10.65	35.76	10.32	4.63	23.21	243
118	12.48	8.37	16.24	1.88	2.82	3.76	5.64	7.52	10.60	35.57	10.25	4.61	23.09	242
119	12.41	8.31	16.10	1.86	2.79	3.72	5.59	7.45	10.55	35.37	10.18	4.59	22.96	241
120	12.34	8.25	15.96	1.84	2.77	3.69	5.53	7.38	10.49	35.16	10.10	4.57	22.83	240
121	12.26	8.19	15.81	1.82	2.74	3.65	5.47	7.30	10.43	34.94	10.02	4.54	22.69	239
122	12.17	8.13	15.66	1.80	2.71	3.61	5.41	7.22	10.37	34.70	9.93	4.52	22.54	238
123	12.08	8.06	15.50	1.78	2.68	3.57	5.35	7.14	10.30	34.49	9.84	4.49	22.37	237
124	11.98	7.99	15.33	1.76	2.64	3.52	5.29	7.05	10.22	34.19	9.75	4.46	22.20	236
125	11.88	7.91	15.16	1.74	2.61	3.48	5.22	6.96	10.14	33.91	9.65	4.43	22.03	235
126	11.78	7.83	14.99	1.72	2.58	3.44	5.15	6.87	10.06	33.62	9.55	4.40	21.84	234
127	11.67	7.75	14.81	1.70	2.54	3.39	5.09	6.78	9.97	33.31	9.45	4.36	21.64	233
128	11.56	7.67	14.62	1.67	2.51	3.34	5.02	6.69	9.88	32.99	9.34	4.32	21.44	232
129	11.44	7.58	14.43	1.65	2.48	3.30	4.95	6.60	9.79	32.66	9.23	4.28	21.23	231
130	11.31	7.49	14.23	1.63	2.44	3.26	4.88	6.51	9.69	32.31	9.12	4.23	21.00	230
131	11.18	7.40	14.03	1.60	2.41	3.21	4.81	6.42	9.58	31.95	9.00	4.19	20.76	229
132	11.05	7.30	13.83	1.58	2.37	3.16	4.74	6.32	9.47	31.58	8.88	4.14	20.52	228
133	10.91	7.20	13.62	1.55	2.33	3.11	4.66	6.22	9.36	31.19	8.76	4.09	20.27	227
134	10.77	7.10	13.40	1.53	2.29	3.06	4.58	6.11	9.24	30.79	8.63	4.04	20.01	226
135	10.62	7.00	13.18	1.50	2.25	3.00	4.51	6.01	9.12	30.37	8.50	3.99	19.75	225

NOTE.—For L_2 and M_1 see table 13. For 2SM and MSf, take u of M_2 with sign reversed, for P_1, R_2, S_1, S_2, S^3, S^4, T^2, Mm, Sa, and Ssa, take u=0.

Table 11.—*Values of u for equilibrium arguments*—Continued.

[Use sign at head of column when *N* is between 0 and 180°, reverse sign when *N* is between 180 and 360°.]

N	J_1	K_1	K_2	M_2,N_2 $2N,MS$ λ,μ,ν	M_3	M_4,MN	M_6	M_8	O_1,Q_1 $2Q,\rho$	OO	MK	2MK	Mf	*N*
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
	−	−	−	−	−	−	−	−	+	−	−	+	−	
135	10.62	7.00	13.18	1.50	2.25	3.00	4.51	6.01	9.12	30.37	8.50	3.99	19.75	225
136	10.47	6.89	12.96	1.48	2.21	2.95	4.43	5.90	9.00	29.94	8.36	3.94	19.47	224
137	10.31	6.78	12.73	1.45	2.17	2.90	4.34	5.79	8.87	29.49	8.22	3.88	19.18	223
138	10.15	6.66	12.50	1.42	2.13	2.84	4.26	5.68	8.73	29.04	8.08	3.82	18.88	222
139	9.98	6.55	12.26	1.39	2.09	2.78	4.18	5.57	8.59	28.56	7.94	3.76	18.58	221
140	9.81	6.43	12.02	1.36	2.05	2.73	4.09	5.46	8.45	28.08	7.79	3.70	18.26	220
141	9.64	6.31	11.77	1.34	2.00	2.67	4.01	5.34	8.30	27.58	7.64	3.64	17.94	219
142	9.46	6.18	11.52	1.31	1.96	2.61	3.92	5.22	8.15	27.07	7.49	3.57	17.61	218
143	9.27	6.06	11.27	1.28	1.91	2.55	3.83	5.10	8.00	26.54	7.33	3.50	17.27	217
144	9.08	5.93	11.01	1.25	1.87	2.49	3.74	4.98	7.84	26.00	7.17	3.43	16.92	216
145	8.89	5.80	10.74	1.22	1.82	2.43	3.65	4.86	7.67	25.45	7.01	3.36	16.56	215
146	8.69	5.66	10.48	1.19	1.78	2.37	3.56	4.74	7.50	24.89	6.84	3.29	16.20	214
147	8.49	5.52	10.21	1.16	1.73	2.31	3.47	4.62	7.33	24.31	6.68	3.21	15.82	213
148	8.28	5.38	9.94	1.12	1.69	2.25	3.37	4.50	7.16	23.72	6.51	3.14	15.44	212
149	8.07	5.24	9.66	1.09	1.64	2.18	3.28	4.37	6.98	23.12	6.33	3.06	15.05	211
150	7.85	5.10	9.38	1.06	1.59	2.12	3.18	4.24	6.80	22.51	6.16	2.98	14.65	210
151	7.63	4.95	9.10	1.03	1.54	2.06	3.08	4.11	6.61	21.88	5.98	2.90	14.24	209
152	7.41	4.80	8.81	1.00	1.49	1.99	2.99	3.98	6.42	21.24	5.80	2.81	13.83	208
153	7.18	4.65	8.52	0.96	1.44	1.92	2.89	3.85	6.22	20.59	5.61	2.73	13.41	207
154	6.95	4.50	8.23	0.93	1.39	1.86	2.78	3.71	6.03	19.93	5.43	2.64	12.98	206
155	6.72	4.34	7.94	0.90	1.34	1.79	2.69	3.58	5.82	19.26	5.24	2.55	12.54	205
156	6.48	4.19	7.64	0.86	1.29	1.72	2.59	3.45	5.62	18.58	5.05	2.46	12.10	204
157	6.24	4.03	7.34	0.83	1.24	1.66	2.48	3.31	5.41	17.89	4.85	2.37	11.65	203
158	5.99	3.87	7.04	0.79	1.19	1.59	2.38	3.18	5.20	17.19	4.66	2.28	11.19	202
159	5.74	3.70	6.74	0.76	1.14	1.52	2.28	3.04	4.99	16.48	4.46	2.18	10.73	201
160	5.49	3.54	6.43	0.72	1.09	1.45	2.17	2.90	4.77	15.75	4.26	2.09	10.26	200
161	5.24	3.37	6.12	0.69	1.04	1.38	2.07	2.76	4.55	15.02	4.06	1.99	9.79	199
162	4.98	3.20	5.81	0.66	0.98	1.31	1.97	2.62	4.33	14.29	3.86	1.89	9.31	198
163	4.72	3.03	5.50	0.62	0.93	1.24	1.86	2.48	4.10	13.54	3.66	1.79	8.82	197
164	4.46	2.86	5.19	0.58	0.88	1.17	1.75	2.34	3.87	12.78	3.45	1.70	8.33	196
165	4.19	2.69	4.87	0.55	0.82	1.10	1.64	2.19	3.64	12.02	3.24	1.60	7.83	195
166	3.92	2.52	4.55	0.51	0.77	1.02	1.54	2.05	3.41	11.25	3.03	1.49	7.33	194
167	3.65	2.34	4.23	0.48	0.71	0.95	1.43	1.90	3.18	10.48	2.82	1.39	6.83	193
168	3.38	2.17	3.91	0.44	0.66	0.88	1.32	1.76	2.94	9.70	2.61	1.29	6.32	192
169	3.10	1.99	3.59	0.40	0.61	0.81	1.21	1.62	2.70	8.91	2.39	1.18	5.80	191
170	2.83	1.81	3.27	0.37	0.55	0.74	1.10	1.47	2.46	8.12	2.18	1.08	5.29	190
171	2.55	1.63	2.94	0.33	0.50	0.66	1.00	1.33	2.22	7.32	1.97	0.97	4.77	189
172	2.27	1.45	2.62	0.30	0.44	0.59	0.89	1.18	1.97	6.51	1.75	0.86	4.24	188
173	1.99	1.27	2.29	0.26	0.39	0.51	0.77	1.03	1.73	5.71	1.53	0.76	3.72	187
174	1.71	1.09	1.97	0.22	0.33	0.44	0.66	0.88	1.49	4.90	1.31	0.65	3.19	186
175	1.42	0.91	1.64	0.18	0.28	0.37	0.55	0.74	1.24	4.09	1.10	0.54	2.66	185
176	1.14	0.73	1.31	0.15	0.22	0.30	0.44	0.59	0.99	3.27	0.88	0.43	2.13	184
177	0.86	0.55	0.99	0.11	0.17	0.22	0.33	0.44	0.75	2.46	0.66	0.33	1.60	183
178	0.57	0.37	0.66	0.07	0.11	0.14	0.22	0.29	0.50	1.64	0.44	0.22	1.07	182
179	0.29	0.18	0.33	0.04	0.05	0.07	0.11	0.14	0.25	0.82	0.22	0.11	0.53	181
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	180

NOTE.—For L_2 and M_1 see Table 13; for 2SM and MSf, take *u* of M_2 with sign reversed; for P_1, R_2, S_1, S_2, S_3, S_4, T_2, Mm, Sa, and Ssa, take $u=0$.

TABLE 12.—*Log factor F corresponding to every tenth of a degree of I.*

Component. \ I	18.3°	Diff.	18.4°	Diff.	18.5°	Diff.	18.6°	Diff.	18.7°	Diff.	18.8°	Diff.
J_1	0.0827	−21	0.0806	−20	0.0786	−20	0.0766	−20	0.0746	−19	0.0727	−20
K_1	0.0547	−12	0.0535	−12	0.0523	−11	0.0512	−12	0.0500	−12	0.0488	−11
K_2	0.1263	−22	0.1241	−21	0.1220	−21	0.1199	−22	0.1177	−22	0.1155	−21
M_2*, N_2, 2N	9.9839	+2	9.9841	+3	9.9844	+2	9.9846	+3	9.9849	+2	9.9851	+3
M_3	9.9758	+4	9.9762	+4	9.9766	+3	9.9769	+4	9.9773	+4	9.9777	+3
M_4, MN	9.9678	+4	9.9682	+5	9.9687	+5	9.9692	+5	9.9697	+5	9.9702	+5
M_6	9.9516	+8	9.9524	+7	9.9531	+7	9.9538	+8	9.9546	+7	9.9553	+8
M_8	9.9355	+10	9.9365	+10	9.9375	+10	9.9385	+10	9.9395	+10	9.9405	+10
O_1, Q_1 2Q, ρ_1	0.0939	−22	0.0917	−21	0.0896	−22	0.0874	−21	0.0853	−21	0.0832	−21
OO	0.3139	−69	0.3070	−70	0.3000	−69	0.2931	−68	0.2863	−69	0.2794	−68
MK	0.0386	−10	0.0376	−9	0.0367	−9	0.0358	−9	0.0349	−10	0.0339	−9
2MK	0.0224	−7	0.0217	−6	0.0211	−7	0.0204	−7	0.0197	−7	0.0190	−6
Mf	0.2039	−46	0.1993	−45	0.1948	−45	0.1903	−45	0.1858	−45	0.1813	−44
Mm	9.9465	+8	9.9473	+8	9.9481	+8	9.9489	+8	9.9497	+8	9.9505	9

Component. \ I	18.9°	Diff.	19.0°	Diff.	19.1°	Diff.	19.2°	Diff.	19.3°	Diff.	19.4°	Diff.
J_1	0.0707	−20	0.0687	−19	0.0668	−19	0.0649	−19	0.0630	−19	0.0611	−19
K_1	0.0477	−12	0.0465	−12	0.0453	−11	0.0442	−11	0.0431	−12	0.0419	−11
K_2	0.1134	−22	0.1112	−22	0.1090	−22	0.1068	−23	0.1045	−22	0.1023	−22
M_2*, N_2, 2N	9.9854	+2	9.9856	+3	9.9859	+2	9.9861	+3	9.9864	+2	9.9866	+3
M_3	9.9780	+4	9.9784	+4	9.9788	+4	9.9792	+4	9.9796	+4	9.9800	+4
M_4, MN	9.9707	+5	9.9712	+5	9.9717	+6	9.9723	+5	9.9728	+5	9.9733	+5
M_6	9.9561	+8	9.9569	+7	9.9576	+8	9.9584	+8	9.9592	+7	9.9599	+8
M_8	9.9415	+10	9.9425	+10	9.9435	+10	9.9445	+10	9.9455	+11	9.9466	+10
O_1, Q_1, 2Q, ρ_1	0.0811	−21	0.0790	−20	0.0770	−21	0.0749	−20	0.0729	−20	0.0709	−21
OO	0.2726	−67	0.2659	−67	0.2592	−67	0.2525	−66	0.2459	−66	0.2393	−66
MK	0.0330	−9	0.0321	−9	0.0312	−9	0.0303	−9	0.0294	−9	0.0285	−8
2MK	0.0184	−7	0.0177	−6	0.0171	−7	0.0164	−6	0.0158	−6	0.0152	−6
Mf	0.1769	−44	0.1725	−44	0.1681	−44	0.1637	−43	0.1594	−43	0.1551	−43
Mm	9.9514	+8	9.9522	+8	9.9530	+9	9.9539	+8	9.9547	+9	9.9556	+8

Component. \ I	19.5°	Diff.	19.6°	Diff.	19.7°	Diff.	19.8°	Diff.	19.9°	Diff.	20.0°	Diff.
J_1	0.0592	−18	0.0574	−19	0.0555	−18	0.0537	−19	0.0518	−18	0.0500	−18
K_1	0.0408	−12	0.0396	−11	0.0385	−11	0.0374	−12	0.0362	−11	0.0351	−11
K_2	0.1001	−23	0.0978	−22	0.0956	−23	0.0933	−22	0.0911	−23	0.0888	−24
M_2*, N_2, 2N	9.9869	+3	9.9872	+2	9.9874	+3	9.9877	+3	9.9880	+2	9.9882	+3
M_3	9.9804	+3	9.9807	+4	9.9811	+4	9.9815	+4	9.9819	+4	9.9823	+4
M_4, MN	9.9738	+5	9.9743	+6	9.9749	+5	9.9754	+5	9.9759	+5	9.9764	+6
M_6	9.9607	+8	9.9615	+8	9.9623	+8	9.9631	+8	9.9639	+8	9.9647	+8
M_8	9.9476	+11	9.9487	+10	9.9497	+11	9.9508	+10	9.9518	+11	9.9529	+11
O_1, Q_1, 2Q, ρ_1	0.0688	−20	0.0668	−20	0.0648	−19	0.0629	−20	0.0609	−20	0.0589	−19
OO	0.2327	−65	0.2262	−65	0.2197	−65	0.2132	−64	0.2068	−64	0.2004	−64
MK	0.0277	−9	0.0268	−9	0.0259	−9	0.0250	−8	0.0242	−9	0.0233	−8
2MK	0.0146	−6	0.0140	−7	0.0133	−6	0.0127	−6	0.0121	−6	0.0115	−6
Mf	0.1508	−43	0.1465	−42	0.1423	−43	0.1380	−42	0.1338	−41	0.1297	−42
MM	9.9564	+9	9.9573	+8	9.9581	+9	9.9590	+9	9.9599	+9	9.9608	+9

*Log F of λ_2, μ_2, ν_2, MS, 2SM, and MSf are each equal to log F of M_2.
Log F of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each zero.
For log F of L_2 and M_1 see Table 13.

TABLE 12.—*Log factor F corresponding to every tenth of a degree of I*—Contd.

Component. \ I	20.1°	Diff.	20.2°	Diff.	20.3°	Diff.	20.4°	Diff.	20.5°	Diff.	20.6°	Diff.
J_1	0.0482	−18	0.0464	−17	0.0447	−18	0.0429	−18	0.0411	−17	0.0394	−17
K_1	0.0340	−11	0.0329	−11	0.0318	−11	0.0307	−11	0.0296	−11	0.0285	−11
K_2	0.0864	−23	0.0841	−23	0.0818	−23	0.0795	−24	0.0771	−23	0.0748	−23
M_2*, N_2, 2N	9.9885	+3	9.9888	+2	9.9890	+3	9.9893	+3	9.9896	+3	9.9899	+2
M_3	9.9827	+4	9.9831	+4	9.9835	+5	9.9840	+4	9.9844	+4	9.9848	+4
M_4, MN	9.9770	+5	9.9775	+6	9.9781	+5	9.9786	+6	9.9792	+5	9.9797	+6
M_6	9.9655	+8	9.9663	+8	9.9671	+8	9.9679	+8	9.9687	+9	9.9696	+8
M_8	9.9540	+10	9.9550	+11	9.9561	+11	9.9572	+11	9.9583	+11	9.9394	+11
O_1, Q_1, 2Q, ρ_1	0.0570	−19	0.0551	−20	0.0531	−19	0.0512	−19	0.0493	−18	0.0475	−19
OO	0.1940	−63	0.1877	−63	0.1814	−63	0.1751	−62	0.1689	−62	0.1627	−62
MK	0.0225	−8	0.0217	−9	0.0208	−8	0.0200	−9	0.0191	−8	0.0183	−8
2MK	0.0109	−5	0.0104	−6	0.0098	−5	0.0093	−6	0.0087	−5	0.0082	−6
Mf	0.1255	−41	0.1214	−41	0.1173	−41	0.1132	−41	0.1091	−40	0.1051	−41
Mm	9.9617	+9	9.9626	+9	9.9635	+9	9.9644	+9	9.9653	+9	9.9662	+9

Component. \ I	20.7°	Diff.	20.8°	Diff.	20.9°	Diff.	21.0°	Diff.	21.1°	Diff.	21.2°	Diff.
J_1	0.0377	−17	0.0360	−17	0.0343	−17	0.0326	−17	0.0309	−17	0.0292	−16
K_1	0.0274	−11	0.0263	−11	0.0252	−11	0.0241	−11	0.0230	−11	0.0219	−10
K_2	0.0725	−24	0.0701	−23	0.0678	−24	0.0654	−24	0.0630	−23	0.0607	−24
M_2*, N_2, 2N	9.9901	+3	9.9904	+3	9.9907	+3	9.9910	+2	9.9912	+3	9.9915	+3
M_3	9.9852	+4	9.9856	+4	9.9860	+4	9.9864	+5	9.9869	+4	9.9873	+4
M_4, MN	9.9803	+5	9.9808	+6	9.9814	+5	9.9819	+6	9.9825	+6	9.9831	+5
M_6	9.9704	+8	9.9712	+8	9.9720	+9	9.9729	+8	9.9737	+9	9.9746	+8
M_8	9.9605	+11	9.9616	+11	9.9627	+12	9.9639	+11	9.9650	+11	9.9661	+12
O_1, Q_1, 2Q, ρ_1	0.0456	−19	0.0437	−18	0.0419	−19	0.0400	−18	0.0382	−18	0.0364	−18
OO	0.1565	−61	0.1504	−61	0.1443	−61	0.1382	−61	0.1321	−60	0.1261	−60
MK	0.0175	−8	0.0167	−8	0.0159	−8	0.0151	−8	0.0143	−8	0.0135	−8
2MK	0.0076	−5	0.0071	−6	0.0065	−5	0.0060	−5	0.0055	−5	0.0050	−5
Mf	0.1010	−40	0.0970	−39	0.0931	−40	0.0891	−39	0.0852	−40	0.0812	−39
Mm	9.9671	+9	9.9680	+10	9.9690	+9	9.9699	+10	9.9709	+9	9.9718	+10

Component. \ I	21.3°	Diff.	21.4°	Diff.	21.5°	Diff.	21.6°	Diff.	21.7°	Diff.	21.8°	Diff.
J_1	0.0276	−17	0.0259	−16	0.0243	−16	0.0227	−16	0.0211	−16	0.0195	−16
K_1	0.0209	−11	0.0198	−11	0.0187	−10	0.0177	−11	0.0166	−10	0.0156	−11
K_2	0.0583	−24	0.0559	−25	0.0534	−24	0.0510	−24	0.0486	−24	0.0462	−24
M_2*, N_2, 2N	9.9918	+3	9.9921	+3	9.9924	+3	9.9927	+3	9.9930	+3	9.9933	+3
M_3	9.9877	+5	9.9882	+4	9.9886	+4	9.9890	+4	9.9894	+5	9.9899	+4
M_4, MN	9.9836	+6	9.9842	+6	9.9848	+6	9.9854	+5	9.9859	+6	9.9865	+6
M_6	9.9754	+9	9.9763	+9	9.9772	+8	9.9780	+9	9.9789	+9	9.9798	+8
M_8	9.9673	+11	9.9684	+12	9.9696	+11	9.9707	+12	9.9719	+11	9.9730	+12
O_1, Q_1, 2Q, ρ_1	0.0346	−18	0.0328	−18	0.0310	−18	0.0292	−17	0.0275	−18	0.0257	−17
OO	0.1201	−60	0.1141	−59	0.1082	−59	0.1023	−59	0.0964	−58	0.0906	−58
MK	0.0127	−8	0.0119	−8	0.0111	−8	0.0103	−7	0.0096	−8	0.0088	−7
2MK	0.0045	−5	0.0040	−5	0.0035	−5	0.0030	−5	0.0025	−4	0.0021	−5
Mf	0.0773	−38	0.0735	−39	0.0696	−38	0.0658	−39	0.0619	−38	0.0581	−37
Mm	9.9728	+9	9.9737	+10	9.9747	+10	9.9757	+10	9.9767	+9	9.9776	+10

*Log F of λ_2, μ_2, ν_2, MS, 2SM, and MSf are each equal to log F of M_2.
Log F of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each zero.
For log F of L_2 and M_1 see Table 13.

TABLE 12.—*Log factor F corresponding to every tenth of a degree of I*—Contd.

Component. \ I	21.9°	Diff.	22.0°	Diff.	22.1°	Diff.	22.2°	Diff.	22.3°	Diff.	22.4°	Diff.
J_1	0.0179	−16	0.0163	−15	0.0148	−16	0.0132	−15	0.0117	−16	0.0101	−15
K_1	0.0145	−10	0.0135	−11	0.0124	−10	0.0114	−11	0.0103	−10	0.0093	−10
K_2	0.0438	−24	0.0414	−24	0.0390	−25	0.0365	−24	0.0341	−24	0.0317	−24
M_2*, N_2, 2N	9.9936	+2	9.9938	+3	9.9941	+3	9.9944	+3	9.9947	+3	9.9950	+3
M_3	9.9903	+5	9.9908	+4	9.9912	+5	9.9917	+4	9.9921	+5	9.9926	+4
M_4, MN	9.9871	+6	9.9877	+6	9.9883	+6	9.9889	+6	9.9895	+6	9.9901	+6
M_6	9.9806	+9	9.9815	+9	9.9824	+9	9.9833	+9	9.9842	+9	9.9851	+9
M_8	9.9742	+12	9.9754	+12	9.9766	+11	9.9777	+12	9.9789	+12	9.9801	+12
O_1, Q_1, 2Q, ρ_1	0.0240	−18	0.0222	−17	0.0205	−17	0.0188	−17	0.0171	−17	0.0154	−17
OO	0.0848	−58	0.0790	−58	0.0732	−57	0.0675	−57	0.0618	−57	0.0561	−57
MK	0.0081	−8	0.0073	−8	0.0065	−7	0.0058	−7	0.0051	−8	0.0043	−7
2MK	0.0016	−5	0.0011	−4	0.0007	−5	0.0002	−4	9.9998	−4	9.9994	−4
Mf	0.0544	−38	0.0506	−37	0.0469	−38	0.0431	−37	0.0394	−37	0.0357	−36
Mm	9.9786	+10	9.9796	+10	9.9806	+10	9.9816	+11	9.9827	+10	9.9837	+10

Component. \ I	22.5°	Diff.	22.6°	Diff.	22.7°	Diff.	22.8°	Diff.	22.9°	Diff.	23.0°	Diff.
J_1	0.0086	−15	0.0071	−15	0.0056	−15	0.0041	−15	0.0026	−14	0.0012	−15
K_1	0.0083	−10	0.0073	−10	0.0063	−11	0.0052	−10	0.0042	−10	0.0032	−10
K_2	0.0293	−25	0.0268	−24	0.0244	−25	0.0219	−25	0.0194	−24	0.0170	−25
M_2*, N_2, 2N	9.9953	+3	9.9956	+3	9.9959	+3	9.9962	+4	9.9966	+3	9.9969	+3
M_3	9.9930	+5	9.9935	+4	9.9939	+5	9.9944	+4	9.9948	+5	9.9953	+5
M_4, MN	9.9907	+6	9.9913	+6	9.9919	+6	9.9925	+6	9.9931	+6	9.9937	+6
M_6	9.9860	+9	9.9869	+9	9.9878	+9	9.9887	+10	9.9897	+9	9.9906	+9
M_8	9.9813	+12	9.9825	+13	9.9838	+12	9.9850	+12	9.9862	+12	9.9874	+13
O_1, Q_1, 2Q, ρ_1	0.0137	−17	0.0120	−16	0.0104	−17	0.0087	−16	0.0071	−17	0.0054	−16
OO	0.0504	−56	0.0448	−56	0.0392	−56	0.0336	−55	0.0281	−55	0.0226	−55
MK	0.0036	−7	0.0029	−7	0.0022	−7	0.0015	−7	0.0008	−7	0.0001	−7
2MK	9.9990	−5	9.9985	−4	9.9981	−4	9.9977	−4	9.9973	−4	9.9969	−3
Mf	0.0321	−37	0.0284	−36	0.0248	−36	0.0212	−36	0.0176	−36	0.0140	−36
Mm	9.9847	+10	9.9857	+11	9.9868	+10	9.9878	+11	9.9889	+10	9.9899	+11

Component. \ I	23.1°	Diff.	23.2°	Diff.	23.3°	Diff.	23.4°	Diff.	23.5°	Diff.	23.6°	Diff.
J_1	9.9997	−15	9.9982	−14	9.9968	−14	9.9954	−14	9.9940	−14	9.9926	−14
K_1	0.0022	−10	0.0012	−10	0.0002	−10	9.9992	−10	9.9982	−9	9.9973	−10
K_2	0.0145	−24	0.0121	−25	0.0096	−24	0.0072	−25	0.0047	−25	0.0022	−24
M_2*, N_2, 2N	9.9972	+3	9.9975	+3	9.9978	+3	9.9981	+3	9.9984	+3	9.9987	+4
M_3	9.9958	+5	9.9963	+4	9.9967	+5	9.9972	+4	9.9976	+5	9.9981	+5
M_4, MN	9.9943	+7	9.9950	+6	9.9956	+6	9.9962	+6	9.9968	+7	9.9975	+6
M_6	9.9915	+9	9.9924	+10	9.9934	+9	9.9943	+10	9.9953	+9	9.9962	+10
M_8	9.9887	+12	9.9899	+13	9.9912	+12	9.9924	+13	9.9937	+12	9.9949	+13
O_1, Q_1, 2Q, ρ_1	0.0038	−16	0.0022	−16	0.0006	−16	9.9990	−16	9.9974	−16	9.9958	−16
OO	0.0171	−55	0.0116	−54	0.0062	−55	0.0007	−54	9.9953	−53	9.9900	−54
MK	9.9994	−7	9.9987	−7	9.9980	−6	9.9974	−7	9.9967	−7	9.9960	−6
2MK	0.9966	−4	9.9962	−4	9.9958	−3	9.9955	−4	9.9951	−3	9.9948	−4
Mf	0.0104	−35	0.0069	−35	0.0034	−35	9.9999	−35	9.9964	−35	9.9929	−35
Mm	9.9910	+11	9.9921	+10	9.9931	+11	9.9942	+11	9.9953	+11	9.9964	+11

* Log F of λ_2, μ_2, ν_2, MS, 2SM and MSf are each equal to log F of M_2.
Log F of P_1, R_2, S_1, S_2, S_4, S_6, T_2 Sa, and Ssa are each zero.
For log F of L_2 and M_1 see Table 13.

TABLE 12.—*Log factor F corresponding to every tenth of a degree of I.*—Contd.

Component. \ I	23.7°	Diff.	23.8°	Diff.	23.9°	Diff.	24.0°	Diff.	24.1°	Diff.	24.2°	Diff.
J_1	9.9912	−14	9.9898	−14	9.9884	−14	9.9870	−13	9.9857	−14	9.9843	−13
K_1	9.9963	−9	9.9954	−10	9.9944	−10	9.9934	−10	9.9924	−9	9.9915	−10
K_2	9.9998	−25	9.9973	−25	9.9948	−24	9.9924	−25	9.9899	−25	9.9874	−24
M^*_2, N_2, 2N	9.9991	+3	9.9994	+3	9.9997	+3	0.0000	+3	0.0003	+4	0.0007	+3
M_3	9.9986	+5	9.9991	+4	9.9995	+5	0.0000	+5	0.0005	+5	0.0010	+5
M_4, MN	9.9981	+6	9.9987	+7	9.9994	+6	0.0000	+7	0.0007	+6	0.0013	+7
M_6	9.9972	+9	9.9981	+10	9.9991	+10	0.0001	+9	0.0010	+10	0.0020	+10
M_8	9.9962	+13	9.9975	+13	9.9988	+13	0.0001	+12	0.0013	+13	0.0026	+13
O_1, Q_1, 2Q, ρ_1	9.9942	−15	9.9927	−16	9.9911	−15	9.9896	−16	9.9880	−15	9.9865	−15
OO	9.9846	−53	9.9793	−53	9.9740	−53	9.9687	−53	9.9634	−52	9.9582	−52
MK	9.9954	−7	9.9947	−6	9.9941	−7	9.9934	−7	9.9927	−6	9.9921	−6
2MK	9.9944	−3	9.9941	−4	9.9937	−3	9.9934	−3	9.9931	−3	9.9928	−3
Mf	9.9894	−34	9.9860	−35	9.9825	−34	9.9791	−34	9.9757	−33	9.9724	−34
Mm	9.9975	+11	9.9986	+11	9.9997	+12	0.0009	+11	0.0020	+11	0.0031	+12

Component. \ I	24.3°	Diff.	24.4°	Diff.	24.5°	Diff.	24.6°	Diff.	24.7°	Diff.	24.8°	Diff.
J_1	9.9836	−14	9.9816	−13	9.9803	−13	9.9790	−13	9.9777	−13	9.9764	−13
K_1	9.9905	−9	9.9896	−9	9.9887	−10	9.9877	−9	9.9868	−10	9.9858	−9
K_2	9.9850	−25	9.9825	−25	9.9800	−24	9.9776	−25	9.9751	−25	9.9726	−25
M^*_2, N_2, 2N	0.0010	+3	0.0013	+3	0.0016	+4	0.0020	+3	0.0023	+3	0.0026	+4
M_3	0.0015	+5	0.0020	+5	0.0025	+5	0.0030	+5	0.0035	+5	0.0040	+5
M_4, MN	0.0020	+6	0.0026	+7	0.0033	+6	0.0039	+7	0.0046	+7	0.0053	+6
M_6	0.0030	+9	0.0039	+10	0.0049	+10	0.0059	+10	0.0069	+10	0.0079	+10
M_8	0.0039	+14	0.0053	+13	0.0066	+13	0.0079	+13	0.0092	+13	0.0105	+14
O_1, Q_1, 2Q, ρ_1	9.9850	−15	9.9835	−15	9.9820	−15	9.9805	−15	9.9790	−15	9.9775	−15
OO	9.9530	−52	9.9478	−52	9.9426	−51	9.9375	−51	9.9324	−51	9.9273	−51
MK	9.9915	−6	9.9909	−6	9.9903	−6	9.9897	−6	9.9891	−6	9.9885	−6
2MK	9.9925	−3	9.9922	−3	9.9919	−3	9.9916	−2	9.9914	−3	9.9911	−2
Mf	9.9690	−34	9.9656	−33	9.9623	−33	9.9590	−33	9.9557	−33	9.9524	−33
Mm	0.0043	+11	0.0054	+12	0.0066	+11	0.0077	+12	0.0089	+12	0.0101	+11

Component. \ I	24.9°	Diff.	25.0°	Diff.	25.1°	Diff.	25.2°	Diff.	25.3°	Diff.	25.4°	Diff.
J_1	9.9751	−13	9.9738	−12	9.9726	−13	9.9713	−12	9.9701	−13	9.9688	−12
K_1	9.9849	−9	9.9840	−9	9.9831	−9	9.9822	−10	9.9812	−9	9.9803	−9
K_2	9.9701	−24	9.9677	−25	9.9652	−24	9.9628	−25	9.9603	−24	9.9579	−25
M^*_2, N_2, 2N	0.0030	+3	0.0033	+3	0.0036	+4	0.0040	+3	0.0043	+4	0.0047	+3
M_3	0.0045	+5	0.0050	+5	0.0055	+5	0.0060	+5	0.0065	+5	0.0070	+5
M_4, MN	0.0059	+7	0.0066	+7	0.0073	+7	0.0080	+6	0.0086	+7	0.0093	+7
M_6	0.0089	+10	0.0099	+10	0.0109	+10	0.0119	+11	0.0130	+10	0.0140	+10
M_8	0.0119	+13	0.0132	+14	0.0146	+13	0.0159	+14	0.0173	+13	0.0186	+14
O_1, Q_1, 2Q, ρ_1	9.9760	−14	9.9746	−15	9.9731	−14	9.9717	−15	9.9702	−14	9.9688	−14
OO	9.9222	−51	9.9171	−50	9.9121	−50	9.9071	−50	9.9021	−50	9.8971	−49
MK	9.9879	−6	9.9873	−6	9.9867	−6	9.9861	−5	9.9856	−6	9.9850	−6
2MK	9.9909	−3	9.9906	−2	9.9904	−3	9.9901	−2	9.9899	−2	9.9897	−3
Mf	9.9491	−32	9.9459	−33	9.9426	−32	9.9394	−32	9.9362	−32	9.9330	−32
Mm	0.0112	+12	0.0124	+12	0.0136	+12	0.0148	+12	0.0160	+12	0.0172	+13

*Log F of λ_2, μ_2, ν_2, MS, 2SM, and MSf are each equal to log F of M_2.
Log F of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each zero.
For log F of L_2 and M_1 see Table 13.

TABLE 12.—*Log factor F corresponding to every tenth of a degree of I*—Contd.

Component. \ I	25.5°	Diff.	25.6°	Diff.	25.7°	Diff.	25.8°	Diff.	25.9°	Diff.	26.0°	Diff.
J_1	9.9676	−12	9.9664	−12	9.9652	−13	9.9639	−12	9.9627	−11	9.9616	−12
K_1	9.9794	−9	9.9785	−9	9.9776	−8	9.9768	−9	9.9759	−9	9.9750	−9
K_2	9.9554	−25	9.9529	−25	9.9504	−24	9.9480	−25	9.9455	−24	9.9431	−25
M^*_2, N_2, 2N	0.0050	+3	0.0053	+4	0.0057	+3	0.0060	+4	0.0064	+3	0.0067	+4
M_3	0.0075	+5	0.0080	+5	0.0085	+6	0.0091	+5	0.0096	+5	0.0101	+5
M_4, MN	0.0100	+7	0.0107	+7	0.0114	+7	0.0121	+7	0.0128	+7	0.0135	+7
M_6	0.0150	+10	0.0160	+11	0.0171	+10	0.0181	+11	0.0192	+10	0.0202	+11
M_8	0.0200	+14	0.0214	+14	0.0228	+13	0.0241	+14	0.0255	+14	0.0269	+14
O_1, Q_1, 2Q, ρ_1	9.9674	−14	9.9660	−14	9.9646	−14	9.9632	−14	9.9618	−14	9.9604	−14
OO	9.8922	−49	9.8873	−49	9.8824	−49	9.8775	−49	9.8726	−49	9.8677	−48
MK	9.9844	−5	9.9839	−6	9.9833	−5	9.9828	−5	9.9823	−6	9.9817	−5
2MK	9.9894	−2	9.9892	−2	9.9890	−2	9.9888	−2	9.9886	−1	9.9885	−2
Mf	9.9298	−32	9.9266	−31	9.9235	−32	9.9203	−31	9.9172	−31	9.9141	−31
Mm	0.0185	+12	0.0197	+12	0.0209	+13	0.0222	+12	0.0234	+13	0.0247	+12

Component. \ I	26.1°	Diff.	26.2°	Diff.	26.3°	Diff.	26.4°	Diff.	26.5°	Diff.	26.6°	Diff.
J_1	9.9604	−12	9.9592	−12	9.9580	−11	9.9569	−12	9.9557	−11	9.9546	−11
K_1	9.9741	−9	9.9732	−8	9.9724	−9	9.9715	−9	9.9706	−8	9.9698	−9
K_2	9.9406	−24	9.9382	−25	9.9357	−24	9.9333	−25	9.9308	−24	9.9284	−24
M^*_2, N_2, 2N	0.0071	+3	0.0074	+4	0.0078	+3	0.0081	+4	0.0085	+4	0.0089	+3
M_3	0.0106	+6	0.0112	+5	0.0117	+5	0.0122	+6	0.0128	+5	0.0133	+5
M_4, MN	0.0142	+7	0.0149	+7	0.0156	+7	0.0163	+7	0.0170	+7	0.0177	+7
M_6	0.0213	+10	0.0223	+11	0.0234	+10	0.0244	+11	0.0255	+11	0.0266	+11
M_8	0.0283	+15	0.0298	+14	0.0312	+14	0.0326	+14	0.0340	+14	0.0354	+15
O_1, Q_1, 2Q, ρ_1	9.9590	−13	9.9577	−14	9.9563	−14	9.9549	−13	9.9536	−13	9.9523	−14
OO	9.8629	−48	9.8581	−48	9.8533	−47	9.8486	−48	9.8438	−47	9.8391	−47
MK	9.9812	−5	9.9807	−5	9.9802	−5	9.9797	−5	9.9792	−5	9.9787	−5
2MK	9.9883	−2	9.9881	−1	9.9880	−2	9.9878	−1	9.9877	−2	9.9875	−1
Mf	9.9110	−31	9.9079	−31	9.9048	−31	9.9017	−30	9.8987	−30	9.8957	−31
Mm	0.0259	+13	0.0272	+13	0.0285	+13	0.0298	+12	0.0310	+13	0.0323	+13

Component. \ I	26.7°	Diff.	26.8°	Diff.	26.9°	Diff.	27.0°	Diff.	27.1°	Diff.	27.2°	Diff.
J_1	9.9535	−11	9.9524	−12	9.9512	−11	9.9501	−11	9.9490	−11	9.9479	−10
K_1	9.9689	−8	9.9681	−9	9.9672	−8	9.9664	−8	9.9656	−9	9.9647	−8
K_2	9.9260	−25	9.9235	−24	9.9211	−24	9.9187	−25	9.9162	−24	9.9138	−24
M^*_2, N_2, 2N	0.0092	+4	0.0096	+3	0.0099	+4	0.0103	+4	0.0107	+3	0.0110	+4
M_3	0.0138	+6	0.0144	+5	0.0149	+6	0.0155	+5	0.0160	+6	0.0166	+5
M_4, MN	0.0184	+8	0.0192	+7	0.0199	+7	0.0206	+7	0.0213	+8	0.0221	+7
M_6	0.0277	+10	0.0287	+11	0.0298	+11	0.0309	+11	0.0320	+11	0.0331	+11
M_8	0.0369	+14	0.0383	+15	0.0398	+14	0.0412	+15	0.0427	+14	0.0441	+15
O_1, Q_1, 2Q, ρ_1	9.9509	−13	9.9496	−13	9.9483	−13	9.9470	−13	9.9457	−13	9.9444	−13
OO	9.8344	−47	9.8297	−47	9.8250	−47	9.8203	−46	9.8157	−46	9.8111	−46
MK	9.9782	−5	9.9777	−5	9.9772	−5	9.9767	−5	9.9762	−4	9.9758	−5
2MK	9.9874	−2	9.9872	−1	9.9871	−1	9.9870	−1	9.9869	−1	9.9868	−1
Mf	9.8926	−30	9.8896	−30	9.8866	−29	9.8837	−30	9.8807	−30	9.8777	−29
Mm	0.0336	+14	0.0350	+13	0.0363	+13	0.0376	+13	0.0389	+14	0.0403	+13

*Log F of λ_2, μ_2, ν_2, MS, 2SM, and MSf are each equal to log F of M_2.
Log F of P_1, R_2, S_1, S_2, S_4, S_6, T_2 Sa, and Ssa are each zero.
For log F of L_2 and M_1 see Table 13.

TABLE 12.—*Log factor F corresponding to every tenth of a degree of I*—Contd.

Component. \ I	27.3°	Diff.	27.4°	Diff.	27.5°	Diff.	27.6°	Diff.	27.7°	Diff.
J_1	9.9469	−11	9.9458	−11	9.9447	−10	9.9437	−11	9.9426	−10
K_1	9.9639	−8	9.9631	−8	9.9623	−8	9.9615	−8	9.9607	−8
K_2	9.9114	−24	9.9090	−24	9.9066	−24	9.9042	−24	9.9018	−24
M_2*, N_2, 2N	0.0114	+4	0.0118	+3	0.0121	+4	0.0125	+4	0.0129	+4
M_3	0.0171	+6	0.0177	+5	0.0182	+6	0.0188	+5	0.0193	+6
M_4, MN	0.0228	+7	0.0235	+8	0.0243	+7	0.0250	+8	0.0258	+7
M_6	0.0342	+11	0.0353	+11	0.0364	+11	0.0375	+12	0.0387	+11
M_8	0.0456	+15	0.0471	+15	0.0486	+15	0.0501	+14	0.0515	+15
O_1, Q_1, 2Q, ρ_1	9.9431	−13	9.9418	−13	9.9405	−12	9.9393	−13	9.9380	−12
OO	9.8065	−46	9.8019	−46	9.7973	−45	9.7928	−45	9.7883	−45
MK	9.9753	−4	9.9749	−5	9.9744	−4	9.9740	−5	9.9735	−4
2MK	9.9867	−1	9.9866	−1	9.9865	0	9.9865	−1	9.9864	0
Mf	9.8748	−29	9.8719	−30	9.8689	−29	9.8660	−29	9.8631	−28
Mm	0.0416	+14	0.0430	+14	0.0444	+13	0.0457	+14	0.0471	+14

Component. \ I	27.8°	Diff.	27.9°	Diff.	28.0°	Diff.	28.1°	Diff.	28.2°	Diff.
J_1	9.9416	−11	9.9405	−10	9.9395	−10	9.9385	−10	9.9375	−10
K_1	9.9599	−9	9.9590	−8	9.9582	−8	9.9574	−7	9.9567	−8
K_2	9.8994	−24	9.8970	−24	9.8946	−24	9.8922	−24	9.8898	−24
M_2*, N_2, 2N	0.0133	+3	0.0136	+4	0.0140	+4	0.0144	+4	0.0148	+4
M_3	0.0199	+6	0.0205	+5	0.0210	+6	0.0216	+6	0.0222	+5
M_4, MN	0.0265	+8	0.0273	+7	0.0280	+8	0.0288	+7	0.0295	+8
M_6	0.0398	+11	0.0409	+11	0.0420	+12	0.0432	+11	0.0443	+12
M_8	0.0530	+15	0.0545	+16	0.0561	+15	0.0576	+15	0.0591	+15
O_1, Q_1, 2Q, ρ_1	9.9368	−13	9.9355	−12	9.9343	−13	9.9330	−12	9.9318	−12
OO	9.7838	−45	9.7793	−45	9.7748	−45	9.7703	−44	9.7659	−44
MK	9.9731	−4	9.9727	−4	9.9723	−5	9.9718	−4	9.9714	−4
2MK	9.9864	−1	9.9863	0	9.9863	−1	9.9862	0	9.9862	0
Mf	9.8603	−29	9.8574	−29	9.8545	−28	9.8517	−28	9.8489	−29
Mm	0.0485	+14	0.0499	+14	0.0513	+14	0.0527	+15	0.0542	+14

Component. \ I	28.3°	Diff.	28.4°	Diff.	28.5°	Diff.	28.6°
J_1	9.9365	−10	9.9355	−10	9.9345	−10	9.9335
K_1	9.9559	−8	9.9551	−8	9.9543	−8	9.9535
K_2	9.8874	−24	9.8850	−24	9.8826	−23	9.8803
M_2*, N_2, 2N	0.0152	+3	0.0155	+4	0.0159	+4	0.0163
M_3	0.0227	+6	0.0233	+6	0.0239	+6	0.0245
M_4, MN	0.0303	+8	0.0311	+7	0.0318	+8	0.0326
M_6	0.0455	11	0.0466	+12	0.0478	+11	0.0489
M_8	0.0606	15	0.0621	+16	0.0637	+15	0.0652
O_1, Q_1, 2Q, ρ_1	9.9306	−12	9.9294	−12	9.9282	−12	9.9270
OO	9.7615	−44	9.7571	−44	9.7527	−44	9.7483
MK	9.9710	−4	9.9706	−4	9.9702	−4	9.9698
2MK	9.9862	0	9.9862	0	9.9862	0	9.9862
Mf	9.8460	−28	9.8432	−28	9.8404	−28	9.8376
Mm	0.0556	+14	0.0570	+14	0.0584	+15	0.0599

* Log F of λ_2, μ_2, ν_2, MS, 2SM, and MSf are each equal to log F of M_2.
Log F of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each zero.
For log F of L_2 and M_1 see Table 13.

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000.*

Year.	N	u of L_2	Diff.	u of M_1	Diff.	Log $F(L_2)$	Diff.	Log $F(M_1)$	Diff.	N
	°	°		°						°
1899	260	+11.4	6.3	353.5	5.2	0.0964	161	9.7295	35	260
1900	255	+5.1	6.4	358.7	5.0	0.1125	073	9.7260	78	255
	250	−1.3	4.9	3.7	5.1	0.1052	259	9.7338	189	250
	245	−6.2	2.9	8.8	5.4	0.0793	348	9.7527	297	245
	240	−9.1	0.9	14.2	6.2	0.0445	353	9.7824	404	240
1901	235	−10.0	0.6	20.4	7.2	0.0092	313	9.8228	506	235
	230	−9.4	1.6	27.6	8.9	9.9779	250	9.8734	596	230
	225	−7.8	2.3	36.5	11.4	9.9529	182	9.9330	647	225
1902	220	−5.5	2.5	47.9	14.6	9.9347	114	9.9977	609	220
	215	−3.0	2.6	62.5	18.0	9.9233	50	0.0586	412	215
	210	−0.4	2.6	80.5	19.4	9.9183	10	0.0998	58	210
	205	+2.2	2.3	99.9	17.7	9.9193	61	0.1056	276	205
1903	200	+4.5	2.0	117.6	14.4	9.9254	115	0.0780	497	200
	195	+6.5	1.5	132.0	11.0	9.9369	154	0.0283	523	195
	190	+8.0	0.8	143.0	8.6	9.9523	190	9.9760	485	190
	185	+8.8	0.1	151.6	7.0	9.9713	213	9.9275	414	185
1904	180	+8.9	0.7	158.6	5.8	9.9926	222	9.8861	336	180
	175	+8.2	1.8	164.4	5.1	0.0148	209	9.8525	256	175
	170	+6.4	2.8	169.5	4.6	0.0357	166	9.8269	178	170
	165	+3.6	3.5	174.1	4.5	0.0523	93	9.8091	100	165
1905	160	+0.1	3.8	178.6	4.5	0.0616	5	9.7991	21	160
	155	−3.7	3.6	183.1	4.6	0.0611	109	9.7970	63	155
	150	−7.3	2.8	187.7	5.1	0.0502	195	9.8033	152	150
	145	−10.1	1.7	192.8	5.8	0.0307	249	9.8185	248	145
1906	140	−11.8	0.3	198.6	7.0	0.0058	268	9.8433	349	140
	135	−12.1	0.8	205.6	8.8	9.9790	254	9.8782	446	135
	130	−11.3	1.9	214.4	11.5	9.9536	216	9.9228	516	130
	125	−9.4	2.7	225.9	15.4	9.9320	161	9.9744	494	125
1907	120	−6.7	3.3	241.3	19.4	9.9159	90	0.0238	283	120
	115	−3.4	3.7	260.7	21.1	9.9069	11	0.0521	124	115
	110	+0.3	3.9	281.8	19.0	9.9058	79	0.0397	514	110
	105	+4.2	3.8	300.8	15.0	9.9137	177	9.9883	688	105
1908	100	+8.0	3.2	315.8	11.3	9.9314	282	9.9195	683	100
	95	+11.2	2.2	327.1	8.7	9.9596	390	9.8512	591	95
	90	+13.4	0.4	335.8	7.2	9.9986	487	9.7921	472	90
1909	85	+13.8	2.5	343.0	6.1	0.0473	536	9.7449	346	85
	80	+11.3	6.0	349.1	5.5	0.1009	463	9.7103	220	80
	75	+5.3	9.2	354.6	5.4	0.1472	191	9.6883	94	75
	70	−3.9	9.3	0.0	5.5	0.1663	209	9.6789	33	70
1910	65	−13.2	6.2	5.5	5.8	0.1454	509	9.6822	164	65
	60	−19.4	2.1	11.3	6.7	0.0945	602	9.6986	299	60
	55	−21.5	1.1	18.0	8.2	0.0343	556	9.7285	437	55
	50	−20.4	3.4	26.2	10.5	9.9787	449	9.7722	564	50
1911	45	−17.0	4.8	36.7	14.1	9.9338	324	9.8286	635	45
	40	−12.2	5.8	50.8	19.0	9.9014	191	9.8921	540	40
	35	−6.4	6.2	69.8	22.8	9.8823	59	9.9461	165	35
	30	−0.2	6.3	92.6	22.2	9.8764	77	9.9626	343	30
1912	25	+6.1	6.0	114.8	17.7	9.8841	219	9.9283	643	25
	20	+12.1	5.3	132.5	13.1	9.9060	368	9.8640	681	20
	15	+17.4	3.9	145.6	9.9	9.9428	526	9.7959	585	15
	10	+21.3	1.4	155.5	7.7	9.9954	680	9.7374	450	10
1913	5	+22.7	2.8	163.2	6.6	0.0634	780	9.6924	308	5
	0	+19.9	8.9	169.8	5.9	0.1414	675	9.6616	169	0
	355	+11.0	13.6	175.7	5.6	0.2089	187	9.6447	33	355
	350	−2.6	11.9	181.3	5.7	0.2276	450	9.6414	101	350
1914	345	−14.5	6.0	187.0	6.1	0.1826	754	9.6515	240	345
	340	−20.5	0.7	193.1	6.9	0.1072	738	9.6755	378	340
	335	−21.2	2.5	200.0	8.5	0.0334	604	9.7133	518	335
	330	−18.7		208.5		9.9730		9.7651		330

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000*—Contd.

Year.	N	u of L_2	Diff.	u of M_1	Diff.	Log $F(L_2)$	Diff.	Log $F(M_1)$	Diff.	N
	°	°		°						°
1914	330	−18.7	4.4	208.5	10.9	9.9730	447	9.7651	643	330
1915	325	−14.3	5.5	219.4	14.6	9.9283	295	9.8294	699	325
	320	−8.8	5.9	234.0	19.5	9.8988	153	9.8993	574	320
	315	−2.9	5.9	253.5	22.8	9.8835	20	9.9567	174	315
	310	+3.0	5.6	276.3	21.6	9.8815	108	9.9741	316	310
1916	305	+8.6	5.0	297.9	17.0	9.8923	230	9.9425	581	305
	300	+13.6	3.8	314.9	12.5	9.9153	346	9.8844	600	300
	295	+17.4	2.2	327.4	9.4	9.9499	449	9.8244	506	295
1917	290	+19.6	0.2	336.8	7.5	9.9948	510	9.7738	370	290
	285	+19.4	3.3	344.3	6.3	0.0458	496	9.7368	239	285
	280	+16.1	6.5	350.6	5.6	0.0954	351	9.7129	111	280
	275	+9.6	7.9	356.2	5.2	0.1305	63	9.7018	15	275
1918	270	+1.7	7.1	1.4	5.2	0.1368	227	9.7033	134	270
	265	−5.4	4.4	6.6	5.5	0.1141	401	9.7167	252	265
	260	−9.8	1.8	12.1	6.0	0.0740	440	9.7419	370	260
	255	−11.6	0.4	18.1	7.1	0.0300	398	9.7789	486	255
1919	250	−11.2	1.8	25.2	8.6	9.9902	320	9.8275	594	250
	245	−9.4	2.6	33.8	11.2	9.9582	234	9.8869	670	245
	240	−6.8	3.1	45.0	14.5	9.9348	148	9.9539	664	240
	235	−3.7	3.2	59.5	18.2	9.9200	67	0.0203	493	235
1920	230	−0.5	3.1	77.7	20.2	9.9133	6	0.0696	134	230
	225	+2.6	2.8	97.9	18.8	9.9139	71	0.0830	250	225
	220	+5.4	2.2	116.7	15.1	9.9210	128	0.0580	467	220
	215	+7.6	1.6	131.8	11.5	9.9338	174	0.0113	510	215
1921	210	+9.2	0.9	143.3	8.9	9.9512	209	9.9603	462	210
	205	+10.1	0.0	152.2	7.0	9.9721	227	9.9141	381	205
	200	+10.1	1.1	159.2	5.9	9.9948	224	9.8760	294	200
	195	+9.0	2.0	165.1	5.0	0.0172	196	9.8466	209	195
1922	190	+7.0	2.9	170.1	4.7	0.0368	141	9.8257	130	190
	185	+4.1	3.5	174.8	4.4	0.0509	63	9.8127	54	185
	180	+0.6	3.5	179.2	4.3	0.0572	27	9.8073	22	180
	175	−2.9	3.2	183.5	4.5	0.0545	113	9.8095	97	175
1923	170	−6.1	2.4	188.0	4.9	0.0432	179	9.8192	176	170
	165	−8.5	1.4	192.9	5.6	0.0253	218	9.8368	259	165
	160	−9.9	0.4	198.5	6.5	0.0035	231	9.8627	347	160
1924	155	−10.3	0.5	205.0	8.2	9.9804	220	9.8974	433	155
	150	−9.8	1.4	213.2	10.4	9.9584	191	9.9407	499	150
	145	−8.4	2.1	223.6	13.9	9.9393	148	9.9906	498	145
	140	−6.3	2.6	237.5	17.6	9.9245	94	0.0404	351	140
1925	135	−3.7	3.0	255.1	20.2	9.9151	30	0.0755	9	135
	130	−0.7	3.3	275.3	19.3	9.9121	42	0.0764	387	130
	125	+2.6	3.2	294.6	15.9	9.9163	121	0.0377	631	125
	120	+5.8	2.9	310.5	12.2	9.9284	207	9.9746	683	120
1926	115	+8.7	2.2	322.7	9.4	9.9491	296	9.9063	626	115
	110	+10.9	0.9	332.1	7.6	9.9787	380	9.8437	525	110
	105	+11.8	0.9	339.7	6.3	0.0167	440	9.7912	409	105
	100	+10.9	3.6	346.0	5.7	0.0607	434	9.7503	290	100
1927	95	+7.3	6.4	351.7	5.3	0.1041	306	9.7213	172	95
	90	+0.9	8.1	357.0	5.2	0.1347	34	9.7041	52	90
	85	−7.2	7.3	2.2	5.4	0.1381	276	9.6989	71	85
	80	−14.5	4.4	7.6	6.0	0.1105	475	9.7060	200	80
1928	75	−18.9	1.1	13.6	7.1	0.0630	525	9.7260	332	75
	70	−20.0	1.6	20.7	8.7	0.0105	477	9.7592	466	70
	65	−18.4	3.4	29.4	11.4	9.9628	383	9.8058	579	65
	60	−15.0	4.7	40.8	15.5	9.9245	268	9.8637	609	60
1929	55	−10.3	5.5	56.3	20.4	9.8977	146	9.9246	431	55
	50	−4.8	5.9	76.7	23.0	9.8831	20	9.9677	13	50
	45	+1.1	6.0	99.7	20.9	9.8811	112	9.9664	480	45
	40	+7.1		120.6		9.8923		9.9184		40

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000*—Contd.

Year.	N	u of L_2	Diff.	u of M_1	Diff.	Log F(L_2).	Diff.	Log F (M_1).	Diff.	N
	°	°		°						°
1929	40	+7.1	5.7	120.6	16.1	9.8923	252	9.9184	686	40
1930	35	+12.8	4.8	136.7	11.9	9.9175	401	9.8498	670	35
	30	+17.6	3.3	148.6	9.0	9.9576	558	9.7828	558	30
	25	+20.9	0.4	157.6	7.4	0.0134	706	9.7270	420	25
	20	+21.3	4.2	165.0	6.3	0.0840	774	9.6850	281	20
1931	15	+17.1	10.4	171.3	5.7	0.1614	588	9.6569	141	15
	10	+6.7	13.9	177.0	5.6	0.2202	16	9.6428	7	10
	5	−7.2	10.6	182.6	5.8	0.2218	572	9.6421	129	5
1932	0	−17.8	4.5	188.4	6.3	0.1646	781	9.6550	267	0
	355	−22.3	0.3	194.7	7.3	0.0865	720	9.6817	408	355
	350	−22.0	3.3	202.0	9.1	0.0145	576	9.7225	546	350
	345	−18.7	4.9	211.1	12.0	9.9569	412	9.7771	662	345
1933	340	−13.8	5.9	223.1	16.2	9.9157	262	9.8433	677	340
	335	−7.9	6.3	239.3	21.0	9.8895	119	9.9110	468	335
	330	−1.6	6.2	260.3	23.2	9.8776	18	9.9578	6	330
	325	+4.6	5.9	283.5	20.4	9.8794	151	9.9572	449	325
1934	320	+10.5	5.1	303.9	15.6	9.8945	282	9.9123	633	320
	315	+15.6	3.9	319.5	11.4	9.9227	410	9.8490	594	315
	310	+19.5	1.9	330.9	8.7	9.9637	523	9.7896	478	310
	305	+21.4	1.1	339.6	7.1	0.0160	592	9.7418	340	305
1935	300	+20.3	4.9	346.7	6.1	0.0752	550	9.7078	204	300
	295	+15.4	8.5	352.8	5.5	0.1302	316	9.6874	71	295
	290	+6.9	9.4	358.3	5.4	0.1618	70	9.6803	55	290
	285	−2.5	7.1	3.7	5.4	0.1548	393	9.6858	181	285
1936	280	−9.6	3.6	9.1	6.0	0.1155	530	9.7039	310	280
	275	−13.2	0.3	15.1	6.6	0.0625	496	9.7349	428	275
	270	−13.5	1.6	21.7	8.1	0.0129	418	9.7777	554	270
	265	−11.9	2.9	29.8	10.4	9.9711	313	9.8331	658	265
1937	260	−9.0	3.6	40.2	13.6	9.9398	208	9.8989	701	260
	255	−5.4	3.8	53.8	17.7	9.9190	103	9.9690	595	255
	250	−1.6	3.8	71.5	20.7	9.9087	24	0.0285	270	250
	245	+2.2	3.4	92.2	20.3	9.9063	63	0.0555	160	245
1938	240	+5.6	2.9	112.5	16.8	9.9126	136	0.0395	446	240
	235	+8.5	2.1	129.3	12.7	9.9262	196	9.9949	522	235
	230	+10.6	1.2	142.0	9.6	9.9458	240	9.9427	475	230
	225	+11.8	0.0	151.6	7.4	9.9698	262	9.8952	383	225
1939	220	+11.8	1.1	159.0	6.2	9.9960	256	9.8569	284	220
	215	+10.7	2.4	165.2	5.3	0.0216	216	9.8285	186	215
	210	+8.3	3.3	170.5	4.7	0.0432	141	9.8099	97	210
1940	205	+5.0	3.8	175.2	4.5	0.0573	44	9.8002	13	205
	200	+1.2	3.6	179.7	4.5	0.0617	56	9.7989	68	200
	195	−2.4	3.1	184.2	4.5	0.0561	139	9.8057	145	195
	190	−5.5	2.1	188.7	4.9	0.0422	194	9.8202	223	190
1941	185	−7.6	1.2	193.6	5.5	0.0228	218	9.8425	301	185
	180	−8.8	0.3	199.1	6.5	0.0010	219	9.8726	381	180
	175	−9.1	0.6	205.6	7.9	9.9791	200	9.9107	457	175
	170	−8.5	1.3	213.5	10.1	9.9591	171	9.9564	513	170
1942	165	−7.2	1.8	223.6	13.0	9.9420	130	0.0077	509	165
	160	−5.4	2.2	236.6	16.6	9.9290	83	0.0586	380	160
	155	−3.2	2.6	253.2	19.2	9.9207	31	0.0966	78	155
	150	−0.6	2.7	272.4	18.9	9.9176	28	0.1044	299	150
1943	145	+2.1	2.6	291.3	16.0	9.9204	91	0.0745	563	145
	140	+4.7	2.4	307.3	12.5	9.9295	160	0.0182	652	140
	135	+7.1	1.9	319.8	9.8	9.9455	230	9.9530	624	135
	130	+9.0	1.0	329.6	7.7	9.9685	297	9.8906	542	130
1944	125	+10.0	0.3	337.3	6.5	9.9982	349	9.8364	441	125
	120	+9.7	2.1	343.8	5.6	0.0331	365	9.7923	334	120
	115	+7.6	4.4	349.4	5.2	0.0696	306	9.7589	225	115
	110	+3.2		354.6		0.1002		9.7364		110

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000*—Contd.

Year.	N	u of L_2	Diff.	u of M_1	Diff.	Log. $F(L_2)$	Diff.	Log $F(M_1)$	Diff.	N
	°	°		°						°
1944	110	+3.2	6.2	354.6	5.1	0.1002	147	9.7364	115	110
1945	105	−3.0	6.6	359.7	5.1	0.1149	88	9.7249	3	105
	100	−9.6	5.3	4.8	5.5	0.1061	304	9.7246	117	100
	95	−14.9	2.8	10.3	6.2	0.0757	426	9.7363	240	95
	90	−17.7	0.2	16.5	7.5	0.0331	446	9.7603	370	90
1946	85	−17.9	1.8	24.0	9.5	9.9885	397	9.7973	494	85
	80	−16.1	3.4	33.5	12.6	9.9488	325	9.8467	583	80
	75	−12.7	4.5	46.1	17.0	9.9163	200	9.9050	553	75
1947	70	−8.2	5.2	63.1	21.5	9.8963	99	9.9603	279	70
	65	−3.0	5.6	84.6	22.6	9.8864	20	9.9882	205	65
	60	+2.6	5.5	107.2	19.0	9.8884	146	9.9677	589	60
	55	+8.1	5.1	126.2	14.5	9.9030	282	9.9088	706	55
1948	50	+13.2	4.2	140.7	10.7	9.9312	428	9.8382	648	50
	45	+17.4	2.4	151.4	8.4	9.9740	579	9.7734	526	45
	40	+19.8	0.8	159.8	6.9	0.0319	706	9.7208	388	40
	35	+19.0	5.6	166.7	6.0	0.1025	724	9.6820	250	35
1949	30	+13.4	11.4	172.7	5.7	0.1749	447	9.6570	115	30
	25	+2.0	13.2	178.4	5.6	0.2196	150	9.6455	20	25
	20	−11.2	8.9	184.0	5.8	0.2046	639	9.6475	154	20
	15	−20.1	3.0	189.8	6.6	0.1407	764	9.6629	295	15
1950	10	−23.1	1.1	196.4	7.7	0.0643	680	9.6924	437	10
	5	−22.0	3.8	204.1	9.8	9.9963	532	9.7361	572	5
	0	−18.2	5.3	213.9	13.1	9.9431	377	9.7933	670	0
	355	−12.9	6.1	227.0	17.7	9.9054	227	9.8603	634	355
1951	350	−6.8	6.5	244.7	22.3	9.8827	84	9.9237	335	350
	345	−0.3	6.4	267.0	22.9	9.8743	54	9.9572	174	345
	340	+6.1	6.0	289.9	19.1	9.8797	193	9.9398	555	340
	335	+12.1	5.2	309.0	14.2	9.8990	332	9.8843	652	335
1952	330	+17.3	3.8	323.2	10.6	9.9322	471	9.8191	579	330
	325	+21.1	1.5	333.8	8.2	9.9793	597	9.7612	450	325
	320	+22.6	2.1	342.0	6.7	0.0390	666	9.7162	310	320
	315	+20.5	6.7	348.7	6.0	0.1056	583	9.6852	172	315
1953	310	+13.8	10.6	354.7	5.5	0.1639	242	9.6680	38	310
	305	+3.2	10.4	0.2	5.5	0.1881	238	9.6642	91	305
	300	−7.2	6.4	5.7	5.7	0.1643	558	9.6733	225	300
	295	−13.6	2.3	11.4	6.3	0.1085	600	9.6958	349	295
1954	290	−15.9	0.9	17.7	7.4	0.0485	537	9.7307	484	290
	285	−15.0	2.8	25.1	9.3	9.9948	420	9.7791	608	285
	280	−12.2	3.8	34.4	12.2	9.9528	298	9.8399	703	280
1955	275	−8.4	4.4	46.6	16.1	9.9230	175	9.9102	674	275
	270	−4.0	4.5	62.7	20.2	9.9055	68	9.9776	449	270
	265	+0.5	4.3	82.9	21.8	9.8987	33	0.0225	12	265
	260	+4.8	3.7	104.7	19.0	9.9020	124	0.0237	379	260
1956	255	+8.5	3.0	123.7	14.6	9.9144	204	9.9858	538	255
	250	+11.5	1.9	138.3	10.9	9.9348	267	9.9320	516	250
	245	+13.4	0.6	149.2	8.4	9.9615	308	9.8804	424	245
	240	+14.0	0.9	157.6	6.7	9.9923	315	9.8380	312	240
1957	235	+13.1	2.5	164.3	5.6	0.0238	273	9.8068	202	235
	230	+10.6	3.9	169.9	5.1	0.0511	182	9.7866	97	230
	225	+6.7	4.4	175.0	4.7	0.0693	53	9.7769	1	225
	220	+2.3	4.3	179.7	4.6	0.0746	77	9.7770	92	220
1958	215	−2.0	3.4	184.3	4.7	0.0669	177	9.7862	180	215
	210	−5.4	2.1	189.0	5.1	0.0492	232	9.8042	266	210
	205	−7.5	1.0	194.1	5.6	0.0260	246	9.8308	350	205
	200	−8.5	0.0	199.7	6.6	0.0014	233	9.8658	432	200
1959	195	−8.5	0.9	206.3	8.1	9.9781	202	9.9090	506	195
	190	−7.6	1.3	214.4	10.2	9.9579	162	9.9596	555	190
	185	−6.3	1.9	224.6	13.1	9.9417	118	0.0151	541	185
	180	−4.4		237.7		9.9299		0.0692		180

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000*—Contd.

Year.	N	u of L_2	Diff.	u of M_1	Diff.	Log F (L_2)	Diff.	Log F (M_1)	Diff.	N
	°	°		°						°
1959	180	−4.4	2.1	237.7	16.4	9.9299	71	0.0692	404	180
1960	175	−2.3	2.3	254.1	18.6	9.9228	21	0.1096	107	175
	170	0.0	2.3	272.7	18.3	9.9207	30	0.1203	252	170
	165	+2.3	2.2	291.0	15.6	9.9237	83	0.0951	507	165
	160	+4.5	2.0	306.6	12.3	9.9320	137	0.0444	603	160
1961	155	+6.5	1.6	318.9	9.6	9.9457	191	9.9841	589	155
	150	+8.1	0.8	328.5	7.6	9.9648	242	9.9252	523	150
	145	+8.9	0.2	336.1	6.4	9.9890	280	9.8729	435	145
1962	140	+8.7	1.5	342.5	5.6	0.0170	295	9.8294	344	140
	135	+7.2	3.1	348.1	5.1	0.0465	263	9.7950	247	135
	130	+4.1	4.7	353.2	4.8	0.0728	166	9.7703	149	130
	125	−0.6	5.4	358.0	4.9	0.0894	8	9.7554	47	125
1963	120	−6.0	5.0	2.9	5.1	0.0902	169	9.7507	58	120
	115	−11.0	3.5	8.0	5.6	0.0733	305	9.7565	170	115
	110	−14.5	1.5	13.6	6.6	0.0428	370	9.7735	290	110
	105	−16.0	0.5	20.2	8.1	0.0058	368	9.8025	412	105
1964	100	−15.5	2.1	28.3	10.5	9.9690	320	9.8437	519	100
	95	−13.4	3.3	38.8	14.1	9.9370	245	9.8956	567	95
	90	−10.1	4.2	52.9	18.7	9.9125	156	9.9523	465	90
	85	−5.9	4.8	71.6	22.1	9.8969	48	9.9988	61	85
1965	80	−1.1	5.1	93.7	21.2	9.8921	60	0.0049	392	80
	75	+4.0	5.0	114.9	17.0	9.8981	180	9.9657	666	75
	70	+9.0	4.3	131.9	12.8	9.9161	309	9.8991	702	70
	65	+13.3	3.2	144.7	9.6	9.9470	447	9.8289	615	65
1966	60	+16.5	1.4	154.3	7.7	9.9917	581	9.7674	489	60
	55	+17.9	2.0	162.0	6.5	0.0498	675	9.7185	353	55
	50	+15.9	7.0	168.5	5.8	0.1173	622	9.6832	218	50
	45	+8.9	11.5	174.3	5.5	0.1795	274	9.6614	85	45
1967	40	−2.6	11.6	179.8	5.6	0.2069	283	9.6529	48	40
	35	−14.2	7.0	185.4	6.0	0.1786	651	9.6577	182	35
	30	−21.2	1.9	191.4	6.8	0.1135	717	9.6759	322	30
	25	−23.1	1.8	198.2	8.2	0.0418	624	9.7081	464	25
1968	20	−21.3	4.1	206.4	10.6	9.9794	484	9.7545	592	20
	15	−17.2	5.4	217.0	14.3	9.9310	335	9.8137	666	15
	10	−11.8	6.2	231.3	19.2	9.8975	190	9.8803	567	10
	5	−5.6	6.5	250.5	23.0	9.8785	50	9.9370	185	5
1969	0	+0.9	6.5	273.5	22.2	9.8735	91	9.9555	328	0
	355	+7.4	6.1	295.7	17.7	9.8826	232	9.9227	624	355
	350	+13.5	5.1	313.4	13.0	9.9058	379	9.8603	657	350
1970	345	+18.6	3.6	326.4	9.8	9.9437	528	9.7946	558	345
	340	+22.2	0.9	336.2	7.7	9.9965	663	9.7388	423	340
	335	+23.1	3.3	343.9	6.5	0.0628	727	9.6965	282	335
	330	+19.8	8.7	350.4	5.9	0.1355	583	9.6683	143	330
1971	325	+11.1	12.2	356.3	5.5	0.1938	121	9.6540	9	325
	320	−1.1	10.6	1.8	5.6	0.2059	416	9.6531	125	320
	315	−11.7	5.4	7.4	6.0	0.1643	669	9.6656	256	315
	310	−17.1	0.9	13.4	6.8	0.0974	661	9.6912	393	310
1972	305	−18.0	2.1	20.2	8.2	0.0313	546	9.7305	528	305
	300	−15.9	3.7	28.4	10.4	9.9767	408	9.7833	649	300
	295	−12.2	4.7	38.8	14.0	9.9359	271	9.8482	709	295
	290	−7.5	5.1	52.8	18.5	9.9088	143	9.9191	611	290
1973	285	−2.4	5.1	71.3	22.0	9.8945	26	9.9802	256	285
	280	+2.7	4.6	93.3	21.6	9.8919	86	0.0058	224	280
	275	+7.3	4.0	114.9	17.1	9.9005	183	9.9834	508	275
	270	+11.3	3.1	132.0	12.8	9.9188	274	9.9326	566	270
1974	265	+14.4	1.6	144.8	9.7	9.9462	343	9.8760	491	265
	260	+16.0	0.1	154.5	7.6	9.9805	380	9.8269	374	260
	255	+15.9	2.2	162.1	6.2	0.0185	364	9.7895	253	255
	250	+13.7		168.3		0.0549		9.7642		250

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000*—Contd.

Year.	N	u of L_2	Diff.	u of M_1	Diff.	Log $F(L_2)$	Diff.	Log $F(M_1)$	Diff.	N
	°	°		°						°
1974	250	+13.7	4.1	168.3	5.5	0.0549	274	9.7642	134	250
1975	245	+9.6	5.4	173.8	5.0	0.0823	116	9.7508	22	245
	240	+4.2	5.3	178.8	4.8	0.0939	68	9.7486	82	240
	235	−1.1	4.2	183.6	4.9	0.0871	211	9.7568	183	235
	230	−5.3	2.7	188.5	5.3	0.0660	286	9.7751	282	230
1976	225	−8.0	1.0	193.8	5.8	0.0374	300	9.8033	378	225
	220	−9.0	0.2	199.6	6.8	0.0074	273	9.8411	471	220
	215	−8.8	1.1	206.4	8.3	9.9801	228	9.8882	554	215
	210	−7.7	1.8	214.7	10.5	9.9573	174	9.9436	606	210
1977	205	−5.9	2.2	225.2	13.5	9.9399	118	0.0042	589	205
	200	−3.7	2.3	238.7	16.8	9.9281	63	0.0631	439	200
	195	−1.4	2.4	255.5	18.7	9.9218	10	0.1070	129	195
1978	190	+1.0	2.2	274.2	18.1	9.9208	40	0.1199	228	190
	185	+3.2	2.0	292.3	15.3	9.9248	89	0.0971	469	185
	180	+5.2	1.7	307.6	11.9	9.9337	135	0.0502	553	180
	175	+6.9	1.2	319.5	9.3	9.9472	177	9.9949	536	175
1979	170	+8.1	0.5	328.8	7.4	9.9649	213	9.9413	477	170
	165	+8.6	0.3	336.2	6.2	9.9862	237	9.8936	398	165
	160	+8.3	1.4	342.4	5.4	0.0099	241	9.8538	317	160
	155	+6.9	2.6	347.8	4.9	0.0340	213	9.8221	232	155
1980	150	+4.3	3.7	352.7	4.6	0.0553	143	9.7989	147	150
	145	+0.6	4.3	357.3	4.6	0.0696	33	9.7842	59	145
	140	−3.7	4.3	1.9	4.8	0.0729	99	9.7783	33	140
	135	−8.0	3.4	6.7	5.2	0.0630	214	9.7816	131	135
1981	130	−11.4	2.0	11.9	6.0	0.0416	287	9.7947	237	130
	125	−13.4	0.4	17.9	7.1	0.0129	312	9.8184	349	125
	120	−13.8	1.0	25.0	9.0	9.9817	293	9.8533	457	120
	115	−12.8	2.3	34.0	12.0	9.9524	246	9.8990	533	115
1982	110	−10.5	3.2	46.0	16.0	9.9278	177	9.9523	508	110
	105	−7.3	3.9	62.0	20.1	9.9101	95	0.0031	276	105
	100	−3.4	4.3	82.1	21.7	9.9006	2	0.0307	161	100
	95	+0.9	4.4	103.8	19.1	9.9004	100	0.0146	549	95
1983	90	+5.3	4.2	122.9	14.7	9.9104	211	9.9597	703	90
	85	+9.5	3.5	137.6	11.1	9.9315	330	9.8894	676	85
	80	+13.0	2.3	148.7	8.6	9.9645	454	9.8218	572	80
	75	+15.3	0.1	157.3	7.0	0.0099	560	9.7646	445	75
1984	70	+15.4	3.4	164.3	6.1	0.0659	604	9.7201	312	70
	65	+12.0	7.8	170.4	5.6	0.1263	478	9.6889	183	65
	60	+4.2	10.8	176.0	5.4	0.1741	98	9.6706	54	60
1985	55	−6.6	9.6	181.4	5.6	0.1839	365	9.6652	77	55
	50	−16.2	5.3	187.0	6.2	0.1474	625	9.6729	212	50
	45	−21.5	0.9	193.2	7.1	0.0849	650	9.6941	350	45
	40	−22.4	2.3	200.3	8.7	0.0199	560	9.7291	490	40
1986	35	−20.1	4.2	209.0	11.4	9.9639	429	9.7781	614	35
	30	−15.9	5.5	220.4	15.7	9.9210	290	9.8395	640	30
	25	−10.4	6.2	236.1	20.5	9.8920	152	9.9035	471	25
	20	−4.2	6.5	256.6	23.4	9.8768	14	9.9506	18	20
1987	15	+2.3	6.3	280.0	21.0	9.8754	126	9.9524	456	15
	10	+8.6	5.9	301.0	16.3	9.8880	270	9.9068	668	10
	5	+14.5	4.9	317.3	11.9	9.9150	422	9.8400	650	5
	0	+19.4	3.2	329.2	9.1	9.9572	579	9.7750	535	0
1988	355	+22.6	0.1	338.3	7.3	0.0151	717	9.7215	395	355
	350	+22.7	4.6	345.6	6.3	0.0868	761	9.6820	255	350
	345	+18.1	10.7	351.9	5.8	0.1629	536	9.6565	114	345
	340	+7.4	13.4	357.7	5.6	0.2165	39	9.6451	18	340
1989	335	−6.0	9.8	3.3	5.7	0.2126	573	9.6469	154	335
	330	−15.8	4.0	9.0	6.2	0.1553	744	9.6623	289	330
	325	−19.8	0.4	15.2	7.3	0.0809	677	9.6912	429	325
	320	−19.4		22.5		0.0132		9.7341		320

TABLE 13.—*Values of u and log F of L_2 and M_1 for years 1900 to 2000*—Contd

Year.	N	u of L_2.	Diff.	u of M_1.	Diff.	Log $F(L_2)$.	Diff.	Log $F(M_1)$.	Diff.	N
	°	°		°						°
1989	320	−19.4	3.0	22.5	9.0	0.0132	537	9.7341	565	320
1890	315	−16.4	4.6	31.5	11.7	9.9595	386	9.7906	676	315
	310	−11.8	5.3	43.2	15.8	9.9209	242	9.8582	694	310
	305	−6.5	5.6	59.0	20.5	9.8967	108	9.9276	500	305
	300	−0.9	5.5	79.5	22.7	9.8859	17	9.9776	51	300
1991	295	+4.6	5.1	102.2	20.4	9.8876	135	9.9827	394	295
	290	+9.7	4.3	122.6	15.6	9.9011	246	9.9433	585	290
	285	+14.0	3.0	138.2	11.5	9.9257	344	9.8848	565	285
	280	+17.0	1.3	149.7	8.9	9.9601	428	9.8283	464	280
1992	275	+18.3	1.0	158.6	6.9	0.0029	450	9.7819	326	275
	270	+17.3	3.7	165.5	6.0	0.0479	408	9.7493	203	270
	265	+13.6	5.9	171.5	5.4	0.0887	250	9.7290	79	265
1993	260	+7.7	6.9	176.9	5.1	0.1137	10	9.7211	38	260
	255	+0.8	5.8	182.0	5.0	0.1147	214	9.7249	151	255
	250	−5.0	3.6	187.0	.4	0.0933	342	9.7400	262	250
	245	−8.6	1.6	192.4	5.9	0.0591	373	9.7662	371	245
1994	240	−10.2	0.3	198.3	6.9	0.0218	340	9.8033	477	240
	235	−9.9	1.4	205.2	8.3	9.9878	280	9.8510	576	235
	230	− 8.5	2.1	213.5	10.6	9.9598	209	9.9086	645	230
	225	−6.4	2.6	224.1	13.8	9.9389	137	9.9731	641	225
1995	220	−3.8	2.7	237.9	17.2	9.9252	69	0.0372	496	220
	215	−1.1	2.7	255.1	19.4	9.9183	6	0.0868	173	215
	210	+1.6	2.5	274.5	18.6	9.9177	51	0.1041	202	210
	205	+4.1	2.1	293.1	15.4	9.9228	102	0.0839	444	205
1996	200	+6.2	1.7	308.5	11.9	9.9330	147	0.0395	519	200
	195	+7.9	1.0	320.4	9.3	9.9477	184	9.9876	494	195
	190	+8.9	0.3	329.7	7.3	9.9661	209	9.9382	427	190
	185	+9.2	0.6	337.0	6.0	9.9870	221	9.8955	348	185
1997	180	+8.6	1.6	343.0	5.3	0.0091	211	9.8607	268	180
	175	+7.0	2.5	348.3	4.7	0.0302	175	9.8339	191	175
	170	+4.5	3.3	353.0	4.5	0.0477	109	9.8148	113	170
	165	+1.2	3.7	357.5	4.4	0.0586	19	9.8035	36	165
1998	160	−2.5	3.6	1.9	4.5	0.0605	81	9.7999	45	160
	155	−6.1	3.0	6.4	4.9	0.0524	169	9.8044	130	155
	150	−9.1	2.0	11.3	5.6	0.0355	231	9.8174	221	150
	145	−11.1	0.7	16.9	6.5	0.0124	258	9.8395	319	145
1999	140	−11.8	0.4	23.4	8.1	9.9866	253	9.8714	416	140
	135	−11.4	1.5	31.5	10.5	9.9613	224	9.9130	497	135
	130	−9.9	2.4	42.0	13.9	9.9389	174	9.9627	514	130
2000	125	−7.5	3.1	55.9	18.0	9.9215	112	0.0141	375	125
	120	−4.4	3.5	73.9	20.9	9.9103	37	0.0516	24	120
	115	−0.9	3.7	94.8	19.9	9.9066	45	0.0540	398	115
	110	+2.8		114.7		9.9111		0.0142		110

TABLE 14.—*Factor f for middle of each calendar year, 1850 to 1999.*

Component.	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
J_1	0.892	0.948	1.007	1.061	1.105	1.138	1.158	1.165	1.160	1.141
K_1	0.922	0.959	0.999	1.037	1.069	1.092	1.107	1.113	1.108	1.095
K_2	0.816	0.887	0.977	1.075	1.168	1.246	1.298	1.317	1.302	1.254
L_2	1.163	0.905	0.725	1.055	1.263	0.944	0.469	0.962	1.283	1.001
M_1	1.023	1.675	1.974	1.559	1.118	1.860	2.348	1.872	1.177	1.776
M_2*, N_2, 2N, λ_2, μ_2, ν_2	1.027	1.017	1.005	0.993	0.981	0.972	0.966	0.963	0.965	0.971
M_3	1.042	1.026	1.008	0.989	0.972	0.958	0.949	0.945	0.948	0.957
M_4, MN	1.056	1.035	1.011	0.986	0.963	0.944	0.932	0.928	0.931	0.942
M_6	1.085	1.053	1.016	0.978	0.944	0.918	0.900	0.894	0.899	0.915
M_8	1.114	1.071	1.021	0.971	0.927	0.892	0.869	0.861	0.867	0.888
O_1, Q_1, 2Q, ρ_1	0.874	0.933	0.998	1.059	1.110	1.150	1.174	1.183	1.176	1.153
OO	0.631	0.786	0.983	1.204	1.422	1.608	1.735	1.783	1.745	1.627
MK	0.948	0.976	1.004	1.029	1.048	1.062	1.069	1.072	1.070	1.063
2MK	0.974	0.993	1.010	1.022	1.029	1.032	1.032	1.032	1.032	1.032
Mf	0.743	0.856	0.990	1.129	1.257	1.360	1.427	1.452	1.432	1.370
Mm	1.094	1.059	1.016	0.973	0.933	0.900	0.879	0.871	0.878	0.897

Component.	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869
J_1	1.110	1.066	1.013	0.955	0.898	0.852	0.829	0.832	0.863	0.912
K_1	1.072	1.041	1.004	0.964	0.926	0.898	0.883	0.885	0.904	0.936
K_2	1.179	1.086	0.988	0.897	0.823	0.773	0.749	0.753	0.784	0.840
L_2	0.568	0.924	1.225	1.117	0.865	0.879	1.082	1.190	1.091	0.840
M_1	2.227	1.792	1.046	1.260	1.680	1.609	1.164	0.812	1.189	1.731
M_2*, N_2, 2N, λ_2, μ_2, ν_2	0.980	0.991	1.004	1.016	1.026	1.034	1.038	1.037	1.032	1.024
M_3	0.970	0.987	1.006	1.024	1.040	1.051	1.057	1.056	1.049	1.036
M_4, MN	0.960	0.983	1.008	1.032	1.054	1.069	1.076	1.075	1.036	1.048
M_6	0.941	0.974	1.011	1.049	1.081	1.105	1.117	1.115	1.100	1.073
M_8	0.922	0.966	1.015	1.065	1.110	1.143	1.159	1.156	1.135	1.099
O_1, Q_1, 2Q, ρ_1	1.116	1.065	1.005	0.941	0.880	0.832	0.808	0.812	0.843	0.896
OO	1.447	1.230	1.008	0.807	0.647	0.540	0.489	0.497	0.563	0.685
MK	1.050	1.032	1.007	0.979	0.951	0.928	0.916	0.918	0.933	0.958
2MK	1.029	1.023	1.011	0.995	0.976	0.960	0.950	0.952	0.964	0.981
Mf	1.270	1.145	1.007	0.872	0.755	0.670	0.629	0.635	0.689	0.783
Mm	0.928	0.968	1.011	1.054	1.091	1.117	1.130	1.128	1.111	1.082

Component.	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879
J_1	0.971	1.028	1.079	1.120	1.147	1.162	1.164	1.154	1.130	1.094
K_1	0.974	1.014	1.050	1.079	1.099	1.111	1.112	1.104	1.087	1.061
K_2	0.920	1.014	1.112	1.201	1.269	1.309	1.315	1.287	1.227	1.144
L_2	0.828	1.148	1.224	0.816	0.545	1.087	1.270	0.858	0.543	1.036
M_1	1.811	1.300	1.185	2.004	2.286	1.656	1.227	1.998	2.269	1.645
M_2*, N_2, 2N, λ_2, μ_2, ν_2	1.013	1.000	0.988	0.977	0.969	0.964	0.963	0.967	0.974	0.984
M_3	1.019	1.001	0.982	0.966	0.954	0.947	0.946	0.951	0.961	0.976
M_4, MN	1.026	1.001	0.976	0.955	0.939	0.930	0.928	0.935	0.949	0.968
M_6	1.039	1.001	0.965	0.933	0.910	0.896	0.894	0.904	0.924	0.953
M_8	1.052	1.002	0.953	0.912	0.881	0.864	0.862	0.874	0.900	0.938
O_1, Q_1, 2Q, ρ_1	0.958	1.022	1.080	1.127	1.161	1.179	1.182	1.169	1.140	1.098
OO	0.858	1.067	1.290	1.500	1.666	1.764	1.779	1.708	1.563	1.366
MK	0.987	1.014	1.037	1.054	1.065	1.071	1.072	1.068	1.059	1.044
2MK	1.000	1.015	1.025	1.030	1.032	1.032	1.032	1.032	1.031	1.027
Mf	0.907	1.044	1.181	1.300	1.390	1.442	1.450	1.413	1.335	1.224
Mm	1.043	1.000	0.957	0.919	0.891	0.874	0.872	0.884	0.908	0.943

*Factor *f* of MS, 2SM, and MSf are each equal to factor *f* of M_2.
Factor *f* of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each unity.

TABLE 14.—*Factor f for middle of each calendar year, 1850 to 1999*—Continued.

Component.	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889
J_1	1.047	0.991	0.932	0.878	0.840	0.827	0.841	0.880	0.934	0.994
K_1	1.027	0.988	0.949	0.914	0.890	0.882	0.891	0.915	0.950	0.990
K_2	1.048	0.951	0.866	0.800	0.760	0.748	0.762	0.803	0.869	0.955
L_2	1.246	1.020	0.786	0.944	1.152	1.171	1.006	0.824	0.945	1.205
M_1	1.046	1.528	1.824	1.529	0.970	0.877	1.364	1.721	1.593	1.075
M_2*, N_2, 2N, λ_2, μ_2, ν_2	0.996	1.009	1.020	1.030	1.036	1.038	1.036	1.029	1.020	1.008
M_3	0.994	1.013	1.031	1.045	1.054	1.057	1.054	1.044	1.030	1.012
M_4, MN	0.992	1.017	1.041	1.060	1.073	1.077	1.072	1.060	1.040	1.016
M_6	0.988	1.026	1.062	1.092	1.111	1.118	1.111	1.091	1.061	1.024
M_8	0.984	1.035	1.084	1.124	1.151	1.160	1.150	1.123	1.082	1.033
O_1, Q_1, 2Q, ρ_1	1.043	0.980	0.916	0.860	0.820	0.806	0.821	0.862	0.919	0.983
OO	1.144	0.926	0.739	0.599	0.513	0.486	0.516	0.604	0.746	0.936
MK	1.023	0.997	0.968	0.941	0.922	0.915	0.922	0.942	0.969	0.998
2MK	1.019	1.005	0.988	0.969	0.955	0.950	0.955	0.970	0.988	1.006
Mf	1.092	0.953	0.823	0.717	0.649	0.626	0.651	0.721	0.828	0.959
Mm	0.984	1.028	1.069	1.102	1.124	1.131	1.123	1.101	1.067	1.026

Component.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
J_1	1.049	1.096	1.132	1.155	1.165	1.162	1.146	1.118	1.077	1.026
K_1	1.028	1.062	1.088	1.105	1.112	1.110	1.099	1.078	1.048	1.012
K_2	1.052	1.148	1.230	1.289	1.316	1.308	1.267	1.197	1.108	1.010
L_2	1.153	0.709	0.683	1.185	1.219	0.704	0.607	1.141	1.229	0.897
M_1	1.323	2.091	2.158	1.434	1.369	2.176	2.240	1.471	1.166	1.781
M_2*, N_2, 2N, λ_2, μ_2, ν_2	0.996	0.984	0.974	0.967	0.963	0.964	0.969	0.978	0.989	1.001
M_3	0.993	0.976	0.961	0.950	0.946	0.947	0.954	0.967	0.983	1.002
M_4, MN	0.991	0.968	0.948	0.934	0.928	0.930	0.939	0.956	0.977	1.002
M_6	0.987	0.952	0.923	0.903	0.894	0.896	0.910	0.934	0.966	1.003
M_8	0.982	0.936	0.898	0.873	0.861	0.864	0.882	0.913	0.955	1.004
O_1, Q_1, 2Q, ρ_1	1.046	1.100	1.142	1.170	1.182	1.179	1.160	1.125	1.078	1.020
OO	1.153	1.375	1.571	1.713	1.780	1.761	1.660	1.491	1.281	1.058
MK	1.024	1.045	1.059	1.068	1.072	1.071	1.065	1.054	1.036	1.013
2MK	1.019	1.028	1.031	1.032	1.032	1.032	1.032	1.030	1.025	1.014
Mf	1.098	1.230	1.339	1.416	1.451	1.441	1.387	1.296	1.175	1.038
Mm	0.983	0.941	0.907	0.883	0.872	0.875	0.892	0.921	0.958	1.001

Component.	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
J_1	0.968	0.910	0.861	0.832	0.829	0.854	0.900	0.957	1.016	1.069
K_1	0.973	0.934	0.903	0.885	0.883	0.899	0.928	0.965	1.005	1.042
K_2	0.916	0.838	0.782	0.752	0.750	0.774	0.825	0.900	0.992	1.090
L_2	0.753	1.030	1.193	1.117	0.925	0.858	1.051	1.221	1.062	0.653
M_1	1.902	1.399	0.858	1.069	1.507	1.643	1.340	0.946	1.479	2.112
M_2*, N_2, 2N, λ_2, μ_2, ν_2	1.013	1.024	1.032	1.037	1.038	1.034	1.026	1.016	1.003	0.991
M_3	1.020	1.036	1.049	1.056	1.057	1.051	1.039	1.023	1.005	0.986
M_4, MN	1.027	1.049	1.066	1.076	1.076	1.068	1.053	1.031	1.007	0.982
M_6	1.040	1.074	1.101	1.115	1.117	1.104	1.080	1.047	1.010	0.973
M_8	1.054	1.100	1.136	1.157	1.159	1.142	1.108	1.063	1.013	0.964
O_1, Q_1, 2Q, ρ_1	0.956	0.893	0.842	0.811	0.808	0.834	0.882	0.944	1.008	1.068
OO	0.850	0.679	0.559	0.496	0.490	0.543	0.652	0.814	1.017	1.240
MK	0.986	0.957	0.933	0.918	0.916	0.929	0.952	0.980	1.008	1.033
2MK	0.999	0.980	0.963	0.952	0.951	0.960	0.977	0.996	1.012	1.023
Mf	0.901	0.779	0.686	0.634	0.630	0.673	0.759	0.877	1.012	1.151
Mm	1.045	1.083	1.112	1.128	1.130	1.116	1.089	1.052	1.010	0.966

*Factor f of MS, 2SM, and MSf are each equal to factor f of M_2.
Factor f of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each unity.

TABLE 14.—*Factor f for middle of each calendar year, 1850 to 1999*—Continued.

Component.	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
J_1	1.111	1.142	1.160	1.165	1.157	1.137	1.104	1.059	1.004	0.945
K_1	1.073	1.096	1.109	1.113	1.107	1.092	1.067	1.035	0.997	0.958
K_2	1.182	1.256	1.303	1.317	1.296	1.243	1.165	1.071	0.973	0.884
L_2	0.834	1.246	1.135	0.561	0.729	1.221	1.172	0.761	0.780	1.118
M_1	1.972	1.248	1.557	2.297	2.146	1.310	1.371	1.993	1.909	1.243
M_2*, N_2, $2N$, λ_2, μ_2, ν_2	0.980	0.970	0.965	0.963	0.966	0.972	0.982	0.993	1.006	1.018
M_3	0.969	0.956	0.948	0.945	0.949	0.958	0.972	0.990	1.009	1.027
M_4, MN	0.959	0.942	0.931	0.928	0.933	0.945	0.964	0.987	1.012	1.036
M_6	0.940	0.914	0.898	0.894	0.901	0.918	0.946	0.980	1.017	1.054
M_8	0.920	0.887	0.867	0.861	0.870	0.893	0.928	0.973	1.023	1.073
O_1, Q_1, $2Q$, ρ_1	1.118	1.154	1.176	1.183	1.173	1.148	1.109	1.056	0.995	0.931
OO	1.455	1.633	1.748	1.783	1.732	1.602	1.414	1.195	0.974	0.779
MK	1.051	1.063	1.070	1.072	1.069	1.061	1.048	1.028	1.003	0.975
2MK	1.029	1.032	1.032	1.032	1.032	1.032	1.028	1.021	1.009	0.992
Mf	1.275	1.373	1.434	1.452	1.425	1.356	1.252	1.124	0.985	0.851
Mm	0.927	0.896	0.877	0.871	0.880	0.902	0.934	0.975	1.018	1.060

Component.	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
J_1	0.890	0.847	0.827	0.836	0.870	0.921	0.980	1.037	1.086	1.125
K_1	0.921	0.894	0.882	0.887	0.909	0.942	0.981	1.020	1.055	1.083
K_2	0.813	0.767	0.748	0.756	0.791	0.852	0.934	1.030	1.127	1.214
L_2	1.198	1.034	0.870	0.932	1.133	1.199	0.963	0.669	0.975	1.270
M_1	0.896	1.308	1.597	1.503	1.082	0.954	1.619	2.063	1.739	1.138
M_2*, N_2, $2N$, λ_2, μ_2, ν_2	1.028	1.035	1.038	1.036	1.031	1.022	1.011	0.998	0.986	0.976
M_3	1.042	1.052	1.057	1.055	1.047	1.034	1.016	0.998	0.979	0.964
M_4, MN	1.056	1.071	1.077	1.074	1.063	1.045	1.022	0.997	0.973	0.952
M_6	1.086	1.108	1.118	1.114	1.096	1.068	1.033	0.995	0.959	0.929
M_8	1.116	1.146	1.160	1.154	1.130	1.092	1.044	0.994	0.946	0.906
O_1, Q_1, $2Q$, ρ_1	0.871	0.827	0.806	0.815	0.850	0.905	0.968	1.032	1.088	1.134
OO	0.626	0.528	0.487	0.504	0.579	0.710	0.889	1.102	1.325	1.530
MK	0.947	0.925	0.915	0.920	0.937	0.963	0.992	1.018	1.040	1.056
2MK	0.973	0.958	0.950	0.953	0.966	0.984	1.002	1.017	1.026	1.031
Mf	0.739	0.660	0.626	0.641	0.701	0.801	0.928	1.066	1.201	1.317
Mm	1.096	1.120	1.131	1.126	1.107	1.076	1.036	0.993	0.950	0.914

Component.	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
J_1	1.150	1.163	1.164	1.151	1.126	1.088	1.038	0.982	0.923	0.871
K_1	1.102	1.112	1.112	1.102	1.083	1.056	1.021	0.982	0.943	0.909
K_2	1.278	1.312	1.313	1.279	1.216	1.130	1.033	0.937	0.854	0.792
L_2	1.022	0.471	0.873	1.270	1.078	0.636	0.859	1.190	1.162	0.936
M_1	1.312	2.353	1.992	1.197	1.614	2.148	1.850	1.098	1.079	1.534
M_2*, N_2, $2N$, λ_2, μ_2, ν_2	0.968	0.964	0.964	0.968	0.975	0.986	0.998	1.011	1.022	1.031
M_3	0.952	0.946	0.946	0.952	0.963	0.979	0.997	1.016	1.033	1.047
M_4, MN	0.937	0.929	0.929	0.936	0.951	0.972	0.996	1.021	1.044	1.063
M_6	0.907	0.895	0.895	0.906	0.928	0.958	0.994	1.032	1.067	1.096
M_8	0.878	0.863	0.862	0.877	0.905	0.945	0.992	1.043	1.091	1.130
O_1, Q_1, $2Q$, ρ_1	1.165	1.181	1.181	1.165	1.134	1.090	1.034	0.970	0.907	0.852
OO	1.686	1.772	1.773	1.690	1.535	1.332	1.108	0.894	0.714	0.581
MK	1.066	1.071	1.071	1.067	1.057	1.041	1.019	0.992	0.964	0.938
2MK	1.032	1.032	1.032	1.032	1.031	1.026	1.017	1.003	0.985	0.966
Mf	1.402	1.446	1.447	1.403	1.320	1.205	1.070	0.931	0.804	0.704
Mm	0.887	0.873	0.873	0.887	0.913	0.949	0.991	1.035	1.075	1.107

* Factor f of MS, 2SM, and MSf are each equal to factor f of M_2.
Factor f of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each unity.

TABLE 14.—*Factor f for middle of each calendar year, 1850 to 1999*—Continued.

Component.	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
J_1	0.836	0.827	0.846	0.888	0.944	1.003	1.057	1.103	1.136	1.157
K_1	0.888	0.882	0.894	0.920	0.956	0.996	1.034	1.067	1.091	1.107
K_2	0.757	0.748	0.766	0.812	0.882	0.970	1.068	1.162	1.242	1.295
L_2	0.860	1.021	1.180	1.144	0.876	0.748	1.091	1.255	0.894	0.482
M_1	1.623	1.313	0.879	1.076	1.714	1.944	1.480	1.138	1.927	2.339
M_2*, N_2, 2N, λ_2, μ_2, ν_2	1.036	1.038	1.035	1.028	1.018	1.006	0.994	0.982	0.972	0.966
M_3	1.055	1.057	1.053	1.042	1.027	1.009	0.990	0.973	0.959	0.949
M_4, MN	1.074	1.077	1.071	1.057	1.036	1.012	0.987	0.964	0.945	0.933
M_6	1.113	1.118	1.108	1.086	1.055	1.018	0.981	0.947	0.919	0.901
M_8	1.154	1.160	1.147	1.117	1.074	1.025	0.975	0.929	0.894	0.870
O_1, Q_1, 2Q, ρ_1	0.816	0.806	0.826	0.870	0.929	0.994	1.055	1.107	1.147	1.173
OO	0.505	0.486	0.526	0.623	0.774	0.969	1.189	1.408	1.598	1.729
MK	0.920	0.915	0.925	0.946	0.974	1.002	1.028	1.047	1.061	1.069
2MK	0.953	0.950	0.957	0.973	0.991	1.008	1.021	1.028	1.032	1.032
Mf	0.642	0.626	0.659	0.736	0.848	0.981	1.120	1.249	1.354	1.424
Mm	1.126	1.131	1.121	1.096	1.061	1.019	0.976	0.935	0.902	0.880

Component.	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
J_1	1.165	1.160	1.143	1.112	1.070	1.002	0.959	0.901	0.855	0.829
K_1	1.113	1.109	1.096	1.074	1.043	1.001	0.966	0.929	0.900	0.883
K_2	1.317	1.303	1.257	1.184	1.092	0.995	0.903	0.827	0.776	0.770
L_2	1.074	1.330	1.014	0.653	1.001	1.260	1.112	0.867	0.915	1.115
M_1	1.717	1.120	1.778	2.161	1.664	0.964	1.276	1.656	1.527	1.053
M_2*, N_2, 2N, λ_2, μ_2, ν_2	0.963	0.965	0.970	0.982	0.990	1.003	1.015	1.026	1.033	1.038
M_3	0.945	0.948	0.956	0.969	0.986	1.004	1.023	1.039	1.051	1.057
M_4, MN	0.928	0.931	0.941	0.959	0.981	1.006	1.031	1.052	1.068	1.076
M_6	0.894	0.898	0.914	0.939	0.972	1.009	1.046	1.079	1.104	1.116
M_8	0.861	0.867	0.887	0.920	0.962	1.012	1.062	1.107	1.141	1.158
O_1, Q_1, 2Q, ρ_1	1.183	1.177	1.155	1.119	1.069	1.010	0.945	0.884	0.835	0.808
OO	1.784	1.750	1.637	1.459	1.246	1.023	0.819	0.656	0.546	0.491
MK	1.072	1.070	1.063	1.051	1.033	1.009	0.981	0.953	0.930	0.916
2MK	1.032	1.032	1.032	1.029	1.023	1.012	0.996	0.977	0.960	0.951
Mf	1.452	1.435	1.375	1.278	1.154	1.016	0.880	0.761	0.675	0.630
Mm	0.872	0.877	0.896	0.926	0.965	1.008	1.051	1.088	1.116	1.130

Component.	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
J_1	0.831	0.860	0.909	0.766	1.025	1.076	1.117	1.146	1.161	1.165
K_1	0.885	0.903	0.934	0.972	1.011	1.048	1.077	1.098	1.110	1.113
K_2	0.752	0.781	0.836	0.914	1.008	1.106	1.195	1.265	1.307	1.316
L_2	1.199	1.081	0.849	0.893	1.200	1.237	0.838	0.690	1.185	1.310
M_1	0.767	1.197	1.690	1.699	1.166	1.175	1.976	2.175	1.503	1.197
M_2*, N_2, 2N, λ_2, μ_2, ν_2	1.037	1.033	1.024	1.014	1.001	0.989	0.978	0.969	0.964	0.963
M_3	1.056	1.049	1.037	1.020	1.002	0.983	0.967	0.954	0.947	0.945
M_4, MN	1.076	1.066	1.050	1.027	1.003	0.978	0.956	0.940	0.930	0.928
M_6	1.116	1.111	1.075	1.041	1.004	0.967	0.935	0.911	0.897	0.894
M_8	1.157	1.137	1.102	1.055	1.005	0.956	0.914	0.883	0.865	0.861
O_1, Q_1, 2Q, ρ_1	0.810	0.840	0.891	0.954	1.018	1.076	1.124	1.159	1.178	1.182
OO	0.495	0.557	0.675	0.845	1.053	1.276	1.487	1.655	1.758	1.782
MK	0.917	0.932	0.956	0.985	1.013	1.036	1.053	1.064	1.071	1.072
2MK	0.952	0.962	0.980	0.998	1.014	1.024	1.030	1.032	1.032	1.032
Mf	0.633	0.684	0.776	0.898	1.035	1.172	1.293	1.385	1.439	1.451
Mm	1.128	1.113	1.084	1.046	1.003	0.959	0.922	0.893	0.876	0.872

*Factor f of MS, 2SM, and MSf are each equal to factor f of M_2.
Factor f of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each unity.

TABLE 14.—*Factor f for middle of each calendar year, 1850 to 1999*—Continued.

Component.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
J_1	1.155	1.132	1.097	1.051	0.995	0.936	0.881	0.842	0.827	0.839
K_1	1.105	1.088	1.063	1.029	0.991	0.951	0.916	0.891	0.882	0.890
K_2	1.289	1.232	1.150	1.055	0.957	0.871	0.804	0.763	0.748	0.760
L_2	0.882	0.668	1.118	1.270	1.014	0.808	0.988	1.179	1.169	0.994
M_1	1.987	2.176	1.503	1.012	1.535	1.777	1.428	0.870	0.874	1.361
M_2*, N_2, $2N$, λ_2, μ_2, ν_2	0.966	0.973	0.983	0.995	1.008	1.020	1.029	1.035	1.038	1.036
M_3	0.950	0.960	0.975	0.993	1.012	1.029	1.044	1.054	1.057	1.054
M_4, MN	0.934	0.948	0.967	0.991	1.016	1.039	1.059	1.072	1.077	1.073
M_6	0.903	0.922	0.951	0.986	1.024	1.060	1.090	1.110	1.118	1.112
M_8	0.873	0.898	0.935	0.981	1.032	1.081	1.122	1.149	1.160	1.151
O_1, Q_1, $2Q$, ρ_1	1.170	1.143	1.101	1.047	0.984	0.920	0.863	0.822	0.806	0.819
OO	1.716	1.575	1.380	1.159	0.940	0.750	0.607	0.517	0.485	0.512
MK	1.068	1.059	1.045	1.024	0.998	0.970	0.943	0.923	0.915	0.922
2MK	1.032	1.031	1.028	1.020	1.006	0.989	0.970	0.956	0.950	0.955
Mf	1.417	1.341	1.233	1.102	0.962	0.831	0.723	0.652	0.625	.647
Mm	0.882	0.906	0.940	0.982	1.025	1.067	1.100	1.123	1.131	1.124

Component.	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
J_1	0.877	0.930	0.989	1.045	1.093	1.130	1.153	1.164	1.163	1.148
K_1	0.913	0.948	0.987	1.026	1.060	1.086	1.104	1.112	1.111	1.100
K_2	0.799	0.864	0.949	1.045	1.142	1.226	1.285	1.315	1.310	1.270
L_2	0.848	1.001	1.238	1.157	0.745	0.811	1.263	1.244	0.749	0.746
M_1	1.656	1.468	0.974	1.323	2.050	2.032	1.292	1.367	2.142	2.122
M_2*, N_2, $2N$, λ_2, μ_2, ν_2	1.030	1.021	1.009	0.997	0.984	0.974	0.967	0.964	0.964	0.969
M_3	1.045	1.031	1.013	0.994	0.977	0.962	0.951	0.946	0.947	0.954
M_4, MN	1.061	1.042	1.018	0.993	0.969	0.949	0.935	0.928	0.930	0.939
M_6	1.092	1.063	1.027	0.989	0.954	0.924	0.904	0.894	0.896	0.910
M_8	1.125	1.085	1.036	0.986	0.939	0.901	0.874	0.862	0.864	0.881
O_1, Q_1, $2Q$, ρ_1	0.858	0.915	0.979	1.041	1.096	1.140	1.168	1.182	1.180	1.161
OO	0.596	0.735	0.921	1.137	1.361	1.560	1.706	1.778	1.766	1.668
MK	0.941	0.967	0.996	1.022	1.043	1.058	1.068	1.072	1.071	1.065
2MK	0.969	0.987	1.005	1.019	1.027	1.031	1.032	1.032	1.032	1.032
Mf	0.715	0.820	0.949	1.088	1.221	1.333	1.412	1.450	1.443	1.392
Mm	1.103	1.070	1.029	0.986	0.944	0.909	0.884	0.872	0.874	0.891

Component.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
J_1	1.120	1.080	1.030	0.972	0.914	0.864	0.833	0.829	0.852	0.896
K_1	1.079	1.051	1.015	0.976	0.937	0.905	0.886	0.883	0.897	0.926
K_2	1.203	1.115	1.016	0.922	0.842	0.785	0.754	0.750	0.772	0.821
L_2	1.216	1.248	0.898	0.801	1.077	1.208	1.107	0.921	0.893	1.096
M_1	1.334	1.156	1.778	1.829	1.282	0.800	1.083	1.487	1.560	1.214
M_2*, N_2, $2N$, λ_2, μ_2, ν_2	0.977	0.988	1.000	1.013	1.024	1.032	1.037	1.038	1.034	1.027
M_3	0.966	0.982	1.000	1.019	1.036	1.048	1.056	1.057	1.051	1.040
M_4, MN	0.955	0.976	1.000	1.025	1.048	1.065	1.075	1.076	1.069	1.054
M_6	0.932	0.964	1.000	1.038	1.072	1.099	1.115	1.117	1.105	1.082
M_8	0.911	0.952	1.000	1.051	1.098	1.134	1.156	1.159	1.143	1.111
O_1, Q_1, $2Q$, ρ_1	1.128	1.081	1.024	0.960	0.897	0.844	0.812	0.808	0.832	0.879
OO	1.505	1.296	1.072	0.863	0.688	0.565	0.498	0.489	0.538	0.643
MK	1.054	1.038	1.015	0.988	0.959	0.934	0.918	0.916	0.928	0.950
2MK	1.030	1.025	1.015	1.000	0.982	0.964	0.952	0.951	0.959	0.976
Mf	1.303	1.184	1.048	0.910	0.786	0.691	0.636	0.629	0.669	0.752
Mm	0.918	0.956	0.998	1.042	1.081	1.110	1.128	1.130	1.117	1.091

*Factor f of MS, 2SM, and MSf are each equal to factor f of M_2.
Factor f of P_1, R_2, S_1, S_2, S_4, S_6, T_2, Sa, and Ssa are each unity.

TABLE 15.—*Equilibrium argument* (V_o+u) *for meridian of Greenwich at beginning of each calendar year, 1850 to 2000.*

Component.	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	29.7	116.0	204.0	307.5	38.1	129.4	221.2	327.3	59.4	151.2	242.6	347.4	77.0	165.2	251.7	350.6	74.0	157.0	240.8	340.1
K_1	3.5	1.6	0.9	2.2	3.3	5.0	7.1	10.4	12.8	14.9	16.7	18.9	19.3	18.7	17.0	15.2	11.7	8.0	4.6	3.1
K_2	187.8	183.8	181.8	184.0	186.0	189.5	194.0	200.9	205.8	210.4	214.0	218.2	218.6	217.0	213.2	209.7	203.2	196.4	190.0	187.0
L_2	155.7	350.6	161.5	330.9	177.7	26.0	194.6	353.3	204.2	54.4	229.0	26.0	229.0	72.2	259.4	62.5	249.4	86.0	283.9	100.4
M_1	6.8	273.5	165.2	50.6	346.9	274.8	170.8	55.4	347.2	281.7	178.9	61.0	341.0	280.0	179.7	56.8	311.8	235.5	162.6	47.2
M_2	299.8	40.1	140.6	217.0	318.0	59.3	160.6	237.7	339.2	80.6	181.8	258.5	359.3	99.8	200.2	276.0	16.0	116.1	216.2	292.0
M_3	269.7	240.2	211.0	145.5	117.0	88.9	61.0	356.6	328.8	300.9	272.7	207.7	178.9	149.7	120.2	53.9	24.0	354.1	324.2	258.0
M_4	239.6	80.2	281.3	74.1	276.1	118.5	321.3	115.4	318.4	161.2	3.6	156.9	358.5	199.6	40.3	191.9	32.1	232.2	72.3	224.0
M_6	179.4	120.3	61.9	291.1	234.1	177.8	121.9	353.1	297.6	241.7	185.4	55.4	357.8	299.5	240.5	107.9	48.1	348.2	288.5	156.0
M_8	119.2	160.4	202.6	148.1	192.1	237.0	282.5	230.9	276.7	322.3	7.3	313.9	357.1	39.3	80.7	23.8	64.1	104.3	144.7	88.0
N_2	270.0	281.6	293.4	268.0	280.3	292.8	305.5	280.8	293.5	306.2	318.7	293.6	305.6	317.5	329.1	303.1	314.5	325.8	337.2	311.2
2N	240.3	163.2	86.2	319.1	242.6	166.4	90.3	323.8	247.9	171.8	95.6	328.7	252.0	175.2	98.0	330.3	252.9	175.5	98.1	330.4
O_1	299.9	42.6	143.8	218.5	317.7	56.3	154.6	227.3	325.4	63.7	162.3	236.0	335.9	77.0	179.5	258.2	3.6	109.3	214.4	292.7
OO	240.0	132.5	29.8	318.6	223.1	129.6	37.5	333.4	242.0	150.0	56.8	348.9	250.7	148.7	41.8	317.2	201.3	84.1	329.1	245.8
P_1	349.7	349.9	350.2	349.4	349.7	349.9	350.2	349.4	349.6	349.9	350.1	349.4	349.6	349.8	350.1	349.3	349.6	349.8	350.1	349.3
Q_1	270.1	284.1	296.6	269.5	280.0	289.9	299.4	270.4	279.8	289.3	299.2	271.1	282.3	294.7	308.5	285.4	302.0	319.0	335.4	311.9
2Q	240.4	165.6	89.4	320.5	242.2	163.4	84.3	313.4	234.1	154.9	76.1	306.2	228.7	152.3	77.4	312.6	240.5	168.8	96.4	331.1
R_2	179.9	179.7	179.4	180.2	179.9	179.6	179.4	180.1	179.8	179.6	179.3	180.1	179.8	179.6	179.3	180.0	179.8	179.5	179.3	180.0
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	0.1	0.3	0.6	359.8	0.1	0.4	0.6	359.9	0.2	0.4	0.7	359.9	0.2	0.4	0.7	0.0	0.2	0.5	0.7	0.0
λ_2	148.8	59.6	330.7	228.9	140.4	52.2	324.1	223.0	135.0	46.9	318.7	217.2	128.5	39.6	310.5	208.1	118.7	29.3	299.9	197.6
μ_2	241.0	82.1	283.4	76.2	277.9	119.9	322.0	115.5	317.7	159.8	1.8	154.9	356.4	197.7	38.8	191.0	31.8	232.6	73.4	225.6
ν_2	270.8	200.6	130.6	25.1	315.6	246.3	177.2	72.4	3.4	294.2	224.9	119.8	50.0	340.1	269.9	163.8	93.4	22.9	312.4	206.4
ρ_1	270.9	203.1	133.8	26.6	315.3	243.4	171.1	62.0	349.6	277.3	205.4	97.3	26.7	317.2	249.2	146.1	80.9	16.2	310.7	207.2
MK	303.3	41.8	141.6	219.2	321.4	64.3	167.8	248.2	352.0	95.5	198.5	277.4	18.5	118.5	217.2	291.2	27.7	124.0	220.8	295.1
2MK	236.1	78.6	280.4	71.9	272.8	113.5	314.1	105.0	305.6	146.2	346.9	138.1	339.2	181.0	23.3	176.7	20.4	224.2	67.7	220.9
MN	209.8	321.8	74.1	125.1	238.4	352.1	106.1	158.5	272.7	26.8	140.5	192.0	304.9	57.3	169.3	219.1	330.5	81.9	193.3	243.2
MS	299.8	40.1	140.6	217.0	318.0	59.3	160.6	237.7	339.2	80.6	181.8	258.5	359.3	99.8	200.2	276.0	16.0	116.1	216.2	292.0
2SM	60.2	319.9	219.4	143.0	42.0	300.7	199.4	122.3	20.8	279.4	178.2	101.5	0.7	260.2	159.8	84.0	344.0	243.9	143.8	68.0
Mf	240.0	134.9	33.0	320.1	222.7	126.7	31.5	323.1	228.3	133.2	37.3	326.4	227.4	125.8	21.1	299.4	188.8	77.4	327.3	246.5
MSf	60.2	319.9	219.4	143.0	42.0	300.7	199.4	122.3	20.8	279.4	178.2	101.5	0.7	260.2	159.8	84.0	344.0	243.9	143.8	68.0
Mm	29.8	118.5	207.2	309.0	37.7	126.4	215.2	316.9	45.7	134.4	223.1	324.9	53.6	142.3	231.1	332.8	61.6	150.3	239.0	340.8
Sa	280.3	280.1	279.8	280.6	280.3	280.1	279.8	280.6	280.4	280.1	279.9	280.6	280.4	280.2	279.9	280.7	280.4	280.2	279.9	280.7
Ssa	200.6	200.1	199.6	201.1	200.7	200.2	199.7	201.2	200.7	200.2	199.8	201.3	200.8	200.3	199.8	201.3	200.8	200.4	199.9	201.4

TABLE 15.—*Equilibrium argument (V_o+u) for meridian of Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	67.1	155.7	245.6	350.5	82.1	174.0	266.1	12.2	103.9	195.0	285.3	28.5	116.1	201.9	286.1	23.3	106.5	190.8	276.7	18.4
K_1	1.7	1.4	2.0	4.4	6.3	8.5	10.9	14.1	16.2	17.7	18.6	19.7	18.6	16.5	13.4	10.7	7.1	4.0	1.9	2.0
K_2	183.7	182.6	183.6	188.2	192.1	196.8	201.8	208.6	212.9	216.0	217.6	219.2	216.7	212.0	206.2	201.5	194.8	188.9	184.4	184.0
L_2	271.0	100.6	307.8	139.4	296.9	121.8	334.7	170.6	331.4	151.8	359.2	189.8	8.8	184.5	17.7	204.5	38.9	219.8	35.4	219.6
M_1	297.7	201.0	145.3	48.0	301.8	202.5	145.5	55.4	310.0	207.8	142.2	58.2	312.8	203.4	108.2	31.1	301.4	192.6	83.7	344.5
M_2	32.4	133.0	233.9	310.6	51.9	153.3	254.8	331.8	73.2	174.4	275.3	351.6	92.1	192.4	292.5	8.2	108.2	208.3	308.6	24.7
M_3	228.6	199.5	170.8	105.9	77.8	50.0	22.2	317.8	289.8	261.5	232.9	167.4	138.1	108.5	78.7	12.2	342.3	312.5	282.9	217.1
M_4	64.8	266.0	107.8	261.2	103.8	306.6	149.6	303.7	146.4	348.7	190.6	343.2	184.2	24.7	225.0	16.3	216.4	56.7	257.2	49.4
M_6	97.2	39.0	341.6	211.8	155.6	99.9	44.3	275.5	219.6	163.0	105.9	334.8	276.2	217.1	157.4	24.4	324.6	265.0	205.8	72.1
M_8	129.6	172.1	215.5	162.4	207.5	253.2	299.1	247.4	292.7	337.4	21.2	326.5	8.3	49.4	89.9	32.6	72.8	113.3	154.4	98.8
N_2	322.9	334.8	346.9	321.8	334.4	347.1	359.8	335.1	347.8	0.2	12.4	347.0	358.7	10.2	21.6	355.5	6.9	18.3	29.8	4.1
2N	253.4	176.5	99.9	333.1	256.9	180.9	104.9	338.4	262.3	186.0	109.5	342.3	265.3	188.1	110.8	342.9	265.5	188.2	111.0	343.6
O_1	34.8	135.6	235.2	308.8	47.3	145.5	243.6	316.4	54.7	153.5	252.8	327.8	69.4	172.5	277.2	357.5	103.1	207.6	310.7	26.9
OO	140.3	39.3	302.0	234.8	141.9	50.2	318.8	254.6	162.2	68.3	332.0	259.8	156.0	47.1	293.4	203.9	87.2	333.7	225.1	148.8
P_1	349.6	349.8	350.0	349.3	349.5	349.8	350.0	349.2	349.5	349.7	350.0	349.2	349.5	349.7	349.9	349.2	349.4	349.7	349.9	349.2
Q_1	325.3	337.3	348.3	320.0	329.8	339.3	348.7	319.6	329.3	339.3	350.0	323.2	336.0	350.4	6.4	344.8	1.7	17.6	31.9	6.3
2Q	255.8	179.1	101.3	331.3	252.3	173.1	93.7	322.9	243.9	165.2	87.1	318.5	242.6	168.3	95.5	332.2	260.4	187.5	113.1	345.7
R_2	179.7	179.5	179.2	180.0	179.7	179.4	179.2	179.9	179.7	179.4	179.2	179.9	179.6	179.4	179.1	179.8	179.6	179.3	179.1	179.8
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	0.3	0.5	0.8	0.0	0.3	0.6	0.8	0.1	0.3	0.6	0.8	0.1	0.4	0.6	0.9	0.2	0.4	0.7	0.9	0.2
λ_2	108.5	19.6	291.0	189.6	101.4	13.3	285.3	184.2	96.1	7.8	279.2	177.4	88.4	359.2	269.8	167.4	77.9	348.6	259.4	157.3
μ_2	66.8	268.2	109.8	262.9	104.9	307.1	149.3	302.8	144.8	346.8	188.5	341.2	182.4	23.4	224.3	16.3	217.1	58.0	259.0	51.5
ν_2	136.3	66.4	356.8	251.6	182.4	113.3	44.2	299.5	230.3	160.9	91.3	345.8	275.8	205.5	135.1	28.9	318.5	248.1	177.8	72.1
ρ_1	138.8	69.0	358.1	249.8	177.8	105.5	33.1	284.0	211.8	140.0	68.9	322.0	253.1	185.7	119.8	18.2	313.3	247.4	179.9	74.2
MK	34.1	134.4	235.9	315.0	58.2	161.8	265.6	346.0	89.3	192.1	293.9	11.3	110.7	208.9	305.9	18.9	115.3	212.3	310.6	26.7
2MK	63.1	264.6	105.7	256.8	97.5	298.1	138.7	289.6	130.2	331.0	172.0	323.6	165.5	8.2	211.5	5.6	209.3	52.7	255.3	47.5
MN	355.3	107.8	220.8	272.4	26.3	140.4	254.6	307.0	60.9	174.5	287.7	338.6	90.8	202.6	314.1	3.7	115.1	226.6	338.4	28.8
MS	32.4	133.0	233.9	310.6	51.9	153.3	254.8	331.8	73.2	174.4	275.3	351.6	92.1	192.4	292.5	8.2	108.2	208.3	308.6	24.7
2SM	327.6	227.0	126.1	49.4	308.1	206.7	105.2	28.2	286.8	185.6	84.7	8.4	267.9	167.6	67.5	351.8	251.8	151.7	51.4	335.3
Mf	142.7	41.9	303.4	233.0	137.3	42.3	307.6	239.1	143.7	47.4	309.6	236.0	133.3	27.3	278.1	193.2	82.1	333.0	227.2	150.9
MSf	327.6	227.0	126.1	49.4	308.1	206.7	105.2	28.2	286.8	185.6	84.7	8.4	267.9	167.6	67.5	351.8	251.8	151.7	51.4	335.3
Mm	69.5	158.2	247.0	348.8	77.5	166.2	254.9	356.7	85.4	174.2	262.9	4.7	93.4	182.1	270.8	12.6	101.3	190.1	278.8	20.6
Sa	280.4	280.2	280.0	280.7	280.5	280.2	280.0	280.8	280.5	280.3	280.0	280.8	280.5	280.3	280.1	280.8	280.6	280.3	280.1	280.8
Ssa	200.9	200.4	200.0	201.4	201.0	200.5	200.0	201.5	201.0	200.6	200.1	201.6	201.1	200.6	200.1	201.6	201.2	200.7	200.2	201.7

TABLE 15.—*Equilibrium argument (V_o+u) for meridian of Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	107.6	197.9	289.0	34.8	126.9	219.0	310.9	56.4	147.3	237.2	325.7	52.7	137.8	221.5	304.6	42.1	127.0	213.6	301.8	45.5
K_1	2.0	3.0	4.6	7.6	9.9	12.2	14.4	17.3	18.6	19.2	18.9	17.5	14.9	11.6	7.8	5.3	2.6	0.9	0.4	1.8
K_2	183.8	185.4	188.6	194.8	199.7	204.7	209.4	215.2	217.8	218.7	217.5	214.2	209.0	202.7	195.9	191.4	186.0	182.3	180.7	183.2
L_2	65.8	260.3	55.9	240.3	94.0	295.3	86.6	268.4	118.4	317.1	127.1	309.0	147.1	345.0	174.1	339.6	162.5	1.2	204.8	17.5
M_1	287.7	192.3	85.3	340.4	288.6	199.8	93.4	344.8	289.6	205.1	97.5	351.6	271.7	203.3	101.6	338.1	232.1	158.1	90.6	336.2
M_2	125.4	226.4	327.6	44.5	146.0	247.4	348.9	65.8	166.8	267.7	8.3	108.7	208.9	309.0	49.0	124.7	224.9	325.3	65.8	142.2
M_3	188.1	159.6	131.3	66.8	39.0	11.2	343.3	278.6	250.3	221.6	192.5	163.0	133.4	103.5	73.6	7.1	337.4	307.9	278.7	213.4
M_4	250.8	92.8	295.1	89.0	291.9	134.9	337.7	131.5	333.7	175.4	16.6	217.4	57.8	258.0	98.1	249.4	89.8	290.5	131.6	284.5
M_6	16.3	319.1	262.7	133.6	77.9	22.3	326.6	197.3	140.5	83.1	24.9	326.1	266.7	207.0	147.1	14.2	314.7	255.8	197.5	66.7
M_8	141.7	185.5	230.2	178.1	223.9	269.8	315.4	263.0	307.4	350.8	33.2	74.8	115.6	156.0	196.1	138.9	179.6	221.0	263.3	209.0
N_2	16.1	28.4	40.8	16.0	28.7	41.5	54.2	29.3	41.6	53.8	65.7	77.3	88.8	100.2	111.5	85.4	96.8	108.5	120.3	95.0
2N	266.8	190.3	114.1	347.5	271.5	195.5	119.5	352.8	276.4	199.8	123.0	46.0	328.7	251.4	174.0	46.1	328.8	251.7	174.8	47.7
O_1	127.2	226.5	325.2	38.2	136.4	234.5	332.7	45.8	144.8	244.5	345.2	87.4	191.2	296.3	42.0	122.0	226.0	328.5	69.5	144.0
OO	49.4	313.2	219.4	154.4	62.8	331.5	239.7	174.1	79.4	342.0	240.9	135.2	24.3	269.2	152.0	63.5	311.8	205.1	103.2	32.5
P_1	349.4	349.6	349.9	349.1	349.4	349.6	349.8	349.1	349.3	349.6	349.8	350.0	350.3	350.5	350.8	350.0	350.3	350.5	350.7	350.0
Q_1	17.9	28.5	38.5	9.7	19.1	28.5	38.0	9.3	19.6	30.5	42.6	56.0	71.1	87.5	104.5	82.6	98.0	111.7	124.0	96.7
2Q	268.6	190.5	111.8	341.2	261.9	182.5	103.3	332.8	254.4	176.6	99.9	24.7	311.0	238.6	167.0	43.3	329.9	254.9	178.5	49.4
R_2	179.6	179.3	179.0	179.8	179.5	179.3	179.0	179.7	179.5	179.2	179.0	178.7	178.4	178.2	177.9	178.7	178.4	178.2	177.9	178.6
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2, 4, 6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	0.4	0.7	1.0	0.2	0.5	0.7	1.0	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	1.3	1.6	1.8	2.1	1.4
λ_2	68.6	340.1	251.8	150.6	62.5	334.5	246.5	145.2	56.8	328.2	239.4	150.3	61.0	331.6	242.2	139.7	50.4	321.3	232.4	130.6
μ_2	253.0	94.7	296.6	89.9	292.2	134.4	336.5	129.8	331.6	173.3	14.6	215.8	56.7	257.6	98.4	250.4	91.4	292.5	133.8	286.6
ν_2	2.3	292.7	223.4	118.5	49.4	340.4	271.2	166.3	96.8	27.2	317.3	247.1	176.8	106.4	35.9	289.8	219.4	149.2	79.3	333.8
ρ_1	4.0	292.8	221.0	112.2	39.8	327.4	255.1	146.3	74.8	4.0	294.2	225.8	159.1	93.7	28.9	287.0	220.5	152.5	82.9	335.6
MK	127.5	229.4	332.1	52.1	155.9	259.7	3.3	83.1	185.5	287.0	27.2	126.2	223.8	320.6	56.8	130.0	227.5	326.2	66.2	144.1
2MK	248.8	89.8	290.5	81.4	282.0	122.6	323.3	114.2	315.0	156.1	357.7	199.9	42.9	246.4	90.3	244.2	87.2	289.6	131.3	282.7
MN	141.6	254.7	8.4	60.5	174.7	288.9	43.0	95.0	208.5	321.5	74.0	186.0	297.7	49.2	160.5	210.1	321.8	73.8	186.2	237.2
MS	125.4	226.4	327.6	44.5	146.0	247.4	348.9	65.8	166.8	267.7	8.3	108.7	208.9	309.0	49.0	124.7	224.9	325.3	65.8	142.2
2SM	234.6	133.6	32.4	315.5	214.0	112.6	11.1	294.2	193.2	92.3	351.7	251.3	151.1	51.0	311.0	235.3	135.1	34.7	294.2	217.8
Mf	51.1	313.3	217.1	148.1	53.2	318.5	223.5	154.2	57.3	318.8	217.8	113.9	6.6	256.4	145.0	60.8	312.9	208.3	106.9	34.3
MSf	234.6	133.6	32.4	315.5	214.0	112.6	11.1	294.2	193.2	92.3	351.7	251.3	151.1	51.0	311.0	235.3	135.1	34.7	294.2	217.8
Mm	109.3	198.0	286.7	28.5	117.2	206.0	294.7	36.5	125.2	213.9	302.6	31.4	120.1	208.8	297.5	39.3	128.0	216.8	305.5	47.3
Sa	280.6	280.4	280.1	280.9	280.6	280.4	280.2	280.9	280.7	280.4	280.2	280.0	279.7	279.5	279.2	280.0	279.7	279.5	279.3	280.0
Ssa	201.2	200.7	200.3	201.8	201.3	200.8	200.3	201.8	201.3	200.9	200.4	199.9	199.4	199.0	198.5	200.0	199.5	199.0	198.5	200.0

TABLE 15.—*Equilibrium argument* (V_o+u) *for meridian of Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	136.2	227.6	319.5	65.6	157.7	249.5	340.8	85.4	174.8	262.7	349.0	87.6	170.9	253.9	337.9	77.4	164.7	253.6	343.7	88.7
K_1	3.0	4.8	7.0	10.3	12.6	14.7	16.4	18.5	18.7	18.0	16.1	14.2	10.6	6.9	3.6	2.3	1.1	0.9	1.7	4.2
K_2	185.5	189.1	193.7	200.6	205.6	210.0	213.4	217.4	217.5	215.5	211.4	207.7	201.0	194.3	188.1	185.3	182.4	181.6	182.9	187.7
L_2	179.7	22.0	235.0	55.4	206.6	49.0	260.2	81.5	245.3	75.8	277.1	101.6	284.2	101.7	291.2	119.9	319.1	133.4	306.7	141.4
M_1	229.6	146.2	92.1	343.4	237.0	149.2	96.3	350.1	242.0	142.6	78.4	344.0	236.0	124.6	25.1	309.9	226.5	120.0	15.3	292.0
M_2	243.3	344.5	85.9	163.0	264.5	5.9	107.1	183.7	284.4	25.0	125.3	201.0	301.1	41.2	141.3	217.1	317.6	58.2	159.1	235.9
M_3	184.9	156.8	128.9	64.5	36.7	8.8	340.6	275.5	246.7	217.5	187.9	121.6	91.7	61.7	31.9	325.7	296.3	267.3	238.7	173.8
M_4	126.6	329.1	171.9	326.1	169.0	11.7	214.2	7.4	208.9	49.9	250.6	42.1	242.2	82.3	282.5	74.2	275.1	116.4	318.2	111.7
M_6	9.9	313.6	257.8	129.1	73.5	17.6	321.2	191.1	133.3	74.9	15.8	243.2	183.3	123.5	63.8	291.4	232.6	174.6	117.3	347.6
M_8	253.2	298.2	343.8	292.1	337.9	23.4	68.3	14.8	57.8	99.9	141.1	84.2	124.4	164.6	205.1	148.5	190.2	232.8	276.5	223.4
N_2	107.3	119.8	132.5	107.8	120.5	133.2	145.7	120.5	132.5	144.3	155.9	129.9	141.2	152.6	164.0	138.0	149.7	161.7	173.8	148.8
2N	331.3	255.1	179.0	52.6	336.6	260.5	184.3	57.3	340.6	263.7	186.6	58.8	341.4	264.0	186.6	58.9	341.9	265.1	188.6	61.8
O_1	243.1	341.6	79.9	152.6	250.8	349.0	87.7	161.5	261.6	2.9	105.7	184.6	290.1	35.8	140.7	218.8	320.6	61.2	160.7	234.2
OO	297.4	204.2	112.2	48.2	316.7	224.6	131.1	62.8	324.1	221.3	113.6	28.2	271.9	154.9	40.4	317.9	213.2	112.9	16.1	309.2
P_1	350.2	350.5	350.7	350.0	350.2	350.4	350.7	349.9	350.2	350.4	350.6	349.9	350.1	350.4	350.6	349.9	350.1	350.3	350.6	349.8
Q_1	107.1	116.9	126.4	97.4	106.8	116.4	126.3	98.3	109.7	122.3	136.3	113.5	130.2	147.2	163.4	139.7	152.8	164.6	175.4	147.1
2Q	331.1	252.2	173.0	42.2	322.8	243.7	164.9	35.2	317.8	241.6	167.0	42.4	330.4	258.6	186.1	60.6	345.0	268.1	190.2	60.1
R_2	178.4	178.1	177.9	178.6	178.3	178.1	177.8	178.6	178.3	178.0	177.8	178.5	178.3	178.0	177.8	178.5	178.2	178.0	177.7	178.4
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	1.6	1.9	2.1	1.4	1.7	1.9	2.2	1.4	1.7	2.0	2.2	1.5	1.7	2.0	2.2	1.5	1.8	2.0	2.3	1.6
λ_2	42.2	314.0	225.9	124.8	36.8	308.7	220.5	118.9	30.2	301.2	212.1	109.7	20.3	290.8	201.5	99.2	10.1	281.3	192.8	91.3
μ_2	128.4	330.4	172.5	326.0	168.2	10.3	212.3	5.3	206.8	48.1	249.1	41.3	242.1	82.9	283.7	76.0	277.1	118.6	320.2	113.3
ν_2	264.4	195.1	126.0	21.2	312.2	243.0	173.7	68.5	358.7	288.7	218.5	112.4	41.9	331.5	261.0	155.1	85.0	15.1	305.5	200.4
ρ_1	264.2	192.2	119.9	10.8	298.4	226.2	154.3	46.3	335.8	266.6	198.9	96.0	30.9	326.1	260.5	156.7	88.0	18.1	307.1	198.7
MK	246.3	349.4	92.9	173.3	277.1	20.6	123.5	202.2	303.2	43.0	141.4	215.2	311.7	48.0	144.9	219.4	318.6	59.2	160.8	240.0
2MK	123.6	324.3	164.9	315.8	156.4	357.0	197.7	348.9	190.2	32.0	234.5	27.9	231.6	75.4	278.9	72.0	274.0	115.5	316.5	107.6
MN	350.6	104.4	218.4	270.8	25.0	139.0	252.8	304.2	57.0	169.3	281.2	331.0	82.4	193.7	305.2	355.2	107.3	219.9	333.0	24.7
MS	243.3	344.5	85.9	163.0	264.5	5.9	107.1	183.7	284.4	25.0	125.3	201.0	301.1	41.2	141.3	217.1	317.6	58.2	159.1	235.9
2SM	116.7	15.5	274.1	197.0	95.5	354.1	252.9	176.3	75.6	335.0	234.7	159.0	58.9	318.8	218.7	142.9	42.4	301.8	200.9	124.1
Mf	297.1	201.3	106.2	37.8	303.0	207.8	111.7	40.6	301.2	199.2	94.0	11.8	260.9	149.5	39.9	319.6	216.3	115.9	17.7	307.5
MSf	116.7	15.5	274.1	197.0	95.5	354.1	352.9	176.3	75.6	335.0	234.7	159.0	58.9	318.8	218.7	142.9	42.4	301.8	200.9	124.1
Mm	136.0	224.7	313.4	55.2	144.0	232.7	321.4	63.2	151.9	240.6	329.4	71.1	159.9	248.6	337.3	79.1	167.8	256.5	345.3	87.0
Sa	279.8	279.5	279.3	280.0	279.8	279.6	279.3	280.1	279.8	279.6	279.4	280.1	279.9	279.6	279.4	280.1	279.9	279.7	279.4	280.2
Ssa	199.6	199.1	198.6	200.1	199.6	199.1	198.7	200.2	199.7	199.2	198.7	200.2	199.7	199.3	198.8	200.3	199.8	199.3	198.8	200.3

TABLE 15.—*Equilbrium argument* (V_o+u) *for meridian of Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	180.4	272.3	4.4	110.5	202.1	293.1	23.2	126.2	213.5	299.1	23.1	120.2	203.5	288.0	14.2	116.2	205.5	296.0	27.3	133.1
K_1	6.1	8.4	10.7	14.0	15.9	17.4	18.2	19.1	17.9	15.6	12.4	9.6	6.0	3.1	1.2	1.4	1.6	2.7	4.4	7.4
K_2	191.8	196.6	201.6	208.3	212.4	215.3	216.6	217.9	215.1	210.3	204.2	199.4	192.7	187.0	182.9	182.8	182.8	184.8	188.2	194.6
L_2	352.2	170.1	330.8	167.9	18.8	201.7	6.0	193.1	35.9	227.4	44.3	215.2	49.6	249.0	82.0	240.2	64.4	271.8	118.7	270.7
M_1	228.3	126.5	21.6	293.3	234.4	134.1	27.0	285.7	227.4	132.6	22.0	260.9	173.4	109.5	12.9	252.0	151.2	91.3	14.5	257.4
M_2	337.2	78.6	180.1	257.1	358.4	99.6	200.5	276.8	17.2	117.5	217.6	293.2	33.3	133.4	233.8	309.9	50.6	151.6	252.8	329.8
M_3	145.8	117.9	90.1	25.7	357.7	329.4	300.7	235.2	205.8	176.2	146.4	79.9	49.9	20.2	350.6	284.8	256.0	227.4	199.2	134.7
M_4	314.3	157.2	0.2	154.3	356.9	199.2	41.0	193.6	34.4	234.9	75.1	226.5	66.6	266.9	107.5	259.8	101.3	303.2	145.7	299.6
M_6	291.5	235.8	180.2	51.4	355.4	298.8	241.5	110.3	51.6	352.4	292.7	159.7	99.9	40.3	341.2	209.6	151.9	94.9	38.5	269.5
M_8	268.7	314.4	0.3	308.6	353.8	38.4	82.0	27.1	68.9	109.8	150.3	92.9	133.2	173.8	215.0	159.5	202.5	246.5	291.3	239.3
N_2	161.4	174.1	186.9	162.1	174.7	187.1	199.3	173.8	185.5	197.1	208.4	182.3	193.6	205.1	216.7	191.0	203.0	215.3	227.8	203.0
2N	345.6	269.6	193.6	67.1	351.0	274.7	198.2	70.9	353.8	276.6	199.3	71.4	354.0	276.7	199.6	72.1	355.4	279.0	202.8	76.2
O_1	332.6	70.8	168.9	241.7	340.1	78.9	178.4	253.6	355.4	98.8	203.6	284.0	29.5	133.8	236.6	312.6	52.7	151.9	250.6	323.5
OO	216.6	124.9	33.6	329.2	236.7	142.4	45.7	332.9	228.3	118.6	4.2	274.6	158.2	45.4	297.5	222.0	123.2	27.4	293.9	229.1
P_1	350.1	350.3	350.6	349.8	350.0	350.3	350.5	349.8	350.0	350.2	350.5	349.7	350.0	350.2	350.5	349.7	350.0	350.2	350.4	349.7
Q_1	156.8	166.3	175.6	146.7	156.4	166.5	177.2	150.6	163.7	178.4	194.5	173.1	189.8	205.5	219.6	193.7	205.1	215.6	225.6	196.7
2Q	341.0	261.8	182.4	51.7	332.6	254.0	176.1	47.6	332.0	258.0	185.4	62.1	350.2	277.1	202.5	74.9	357.5	279.3	200.5	69.9
R_2	178.2	177.9	177.7	178.4	178.2	177.9	177.6	178.4	178.1	177.9	177.6	178.3	178.1	177.8	177.6	178.3	178.0	177.8	177.5	178.3
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	1.8	2.1	2.3	1.6	1.8	2.1	2.4	1.6	1.9	2.1	2.4	1.7	1.9	2.2	2.4	1.7	2.0	2.2	2.5	1.7
λ_2	3.2	275.1	187.1	86.0	357.9	269.5	181.0	79.1	350.0	260.8	171.4	69.0	339.5	250.2	161.0	59.0	330.3	241.8	153.6	52.4
μ_2	315.4	157.6	359.8	153.2	355.3	197.2	38.9	191.5	32.7	233.7	74.6	226.6	67.4	268.3	109.4	261.9	103.4	305.1	147.1	300.4
ν_2	131.2	62.1	353.0	248.2	179.0	109.6	40.0	294.5	224.4	154.1	83.7	337.5	267.0	196.7	126.4	20.7	311.0	241.4	172.1	67.3
ρ_1	126.6	54.3	341.8	232.8	160.7	89.0	18.0	271.3	202.6	135.4	69.8	328.3	263.2	197.1	129.4	23.4	313.0	241.8	169.9	61.0
MK	343.3	87.0	190.8	271.1	14.4	117.0	218.7	295.8	35.1	133.0	229.9	302.8	39.3	136.5	234.9	311.3	52.2	154.3	257.2	337.3
2MK	308.2	148.8	349.5	140.3	341.0	181.8	22.8	174.5	16.6	219.4	62.8	216.8	60.6	263.8	106.3	258.4	99.6	300.6	141.3	292.2
MN	138.6	252.7	7.0	59.3	173.2	286.7	39.8	90.6	202.8	314.5	66.0	115.6	226.9	338.5	90.4	140.9	253.7	6.9	120.6	172.8
MS	337.2	78.6	180.1	257.1	358.4	99.6	200.5	276.8	17.2	117.5	217.6	293.2	33.3	133.4	233.8	309.9	50.6	151.6	252.8	329.8
2SM	22.8	281.4	179.9	102.9	1.6	260.4	159.5	83.2	342.8	242.5	142.4	66.8	326.7	226.6	126.2	50.1	309.4	208.4	107.2	30.2
Mf	212.0	117.1	22.3	313.8	218.3	121.8	23.6	309.7	206.4	99.9	350.3	265.3	154.4	45.8	300.4	224.7	125.2	27.7	291.6	222.8
MSf	22.8	281.4	179.9	102.9	1.6	260.4	159.5	83.2	342.8	242.5	142.4	66.8	326.7	226.6	126.2	50.1	309.4	208.4	107.2	30.2
Mm	175.8	264.5	353.2	95.0	183.7	272.4	1.2	103.0	191.7	280.4	9.1	110.9	199.6	288.4	17.1	118.9	207.6	296.3	25.0	126.8
Sa	279.9	279.7	279.4	280.2	280.0	279.7	279.5	280.2	280.0	279.8	279.5	280.3	280.0	279.8	279.5	280.3	280.0	279.8	279.6	280.3
Ssa	199.9	199.4	198.9	200.4	199.9	199.4	199.0	200.5	200.0	199.5	199.0	200.5	200.0	199.6	199.1	200.6	200.1	199.6	199.2	200.6

TABLE 15.—*Equilibrium argument (V_o+u) for meridain at Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	225.2	317.2	49.1	154.6	245.3	335.0	63.3	164.0	249.0	332.5	55.5	153.2	238.3	325.2	53.7	157.6	248.4	340.0	71.9	178.0
K_1	9.8	12.1	14.2	17.0	18.3	18.7	18.2	17.6	14.9	11.4	7.7	5.3	2.7	1.2	0.9	2.4	3.8	5.6	7.8	11.2
K_2	199.5	204.4	209.0	214.7	217.0	217.6	216.0	214.4	209.0	202.6	195.8	191.4	186.2	182.8	181.6	184.4	186.9	190.8	195.4	202.4
L_2	86.6	298.5	147.4	306.1	118.5	322.8	165.4	338.9	153.8	342.4	179.5	5.4	191.0	2.4	194.4	30.4	230.4	26.6	215.8	57.9
M_1	155.3	91.6	22.2	265.5	159.0	85.3	21.9	266.9	155.7	52.4	341.3	252.2	146.5	36.5	302.6	236.6	147.6	40.3	302.7	237.8
M_2	71.3	172.8	274.2	351.0	92.1	192.9	293.5	9.4	109.6	209.7	309.8	25.5	125.7	226.0	326.7	43.1	144.2	245.5	346.9	64.0
M_3	106.9	79.2	51.3	346.6	318.1	289.4	260.2	194.2	164.5	134.6	104.6	38.2	8.5	339.1	310.0	244.7	216.3	188.2	160.3	96.0
M_4	142.6	345.5	188.3	342.1	184.2	25.8	227.0	18.9	219.3	59.4	259.5	50.9	251.3	92.1	293.3	86.2	288.4	130.9	333.8	128.0
M_6	213.8	158.3	102.5	333.1	276.3	218.7	160.4	28.4	328.9	269.2	209.3	76.4	17.0	318.1	260.0	129.4	72.6	16.4	320.7	191.9
M_8	285.1	331.1	16.7	324.2	8.4	51.6	93.9	37.8	78.6	118.9	159.0	101.8	142.6	184.2	226.6	172.5	216.8	261.9	307.6	255.9
N_2	215.7	228.5	241.2	216.3	228.6	240.7	252.5	226.7	238.2	249.5	260.9	234.8	246.2	257.9	269.8	244.5	256.8	269.4	282.1	257.4
2N	0.2	284.2	208.2	81.5	5.1	288.5	211.6	84.0	6.7	289.4	212.0	84.1	6.8	289.8	213.0	85.8	9.5	293.2	217.3	90.7
O_1	61.6	159.8	258.0	331.2	70.3	170.1	271.1	348.2	92.2	197.4	303.2	23.0	126.8	229.0	329.8	44.1	143.1	241.6	339.8	52.6
OO	137.6	46.2	314.2	248.5	153.4	155.4	313.6	234.4	122.8	7.1	250.0	162.0	51.1	305.2	204.0	133.8	39.0	306.1	214.3	150.3
P_1	349.9	350.2	350.4	349.6	349.9	350.1	350.4	349.6	349.9	350.1	350.3	349.6	349.8	350.1	350.3	349.6	349.8	350.0	350.3	349.5
Q_1	206.1	215.5	225.0	196.4	206.8	217.9	230.2	205.4	220.7	237.2	254.3	232.3	247.4	260.8	272.9	245.5	255.8	265.5	275.0	246.0
2Q	350.6	271.3	192.0	61.6	343.3	265.7	189.2	62.7	349.2	277.1	205.4	81.6	7.9	292.7	216.1	86.8	8.4	289.4	210.2	79.4
R_2	178.0	177.7	177.5	178.2	178.0	177.7	177.4	178.2	177.9	177.7	177.4	178.1	177.9	177.6	177.4	178.1	177.8	177.6	177.3	178.1
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	2.0	2.3	2.5	1.8	2.0	2.3	2.6	1.8	2.1	2.3	2.6	1.9	2.1	2.4	2.6	1.9	2.2	2.4	2.7	1.9
λ_2	324.4	236.4	148.3	47.0	318.6	229.9	141.0	38.8	309.5	320.1	130.7	28.2	299.0	209.9	121.0	19.3	290.9	202.7	114.7	13.6
μ_2	142.6	344.9	187.1	340.3	182.1	23.7	225.0	17.4	218.3	59.1	259.9	52.0	253.0	94.1	295.4	88.3	290.1	132.1	334.3	127.8
ν_2	358.2	289.2	220.1	115.1	45.6	335.9	266.0	160.1	89.8	19.3	308.8	202.7	132.4	62.2	352.3	246.9	177.5	108.2	39.1	294.4
ρ_1	348.6	276.2	203.9	95.3	23.8	313.1	243.6	138.8	72.3	7.0	302.2	200.2	133.4	65.1	355.4	247.9	176.4	104.4	32.0	282.9
MK	81.0	184.9	288.4	8.1	110.4	211.6	311.7	27.0	124.6	221.2	317.4	30.7	128.4	227.3	327.5	45.6	148.0	251.1	354.7	75.1
2MK	132.8	333.5	174.1	325.0	165.9	7.1	208.7	1.3	204.4	48.0	251.8	45.7	248.6	90.8	292.4	83.8	284.6	125.3	326.0	116.8
MN	287.0	41.3	155.4	207.3	320.7	73.6	186.0	236.2	347.8	99.2	210.6	260.2	11.9	24.0	236.4	287.6	41.0	154.8	269.0	321.4
MS	71.3	172.8	274.2	351.0	92.1	192.9	293.5	9.4	109.6	209.7	309.8	25.5	125.7	226.0	326.7	43.1	144.2	245.5	346.9	64.0
2SM	288.7	187.2	85.8	9.0	267.9	167.1	66.5	350.6	250.4	150.3	50.2	334.5	234.3	134.0	33.3	316.9	215.8	114.5	13.1	296.0
Mf	128.0	33.2	298.1	228.6	131.6	32.7	291.3	213.1	105.3	354.8	243.4	159.5	52.1	308.1	207.1	134.8	38.0	302.3	207.2	138.9
MSf	288.7	187.2	85.8	9.0	267.9	167.1	66.5	350.6	250.4	150.3	50.2	334.5	234.3	134.0	33.3	316.9	215.8	114.5	13.1	296.0
Mm	215.6	304.3	33.0	134.8	223.5	312.2	41.0	142.7	231.5	320.2	48.9	150.7	239.4	328.1	56.9	158.6	247.4	336.1	64.8	166.6
Sa	280.1	279.8	279.6	280.4	280.1	279.9	279.6	280.4	280.1	280.0	279.7	280.4	280.2	279.9	279.7	280.4	280.2	280.0	279.7	280.5
Ssa	200.2	199.7	199.2	200.7	200.2	199.8	199.3	200.8	200.3	199.8	199.3	200.8	200.4	199.9	199.4	200.9	200.4	199.9	199.4	201.0

TABLE 15.—*Equilibrium argument* (V_o+u) *for meridian of Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
J_1	270.0	1.8	93.1	197.4	286.6	14.3	100.2	198.6	281.8	4.9	89.1	188.9	276.5	5.6	95.8	201.0	292.7	24.7	116.8	222.8
K_1	13.4	15.5	17.1	19.0	19.2	18.2	16.2	14.1	10.5	6.8	3.7	2.5	1.5	1.5	2.4	4.9	6.9	9.2	11.6	14.8
K_2	207.2	211.5	214.8	218.4	218.2	215.8	211.5	207.6	200.9	194.2	188.2	185.6	183.1	182.6	184.2	189.3	193.5	198.3	203.3	210.0
L_2	262.8	60.3	245.2	81.8	282.4	99.0	276.4	99.7	297.9	130.9	310.2	116.6	313.4	159.2	350.3	135.8	334.5	188.0	25.5	166.0
M_1	155.2	48.6	307.8	234.9	158.7	51.8	302.5	198.6	135.7	41.8	291.5	170.8	87.9	30.0	291.6	171.7	82.0	31.2	299.1	179.8
M_2	165.4	266.8	8.0	84.5	185.3	285.8	26.0	101.8	201.8	301.9	42.0	117.9	218.4	319.1	60.0	136.8	238.1	339.6	81.0	158.1
M_3	68.1	40.2	11.9	306.8	277.9	248.6	219.0	152.7	122.7	92.8	63.0	356.8	327.6	298.6	270.0	205.2	177.2	149.3	121.6	57.1
M_4	330.9	173.6	15.9	169.1	10.5	211.5	52.1	203.6	43.7	243.8	84.0	235.8	76.7	278.1	120.0	273.6	116.2	319.1	162.1	316.2
M_6	136.3	80.4	23.9	253.6	195.8	137.2	78.1	305.3	245.5	185.7	126.0	353.7	295.1	237.2	180.0	50.3	354.3	298.7	243.1	114.2
M_8	301.7	347.1	31.8	338.2	21.0	63.0	104.1	47.1	87.3	127.5	168.0	111.6	153.4	196.2	240.0	187.1	232.4	278.2	324.1	272.3
N_2	270.1	282.7	295.2	270.0	282.0	293.8	305.3	279.3	290.6	301.9	313.3	287.4	299.2	311.2	323.4	298.4	311.0	323.7	336.4	311.7
2N	14.8	298.7	222.4	95.4	18.7	301.8	224.6	96.8	19.4	302.0	224.7	97.0	20.0	303.2	226.7	100.0	23.8	307.8	231.9	105.3
O_1	150.7	249.0	347.8	61.7	162.0	263.5	6.5	85.7	191.3	296.9	41.6	119.4	221.1	321.4	60.8	134.2	232.6	330.7	68.8	141.6
OO	58.7	326.4	232.6	163.9	64.6	321.1	212.6	126.5	9.8	253.0	139.2	57.5	313.6	213.9	117.6	51.0	318.5	227.0	135.6	71.2
P_1	349.8	350.0	350.2	349.5	349.7	350.0	350.2	349.5	349.7	349.9	350.2	349.4	349.7	349.9	350.2	349.4	349.6	349.9	350.1	349.4
Q_1	255.4	265.0	275.0	247.2	258.7	271.5	285.8	263.2	280.1	297.0	312.9	289.0	301.9	313.5	324.2	295.8	305.4	314.8	324.2	295.3
2Q	0.1	281.0	202.2	72.6	355.4	279.5	205.1	80.7	8.8	297.0	224.3	98.5	22.7	305.6	227.5	97.4	18.3	299.0	219.6	88.9
R_2	177.8	177.6	177.3	178.0	177.8	177.5	177.3	178.0	177.7	177.5	177.2	178.0	177.7	177.4	177.2	177.9	177.7	177.4	177.2	177.9
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	2.2	2.4	2.7	2.0	2.2	2.5	2.7	2.0	2.3	2.5	2.8	2.0	2.3	2.6	2.8	2.1	2.3	2.6	2.8	2.1
λ_2	285.6	197.4	109.1	7.6	278.8	189.8	100.6	358.2	268.8	179.4	90.0	347.8	258.8	170.0	81.4	340.0	251.9	163.0	75.9	334.8
μ_2	330.0	172.1	14.0	167.0	8.4	209.7	50.7	202.8	43.6	244.4	85.3	237.6	78.8	280.2	121.9	275.1	117.2	319.4	161.6	315.0
ν_2	225.3	156.1	86.8	341.5	271.7	201.7	131.4	25.3	314.9	244.4	174.0	68.0	358.0	288.2	218.6	113.5	44.3	335.2	266.2	161.4
ρ_1	210.6	138.4	66.6	318.7	248.4	179.4	111.9	9.2	304.3	239.4	173.6	69.6	0.7	290.5	219.4	110.9	38.8	326.4	254.0	145.0
MK	178.9	282.3	25.1	103.6	204.4	304.0	42.2	115.9	212.3	308.7	45.7	120.4	219.8	320.5	62.4	141.7	245.0	348.8	92.6	172.8
2MK	317.4	158.1	358.8	150.0	351.4	193.3	35.9	189.4	33.2	237.0	80.4	233.3	75.3	276.6	117.6	268.6	109.3	309.9	150.5	301.4
MN	75.6	189.5	303.2	354.5	107.2	219.5	331.3	21.1	132.4	243.8	355.3	45.3	157.5	242.2	23.4	75.1	189.1	303.2	57.5	109.8
MS	165.4	266.8	8.0	84.5	185.3	285.8	26.0	101.8	201.8	301.9	42.0	117.9	218.4	319.1	60.0	136.8	238.1	339.6	81.0	158.1
2SM	194.6	93.2	352.0	275.5	174.7	74.2	334.0	258.2	158.2	58.1	318.0	242.1	141.6	40.9	300.0	223.2	121.9	20.4	279.0	201.9
Mf	44.0	308.7	212.4	141.1	41.3	298.8	193.0	110.4	359.3	248.0	138.8	59.0	316.2	216.2	118.4	48.4	313.0	218.1	123.4	54.8
MSf	194.6	93.2	352.0	275.5	174.7	74.2	334.0	258.2	158.2	58.1	318.0	242.1	141.6	40.9	300.0	223.2	121.9	20.4	279.0	201.9
Mm	255.3	344.0	72.8	174.6	263.3	352.0	80.7	182.5	271.2	0.0	88.7	190.5	279.2	7.9	96.6	198.4	287.1	15.9	104.6	206.4
Sa	280.2	280.0	279.8	280.5	280.3	280.0	279.8	280.5	280.3	280.1	279.8	280.6	280.3	280.1	279.8	280.6	280.4	280.1	279.9	280.6
Ssa	200.5	200.0	199.5	201.0	200.5	200.0	199.6	201.1	200.6	200.1	199.6	201.1	200.6	200.2	199.7	201.2	200.7	200.2	199.8	201.3

TABLE 15.—*Equilibrium argument* (V_0+u) *for meridian of Greenwich at beginning of each calendar year, 1850 to 2000*—Continued.

Component.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	°	°	°	°	°	°	°	°	°	°	°
J_1	314.4	45.2	135.2	237.9	325.0	50.2	134.0	231.1	322.5	39.3	125.8
K_1	16.7	18.0	18.7	19.4	18.0	15.6	12.2	9.5	6.0	3.2	1.5
K_2	213.9	216.6	217.6	218.5	215.4	210.3	204.0	199.2	192.7	187.2	183.4
L_2	2.2	212.4	49.0	205.8	30.4	229.4	66.7	242.7	59.3	244.2	83.7
M_1	85.9	33.5	305.0	184.1	79.3	4.9	293.5	176.9	64.8	319.9	251.4
M_2	259.4	0.5	101.3	177.6	278.0	18.2	118.3	194.0	294.0	34.2	134.5
M_3	29.1	0.7	332.0	266.4	237.0	207.3	177.4	110.9	81.0	51.3	21.8
M_4	158.7	0.9	202.7	355.2	196.0	36.4	236.6	27.9	228.0	68.4	269.1
M_6	58.1	1.4	304.0	172.8	114.0	54.6	354.9	221.9	162.1	102.6	43.6
M_8	317.5	1.9	45.3	350.3	31.9	72.8	113.2	55.8	96.1	136.8	178.1
N_2	324.3	336.7	348.8	323.3	334.9	346.4	357.8	331.7	83.0	354.5	6.1
2N	29.2	312.8	236.3	108.9	31.9	314.6	237.3	109.4	32.0	314.7	237.6
O_1	240.1	239.0	78.7	154.0	256.1	359.7	104.8	185.2	290.5	34.6	137.2
OO	338.4	243.8	146.6	73.2	327.7	217.2	102.3	12.5	256.5	144.4	37.4
P_1	349.6	349.8	350.1	349.3	349.6	349.8	350.1	349.3	349.6	349.8	350.0
Q_1	305.0	315.2	326.1	299.7	313.0	327.9	344.3	322.9	339.5	354.9	8.8
2Q	9.9	291.4	213.6	85.4	10.0	296.2	223.8	100.6	28.5	315.2	240.3
R_2	177.6	177.4	177.1	177.8	177.6	177.3	177.1	177.8	177.5	177.3	177.0
S_1	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0
$S_{2,4,6}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_2	2.4	2.6	2.9	2.2	2.4	2.7	2.9	2.2	2.5	2.7	3.0
λ_2	246.6	158.2	69.6	327.7	238.6	149.4	60.0	317.5	228.1	138.8	49.6
μ_2	157.1	358.9	200.5	353.2	194.3	35.3	236.1	28.2	229.0	69.9	271.0
ν_2	92.2	22.7	313.1	207.5	137.4	67.0	356.6	250.4	180.0	109.6	39.4
ρ_1	72.9	1.3	290.4	183.9	115.4	48.6	343.1	241.6	176.5	110.1	42.1
MK	276.0	18.5	120.0	197.0	296.0	33.8	130.5	203.4	300.0	37.4	136.0
2MK	142.1	342.9	184.0	335.8	177.9	20.8	224.4	18.4	222.1	65.2	267.6
MN	223.6	337.1	90.1	140.8	252.9	4.6	116.1	165.6	277.0	28.7	140.6
MS	259.4	0.5	101.3	177.6	278.0	18.2	118.3	194.0	294.0	34.2	134.5
2SM	100.6	359.5	258.7	182.4	82.0	341.8	241.7	166.0	66.0	325.8	225.5
Mf	319.2	222.4	124.0	49.6	305.9	198.8	88.8	3.7	253.0	144.9	40.1
MSf	100.6	359.5	258.7	182.4	82.0	341.8	241.7	166.0	66.0	325.8	225.5
Mm	295.1	23.8	112.5	214.3	303.0	31.8	120.5	222.3	311.0	39.7	128.4
Sa	280.4	280.2	279.9	280.7	280.4	280.2	279.9	280.7	280.4	280.2	280.0
Ssa	200.8	200.3	199.8	201.3	200.8	200.4	199.9	201.4	200.9	200.4	200.0

TABLE 16.—*Differences to adapt Table 15 to beginning of each calendar month.*

Component.	Month of year.*											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
J_1	0.00	75.57	108.99	184.56	246.08	321.65	23.17	98.74	174.31	235.82	311.39	12.91
K_1	0.00	30.56	58.15	88.71	118.28	148.83	178.40	208.96	239.51	269.08	299.64	329.21
K_2	0.00	61.11	116.31	177.42	236.56	297.66	356.80	57.91	119.02	178.16	239.27	298.41
L_2	0.00	9.19	52.33	61.54	82.02	91.21	111.71	120.90	130.09	150.59	159.78	180.29
M_1†	0.00	345.54	7.32	352.86	350.48	336.02	333.64	319.18	304.72	302.34	287.88	285.50
M_1	0.00	342.09	0.75	342.83	337.11	319.20	313.47	295.56	277.65	271.93	254.01	248.29
M_2	0.00	324.17	1.49	325.66	314.22	278.39	266.95	231.12	195.30	183.85	148.02	136.58
M_3	0.00	306.26	2.24	308.50	291.33	237.59	220.42	166.68	112.94	95.78	42.04	24.87
M_4	0.00	288.35	2.98	291.33	268.44	196.79	173.90	102.24	30.59	7.70	296.05	273.16
M_6	0.00	252.52	4.48	257.00	222.66	115.18	80.85	333.37	225.89	191.55	84.07	49.74
M_8	0.00	216.69	5.97	222.66	176.88	33.58	347.80	204.49	61.18	15.40	232.10	186.32
N_2	0.00	279.16	310.66	229.82	186.42	105.58	62.18	341.34	260.50	217.11	136.27	92.87
2N	0.00	234.14	259.82	133.97	58.62	292.77	217.42	91.57	325.71	250.36	124.51	49.16
O_1	0.00	293.62	303.34	236.96	195.94	129.56	88.55	22.16	315.78	274.77	208.39	167.37
OO	0.00	127.49	172.97	300.46	40.61	168.10	268.26	35.75	163.24	263.39	30.89	131.04
P_1	0.00	329.44	301.85	271.29	241.72	211.17	181.60	151.04	120.49	90.92	60.36	30.79
Q_1	0.00	248.60	252.50	141.11	68.14	316.75	243.78	132.39	20.99	308.03	196.63	123.67
2Q	0.00	203.59	201.67	45.26	300.34	143.93	39.02	242.61	86.20	341.28	184.87	79.96
R_2	0.00	30.56	58.15	88.71	118.28	148.83	178.40	208.96	239.51	269.08	299.64	329.21
S‡	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_2	0.00	329.44	301.85	271.29	241.72	211.17	181.60	151.04	120.49	90.92	60.36	30.79
λ_2	0.00	314.98	309.16	264.15	232.20	187.19	155.24	110.22	65.21	33.26	348.24	316.29
μ_2	0.00	288.35	2.98	291.33	268.44	196.79	173.90	102.24	30.59	7.70	296.05	273.16
ν_2	0.00	333.36	53.82	27.18	36.24	9.60	18.66	352.02	325.38	334.44	307.81	316.87
ρ_1	0.00	302.81	355.66	298.47	277.96	220.77	200.26	143.07	85.87	65.36	8.17	347.66
MK	0.00	354.73	59.64	54.37	72.50	67.23	85.35	80.08	74.81	92.93	87.66	105.79
2MK	0.00	257.79	304.83	202.62	150.16	47.96	355.50	253.29	151.08	98.62	356.41	303.95
MN	0.00	243.33	312.15	195.48	140.64	23.97	329.13	212.47	95.80	40.96	284.29	229.45
MS	0.00	324.17	1.49	325.66	314.22	278.39	266.95	231.12	195.30	183.85	148.02	136.58
2SM	0.00	35.83	358.51	34.34	45.78	81.61	93.05	128.88	164.70	176.15	211.98	223.42
Mf	0.00	96.94	114.82	211.75	282.34	19.27	89.86	186.79	283.73	354.31	91.25	161.83
MSf	0.00	35.83	358.51	34.34	45.78	81.61	93.05	128.88	164.70	176.15	211.98	223.42
Mm	0.00	45.02	50.84	95.85	127.80	172.81	204.76	249.78	294.79	326.74	11.76	43.71
Sa	0.00	30.56	58.15	88.71	118.28	148.83	178.40	208.96	239.51	269.08	299.64	329.21
Ssa	0.00	61.11	116.31	177.42	236.56	297.66	356.80	57.91	119.02	178.16	239.27	298.41

* This table was designed for direct use for common years. For a leap year the values given for the months of March to December, inclusive, apply to the last day of the preceding month, but may be used directly, provided an allowance is made in the day of month as indicated in the following table.

† The first line for component M_1 gives the difference as based upon the formula in Table 3; the second line gives the differences as derived from the half speed of component M_2.

‡ The differences for components S_1, S_2, S_4, S_6, etc., are each zero for every month.

TABLE 17.—*Differences to adapt Table 15 to beginning of each day of month.*

Component.	Day of month.*										
	1	2	3	4	5	6	7	8	9	10	11
	°	°	°	°	°	°	°	°	°	°	°
J_1	0.00	14.05	28.10	42.15	56.20	70.25	84.30	98.35	112.41	126.46	140.51
K_1	0.00	0.99	1.97	2.96	3.94	4.93	5.91	6.90	7.88	8.87	9.86
K_2	0.00	1.97	3.94	5.91	7.88	9.86	11.83	13.80	15.77	17.74	19.71
L_2	0.00	348.68	337.37	326.05	314.73	303.42	292.10	280.78	269.47	258.15	246.84
M_1†	0.00	347.92	335.84	323.76	311.68	299.60	287.52	275.44	263.37	251.29	239.21
M_1	0.00	347.81	335.62	323.43	311.24	299.05	286.86	274.66	262.47	250.28	238.09
M_2	0.00	335.62	311.24	286.86	262.47	238.09	213.71	189.33	164.95	140.57	116.18
M_3	0.00	323.43	286.86	250.28	213.71	177.14	140.57	103.99	67.42	30.85	354.28
M_4	0.00	311.24	262.47	213.71	164.95	116.18	67.42	18.66	329.90	281.13	232.37
M_6	0.00	286.86	213.71	140.57	67.42	354.28	281.13	207.99	134.84	61.70	348.56
M_8	0.00	262.47	164.95	67.42	329.90	232.37	134.84	37.32	299.79	202.27	104.74
N_2	0.00	322.55	285.11	247.66	210.21	172.77	135.32	97.88	60.43	22.98	345.54
2N	0.00	309.49	258.98	208.47	157.95	107.44	56.93	6.42	315.91	265.40	214.89
O_1	0.00	334.63	309.27	283.90	258.53	233.16	207.80	182.43	157.06	131.70	106.33
OO	0.00	27.34	54.68	82.02	109.35	136.69	164.03	191.37	218.71	246.05	273.38
P_1	0.00	−0.99	−1.97	−2.96	−3.94	−4.93	−5.91	−6.90	−7.88	−8.87	−9.86
Q_1	0.00	321.57	283.14	244.70	206.27	167.84	129.41	90.98	52.54	14.11	335.68
2Q	0.00	308.50	257.01	205.51	154.01	102.51	51.02	359.52	308.02	256.53	205.03
R_2	0.00	0.99	1.97	2.96	3.94	4.93	5.91	6.90	7.88	8.87	9.86
S‡	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_2	0.00	−0.99	−1.97	−2.96	−3.94	−4.93	−5.91	−6.90	−7.88	−8.87	−9.86
λ_2	0.00	346.93	333.87	320.80	307.74	294.68	281.61	268.54	255.48	242.42	229.35
μ_2	0.00	311.24	262.47	213.71	164.95	116.18	67.42	18.66	329.90	281.13	232.37
ν_2	0.00	324.30	288.60	252.91	217.21	181.51	145.81	110.11	74.42	38.72	3.02
ρ_1	0.00	323.32	286.63	249.95	213.27	176.58	139.90	103.21	66.53	29.85	353.16
MK	0.00	336.60	313.21	289.81	266.42	243.02	219.62	196.23	172.83	149.44	126.04
2MK	0.00	310.25	260.50	210.75	161.00	111.26	61.51	11.76	322.01	272.26	222.51
MN	0.00	298.17	236.34	174.52	112.69	50.86	349.03	287.20	225.38	163.55	101.72
MS	0.00	335.62	311.24	286.86	262.47	238.09	213.71	189.33	164.95	140.57	116.18
2SM	0.00	24.38	48.76	73.14	97.53	121.91	146.29	170.67	195.05	219.43	243.82
Mf	0.00	26.35	52.71	79.06	105.41	131.76	158.12	184.47	210.82	237.18	263.53
MSf	0.00	24.38	48.76	73.14	97.53	121.91	146.29	170.67	195.05	219.43	243.82
Mm	0.00	13.07	26.13	39.20	52.26	65.32	78.39	91.46	104.52	117.58	130.65
Sa	0.00	0.99	1.97	2.96	3.94	4.93	5.91	6.90	7.88	8.87	9.86
Ssa	0.00	1.97	3.94	5.91	7.88	9.86	11.83	13.80	15.77	17.74	19.71

*The table is adapted directly for use with common years, but if the required date falls between Mar. 1 and Dec. 31, inclusive, in a leap year the day of month should be increased by one before entering the table.

†The first line for component M_1 gives the differences as based upon the formula in Table 3, the second line gives the differences as derived from the half speed of component M_2.

‡The differences for components S_1, S_2, S_4, S_6, etc., are each zero for the beginning of every day.

TABLE 17.—*Differences to adapt Table 15 to beginning of each day of month*—Continued.

Component.	Day of month.* 12	13	14	15	16	17	18	19	20	21	22
	°	°	°	°	°	°	°	°	°	°	°
J_1	154.56	168.61	182.66	196.71	210.76	224.81	238.86	252.91	266.96	281.01	295.06
K_1	10.84	11.83	12.81	13.80	14.78	15.77	16.76	17.74	18.73	19.71	20.70
K_2	21.68	23.66	25.63	27.60	29.57	31.54	33.51	35.48	37.46	39.43	41.40
L_2	235.52	224.20	212.88	201.57	190.25	178.94	167.62	156.30	144.99	133.67	122.35
M_1†	227.13	215.05	202.97	190.89	178.81	166.73	154.65	142.57	130.49	118.41	106.33
	225.90	213.71	201.52	189.33	177.14	164.95	152.76	140.57	128.38	116.19	103.99
M_2	91.80	67.42	43.04	18.66	354.28	329.90	305.52	281.13	256.75	232.37	207.99
M_3	317.70	281.13	244.56	207.99	171.42	134.84	98.27	61.70	25.13	348.56	311.98
M_4	183.61	134.84	86.08	37.32	348.56	299.79	251.03	202.27	153.50	104.74	55.98
M_6	275.41	202.27	129.12	55.98	342.83	269.69	196.54	123.40	50.26	337.11	263.97
M_8	7.21	269.69	172.16	74.64	337.11	239.58	142.06	44.53	307.01	209.48	111.95
N_2	308.09	270.64	233.20	195.75	158.30	120.86	83.41	45.96	8.52	331.07	293.62
2N	164.37	113.86	63.35	12.84	322.33	271.82	221.30	170.79	120.28	69.77	19.26
O	80.96	55.59	30.23	4.86	339.49	314.13	288.76	263.39	238.02	212.66	187.29
OO	300.72	328.06	355.40	22.74	50.08	77.42	104.75	132.09	159.43	186.77	214.11
P_1	−10.84	−11.83	−12.81	−13.80	−14.78	−15.77	−16.76	−17.74	−18.73	−19.71	−20.70
Q_1	297.25	258.81	220.38	181.95	143.52	105.09	66.65	28.22	349.79	311.36	272.92
2Q	153.53	102.03	50.54	359.04	307.54	256.05	204.55	153.05	101.55	50.06	358.56
R_2	10.84	11.83	12.81	13.80	14.78	15.77	16.76	17.74	18.73	19.71	20.70
S‡	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_2	−10.84	−11.83	−12.81	−13.80	−14.78	−15.77	−16.76	−17.74	−18.73	−19.71	−20.70
λ_2	216.28	203.22	190.16	177.09	164.02	150.96	137.90	124.83	111.76	98.70	85.64
μ_2	183.61	134.84	86.08	37.32	348.56	299.79	251.03	202.27	153.50	104.74	55.98
ν_2	327.32	291.62	255.93	220.23	184.53	148.83	113.13	77.44	41.74	6.04	330.34
ρ_1	316.48	279.80	243.11	206.43	169.75	133.06	96.38	59.69	23.01	346.33	309.64
MK	102.65	79.25	55.85	32.46	9.06	345.67	322.27	298.88	275.48	252.08	228.69
2MK	172.76	123.02	73.27	23.52	333.77	284.02	234.27	184.52	134.78	85.03	35.28
MN	39.89	338.06	276.24	214.41	152.58	90.75	28.92	327.10	265.27	203.44	141.61
MS	91.80	67.42	43.04	18.66	354.28	329.90	305.52	281.13	256.75	232.37	207.99
2SM	268.20	292.58	316.96	341.34	5.72	30.10	54.48	78.87	103.25	127.63	152.01
Mf	289.88	316.23	342.59	8.94	35.29	61.64	88.00	114.35	140.70	167.06	193.41
MSf	268.20	292.58	316.96	341.34	5.72	30.10	54.48	78.87	103.25	127.63	152.01
Mm	143.72	156.78	169.84	182.91	195.98	209.04	222.10	235.17	248.24	261.30	274.36
Sa	10.84	11.83	12.81	13.80	14.78	15.77	16.76	17.74	18.73	19.71	20.70
Ssa	21.68	23.66	25.63	27.60	29.57	31.54	33.51	35.48	37.46	39.43	41.40

*The table is adapted directly for use with common years, but if the required date falls between Mar. 1 and Dec. 31, inclusive, in a leap year the day of month should be increased by one before entering the table.

†The first line for component M_1 gives the differences as based upon the formula in Table 3 the second line gives the differences as derived from the half speed of component M_2.

‡The differences for components S_1, S_2, S_4, S_6, etc., are each zero for the beginning of every day.

TABLE 17.—*Differences to adapt Table 15 to beginning of each day of month*—Continued.

Component.	Day of month.*									
	23	24	25	26	27	28	29	30	31	32
	°	°	°	°	°	°	°	°	°	°
J_1	309.11	323.16	337.22	351.27	5.32	19.37	33.42	47.47	61.52	75.57
K_1	21.68	22.67	23.66	24.64	25.63	26.61	27.60	28.58	29.57	30.56
K_2	43.37	45.34	47.31	49.28	51.25	53.22	55.20	57.17	59.14	61.11
L_2	111.04	99.72	88.40	77.09	65.77	54.45	43.14	31.82	20.50	9.19
M_1†	94.25	82.18	70.10	58.02	45.94	33.86	21.78	9.70	357.62	345.54
M_1	91.80	79.61	67.42	55.23	43.04	30.85	18.66	6.47	354.28	342.09
M_2	183.61	159.23	134.84	110.46	86.08	61.70	37.32	12.94	348.56	324.17
M_3	275.41	238.84	202.27	165.69	129.12	92.55	55.98	19.40	342.83	306.26
M_4	7.21	318.45	269.69	220.92	172.16	123.40	74.64	25.87	337.11	288.35
M_6	190.82	117.68	44.53	331.39	258.24	185.10	111.95	38.81	325.66	252.52
M_8	14.43	276.90	179.38	81.85	344.32	246.80	149.27	51.75	314.22	216.69
N_2	256.18	218.73	181.28	143.84	106.39	68.94	31.50	354.05	316.60	279.16
$2N$	328.75	278.24	227.72	177.21	126.70	76.19	25.68	335.17	284.66	231.11
O_1	161.92	136.56	111.19	85.82	60.45	35.09	9.72	344.35	318.99	293.62
OO	241.45	268.78	296.12	323.46	350.80	18.14	45.48	72.81	100.15	127.49
P_1	−21.68	−22.67	−23.66	−24.64	−25.63	−26.61	−27.60	−28.58	−29.57	−30.56
Q_1	234.49	196.06	157.63	119.20	80.76	42.33	3.90	325.47	287.04	248.60
$2Q$	307.06	255.57	204.07	152.57	101.07	49.58	358.08	306.58	255.09	203.59
R_2	21.68	22.67	23.66	24.64	25.63	26.61	27.60	28.58	29.57	30.56
S‡	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_2	−21.68	−22.67	−23.66	−24.64	−25.63	−26.61	−27.60	−28.58	−29.57	−30.56
λ_2	72.57	59.50	46.44	33.38	20.31	7.24	354.18	341.12	328.05	314.98
μ_2	7.21	318.45	269.69	220.92	172.16	123.40	74.64	25.87	337.11	288.35
ν_2	294.61	258.95	223.25	187.55	151.85	116.15	80.46	44.76	9.06	333.36
ρ_1	272.96	236.28	199.59	162.91	126.22	89.54	52.86	16.17	339.49	302.81
MK	205.29	181.90	158.50	135.10	111.71	88.31	64.92	41.52	18.12	354.73
2MK	345.53	295.78	246.03	196.28	146.54	96.79	47.04	357.29	307.54	257.79
MN	79.78	17.96	316.13	254.30	192.47	130.64	68.82	6.99	305.16	243.33
MS	183.61	159.23	134.84	110.46	86.08	61.70	37.32	12.94	348.56	324.17
2SM	176.39	200.77	225.16	249.54	273.92	298.30	322.68	347.06	11.44	35.83
Mf	219.76	246.11	272.47	298.82	325.17	351.52	17.88	44.23	70.58	96.64
MSf	176.39	200.77	225.16	249.54	273.92	298.30	322.68	347.06	11.44	35.83
Mm	287.43	300.50	313.56	326.62	339.69	352.76	5.82	18.88	31.95	45.02
Sa	21.68	22.67	23.66	24.64	25.63	26.61	27.60	28.58	29.57	30.56
Ssa	43.37	45.34	47.31	49.28	51.25	53.22	55.20	57.17	59.14	61.11

* The table is adapted directly for use with common years but if the required date falls between Mar. 1 and Dec. 31, inclusive, in a leap year the day of month should be increased by one before entering the table.

† The first line for component M_1 gives the differences as based upon the formula in Table 3; the second line gives the differences as derived from the half speed of component M_2.

‡ The differences for components S_1, S_2, S_4, S_6, etc., are each zero for the beginning of every day.

Table 18.—*Differences to adapt Table 15 to beginning of each hour of day.*

Component.	Hour of day.											
	0	1	2	3	4	5	6	7	8	9	10	11
	°	°	°	°	°	°	°	°	°	°	°	°
J_1	0.00	15.59	31.17	46.76	62.34	77.93	93.51	109.10	124.68	140.27	155.85	171.44
K_1	0.00	15.04	30.08	45.12	60.16	75.21	90.25	105.29	120.33	135.37	150.41	165.45
K_2	0.00	30.08	60.16	90.25	120.33	150.41	180.49	210.57	240.66	270.74	300.82	330.90
L_2	0.00	29.53	59.06	88.59	118.11	147.64	177.17	206.70	236.23	365.76	295.28	324.81
M_1†	0.00	14.50	28.99	43.49	57.99	72.48	86.98	101.48	115.97	130.47	144.97	159.46
M_1	0.00	14.49	28.98	43.48	57.97	72.46	86.95	101.44	115.94	130.43	144.92	159.41
M_2	0.00	28.98	57.97	86.95	115.94	144.92	173.90	202.89	231.87	260.86	289.84	318.83
M_3	0.00	43.48	86.95	130.43	173.90	217.38	260.86	304.33	347.81	31.29	74.76	118.24
M_4	0.00	57.97	115.94	173.90	231.87	289.84	347.81	45.78	103.75	161.71	219.68	277.65
M_6	0.00	86.95	173.90	260.86	347.81	74.76	161.71	248.67	335.62	62.57	149.52	236.48
M_8	0.00	115.94	231.87	347.81	103.75	219.68	335.62	91.55	207.49	323.43	79.36	195.30
N_2	0.00	28.44	56.88	85.32	113.76	142.20	170.64	199.08	227.52	255.96	284.40	312.84
2N	0.00	27.90	55.79	83.69	111.58	139.48	167.37	195.27	223.16	251.06	278.95	306.85
O_1	0.00	13.94	27.89	41.83	55.77	69.72	83.66	97.60	111.54	125.49	139.43	153.37
OO	0.00	16.14	32.28	48.42	64.56	80.70	96.83	112.97	129.11	145.25	161.39	177.53
P_1	0.00	14.96	29.92	44.88	59.84	74.79	89.75	104.71	119.67	134.63	149.59	164.55
Q_1	0.00	13.40	26.80	40.20	53.59	66.99	80.39	93.79	107.19	120.59	133.99	147.39
2Q	0.00	12.85	25.71	38.56	51.42	64.27	77.13	89.98	102.83	115.69	128.54	141.40
R_2	0.00	30.04	60.08	90.12	120.16	150.21	180.25	210.29	240.33	270.37	300.41	330.45
S_1	0.00	15.00	30.00	45.00	60.00	75.00	90.00	105.00	120.00	135.00	150.00	165.00
S_2	0.00	30.00	60.00	90.00	120.00	150.00	180.00	210.00	240.00	270.00	300.00	330.00
S_4	0.00	60.00	120.00	180.00	240.00	300.00	0.00	60.00	120.00	180.00	240.00	300.00
S_6	0.00	90.00	180.00	270.00	0.00	90.00	180.00	270.00	0.00	90.00	180.00	270.00
T_2	0.00	29.96	59.92	89.88	119.84	149.79	179.75	209.71	239.67	269.63	299.59	329.55
λ_2	0.00	29.46	58.91	88.37	117.82	147.28	176.73	206.19	235.65	265.10	294.56	324.01
μ_2	0.00	27.97	55.94	83.90	111.87	139.84	167.81	195.78	223.75	251.71	279.68	307.65
ν_2	0.00	28.51	57.03	85.54	114.05	142.56	171.08	199.59	228.10	256.61	285.13	313.64
ρ_1	0.00	13.47	26.94	40.41	53.89	67.36	80.83	94.30	107.77	121.24	134.72	148.19
MK	0.00	44.03	88.05	132.08	176.10	220.13	264.15	308.18	352.20	36.23	80.25	124.28
2MK	0.00	42.93	85.85	128.78	171.71	214.64	257.56	300.49	343.42	26.34	69.27	112.20
MN	0.00	57.42	114.85	172.27	229.70	287.12	344.54	41.97	99.39	156.81	214.24	271.66
MS	0.00	58.98	117.97	176.95	235.94	294.92	353.90	52.89	111.87	170.86	229.84	288.83
2SM	0.00	31.02	62.03	93.05	124.06	155.08	186.10	217.11	248.13	279.14	310.16	341.17
Mf	0.00	1.10	2.20	3.29	4.39	5.49	6.59	7.69	8.78	9.88	10.98	12.08
MSf	0.00	1.02	2.03	3.05	4.06	5.08	6.10	7.11	8.13	9.14	10.16	11.17
Mm	0.00	0.54	1.09	1.63	2.18	2.72	3.27	3.81	4.35	4.90	5.44	5.99
Sa	0.00	0.04	0.08	0.12	0.16	0.21	0.25	0.29	0.33	0.37	0.41	0.45
Ssa	0.00	0.08	0.16	0.25	0.33	0.41	0.49	0.57	0.66	0.74	0.82	0.90

† The first line for component M_1 gives the differences as based upon the formula in Table 3; the second line gives the differences as derived from the half speed of component M_2.

TABLE 18.—*Differences to adapt Table 15 to beginning of each hour of day*—Continued.

Component.	Hour of day.											
	12	13	14	15	16	17	18	19	20	21	22	23
	°	°	°	°	°	°	°	°	°	°	°	°
J_1	187.03	202.61	218.20	233.78	249.37	264.95	280.54	296.12	311.71	327.29	342.88	358.47
K_1	180.49	195.53	210.57	225.62	240.66	255.70	270.74	285.78	300.82	315.86	330.90	345.94
K_2	0.99	31.07	61.15	91.23	121.31	151.40	181.48	211.56	241.64	271.72	301.81	331.89
L_2	354.34	23.87	53.40	82.93	112.46	141.98	171.51	201.04	230.57	260.10	289.63	319.16
M_1†	173.96	188.46	202.95	217.45	231.95	246.44	260.94	275.44	289.93	304.43	318.93	333.42
M_1	173.90	188.40	202.89	217.38	231.87	246.36	260.86	275.35	289.84	304.33	318.83	333.32
M_2	347.81	16.79	45.78	74.76	103.75	132.73	161.71	190.70	219.68	248.67	277.65	306.63
M_3	161.71	205.19	248.67	292.14	335.62	19.09	62.57	106.05	149.52	193.00	236.48	279.95
M_4	335.62	33.59	91.55	149.52	207.49	265.46	323.43	381.40	79.36	137.33	195.30	253.27
M_6	323.43	50.38	137.33	224.28	311.24	38.19	125.14	212.09	299.05	26.00	112.95	199.90
M_8	311.24	67.17	183.11	299.05	54.98	170.92	286.86	42.79	158.73	274.66	30.60	146.54
N_2	341.28	9.72	38.16	66.60	95.04	123.48	151.92	180.35	208.79	237.23	265.67	294.11
2N	334.74	2.64	30.53	58.43	86.33	114.22	142.12	170.01	197.91	225.80	253.70	281.59
O_1	167.32	181.26	195.20	209.15	223.09	237.03	250.97	264.92	278.86	292.80	306.75	320.69
OO	193.67	209.81	225.95	242.09	258.23	274.36	290.50	306.64	322.78	338.92	355.06	11.20
P_1	179.51	194.47	209.43	224.38	239.34	254.30	269.26	284.22	299.18	314.14	329.10	344.06
Q_1	160.78	174.18	187.58	200.98	214.38	227.78	241.18	254.57	267.97	281.37	294.77	308.17
2Q	154.25	167.11	179.96	192.81	205.67	218.52	231.38	244.23	257.09	269.94	282.79	295.65
R_2	0.49	30.53	60.57	90.62	120.66	150.70	180.74	210.78	240.82	270.86	300.90	330.94
S_1	180.00	195.00	210.00	225.00	240.00	255.00	270.00	285.00	300.00	315.00	330.00	345.00
S_2	0.00	30.00	60.00	90.00	120.00	150.00	180.00	210.00	240.00	270.00	300.00	330.00
S_4	0.00	60.00	120.00	180.00	240.00	300.00	0.00	60.00	120.00	180.00	240.00	300.00
S_6	0.00	90.00	180.00	270.00	0.00	90.00	180.00	270.00	0.00	90.00	180.00	270.00
T_2	359.51	29.47	59.43	89.38	119.34	149.30	179.26	209.22	239.18	269.14	299.10	329.06
λ_2	353.47	22.92	52.38	81.83	111.29	140.75	170.20	199.66	229.11	258.57	288.02	317.48
μ_2	335.62	3.59	31.55	59.52	87.49	115.46	143.43	171.40	199.36	227.33	255.30	283.27
ν_2	342.15	10.66	39.18	67.69	96.20	124.71	153.23	181.74	210.25	238.76	267.28	295.79
ρ_1	161.66	175.13	188.60	202.07	215.54	229.02	242.49	255.96	269.43	282.90	296.37	309.84
MK	168.30	212.33	256.35	300.38	344.40	28.43	72.45	116.48	160.50	204.53	248.55	292.58
2MK	155.13	198.05	240.98	283.91	326.83	9.76	52.69	95.62	138.54	181.47	224.40	267.32
MN	329.09	26.51	83.93	141.36	198.78	256.21	313.63	11.05	68.48	125.90	183.32	240.75
MS	347.81	46.79	105.78	164.76	223.75	282.73	341.71	40.70	99.68	158.67	217.65	276.63
2SM	12.19	43.21	74.22	105.24	136.25	167.27	198.29	229.30	260.32	291.33	322.35	353.37
Mf	13.18	14.27	15.37	16.47	17.57	18.67	19.76	20.86	21.96	23.06	24.16	25.25
MSf	12.19	13.21	14.22	15.24	16.25	17.27	18.29	19.30	20.32	21.33	22.35	23.37
Mm	6.53	7.08	7.62	8.17	8.71	9.25	9.80	10.34	10.89	11.43	11.98	12.52
Sa	0.49	0.53	0.57	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.94
Ssa	0.99	1.07	1.15	1.23	1.31	1.40	1.48	1.56	1.64	1.72	1.81	1.89

†The first line for component M_1 gives the differences as based upon the formula in Table 3; the second line gives the differences as derived from the half speed of component M_2.

TABLE 19.—*Products for Form 194.*

[Multiplier=sin 15°=0.259.]

	0	1	2	3	4	5	6	7	8	9
0.00	0.000	0.259	0.518	0.777	1.036	1.295	1.554	1.813	2.072	2.331
.01	.003	.262	.521	.780	1.039	1.298	1.557	1.816	2.075	2.334
.02	.005	.264	.523	.782	1.041	1.300	1.559	1.818	2.077	2.336
.03	.008	.267	.526	.785	1.044	1.303	1.562	1.821	2.080	2.339
.04	.010	.269	.528	.787	1.046	1.305	1.564	1.823	2.082	2.341
.05	.013	.272	.531	.790	1.049	1.308	1.567	1.826	2.085	2.344
.06	.016	.275	.534	.793	1.052	1.311	1.570	1.829	2.088	2.347
.07	.018	.277	.536	.795	1.054	1.313	1.572	1.831	2.090	2.349
.08	.021	.280	.539	.798	1.057	1.316	1.575	1.834	2.093	2.352
.09	.023	.282	.541	.800	1.059	1.318	1.577	1.836	2.095	2.354
.10	.026	.285	.544	.803	1.062	1.321	1.580	1.839	2.098	2.357
.11	.028	.287	.546	.805	1.064	1.323	1.582	1.841	2.100	2.359
.12	.031	.290	.549	.808	1.067	1.326	1.585	1.844	2.103	2.362
.13	.034	.293	.552	.811	1.070	1.329	1.588	1.847	2.106	2.365
.14	.036	.295	.554	.813	1.072	1.331	1.590	1.849	2.108	2.367
.15	.039	.298	.557	.816	1.075	1.334	1.593	1.852	2.111	2.370
.16	.041	.300	.559	.818	1.077	1.336	1.595	1.854	2.113	2.372
.17	.044	.303	.562	.821	1.080	1.339	1.598	1.857	2.116	2.375
.18	.047	.306	.565	.824	1.083	1.342	1.601	1.860	2.119	2.378
.19	.049	.308	.567	.826	1.085	1.344	1.603	1.862	2.121	2.380
.20	.052	.311	.570	.829	1.088	1.347	1.606	1.865	2.124	2.383
.21	.054	.313	.572	.831	1.090	1.349	1.608	1.867	2.126	2.385
.22	.057	.316	.575	.834	1.093	1.352	1.611	1.870	2.129	2.388
.23	.060	.319	.578	.837	1.096	1.355	1.614	1.873	2.132	2.391
.24	.062	.321	.580	.839	1.098	1.357	1.616	1.875	2.134	2.393
.25	.065	.324	.583	.842	1.101	1.360	1.619	1.878	2.137	2.396
.26	.067	.326	.585	.844	1.103	1.362	1.621	1.880	2.139	2.398
.27	.070	.329	.588	.847	1.106	1.365	1.624	1.883	2.142	2.401
.28	.073	.332	.591	.850	1.109	1.368	1.627	1.886	2.145	2.404
.29	.075	.334	.593	.852	1.111	1.370	1.629	1.888	2.147	2.406
.30	.078	.337	.596	.855	1.114	1.373	1.632	1.891	2.150	2.409
.31	.080	.339	.598	.857	1.116	1.375	1.634	1.893	2.152	2.411
.32	.083	.342	.601	.860	1.119	1.378	1.637	1.896	2.155	2.414
.33	.085	.344	.603	.862	1.121	1.380	1.639	1.898	2.157	2.416
.34	.088	.347	.606	.865	1.124	1.383	1.642	1.901	2.160	2.419
.35	.091	.350	.609	.868	1.127	1.386	1.645	1.904	2.163	2.422
.36	.093	.352	.611	.870	1.129	1.388	1.647	1.906	2.165	2.424
.37	.096	.355	.614	.873	1.132	1.391	1.650	1.909	2.168	2.427
.38	.098	.357	.616	.875	1.134	1.393	1.652	1.911	2.170	2.429
.39	.101	.360	.619	.878	1.137	1.396	1.655	1.914	2.173	2.432
.40	.104	.363	.622	.881	1.140	1.399	1.658	1.917	2.176	2.435
.41	.106	.365	.624	.883	1.142	1.401	1.660	1.919	2.178	2.437
.42	.109	.368	.627	.886	1.145	1.404	1.663	1.922	2.181	2.440
.43	.111	.370	.629	.888	1.147	1.406	1.665	1.924	2.183	2.442
.44	.114	.373	.632	.891	1.150	1.409	1.668	1.927	2.186	2.445
.45	.117	.376	.635	.894	1.153	1.412	1.671	1.930	2.189	2.448
.46	.119	.378	.637	.896	1.155	1.414	1.673	1.932	2.191	2.450
.47	.122	.381	.640	.899	1.158	1.417	1.676	1.935	2.194	2.453
.48	.124	.383	.642	.901	1.160	1.419	1.678	1.937	2.196	2.455
.49	.127	.386	.645	.904	1.163	1.422	1.681	1.940	2.199	2.458
.50	.130	.388	.648	.906	1.166	1.424	1.684	1.942	2.202	2.460
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 15°=0.259.]

	0	1	2	3	4	5	6	7	8	9
0.50	0.130	0.388	0.648	0.906	1.166	1.424	1.684	1.942	2.202	2.460
.51	.132	.391	.650	.909	1.168	1.427	1.686	1.945	2.204	2.463
.52	.135	.394	.653	.912	1.171	1.430	1.689	1.948	2.207	2.466
.53	.137	.396	.655	.914	1.173	1.432	1.691	1.950	2.209	2.468
.54	.140	.399	.658	.917	1.176	1.435	1.694	1.953	2.212	2.471
.55	.142	.401	.660	.919	1.178	1.437	1.696	1.955	2.214	2.473
.56	.145	.404	.663	.922	1.181	1.440	1.699	1.958	2.217	2.476
.57	.148	.407	.666	.925	1.184	1.443	1.702	1.961	2.220	2.479
.58	.150	.409	.668	.927	1.186	1.445	1.704	1.963	2.222	2.481
.59	.153	.412	.671	.930	1.189	1.448	1.707	1.966	2.225	2.484
.60	.155	.414	.673	.932	1.191	1.450	1.709	1.968	2.227	2.486
.61	.158	.417	.676	.935	1.194	1.453	1.712	1.971	2.230	2.489
.62	.161	.420	.679	.938	1.197	1.456	1.715	1.974	2.233	2.492
.63	.163	.422	.681	.940	1.199	1.458	1.717	1.976	2.235	2.494
.64	.166	.425	.684	.943	1.202	1.461	1.720	1.979	2.238	2.497
.65	.168	.427	.686	.945	1.204	1.463	1.722	1.981	2.240	2.499
.66	.171	.430	.689	.948	1.207	1.466	1.725	1.984	2.243	2.502
.67	.174	.433	.692	.951	1.210	1.469	1.728	1.987	2.246	2.505
.68	.176	.435	.694	.953	1.212	1.471	1.730	1.989	2.248	2.507
.69	.179	.438	.697	.956	1.215	1.474	1.733	1.992	2.251	2.510
.70	.181	.440	.699	.958	1.217	1.476	1.735	1.994	2.253	2.512
.71	.184	.443	.702	.961	1.220	1.479	1.738	1.997	2.256	2.515
.72	.186	.445	.704	.963	1.222	1.481	1.740	1.999	2.258	2.517
.73	.189	.448	.707	.966	1.225	1.484	1.743	2.002	2.261	2.520
.74	.192	.451	.710	.969	1.228	1.487	1.746	2.005	2.264	2.523
.75	.194	.453	.712	.971	1.230	1.489	1.748	2.007	2.266	2.525
.76	.197	.456	.715	.974	1.233	1.492	1.751	2.010	2.269	2.528
.77	.199	.458	.717	.976	1.235	1.494	1.753	2.012	2.271	2.530
.78	.202	.461	.720	.979	1.238	1.497	1.756	2.015	2.274	2.533
.79	.205	.464	.723	.982	1.241	1.500	1.759	2.018	2.277	2.536
.80	.207	.466	.725	.984	1.243	1.502	1.761	2.020	2.279	2.538
.81	.210	.469	.728	.987	1.246	1.505	1.764	2.023	2.282	2.541
.82	.212	.471	.730	.989	1.248	1.507	1.766	2.025	2.284	2.543
.83	.215	.474	.733	.992	1.251	1.510	1.769	2.028	2.287	2.546
.84	.218	.477	.736	.995	1.254	1.513	1.772	2.031	2.290	2.549
.85	.220	.479	.738	.997	1.256	1.515	1.774	2.033	2.292	2.551
.86	.223	.482	.741	1.000	1.259	1.518	1.777	2.036	2.295	2.554
.87	.225	.484	.743	1.002	1.261	1.520	1.779	2.038	2.297	2.556
.88	.228	.487	.746	1.005	1.264	1.523	1.782	2.041	2.300	2.559
.89	.231	.490	.749	1.008	1.267	1.526	1.785	2.044	2.303	2.562
.90	.233	.492	.751	1.010	1.269	1.528	1.787	2.046	2.305	2.564
.91	.236	.495	.754	1.013	1.272	1.531	1.790	2.049	2.308	2.567
.92	.238	.497	.756	1.015	1.274	1.533	1.792	2.051	2.310	2.569
.93	.241	.500	.759	1.018	1.277	1.536	1.795	2.054	2.313	2.572
.94	.243	.502	.761	1.020	1.279	1.538	1.797	2.056	2.315	2.574
.95	.246	.505	.764	1.023	1.282	1.541	1.800	2.059	2.318	2.577
.96	.249	.508	.767	1.026	1.285	1.544	1.803	2.062	2.321	2.580
.97	.251	.510	.769	1.028	1.287	1.546	1.805	2.064	2.323	2.582
.98	.254	.513	.772	1.031	1.290	1.549	1.808	2.067	2.326	2.585
.99	.256	.515	.774	1.033	1.292	1.551	1.810	2.069	2.328	2.587
1.00	.259	.518	.777	1.036	1.295	1.554	1.813	2.072	2.331	2.590
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 30°=0.500.]

	0	1	2	3	4	5	6	7	8	9
0.00	0.000	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
.01	.005	.505	1.005	1.505	2.005	2.505	3.005	3.505	4.005	4.505
.02	.010	.510	1.010	1.510	2.010	2.510	3.010	3.510	4.010	4.510
.03	.015	.515	1.015	1.515	2.015	2.515	3.015	3.515	4.015	4.515
.04	.020	.520	1.020	1.520	2.020	2.520	3.020	3.520	4.020	4.520
.05	.025	.525	1.025	1.525	2.025	2.525	3.025	3.525	4.025	4.525
.06	.030	.530	1.030	1.530	2.030	2.530	3.030	3.530	4.030	4.530
.07	.035	.535	1.035	1.535	2.035	2.535	3.035	3.535	4.035	4.535
.08	.040	.540	1.040	1.540	2.040	2.540	3.040	3.540	4.040	4.540
.09	.045	.545	1.045	1.545	2.045	2.545	3.045	3.545	4.045	4.545
.10	.050	.550	1.050	1.550	2.050	2.550	3.050	3.550	4.050	4.550
.11	.055	.555	1.055	1.555	2.055	2.555	3.055	3.555	4.055	4.555
.12	.060	.560	1.060	1.560	2.060	2.560	3.060	3.560	4.060	4.560
.13	.065	.565	1.065	1.565	2.065	2.565	3.065	3.565	4.065	4.565
.14	.070	.570	1.070	1.570	2.070	2.570	3.070	3.570	4.070	4.570
.15	.075	.575	1.075	1.575	2.075	2.575	3.075	3.575	4.075	4.575
.16	.080	.580	1.080	1.580	2.080	2.580	3.080	3.580	4.080	4.580
.17	.085	.585	1.085	1.585	2.085	2.585	3.085	3.585	4.085	4.585
.18	.090	.590	1.090	1.590	2.090	2.590	3.090	3.590	4.090	4.590
.19	.095	.595	1.095	1.595	2.095	2.595	3.095	3.595	4.095	4.595
.20	.100	.600	1.100	1.600	2.100	2.600	3.100	3.600	4.100	4.600
.21	.105	.605	1.105	1.605	2.105	2.605	3.105	3.605	4.105	4.605
.22	.110	.610	1.110	1.610	2.110	2.610	3.110	3.610	4.110	4.610
.23	.115	.615	1.115	1.615	2.115	2.615	3.115	3.615	4.115	4.615
.24	.120	.620	1.120	1.620	2.120	2.620	3.120	3.620	4.120	4.620
.25	.125	.625	1.125	1.625	2.125	2.625	3.125	3.625	4.125	4.625
.26	.130	.630	1.130	1.630	2.130	2.630	3.130	3.630	4.130	4.630
.27	.135	.635	1.135	1.635	2.135	2.635	3.135	3.635	4.135	4.635
.28	.140	.640	1.140	1.640	2.140	2.640	3.140	3.640	4.140	4.640
.29	.145	.645	1.145	1.645	2.145	2.645	3.145	3.645	4.145	4.645
.30	.150	.650	1.150	1.650	2.150	2.650	3.150	3.650	4.150	4.650
.31	.155	.655	1.155	1.655	2.155	2.655	3.155	3.655	4.155	4.655
.32	.160	.660	1.160	1.660	2.160	2.660	3.160	3.660	4.160	4.660
.33	.165	.665	1.165	1.665	2.165	2.665	3.165	3.665	4.165	4.665
.34	.170	.670	1.170	1.670	2.170	2.670	3.170	3.670	4.170	4.670
.35	.175	.675	1.175	1.675	2.175	2.675	3.175	3.675	4.175	4.675
.36	.180	.680	1.180	1.680	2.180	2.680	3.180	3.680	4.180	4.680
.37	.185	.685	1.185	1.685	2.185	2.685	3.185	3.685	4.185	4.685
.38	.190	.690	1.190	1.690	2.190	2.690	3.190	3.690	4.190	4.690
.39	.195	.695	1.195	1.695	2.195	2.695	3.195	3.695	4.195	4.695
.40	.200	.700	1.200	1.700	2.200	2.700	3.200	3.700	4.200	4.700
.41	.205	.705	1.205	1.705	2.205	2.705	3.205	3.705	4.205	4.705
.42	.210	.710	1.210	1.710	2.210	2.710	3.210	3.710	4.210	4.710
.43	.215	.715	1.215	1.715	2.215	2.715	3.215	3.715	4.215	4.715
.44	.220	.720	1.220	1.720	2.220	2.720	3.220	3.720	4.220	4.720
.45	.225	.725	1.225	1.725	2.225	2.725	3.225	3.725	4.225	4.725
.46	.230	.730	1.230	1.730	2.230	2.730	3.230	3.730	4.230	4.730
.47	.235	.735	1.235	1.735	2.235	2.735	3.235	3.735	4.235	4.735
.48	.240	.740	1.240	1.740	2.240	2.740	3.240	3.740	4.240	4.740
.49	.245	.745	1.245	1.745	2.245	2.745	3.245	3.745	4.245	4.745
.50	.250	.750	1.250	1.750	2.250	2.750	3.250	3.750	4.250	4.750
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 30°=0.500.]

	0	1	2	3	4	5	6	7	8	9
0.50	0.250	0.750	1.250	1.750	2.250	2.750	3.250	3.750	4.250	4.750
.51	.255	.755	1.255	1.755	2.255	2.755	3.255	3.755	4.255	4.755
.52	.260	.760	1.260	1.760	2.260	2.760	3.260	3.760	4.260	4.760
.53	.265	.765	1.265	1.765	2.265	2.765	3.265	3.765	4.265	4.765
.54	.270	.770	1.270	1.770	2.270	2.770	3.270	3.770	4.270	4.770
.55	.275	.775	1.275	1.775	2.275	2.775	3.275	3.775	4.275	4.775
.56	.280	.780	1.280	1.780	2.280	2.780	3.280	3.780	4.280	4.780
.57	.285	.785	1.285	1.785	2.285	2.785	3.285	3.785	4.285	4.785
.58	.290	.790	1.290	1.790	2.290	2.790	3.290	3.790	4.290	4.790
.59	.295	.795	1.295	1.795	2.295	2.795	3.295	3.795	4.295	4.795
.60	.300	.800	1.300	1.800	2.300	2.800	3.300	3.800	4.300	4.800
.61	.305	.805	1.305	1.805	2.305	2.805	3.305	3.805	4.305	4.805
.62	.310	.810	1.310	1.810	2.310	2.810	3.310	3.810	4.310	4.810
.63	.315	.815	1.315	1.815	2.315	2.815	3.315	3.815	4.315	4.815
.64	.320	.820	1.320	1.820	2.320	2.820	3.320	3.820	4.320	4.820
.65	.325	.825	1.325	1.825	2.325	2.825	3.325	3.825	4.325	4.825
.66	.330	.830	1.330	1.830	2.330	2.830	3.330	3.830	4.330	4.830
.67	.335	.835	1.335	1.835	2.335	2.835	3.335	3.835	4.335	4.835
.68	.340	.840	1.340	1.840	2.340	2.840	3.340	3.840	4.340	4.840
.69	.345	.845	1.345	1.845	2.345	2.845	3.345	3.845	4.345	4.845
.70	.350	.850	1.350	1.850	2.350	2.850	3.350	3.850	4.350	4.850
.71	.355	.855	1.355	1.855	2.355	2.855	3.355	3.855	4.355	4.855
.72	.360	.860	1.360	1.860	2.360	2.860	3.360	3.860	4.360	4.860
.73	.365	.865	1.365	1.865	2.365	2.865	3.365	3.865	3.865	4.865
.74	.370	.870	1.370	1.870	2.370	2.870	3.370	3.870	4.370	4.870
.75	.375	.875	1.375	1.875	2.375	2.875	3.375	3.875	4.375	4.875
.76	.380	.880	1.380	1.880	2.380	2.880	3.380	3.880	4.380	4.880
.77	.385	.885	1.385	1.885	2.385	2.885	3.385	3.885	4.385	4.885
.78	.390	.890	1.390	1.890	2.390	2.890	3.390	3.890	4.390	4.890
.79	.395	.895	1.395	1.895	2.395	2.895	3.395	3.895	4.395	4.895
.80	.400	.900	1.400	1.900	2.400	2.900	3.400	3.900	4.400	4.900
.81	.405	.905	1.405	1.905	2.405	2.905	3.405	3.905	4.405	4.905
.82	.410	.910	1.410	1.910	2.410	2.910	3.410	3.910	4.410	4.910
.83	.415	.915	1.415	1.915	2.415	2.915	3.415	3.915	4.415	4.915
.84	.420	.920	1.420	1.920	2.420	2.920	3.420	3.920	4.420	4.920
.85	.425	.925	1.425	1.925	2.425	2.925	3.425	3.925	4.425	4.925
.86	.430	.930	1.430	1.930	2.430	2.930	3.430	3.930	4.430	4.930
.87	.435	.935	1.435	1.935	2.435	2.935	3.435	3.935	4.435	4.935
.88	.440	.940	1.440	1.940	2.440	2.940	3.440	3.940	4.440	4.940
.89	.445	.945	1.445	1.945	2.445	2.945	3.445	3.945	4.445	4.945
.90	.450	.950	1.450	1.950	2.450	2.950	3.450	3.950	4.450	4.950
.91	.455	.955	1.455	1.955	2.455	2.955	3.455	3.955	4.455	4.955
.92	.460	.960	1.460	1.960	2.460	2.960	3.460	3.960	4.460	4.960
.93	.465	.965	1.465	1.965	2.465	2.965	3.465	3.965	4.465	4.965
.94	.470	.970	1.470	1.970	2.470	2.970	3.470	3.970	4.470	4.970
.95	.475	.975	1.475	1.975	2.475	2.975	3.475	3.975	4.475	4.975
.96	.480	.980	1.480	1.980	2.480	2.980	3.480	3.980	4.480	4.980
.97	.485	.985	1.485	1.985	2.485	2.985	3.485	3.985	4.485	4.985
.98	.490	.990	1.490	1.990	2.490	2.990	3.490	3.990	4.490	4.990
.99	.495	.995	1.495	1.995	2.495	2.995	3.495	3.995	4.495	4.995
1.00	.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 45°=0.707.]

	0	1	2	3	4	5	6	7	8	9
0.00	0.000	0.707	1.414	2.121	2.828	3.535	4.242	4.949	5.656	6.363
.01	.007	.714	1.421	2.128	2.835	3.542	4.249	4.956	5.663	6.370
.02	.014	.721	1.428	2.135	2.842	3.549	4.256	4.963	5.670	6.377
.03	.021	.728	1.435	2.142	2.849	3.556	4.263	4.970	5.677	6.384
.04	.028	.735	1.442	2.149	2.856	3.563	4.270	4.977	5.684	6.391
.05	.035	.742	1.449	2.156	2.863	3.570	4.277	4.984	5.691	6.398
.06	.042	.749	1.456	2.163	2.870	3.577	4.284	4.991	5.698	6.405
.07	.049	.756	1.463	2.170	2.877	3.584	4.291	4.998	5.705	6.412
.08	.057	.764	1.471	2.178	2.885	3.592	4.299	5.006	5.713	6.420
.09	.034	.771	1.478	2.185	2.892	3.599	4.306	5.013	5.720	6.427
.10	.071	.778	1.485	2.192	2.899	3.606	4.313	5.020	5.727	6.434
.11	.078	.785	1.492	2.199	2.906	3.613	4.320	5.027	5.734	6.441
.12	.085	.792	1.499	2.206	2.913	3.620	4.327	5.034	5.741	6.448
.13	.092	.799	1.506	2.213	2.920	3.627	4.334	5.041	5.748	6.455
.14	.099	.806	1.513	2.220	2.927	3.634	4.341	5.048	5.755	6.462
.15	.106	.813	1.520	2.227	2.934	3.641	4.348	5.055	5.762	6.469
.16	.113	.820	1.527	2.234	2.941	3.648	4.355	5.062	5.769	6.476
.17	.120	.827	1.534	2.241	2.948	3.655	4.362	5.069	5.776	6.483
.18	.127	.834	1.541	2.248	2.955	3.662	4.369	5.076	5.783	6.490
.19	.134	.841	1.548	2.255	2.962	3.669	4.376	5.083	5.790	6.497
.20	.141	.848	1.555	2.262	2.969	3.676	4.383	5.090	5.797	6.504
.21	.148	.855	1.562	2.269	2.976	3.683	4.390	5.097	5.804	6.511
.22	.156	.863	1.570	2.277	2.984	3.691	4.398	5.105	5.812	6.519
.23	.163	.870	1.577	2.284	2.991	3.698	4.405	5.112	5.819	6.526
.24	.170	.877	1.584	2.291	2.998	3.705	4.412	5.119	5.826	6.533
.25	.177	.884	1.591	2.298	3.005	3.712	4.419	5.126	5.833	6.540
.26	.184	.891	1.598	2.305	3.012	3.719	4.426	5.133	5.840	6.547
.27	.191	.898	1.605	2.312	3.019	3.726	4.433	5.140	5.847	6.554
.28	.198	.905	1.612	2.319	3.026	3.733	4.440	5.147	5.854	6.561
.29	.205	.912	1.619	2.326	3.033	3.740	4.447	5.154	5.861	6.568
.30	.212	.919	1.626	2.333	3.040	3.747	4.454	5.161	5.868	6.575
.31	.219	.926	1.633	2.340	3.047	3.754	4.461	5.168	5.875	6.582
.32	.226	.933	1.640	2.347	3.054	3.761	4.468	5.175	5.882	6.589
.33	.233	.940	1.647	2.354	3.061	3.768	4.475	5.182	5.889	6.596
.34	.240	.947	1.654	2.361	3.068	3.775	4.482	5.189	5.896	6.603
.35	.247	.954	1.661	2.368	3.075	3.782	4.489	5.196	5.903	6.610
.36	.255	.962	1.669	2.376	3.083	3.790	4.497	5.204	5.911	6.618
.37	.262	.969	1.676	2.383	3.090	3.797	4.504	5.211	5.918	6.625
.38	.269	.976	1.683	2.390	3.097	3.804	4.511	5.218	5.925	6.632
.39	.276	.983	1.690	2.397	3.104	3.811	4.518	5.225	5.932	6.639
.40	.283	.990	1.697	2.404	3.111	3.818	4.525	5.232	5.939	6.646
.41	.290	.997	1.704	2.411	3.118	3.825	4.532	5.239	5.946	6.653
.42	.297	1.004	1.711	2.418	3.125	3.832	4.539	5.246	5.953	6.660
.43	.304	1.011	1.718	2.425	3.132	3.839	4.546	5.253	5.960	6.667
.44	.311	1.018	1.725	2.432	3.139	3.846	4.553	5.260	5.967	6.674
.45	.318	1.025	1.732	2.439	3.146	3.853	4.560	5.267	5.974	6.681
.46	.325	1.032	1.739	2.446	3.153	3.860	4.567	5.274	5.981	6.688
.47	.332	1.039	1.746	2.453	3.160	3.867	4.574	5.281	5.988	6.695
.48	.339	1.046	1.753	2.460	3.167	3.874	4.581	5.288	5.995	6.702
.49	.346	1.053	1.760	2.467	3.174	3.881	4.588	5.295	6.002	6.709
.50	.354	1.060	1.768	2.474	3.182	3.888	4.596	5.302	6.010	6.716
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 45°=0.707.]

	0	1	2	3	4	5	6	7	8	9
0.50	0.354	1.060	1.768	2.474	3.182	3.888	4.596	5.302	6.010	6.716
.51	.361	1.068	1.775	2.482	3.189	3.896	4.603	5.310	6.017	6.724
.52	.368	1.075	1.782	2.489	3.196	3.903	4.610	5.317	6.024	6.731
.53	.375	1.082	1.789	2.496	3.203	3.910	4.617	5.324	6.031	6.738
.54	.382	1.089	1.796	2.503	3.210	3.917	4.624	5.331	6.038	6.745
.55	.389	1.096	1.803	2.510	3.217	3.924	4.631	5.338	6.045	6.752
.56	.396	1.103	1.810	2.517	3.224	3.931	4.638	5.345	6.052	6.759
.57	.403	1.110	1.817	2.524	3.231	3.938	4.645	5.352	6.059	6.766
.58	.410	1.117	1.824	2.531	3.238	3.945	4.652	5.359	6.066	6.773
.59	.417	1.124	1.831	2.538	3.245	3.952	4.659	5.366	6.073	6.780
.60	.424	1.131	1.838	2.545	3.252	3.959	4.666	5.373	6.080	6.787
.61	.431	1.138	1.845	2.552	3.259	3.966	4.673	5.380	6.087	6.794
.62	.438	1.145	1.852	2.559	3.266	3.973	4.680	5.387	6.094	6.801
.63	.445	1.152	1.859	2.566	3.273	3.980	4.687	5.394	6.101	6.808
.64	.452	1.159	1.866	2.573	3.280	3.987	4.694	5.401	6.108	6.815
.65	.460	1.167	1.874	2.581	3.288	3.995	4.702	5.409	6.116	6.823
.66	.467	1.174	1.881	2.588	3.295	4.002	4.709	5.416	6.123	6.830
.67	.474	1.181	1.888	2.595	3.302	4.009	4.716	5.423	6.130	6.837
.68	.481	1.188	1.895	2.602	3.309	4.016	4.723	5.430	6.137	6.844
.69	.488	1.195	1.902	2.609	3.316	4.023	4.730	5.437	6.144	6.851
.70	.495	1.202	1.909	2.616	3.323	4.030	4.737	5.444	6.151	6.858
.71	.502	1.209	1.916	2.623	3.330	4.037	4.744	5.451	6.158	6.865
.72	.509	1.216	1.923	2.630	3.337	4.044	4.751	5.458	6.165	6.872
.73	.516	1.223	1.930	2.637	3.344	4.051	4.758	5.465	6.172	6.879
.74	.523	1.230	1.937	2.644	3.351	4.058	4.765	5.472	6.179	6.886
.75	.530	1.237	1.944	2.651	3.358	4.065	4.772	5.479	6.186	6.893
.76	.537	1.244	1.951	2.658	3.365	4.072	4.779	5.486	6.193	6.900
.77	.544	1.251	1.958	2.665	3.372	4.079	4.786	5.493	6.200	6.907
.78	.551	1.258	1.965	2.672	3.379	4.086	4.793	5.500	6.207	6.914
.79	.559	1.266	1.973	2.680	3.387	4.094	4.801	5.508	6.215	6.922
.80	.566	1.273	1.980	2.687	3.394	4.101	4.808	5.515	6.222	6.929
.81	.573	1.280	1.987	2.694	3.401	4.108	4.815	5.522	6.229	6.936
.82	.580	1.287	1.994	2.701	3.408	4.115	4.822	5.529	6.236	6.943
.83	.587	1.294	2.001	2.708	3.415	4.122	4.829	5.536	6.243	6.950
.84	.594	1.301	2.008	2.715	3.422	4.129	4.836	5.543	6.250	6.957
.85	.601	1.308	2.015	2.722	3.429	4.136	4.843	5.550	6.257	6.964
.86	.608	1.315	2.022	2.729	3.436	4.143	4.850	5.557	6.264	6.971
.87	.615	1.322	2.029	2.736	3.443	4.150	4.857	5.564	6.271	6.978
.88	.622	1.329	2.036	2.743	3.450	4.157	4.864	5.571	6.278	6.985
.89	.629	1.336	2.043	2.750	3.457	4.164	4.871	5.578	6.285	6.992
.90	.636	1.343	2.050	2.757	3.464	4.171	4.878	5.585	6.292	6.999
.91	.643	1.350	2.057	2.764	3.471	4.178	4.885	5.592	6.299	7.006
.92	.650	1.357	2.064	2.771	3.478	4.185	4.892	5.599	6.306	7.013
.93	.658	1.365	2.072	2.779	3.486	4.193	4.900	5.607	6.314	7.021
.94	.665	1.372	2.079	2.786	3.493	4.200	4.907	5.614	6.321	7.028
.95	.672	1.379	2.086	2.793	3.500	4.207	4.914	5.621	6.328	7.035
.96	.679	1.386	2.093	2.800	3.507	4.214	4.921	5.628	6.335	7.042
.97	.686	1.393	2.100	2.807	3.514	4.221	4.928	5.635	6.342	7.049
.98	.693	1.400	2.107	2.814	3.521	4.228	4.935	5.642	6.349	7.056
.99	.700	1.407	2.114	2.821	3.528	4.235	4.942	5.649	6.356	7.063
1.00	.707	1.414	2.121	2.828	3.535	4.242	4.949	5.656	6.363	7.070
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier = sin 60° = **0.866.**]

	0	1	2	3	4	5	6	7	8	9
0.00	0.000	0.866	1.732	2.598	3.464	4.330	5.196	6.062	6.928	7.794
.01	.009	.875	1.741	2.607	3.473	4.339	5.205	6.071	6.937	7.803
.02	.017	.883	1.749	2.615	3.481	4.347	5.213	6.079	6.945	7.811
.03	.026	.892	1.758	2.624	3.490	4.356	5.222	6.088	6.954	7.820
.04	.035	.901	1.767	2.633	3.499	4.365	5.231	6.097	6.963	7.829
.05	.043	.909	1.775	2.641	3.507	4.373	5.239	6.105	6.971	7.837
.06	.052	.918	1.784	2.650	3.516	4.382	5.248	6.114	6.980	7.846
.07	.061	.927	1.793	2.659	3.525	4.391	4.257	6.123	6.989	7.855
.08	.069	.935	1.801	2.667	3.533	4.399	5.265	6.131	6.997	7.863
.09	.078	.944	1.810	2.676	3.542	4.408	5.274	6.140	7.006	7.872
.10	.087	.953	1.819	2.685	3.551	4.417	5.283	6.149	7.015	7.881
.11	.095	.961	1.827	2.693	3.559	4.425	5.291	6.157	7.023	7.889
.12	.104	.970	1.836	2.702	3.568	4.434	5.300	6.166	7.032	7.898
.13	.113	.979	1.845	2.711	3.577	4.443	5.309	6.175	7.041	7.907
.14	.121	.987	1.853	2.719	3.585	4.451	5.317	6.183	7.049	7.915
.15	.130	.996	1.862	2.728	3.594	4.460	5.326	6.192	7.058	7.924
.16	.139	1.005	1.871	2.737	3.603	4.469	5.335	6.201	7.067	7.933
.17	.147	1.013	1.879	2.745	3.611	4.477	5.343	6.209	7.075	7.941
.18	.156	1.022	1.888	2.754	3.620	4.486	5.352	6.218	7.084	7.950
.19	.165	1.031	1.897	2.763	3.629	4.495	5.361	6.227	7.093	7.959
.20	.173	1.039	1.905	2.771	3.637	4.503	5.369	6.235	7.101	7.967
.21	.182	1.048	1.914	2.780	3.646	4.512	5.378	6.244	7.110	7.976
.22	.191	1.057	1.923	2.789	3.655	4.521	5.387	6.253	7.119	7.985
.23	.199	1.065	1.931	2.797	3.663	4.529	5.395	6.261	7.127	7.993
.24	.208	1.074	1.940	2.806	3.672	4.538	5.404	6.270	7.136	8.002
.25	.216	1.082	1.948	2.814	3.680	4.546	5.412	6.278	7.144	8.010
.26	.225	1.091	1.957	2.823	3.689	4.555	5.421	6.287	7.153	8.019
.27	.234	1.100	1.966	2.832	3.698	4.564	5.430	6.296	7.162	8.028
.28	.242	1.108	1.974	2.840	3.706	4.572	5.438	6.304	7.170	8.036
.29	.251	1.117	1.983	2.849	3.715	4.581	5.447	6.313	7.179	8.045
.30	.260	1.126	1.992	2.858	3.724	4.590	5.456	6.322	7.188	8.054
.31	.268	1.134	2.000	2.866	3.732	4.598	5.464	6.330	7.196	8.062
.32	.277	1.143	2.009	2.875	3.741	4.607	5.473	6.339	7.205	8.071
.33	.286	1.152	2.018	2.884	3.750	4.616	5.482	6.348	7.214	8.080
.34	.294	1.160	2.026	2.892	3.758	4.624	5.490	6.356	7.222	8.088
.35	.303	1.169	2.035	2.901	3.767	4.633	5.499	6.365	7.231	8.097
.36	.312	1.178	2.044	2.910	3.776	4.642	5.508	6.374	7.240	8.106
.37	.320	1.186	2.052	2.918	3.784	4.650	5.516	6.382	7.248	8.114
.38	.329	1.195	2.061	2.927	3.793	4.659	5.525	6.391	7.257	8.123
.39	.338	1.204	2.070	2.936	3.802	4.668	5.534	6.400	7.266	8.132
.40	.346	1.212	2.078	2.944	3.810	4.676	5.542	6.408	7.274	8.140
.41	.355	1.221	2.087	2.953	3.819	4.685	5.551	6.417	7.283	8.149
.42	.364	1.230	2.096	2.962	3.828	4.694	5.560	6.426	7.292	8.158
.43	.372	1.238	2.104	2.970	3.836	4.702	5.568	6.434	7.300	8.166
.44	.381	1.247	2.113	2.979	3.845	4.711	5.577	6.443	7.309	8.175
.45	.390	1.256	2.122	2.988	3.854	4.720	5.586	6.452	7.318	8.184
.46	.398	1.264	2.130	2.996	3.862	4.728	5.594	6.460	7.326	8.192
.47	.407	1.273	2.139	3.005	3.871	4.737	5.603	6.469	7.335	8.201
.48	.416	1.282	2.148	3.014	3.880	4.746	5.612	6.478	7.344	8.210
.49	.424	1.290	2.156	3.022	3.888	4.754	5.620	6.486	7.352	8.218
.50	.433	1.299	2.165	3.031	3.897	4.763	5.629	6.495	7.361	8.227
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 60°=0.866.]

	0	1	2	3	4	5	6	7	8	9
0.50	0.433	1.299	2.165	3.031	3.897	4.763	5.629	6.495	7.361	8.227
.51	.442	1.308	2.174	3.040	3.906	4.772	5.638	6.504	7.370	8.236
.52	.450	1.316	2.182	3.048	3.914	4.780	5.646	6.512	7.378	8.244
.53	.459	1.325	2.191	3.057	3.923	4.789	5.655	6.521	7.387	8.253
.54	.468	1.334	2.200	3.066	3.932	4.798	5.664	6.530	7.396	8.262
.55	.476	1.342	2.208	3.074	3.940	4.806	5.672	6.538	7.404	8.270
.56	.485	1.351	2.217	3.083	3.949	4.815	5.681	6.547	7.413	8.279
.57	.494	1.360	2.226	3.092	3.958	4.824	5.690	6.556	7.422	8.288
.58	.502	1.368	2.234	3.100	3.966	4.832	5.698	6.564	7.430	8.296
.59	.511	1.377	2.243	3.109	3.975	4.841	5.707	6.573	7.439	8.305
.60	.520	1.386	2.252	3.118	3.984	4.850	5.716	6.582	7.448	8.314
.61	.528	1.394	2.260	3.126	3.992	4.858	5.724	6.590	7.456	8.322
.62	.537	1.403	2.269	3.135	4.001	4.867	5.733	6.599	7,465	8.331
.63	.546	1.412	2.278	3.144	4.010	4.876	5.742	6.608	7.474	8.340
.64	.554	1.420	2.286	3.152	4.018	4.884	5.750	6.616	7.482	8.348
.65	.563	1.429	2.295	3.161	4.027	4.893	5.759	6.625	7.491	8.357
66	.572	1.438	2.304	3.170	4.036	4.902	5.768	6.634	7.500	8.366
.67	.580	1.446	2.312	3.178	4.044	4.910	5.776	6.642	7.508	8.374
.68	.589	1.455	2.321	3.187	4.053	4.919	5.785	6.651	7.517	8.383
.69	.598	1.464	2.330	3.196	4.062	4.928	5.794	6.660	7.526	8.392
.70	.606	1.472	2.338	3.204	4.070	4.936	5.802	6.668	7.534	8.400
.71	.615	1.481	2.347	3.213	4.079	4.945	5.811	6.677	7.543	8.409
.72	.624	1.490	2.356	3.222	4.088	4.954	5.820	6.686	7.552	8.418
.73	.632	1.498	2.364	3.230	4.096	4.962	5.828	6.694	7.560	8.426
.74	.641	1.507	2.373	3.239	4.105	4.977	5.837	6.703	7.569	8.435
.75	.650	1.516	2.382	3.248	4.114	4.980	5.846	6.712	7.578	8.444
.76	.658	1.524	2.390	3.256	4.122	4.988	5.854	6.720	7.586	8.452
.77	.667	1.533	2.399	3.265	4.131	4.997	5.863	6.729	7.595	8.461
.78	.675	1.541	2.407	3.273	4.139	5.005	5.871	6.737	7.603	8.469
.79	.684	1.550	2.416	3.282	4.148	5.014	5.880	6.746	7.612	8.478
80	.693	1.559	2.425	3.291	4.157	5.023	5.889	6.755	7.621	8.487
.81	.701	1.567	2.433	3.299	4.165	5.031	5.897	6.763	7.629	8.495
.82	.710	1.576	2.442	3.308	4.174	5.040	5.906	6.772	7.638	8.504
.83	.719	1.585	2.451	3.317	4.183	5.049	5.915	6.781	7.647	8.513
84	.727	1.593	2.459	3.325	4.191	5.057	5.923	6.789	7.655	8.521
.85	.736	1.602	2.468	3.334	4.200	5.066	5.932	6.798	7.664	8.530
.86	.745	1.611	2.477	3.343	4.209	5.075	5.941	6.807	7.673	8.539
.87	.753	1.619	2.485	3.351	4.217	5.083	5.949	6.815	7.681	8.547
.88	.762	1.628	2.494	3.360	4.226	5.092	5.958	6.824	7.690	8.556
.89	.771	1.637	2.503	3.369	4.235	5.101	5.967	6.833	7.699	8.565
.90	.779	1.645	2.511	3.377	4.243	5.109	5.975	6.841	7.707	8.573
.91	.788	1.654	2.520	3.386	4.252	5.118	5.984	6.850	7.716	8.582
.92	.797	1.663	2.529	3.395	4.261	5.127	5.993	6.859	7.725	8,591
.93	.805	1.671	2.537	3.403	4.269	5.135	6.001	6.867	7.733	8.599
.94	.814	1.680	2.546	3.412	4.278	5.144	6.010	6.876	7.742	8.608
.95	.823	1.689	2.555	3.421	4.287	5.153	6.019	6.885	7.751	8.617
.96	.831	1.697	2.563	3.429	4.295	5.161	6.027	6.893	7.759	8.625
.97	.840	1.706	2.572	3.438	4.304	5.170	6.036	6.902	7.768	8.634
.98	.849	1.715	2.581	3.447	4.313	5.179	6.045	6.911	7,777	8.643
.99	.857	1.723	2.589	3.455	4.321	5.187	6.053	6.919	7.785	8.651
1.00	.866	1.732	2.598	3.464	4.330	5.196	6.062	6.928	7.794	8.660
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 75°=0.966.]

	0	1	2	3	4	5	6	7	8	9
0.00	0.000	0.966	1.932	2.898	3.864	4.830	5.796	6.762	7.728	8.694
.01	.010	.976	1.942	2.908	3.874	4.840	5.806	6.772	7.738	8.704
.02	.019	.985	1.951	2.917	3.883	4.849	5.815	6.781	7.747	8.713
.03	.029	.995	1.961	2.927	3.893	4.859	5.825	6.791	7.757	8.723
.04	.039	1.005	1.971	2.937	3.903	4.869	5.835	6.801	7.767	8.733
.05	.048	1.014	1.980	2.946	3.912	4.878	5.844	6.810	7.776	8.742
.06	.058	1.024	1.990	2.956	3.922	4.888	5.854	6.820	7.786	8.752
.07	.068	1.034	2.000	2.966	3.932	4.898	5.864	6.830	7.796	8.762
.08	.077	1.043	2.009	2.975	3.941	4.907	5.873	6.839	7.805	8.771
.09	.087	1.053	2.019	2.985	3.951	4.917	5.883	6.849	7.815	8.781
.10	.097	1.063	2.029	2.995	3.961	4.927	5.893	6.859	7.825	8.791
.11	.106	1.072	2.038	3.004	3.970	4.936	5.902	6.868	7.834	8.800
.12	.116	1.082	2.048	3.014	3.980	4.946	5.912	6.878	7.844	8.810
.13	.126	1.092	2.058	3.024	3.990	4.956	5.922	6.888	7.854	8.820
.14	.135	1.101	2.067	3.033	3.999	4.965	5.931	6.897	7.863	8.829
.15	.145	1.111	2.077	3.043	4.009	4.975	5.941	6.907	7.873	8.839
.16	.155	1.121	2.087	3.053	4.019	4.985	5.951	6.917	7.883	8.849
.17	.164	1.130	2.096	3.062	4.028	4.994	5.960	6.926	7.892	8.858
.18	.174	1.140	2.106	3.072	4.038	5.004	5.970	6.936	7.902	8.868
.19	.184	1.150	2.116	3.082	4.048	5.014	5.980	6.946	7.912	8.878
.20	.193	1.159	2.125	3.091	4.057	5.023	5.989	6.955	7.921	8.887
.21	.203	1.169	2.135	3.101	4.067	5.033	5.999	6.965	7.931	8.897
.22	.213	1.179	2.145	3.111	4.077	5.043	6.009	6.975	7.941	8.907
.23	.222	1.188	2.154	3.120	4.086	5.052	6.018	6.984	7.950	8.916
.24	.232	1.198	2.164	3.130	4.096	5.062	6.028	6.994	7.960	8.926
.25	.242	1.208	2.174	3.140	4.106	5.072	6.038	7.004	7.970	8.936
.26	.251	1.217	2.183	3.149	4.115	5.081	6.047	7.013	7.979	8.945
.27	.261	1.227	2.193	3.159	4.125	5.091	6.057	7.023	7.989	8.955
.28	.270	1.236	2.202	3.168	4.134	5.100	6.066	7.032	7.998	8.964
.29	.280	1.246	2.212	3.178	4.144	5.110	6.076	7.042	8.008	8.974
.30	.290	1.256	2.222	3.188	4.154	5.120	6.086	7.052	8.018	8.984
.31	.299	1.265	2.231	3.197	4.163	5.129	6.095	7.061	8.027	8.993
.32	.309	1.275	2.241	3.207	4.173	5.139	6.105	7.071	8.037	9.003
.33	.319	1.285	2.251	3.217	4.183	5.149	6.115	7.081	8.047	9.013
.34	.328	1.294	2.260	3.226	4.192	5.158	6.124	7.090	8.056	9.022
.35	.338	1.304	2.270	3.236	4.202	5.168	6.134	7.100	8.066	9.032
.36	.348	1.314	2.280	3.246	4.212	5.178	6.144	7.110	8.076	9.042
.37	.357	1.323	2.289	3.255	4.221	5.187	6.153	7.119	8.085	9.051
.38	.367	1.333	2.299	3.265	4.231	5.197	6.163	7.129	8.095	9.061
.39	.377	1.343	2.309	3.275	4.241	5.207	6.173	7.139	8.105	9.071
.40	.386	1.352	2.318	3.284	4.250	5.216	6.182	7.148	8.114	9.080
.41	.396	1.362	2.328	3.294	4.260	5.226	6.192	7.158	8.124	9.090
.42	.406	1.372	2.338	3.304	4.270	5.236	6.202	7.168	8.134	9.100
.43	.415	1.381	2.347	3.313	4.279	5.245	6.211	7.177	8.143	9.109
.44	.425	1.391	2.357	3.323	4.289	5.255	6.221	7.187	8.153	9.119
.45	.435	1.401	2.367	3.333	4.299	5.265	6.231	7.197	8.163	9.129
.46	.444	1.410	2.376	3.342	4.308	5.274	6.240	7.206	8.172	9.138
.47	.454	1.420	2.386	3.352	4.318	5.284	6.250	7.216	8.182	9.148
.48	.464	1.430	2.396	3.362	4.328	5.294	6.260	7.226	8.192	9.158
.49	.473	1.439	2.405	3.371	4.337	5.303	6.269	7.235	8.201	9.167
.50	.483	1.449	2.415	3.381	4.347	5.313	6.279	7.245	8.211	9.177
	0	1	2	3	4	5	6	7	8	9

TABLE 19.—*Products for Form 194*—Continued.

[Multiplier=sin 75°=0.966.]

	0	1	2	3	4	5	6	7	8	9
0.50	0.483	1.449	2.415	3.381	4.347	5.313	6.279	7.245	8.211	9.177
.51	.493	1.459	2.425	3.391	4.357	5.323	6.289	7.255	8.221	9.187
.52	.502	1.468	2.434	3.400	4.366	5.332	6.298	7.264	8.230	9.196
.53	.512	1.478	2.444	3.410	4.376	5.342	6.308	7.274	8.240	9.206
.54	.522	1.488	2.454	3.420	4.386	5.352	6.318	7.284	8.250	9.216
.55	.531	1.497	2.463	3.429	4.395	5.361	6.327	7.293	8.259	9.225
.56	.541	1.507	2.473	3.439	4.405	5.371	6.337	7.303	8.269	9.235
.57	.551	1.517	2.483	3.449	4.415	5.381	6.347	7.313	8.279	9.245
.58	.560	1.526	2.492	3.458	4.424	5.390	6.356	7.322	8.288	9.254
.59	.570	1.536	2.502	3.468	4.434	5.400	6.366	7.332	8.298	9.264
.60	.580	1.546	2.512	3.478	4.444	5.410	6.376	7.342	8.308	9.274
.61	.589	1.555	2.521	3.487	4.453	5.419	6.385	7.351	8.317	9.283
.62	.599	1.565	2.531	3.497	4.463	5.429	6.395	7.361	8.327	9.293
.63	.609	1.575	2.541	3.507	4.473	5.439	6.405	7.371	8.337	9.303
.64	.618	1.584	2.550	3.516	4.482	5.448	6.414	7.380	8.346	9.312
.65	.628	1.594	2.560	3.526	4.492	5.458	6.424	7.390	8.356	9.322
.66	.638	1.604	2.570	3.536	4.502	5.468	6.434	7.400	8.366	9.332
.67	.647	1.613	2.579	3.545	4.511	5.477	6.443	7.409	8.375	9.341
.68	.657	1.623	2.589	3.555	4.521	5.487	6.453	7.419	8.385	9.351
.69	.667	1.633	2.599	3.565	4.531	5.497	6.463	7.429	8.395	9.361
.70	.676	1.642	2.608	3.574	4.540	5.506	6.472	7.438	8.404	9.370
.71	.686	1.652	2.618	3.584	4.550	5.516	6.482	7.448	8.414	9.380
.72	.696	1.662	2.628	3.594	4.560	5.526	6.492	7.458	8.424	9.390
.73	.705	1.671	2.637	3.603	4.569	5.535	6.501	7.467	8.433	9.399
.74	.715	1.681	2.647	3.613	4.579	5.545	6.511	7.477	8.443	9.409
.75	.724	1.690	2.656	3.622	4.588	5.554	6.520	7.486	8.452	9.418
.76	.734	1.700	2.666	3.632	4.598	5.564	6.530	7.496	8.462	9.428
.77	.744	1.710	2.676	3.642	4.608	5.574	6.540	7.506	8.472	9.438
.78	.753	1.719	2.685	3.651	4.617	5.583	6.549	7.515	8.481	9.447
.79	.763	1.729	2.695	3.661	4.627	5.593	6.559	7.525	8.491	9.457
.80	.773	1.739	2.705	3.671	4.637	5.603	6.569	7.535	8.501	9.467
.81	.782	1.748	2.714	3.680	4.646	5.612	6.578	7.544	8.510	9.476
.82	.792	1.758	2.724	3.690	4.656	5.622	6.588	7.554	8.520	9.486
.83	.802	1.768	2.734	3.700	4.666	5.632	6.598	7.564	8.530	9.496
.84	.811	1.777	2.743	3.709	4.675	5.641	6.607	7.573	8.539	9.505
.85	.821	1.787	2.753	3.719	4.685	5.651	6.617	7.583	8.549	9.515
.86	.831	1.797	2.763	3.729	4.695	5.661	6.627	7.593	8.559	9.525
.87	.840	1.806	2.772	3.738	4.704	5.670	6.636	7.602	8.568	9.534
.88	.850	1.816	2.782	3.748	4.714	5.680	6.646	7.612	8.578	9.544
.89	.860	1.826	2.792	3.758	4.724	5.690	6.656	7.622	8.588	9.554
.90	.869	1.835	2.801	3.767	4.733	5.699	6.665	7.631	8.597	9.563
.91	.879	1.845	2.811	3.777	4.743	5.709	6.675	7.641	8.607	9.573
.92	.889	1.855	2.821	3.787	4.753	5.719	6.685	7.651	8.617	9.583
.93	.898	1.864	2.830	3.796	4.762	5.728	6.694	7.660	8.626	9.592
.94	.908	1.874	2.840	3.806	4.772	5.738	6.704	7.670	8.636	9.602
.95	.918	1.884	2.850	3.816	4.782	5.748	6.714	7.680	8.646	9.612
.96	.927	1.893	2.859	3.825	4.791	5.757	6.723	7.689	8.655	9.621
.97	.937	1.903	2.869	3.835	4.801	5.767	6.733	7.699	8.665	9.631
.98	.947	1.913	2.879	3.845	4.811	5.777	6.743	7.709	8.675	9.641
.99	.956	1.922	2.888	3.854	4.820	5.786	6.752	7.718	8.684	9.650
1.00	.966	1.932	2.898	3.864	4.830	5.796	6.762	7.728	8.694	9.660
	0	1	2	3	4	5	6	7	8	9

TABLE 20.—*Augmenting factors.*

SHORT-PERIOD COMPONENTS.* $\left(\text{Formula, augmenting factor} = \frac{\pi p}{24 \sin \frac{15p}{2}}.\right)$

	Augmenting factor.	Logarithm.	Remarks.
Diurnal J_1, K_1, M_1, O_1, OO, P_1, Q_1, 2Q, ρ_1	1.0029	0.001241	Each tabulated solar hourly height used once and once only in summation; group covers one component hour; component day represented by 24 means.
Semidurnal K_2, L_2, M_2, N_2, 2N, R_2, T_2, λ_2, μ_2, ν_2, 2SM.	1.0115	0.004972	
Terdiurnal M_3, MK, 2MK	1.0262	0.011220	
Quarter-diurnal M_4, MN, MS	1.0472	0.020029	
Sixth-diurnal M_6	1.1107	0.045605	
Eighth-diurnal M_8	1.2092	0.082498	

SHORT-PERIOD COMPONENTS.* $\left(\text{Formula, augmenting factor} = \frac{\pi a}{360 \sin \frac{a}{2}}.\right)$

	Augmenting factor.	Logarithm		Augmenting factor.	Logarithm.	Remarks.
J_1	1.0031	0.00134	P_1	1.0028	0.00123	Each component hour of observation period receives one and only one of solar hourly heights in the summation; group covers one solar hour; each solar day represented by 24 hourly heights and component day represented by 24 means.
K_1	1.0029	0.00125	Q_1	1.0023	0.00099	
K_2	1.0116	0.00500	2Q	1.0021	0.00091	
L_2	1.0112	0.00482	R_2	1.0115	0.00499	
M_1	1.0027	0.00116	T_2	1.0115	0.00496	
M_2	1.0107	0.00464	λ_2	1.0111	0.00479	
M_3	1.0244	0.01047	μ_2	1.0100	0.00432	
M_4	1.0440	0.01868	ν_2	1.0104	0.00449	
M_6	1.1028	0.04251	ρ_1	1.0023	0.00100	
M_8	1.1934	0.07680	MK	1.0250	0.01074	
N_2	1.0103	0.00447	2MK	1.0238	0.01021	
2N	1.0099	0.00430	MN	1.0431	0.01833	
O_1	1.0025	0.00107	MS	1.0456	0.01935	
OO	1.0033	0.00144	2SM	1.0123	0.00532	

LONG-PERIOD COMPONENTS. $\left(\text{Formula, augmenting factor} = \frac{\pi p}{\sin \frac{15p}{2}} \times \frac{\sin \frac{a}{2}}{\sin 12a}.\right)$

	Augmenting factor.	Logarithm.	Remarks.
Mm	1.0050	0.00218	Daily sums used as units in the summation for the divisional means, and all daily sums used; component month for Mm, Mf, MSf, and component year for Sa and Ssa represented by 24 means.
Mf	1.0205	0.00880	
MSf	1.0192	0.00825	
Sa	1.0029	0.00125	
Ssa	1.0116	0.00499	

*For component S_1, S_2, S_3, etc., the augmenting factor is unity.

TABLE 21.—*Acceleration in epoch of* K_1 *due to* P_1.

[Argument $h-\frac{1}{2}\nu'$ refers to beginning of series.]

$h-\frac{1}{2}\nu'$ \ Series.		14 days.	29 days.	58 days.	87 days.	105 days.	134 days.	163 days.	192 days.	221 days.	250 days.	279 days.	297 days.	326 days.
		°	°	°	°	°	°	°	°	°	°	°	°	°
0	180	+6.5	+11.4	+14.6	+12.6	+10.1	+5.1	+0.9	+0.2	+2.4	+3.9	+3.9	+3.3	+1.6
10	190	+13.9	+16.4	+16.0	+12.0	+8.8	+3.4	−0.1	+0.7	+3.0	+4.1	+3.6	+2.7	+0.9
20	200	+17.9	+18.3	+15.3	+9.9	+6.4	+1.0	−1.0	+0.9	+3.2	+3.7	+2.8	+1.7	0.0
30	210	+19.0	+17.6	+12.9	+6.7	+3.1	−1.6	−1.7	+1.0	+2.9	+3.0	+1.7	+0.5	−1.0
40	220	+17.6	+15.2	+9.4	+2.8	−0.5	−3.8	−2.1	+1.0	+2.4	+2.0	+0.3	−0.8	−1.7
50	230	+14.7	+11.7	+5.2	−1.2	−4.1	−5.4	−2.1	+0.8	+1.7	+0.8	−1.0	−2.0	−2.0
60	240	+10.8	+7.4	+0.7	−5.2	−7.2	−6.0	−1.9	+0.6	+0.9	−0.4	−2.2	−2.9	−2.1
70	250	+6.4	+2.7	−3.9	−8.7	−9.3	−5.8	−1.5	+0.4	+0.1	−1.5	−3.2	−3.4	−1.9
80	260	+1.5	−2.2	−8.2	−11.3	−10.2	−5.0	−1.0	+0.1	−0.8	−2.6	−3.8	−3.3	−1.5
90	270	−3.5	−6.9	−12.0	−12.5	−9.7	−3.8	−0.5	−0.1	−1.6	−3.5	−3.9	−2.9	−1.1
100	280	−8.2	−11.3	−14.7	−12.1	−8.1	−2.3	0.0	−0.4	−2.3	−4.0	−3.5	−2.2	−0.5
110	290	−12.5	−14.9	−16.0	−10.1	−5.6	−0.7	+0.6	−0.6	−2.8	−4.0	−2.7	−1.3	0.0
120	300	−16.0	−17.5	−15.2	−6.9	−2.7	+1.0	+1.1	−0.8	−3.1	−3.5	−1.6	−0.4	+0.6
130	310	−18.4	−18.3	−12.2	−2.9	+0.5	+2.6	+1.5	−1.0	−3.1	−2.5	−0.3	+0.7	+1.1
140	320	−18.9	−16.7	−7.2	+1.3	+3.6	+4.1	+1.9	−1.0	−2.5	−1.1	+0.9	+1.6	+1.6
150	330	−16.8	−12.1	−1.0	+5.4	+6.4	+5.2	+2.1	−0.9	−1.5	+0.5	+2.1	+2.5	+1.9
160	340	−11.3	−4.7	+5.4	+8.9	+8.6	+5.9	+2.0	−0.7	−0.1	+1.9	+3.1	+3.1	+2.1
170	350	−2.8	+3.9	+10.9	+11.5	+10.0	+5.9	+1.7	−0.3	+1.2	+3.1	+3.8	+3.4	+2.0
180	360	+6.5	+11.4	+14.6	+12.6	+10.1	+5.1	+0.9	+0.2	+2.4	+3.9	+3.9	+3.3	+1.6

TABLE 22.—*Ratio of increase in amplitude of* K_1 *due to* P_1.

[Argument $h-\frac{1}{2}\nu'$ refers to beginning of series.]

$h-\frac{1}{2}\nu'$ \ Series.		14 days.	29 days.	58 days.	87 days.	105 days.	134 days.	163 days.	192 days.	221 days.	250 days.	279 days.	297 days.	326 days.
		°	°	°	°	°	°	°	°	°	°	°	°	°
0	180	−0.31	−0.26	−0.12	+0.01	+0.06	+0.09	+0.06	+0.01	−0.02	0.00	+0.03	+0.05	+0.05
10	190	−0.25	−0.17	−0.02	+0.09	+0.12	+0.12	+0.07	+0.01	0.00	+0.02	+0.06	+0.07	+0.06
20	200	−0.15	−0.06	+0.07	+0.16	+0.17	+0.13	+0.06	+0.02	+0.02	+0.05	+0.08	+0.08	+0.07
30	210	−0.04	+0.04	+0.16	+0.20	+0.20	+0.13	+0.05	+0.02	+0.04	+0.07	+0.09	+0.09	+0.06
40	220	+0.07	+0.14	+0.23	+0.23	+0.21	+0.12	+0.04	+0.03	+0.05	+0.08	+0.09	+0.09	+0.05
50	230	+0.17	+0.23	+0.27	+0.24	+0.19	+0.09	+0.03	+0.03	+0.06	+0.09	+0.09	+0.08	+0.04
60	240	+0.25	+0.28	+0.29	+0.22	+0.15	+0.05	+0.02	+0.04	+0.07	+0.09	+0.08	+0.06	+0.03
70	250	+0.30	+0.31	+0.28	+0.18	+0.10	+0.02	+0.01	+0.04	+0.08	+0.09	+0.07	+0.04	+0.02
80	260	+0.33	+0.32	+0.24	+0.12	+0.05	−0.01	0.00	+0.04	+0.08	+0.08	+0.04	+0.02	+0.01
90	270	+0.32	+0.29	+0.18	+0.04	−0.02	−0.04	0.00	+0.04	+0.07	+0.06	+0.02	0.00	0.00
100	280	+0.28	+0.23	+0.10	−0.03	−0.07	−0.06	−0.01	+0.04	+0.06	+0.03	0.00	−0.01	0.00
110	290	+0.22	+0.15	+0.01	−0.10	−0.11	−0.07	0.00	+0.04	+0.04	+0.01	−0.02	−0.02	−0.01
120	300	+0.13	+0.05	−0.09	−0.15	−0.14	−0.07	0.00	+0.03	+0.02	−0.01	−0.03	−0.03	0.00
130	310	+0.03	−0.06	−0.17	−0.18	−0.14	−0.06	+0.01	+0.03	0.00	−0.03	−0.04	−0.03	0.00
140	320	−0.08	−0.16	−0.23	−0.19	−0.13	−0.04	+0.02	+0.02	−0.01	−0.04	−0.04	−0.02	+0.01
150	330	−0.19	−0.25	−0.26	−0.17	−0.10	−0.01	+0.03	+0.02	−0.02	−0.04	−0.03	−0.01	+0.02
160	340	−0.28	−0.30	−0.25	−0.12	−0.05	+0.03	+0.04	+0.01	−0.03	−0.03	−0.01	+0.01	+0.03
170	350	−0.32	−0.31	−0.19	−0.06	0.00	+0.06	+0.05	+0.01	−0.03	−0.02	+0.01	+0.03	+0.04
180	360	−0.31	−0.26	−0.12	+0.01	+0.06	+0.09	+0.06	+0.01	−0.02	0.00	+0.03	+0.05	+0.05

TABLE 23.—*Acceleration in epoch of* S_2 *due to* K_2.

[Argument $h-\nu''$ refers to beginning of series.]

Series. / $h-\nu''$		15 days.	29 days.	58 days.	87 days.	105 days.	134 days.	163 days.	192 days.	221 days.	250 days.	279 days.	297 days.	326 days.
		°	°	°	°	°	°	°	°	°	°	°	°	°
0	180	+3.2	+5.9	+10.1	+10.4	+8.0	+3.2	+0.4	+0.1	+1.3	+2.9	+3.2	+2.4	+0.9
10	190	+7.2	+9.6	+12.3	+10.0	+6.7	+2.0	0.0	+0.3	+1.9	+3.3	+2.9	+1.9	+0.5
20	200	+10.8	+12.6	+13.2	+8.4	+4.7	−0.6	−0.5	+0.5	+2.4	+3.3	+2.2	+1.1	0.0
30	210	+13.7	+14.6	+12.5	+5.7	+2.3	−0.9	−0.9	+0.7	+2.6	+2.9	+1.3	+0.3	−0.5
40	220	+15.4	+15.0	+9.9	+2.5	−0.4	−2.2	−1.3	+0.8	+2.5	+2.0	+0.3	−0.6	−1.0
50	230	+15.4	+13.5	+5.8	−1.1	−3.0	−3.4	−1.6	+0.8	+2.0	+0.9	−0.8	−1.4	−1.3
60	240	+13.2	+9.6	+0.8	−4.5	−5.4	−4.4	−1.7	+0.7	+1.2	−0.4	−1.8	−2.1	−1.6
70	250	+8.6	+3.7	−4.4	−7.4	−7.2	−4.9	−1.7	+0.5	+0.1	−1.6	−2.6	−2.6	−1.7
80	260	+1.9	−3.0	−8.8	−9.5	−8.3	−4.9	−1.3	+0.2	−1.0	−2.6	−3.1	−2.8	−1.6
90	270	−5.5	−9.1	−11.9	−10.4	−8.3	−4.2	−0.7	−0.2	−1.9	−3.2	−3.3	−2.7	−1.3
100	280	−11.2	−13.2	−13.2	−9.9	−7.3	−2.7	0.0	−0.5	−2.4	−3.4	−3.0	−2.2	−0.7
110	290	−14.6	−15.0	−12.7	−8.2	−5.2	−0.8	+0.8	−0.7	−2.6	−3.1	−2.3	−1.4	0.0
120	300	−15.6	−14.7	−10.9	−5.6	−2.6	+1.2	+1.4	−0.8	−2.4	−2.5	−1.4	−0.4	+0.8
130	310	−14.7	−12.9	−8.0	−2.4	+0.5	+3.1	+1.7	−0.8	−2.0	−1.7	−0.3	+0.7	+1.3
140	320	−12.4	−10.0	−4.4	+1.0	+3.4	+4.4	+1.7	−0.7	−1.5	−0.7	+0.8	+1.6	+1.7
150	330	−9.1	−6.4	−0.6	+4.4	+5.9	+4.9	+1.6	−0.5	−0.8	+0.3	+1.9	+2.4	+1.7
160	340	−5.3	−2.3	+3.3	+7.3	+7.7	+4.8	+1.3	−0.3	−0.1	+1.3	+2.7	+2.8	+1.6
170	350	−1.1	+1.9	+7.0	+9.4	+8.4	+4.2	+0.9	−0.1	+0.7	+2.2	+3.2	+2.8	+1.3
180	360	+3.2	+5.9	+10.1	+10.4	+8.0	+3.2	+0.4	+0.1	+1.3	+2.9	+3.2	+2.4	+0.9

TABLE 24.—*Ratio of increase in amplitude of* S_2 *due to* K_2.

[Argument $h-\nu''$ refers to beginning of series.]

Series. / $h-\nu''$		15 days.	29 days.	58 days.	87 days.	105 days.	134 days.	163 days.	192 days.	221 days.	250 days.	279 days.	297 days.	326 days.
		°	°	°	°	°	°	°	°	°	°	°	°	°
0	180	+0.26	+0.24	+0.15	+0.03	−0.02	−0.04	−0.01	+0.03	+0.05	+0.04	+0.01	0.00	0.00
10	190	+0.23	+0.19	+0.08	−0.03	−0.06	−0.05	−0.01	+0.03	+0.04	+0.02	0.00	−0.01	−0.01
20	200	+0.18	+0.12	0.00	−0.09	−0.10	−0.06	−0.01	+0.03	+0.03	0.00	−0.02	−0.02	−0.01
30	210	+0.10	+0.04	−0.08	−0.13	−0.12	−0.06	0.00	+0.02	+0.01	−0.01	−0.03	−0.03	−0.01
40	220	+0.01	−0.05	−0.15	−0.15	−0.13	−0.05	0.00	+0.02	0.00	−0.03	−0.04	−0.03	0.00
50	230	−0.08	−0.14	−0.19	−0.16	−0.11	−0.03	+0.01	+0.02	−0.01	−0.04	−0.03	−0.02	0.00
60	240	−0.17	−0.21	−0.21	−0.14	−0.09	−0.01	+0.02	+0.01	−0.02	−0.04	−0.02	−0.01	+0.01
70	250	−0.23	−0.25	−0.20	−0.10	−0.05	+0.02	+0.03	+0.01	−0.03	−0.03	−0.01	0.00	+0.02
80	260	−0.27	−0.25	−0.16	−0.05	0.00	+0.05	+0.04	0.00	−0.02	−0.02	0.00	+0.02	+0.03
90	270	−0.25	−0.21	−0.10	+0.01	+0.05	+0.08	+0.05	0.00	−0.01	0.00	+0.02	+0.04	+0.04
100	280	−0.20	−0.15	−0.02	+0.07	+0.10	+0.10	+0.05	+0.01	0.00	+0.02	+0.04	+0.05	+0.05
110	290	−0.13	−0.06	+0.05	+0.12	+0.14	+0.11	+0.05	+0.01	+0.01	+0.04	+0.06	+0.06	+0.05
120	300	−0.03	+0.03	+0.13	+0.17	+0.16	+0.11	+0.04	+0.01	+0.03	+0.05	+0.07	+0.07	+0.05
130	310	+0.06	+0.11	+0.18	+0.19	+0.17	+0.09	+0.03	+0.02	+0.04	+0.07	+0.08	+0.07	+0.04
140	320	+0.14	+0.18	+0.22	+0.19	+0.15	+0.07	+0.02	+0.02	+0.05	+0.07	+0.07	+0.06	+0.03
150	330	+0.21	+0.23	+0.24	+0.18	+0.13	+0.04	+0.01	+0.03	+0.06	+0.07	+0.06	+0.05	+0.02
160	340	+0.25	+0.26	+0.23	+0.14	+0.08	+0.01	0.00	+0.03	+0.06	+0.07	+0.05	+0.03	+0.01
170	350	+0.27	+0.26	+0.20	+0.09	+0.03	−0.02	0.00	+0.03	+0.06	+0.06	+0.03	+0.02	0.00
180	360	+0.26	+0.24	+0.15	+0.03	−0.02	−0.04	−0.01	+0.03	+0.05	+0.04	+0.01	0.00	0.00

TABLE 25.—*Acceleration in epoch of* S_2 *due to* T_2.

[Argument $h-p_1$ refers to beginning of series.]

Series. / $h-p_1$	15 days.	29 days.	58 days.	87 days.	105 days.	134 days.	163 days.	192 days.	221 days.	250 days.	279 days.	297 days.	326 days.
	°	°	°	°	°	°	°	°	°	°	°	°	°
0	−0.4	−0.8	−1.5	−2.0	−2.2	−2.4	−2.3	−2.0	−1.5	−1.1	−0.6	−0.4	−0.1
10	−1.0	−1.3	−1.9	−2.4	−2.5	−2.6	−2.4	−2.0	−1.4	−0.9	−0.5	−0.3	−0.1
20	−1.5	−1.8	−2.2	−2.7	−2.7	−2.7	−2.3	−1.8	−1.3	−0.7	−0.3	−0.2	0.0
30	−2.0	−2.2	−2.7	−2.9	−2.9	−2.7	−2.2	−1.7	−1.1	−0.6	−0.2	0.0	+0.1
40	−2.4	−2.6	−3.0	−3.0	−2.9	−2.6	−2.0	−1.4	−0.8	−0.4	0.0	+0.1	+0.1
50	−2.7	−2.9	−3.1	−3.1	−2.9	−2.4	−1.8	−1.2	−0.6	−0.2	+0.1	+0.2	+0.2
60	−3.0	−3.2	−3.2	−3.0	−2.8	−2.2	−1.5	−0.9	−0.3	+0.1	+0.3	+0.3	+0.2
70	−3.2	−3.3	−3.2	−2.9	−2.5	−1.9	−1.2	−0.5	0.0	+0.3	+0.4	+0.4	+0.3
80	−3.4	−3.3	−3.1	−2.6	−2.2	−1.5	−0.8	−0.2	+0.3	+0.5	+0.6	+0.5	+0.3
90	−3.4	−3.3	−2.9	−2.3	−1.9	−1.1	−0.4	+0.2	+0.5	+0.7	+0.7	+0.6	+0.4
100	−3.3	−3.1	−2.6	−1.9	−1.4	−0.7	0.0	+0.5	+0.8	+0.9	+0.8	+0.6	+0.4
110	−3.1	−2.8	−2.2	−1.4	−1.0	−0.3	+0.4	+0.8	+1.0	+1.0	+0.9	+0.7	+0.4
120	−2.8	−2.5	−1.8	−0.9	−0.4	+0.3	+0.8	+1.1	+1.2	+1.1	+0.9	+0.7	+0.4
130	−2.4	−2.0	−1.2	−0.4	+0.1	+0.8	+1.2	+1.4	+1.4	+1.2	+0.9	+0.7	+0.4
140	−1.9	−1.5	−0.7	+0.2	+0.6	+1.2	+1.5	+1.6	+1.5	+1.3	+0.9	+0.7	+0.3
150	−1.4	−0.9	−0.1	+0.7	+1.1	+1.6	+1.8	+1.8	+1.6	+1.3	+0.9	+0.7	+0.3
160	−0.8	−0.3	+0.5	+1.2	+1.6	+1.9	+2.1	+2.0	+1.7	+1.3	+0.8	+0.6	+0.3
170	−0.2	+0.3	+1.1	+1.7	+2.0	+2.2	+2.2	+2.0	+1.6	+1.2	+0.8	+0.5	+0.2
180	+0.5	+0.9	+1.6	+2.2	+2.3	+2.5	+2.3	+2.0	+1.6	+1.1	+0.7	+0.4	+0.1
190	+1.1	+1.5	+2.1	+2.5	+2.6	+2.6	+2.4	+2.0	+1.5	+1.0	+0.5	+0.3	+0.1
200	+1.6	+2.0	+2.5	+2.8	+2.8	+2.7	+2.3	+1.8	+1.3	+0.8	+0.4	+0.2	0.0
210	+2.1	+2.4	+2.8	+3.0	+3.0	+2.6	+2.2	+1.7	+1.1	+0.6	+0.2	0.0	−0.1
220	+2.6	+2.8	+3.1	+3.1	+2.9	+2.5	+2.0	+1.5	+0.9	+0.4	0.0	−0.1	−0.1
230	+2.9	+3.1	+3.2	+3.0	+2.9	+2.4	+1.8	+1.2	+0.6	+0.2	−0.1	−0.2	−0.2
240	+3.2	+3.3	+3.2	+3.0	+2.7	+2.1	+1.5	+0.9	+0.3	−0.1	−0.3	−0.3	−0.3
250	+3.3	+3.3	+3.2	+2.8	+2.5	+1.8	+1.2	+0.5	0.0	−0.3	−0.4	−0.4	−0.3
260	+3.4	+3.3	+3.0	+2.5	+2.1	+1.5	+0.8	+0.2	−0.3	−0.5	−0.6	−0.5	−0.3
270	+3.3	+3.2	+2.8	+2.2	+1.8	+1.1	+0.4	−0.2	−0.6	−0.7	−0.7	−0.6	−0.4
280	+3.2	+3.0	+2.5	+1.8	+1.4	+0.6	0.0	−0.5	−0.8	−0.9	−0.8	−0.7	−0.4
290	+2.9	+2.7	+2.1	+1.3	+0.9	+0.2	−0.4	−0.8	−1.1	−1.1	−0.9	−0.7	−0.4
300	+2.6	+2.3	+1.6	+0.9	+0.4	−0.3	−0.8	−1.1	−1.3	−1.2	−0.9	−0.7	−0.4
310	+2.2	+1.9	+1.1	+0.4	−0.1	−0.7	−1.2	−1.4	−1.4	−1.3	−0.9	−0.7	−0.4
320	+1.7	+1.4	+0.6	−0.2	−0.6	−1.1	−1.5	−1.7	−1.5	−1.3	−0.9	−0.7	−0.3
330	+1.2	+0.8	+0.1	−0.7	−1.0	−1.5	−1.8	−1.8	−1.6	−1.3	−0.9	−0.6	−0.3
340	+0.7	+0.3	−0.5	−1.1	−1.5	−1.9	−2.0	−2.0	−1.7	−1.3	−0.8	−0.6	−0.2
350	+0.1	−0.2	−1.0	−1.6	−1.9	−2.2	−2.2	−2.0	−1.6	−1.2	−0.7	−0.5	−0.2
360	−0.4	−0.8	−1.5	−2.0	−2.2	−2.4	−2.3	−2.0	−1.5	−1.1	−0.6	−0.4	−0.1

TABLE 26.—*Resultant amplitude of* S_2 *due to* T_2.

[Argument $h-p_1$ refers to beginning of series.]

Series. / $h-p_1$	15 days.	29 days.	58 days.	87 days.	105 days.	134 days.	163 days.	192 days.	221 days.	250 days.	279 days.	297 days.	326 days.
°													
0	1.06	1.06	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.99	0.99	0.99	0.99
10	1.06	1.05	1.05	1.03	1.03	1.01	1.00	0.99	0.99	0.99	0.99	0.99	0.99
20	1.05	1.05	1.04	1.03	1.02	1.00	0.99	0.99	0.98	0.98	0.99	0.99	0.99
30	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.98	0.98	0.98	0.98	0.99	0.99
40	1.04	1.03	1.02	1.01	1.00	0.99	0.98	0.98	0.98	0.98	0.98	0.99	0.99
50	1.03	1.03	1.01	1.00	0.99	0.98	0.97	0.97	0.97	0.98	0.98	0.99	1.00
60	1.02	1.02	1.00	0.99	0.98	0.97	0.97	0.97	0.97	0.98	0.99	0.99	1.00
70	1.01	1.01	0.99	0.98	0.97	0.97	0.96	0.97	0.97	0.98	0.99	0.99	1.00
80	1.00	1.00	0.98	0.97	0.97	0.96	0.96	0.97	0.97	0.98	0.99	0.99	1.00
90	1.00	0.99	0.97	0.96	0.96	0.96	0.96	0.97	0.97	0.98	0.99	0.99	1.00
100	0.99	0.98	0.97	0.96	0.96	0.96	0.96	0.97	0.98	0.98	0.99	1.00	1.00
110	0.98	0.97	0.96	0.95	0.95	0.95	0.96	0.97	0.98	0.99	0.99	1.00	1.00
120	0.97	0.96	0.95	0.95	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00
130	0.96	0.95	0.95	0.95	0.95	0.96	0.97	0.98	0.99	0.99	1.00	1.00	1.00
140	0.95	0.95	0.94	0.95	0.95	0.96	0.97	0.98	0.99	0.99	1.00	1.00	1.00
150	0.95	0.94	0.94	0.95	0.95	0.96	0.97	0.99	1.00	1.00	1.01	1.01	1.01
160	0.94	0.94	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.01	1.01	1.01
170	0.94	0.94	0.95	0.96	0.96	0.97	0.99	1.00	1.01	1.01	1.01	1.01	1.01
180	0.94	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.01	1.01	1.01	1.01
190	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.01	1.02	1.02	1.01	1.01
200	0.95	0.95	0.96	0.98	0.99	1.00	1.01	1.02	1.02	1.02	1.02	1.01	1.01
210	0.96	0.96	0.97	0.99	0.99	1.01	1.02	1.02	1.02	1.02	1.02	1.01	1.01
220	0.96	0.97	0.98	1.00	1.00	1.01	1.02	1.03	1.03	1.02	1.02	1.01	1.01
230	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.03	1.03	1.02	1.02	1.01	1.01
240	0.98	0.99	1.00	1.01	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.01	1.01
250	0.99	1.00	1.01	1.02	1.03	1.04	1.04	1.04	1.03	1.02	1.02	1.01	1.01
260	1.00	1.01	1.02	1.03	1.04	1.04	1.04	1.04	1.03	1.02	1.01	1.01	1.00
270	1.01	1.02	1.03	1.04	1.04	1.04	1.04	1.04	1.03	1.02	1.01	1.01	1.00
280	1.02	1.03	1.04	1.04	1.05	1.05	1.04	1.04	1.03	1.02	1.01	1.01	1.00
290	1.03	1.03	1.04	1.05	1.05	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00
300	1.04	1.04	1.05	1.05	1.05	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00
310	1.04	1.05	1.05	1.05	1.05	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00
320	1.05	1.05	1.06	1.05	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00
330	1.06	1.06	1.06	1.05	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00
340	1.06	1.06	1.06	1.05	1.05	1.03	1.02	1.01	1.00	1.00	0.99	0.99	1.00
350	1.06	1.06	1.05	1.05	1.04	1.03	1.02	1.00	1.00	0.99	0.99	0.99	1.00
360	1.06	1.06	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.99	0.99	0.99	0.99

TABLE 27.—*Critical logarithms for Form 245.*

Natural number.	Logarithm.	Natural number.	Logarithm.	Natural number.	Logarithm.	Natural number.	Logarithm.	Natural number.	Logarithm.
0.000	....	0.050	8.6947	0.100	8.9979	0.150	9.1747	0.200	9.3000
.001	6.6990	.051	8.7033	.101	9.0022	.151	9.1776	.201	9.3022
.002	7.1761	.052	8.7119	.102	9.0065	.152	9.1805	.202	9.3043
.003	7.3980	.053	8.7202	.103	9.0108	.153	9.1833	.203	9.3065
.004	7.5441	.054	8.7284	.104	9.0150	.154	9.1862	.204	9.3086
.005	7.6533	.055	8.7365	.105	9.0192	.155	9.1890	.205	9.3107
.006	7.7404	.056	8.7443	.106	9.0233	.156	9.1918	.206	9.3129
.007	7.8130	.057	8.7521	.107	9.0274	.157	9.1946	.207	9.3150
.008	7.8751	.058	8.7597	.108	9.0315	.158	9.1973	.208	9.3171
.009	7.9295	.059	8.7672	.109	9.0355	.159	9.2001	.209	9.3192
.010	7.9778	.060	8.7746	.110	9.0395	.160	9.2028	.210	9.3212
.011	8.0212	.061	8.7818	.111	9.0434	.161	9.2055	.211	9.3233
.012	8.0607	.062	8.7889	.112	9.0473	.162	9.2082	.212	9.3254
.013	8.0970	.063	8.7959	.113	9.0512	.163	9.2109	.213	9.3274
.014	8.1304	.064	8.8028	.114	9.0551	.164	9.2136	.214	9.3295
.015	8.1614	.065	8.8096	.115	9.0589	.165	9.2162	.215	9.3315
.016	8.1904	.066	8.8163	.116	9.0626	.166	9.2189	.216	9.3335
.017	8.2175	.067	8.8229	.117	9.0664	.167	9.2215	.217	9.3355
.018	8.2431	.068	8.8294	.118	9.0701	.168	9.2241	.218	9.3375
.019	8.2672	.069	8.8357	.119	9.0738	.169	9.2267	.219	9.3395
.020	8.2901	.070	8.8420	.120	9.0774	.170	9.2292	.220	9.3415
.021	8.3118	.071	8.8482	.121	9.0810	.171	9.2318	.221	9.3435
.022	8.3325	.072	8.8544	.122	9.0846	.172	9.2343	.222	9.3454
.023	8.3522	.073	8.8604	.123	9.0882	.173	9.2368	.223	9.3474
.024	8.3711	.074	8.8663	.124	9.0917	.174	9.2394	.224	9.3493
.025	8.3892	.075	8.8722	.125	9.0952	.175	9.2419	.225	9.3513
.026	8.4066	.076	8.8780	.126	9.0987	.176	9.2443	.226	9.3532
.027	8.4233	.077	8.8837	.127	9.1021	.177	9.2468	.227	9.3551
.028	8.4394	.078	8.8894	.128	9.1056	.178	9.2493	.228	9.3570
.029	8.4549	.079	8.8949	.129	9.1090	.179	9.2517	.229	9.3589
.030	8.4699	.080	8.9004	.130	9.1123	.180	9.2541	.230	9.3608
.031	8.4844	.081	8.9059	.131	9.1157	.181	9.2565	.231	9.3627
.032	8.4984	.082	8.9112	.132	9.1190	.182	9.2589	.232	9.3646
.033	8.5119	.083	8.9165	.133	9.1223	.183	9.2613	.233	9.3665
.034	8.5251	.084	8.9217	.134	9.1255	.184	9.2637	.234	9.3683
.035	8.5379	.085	8.9269	.135	9.1288	.185	9.2661	.235	9.3702
.036	8.5503	.086	8.9320	.136	9.1320	.186	9.2684	.236	9.3720
.037	8.5623	.087	8.9371	.137	9.1352	.187	9.2707	.237	9.3739
.038	8.5741	.088	8.9421	.138	9.1384	.188	9.2731	.238	9.3757
.039	8.5855	.089	8.9470	.139	9.1415	.189	9.2754	.239	9.3775
.040	8.5967	.090	8.9519	.140	9.1446	.190	9.2777	.240	9.3794
.041	8.6075	.091	8.9567	.141	9.1477	.191	9.2799	.241	9.3812
.042	8.6181	.092	8.9615	.142	9.1508	.192	9.2822	.242	9.3830
.043	8.6284	.093	8.9662	.143	9.1539	.193	9.2845	.243	9.3848
.044	8.6385	.094	8.9709	.144	9.1569	.194	9.2867	.244	9.3866
.045	8.6484	.095	8.9755	.145	9.1599	.195	9.2890	.245	9.3883
.046	8.6581	.096	8.9801	.146	9.1629	.196	9.2912	.246	9.3901
.047	8.6675	.097	8.9846	.147	9.1659	.197	9.2934	.247	9.3919
.048	8.6767	.098	8.9891	.148	9.1688	.198	9.2956	.248	9.3936
.049	8.6858	.099	8.9935	.149	9.1718	.199	9.2978	.249	9.3954
.050	8.6947	.100	8.9979	.150	9.1747	.200	9.3000	.250	9.3971

TABLE 28.—*Component speed differences* $(b-a)$ *and log* $(b-a)$.

DIURNAL COMPONENTS.

A \ B	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	0 0	−0.544375 9.735898	−1.088749 0.036928	−1.642408 0.215481	+0.553658 9.743242	−0.626512 9.796929	−2.186782 0.339806	−2.731157 0.436347	−0.585443 9.767485	−2.113929 0.325090
K_1	+0.544375 9.735898	0 0	−0.544375 9.735898	−1.098033 0.040615	+1.098033 0.040615	−0.082137 8.914539	−1.642408 0.215481	−2.186782 0.339806	−0.041069 8.613514	−1.569554 0.195776
M_1	+1.088749 0.036928	+0.544375 9.735898	0 0	−0.553658 9.743242	+1.642408 0.215481	+0.462237 9.664865	−1.098033 0.040615	−1.642408 0.215481	+0.503306 9.701832	−1.025179 0.010800
O_1	+1.642408 0.215481	+1.098033 0.040615	+0.553658 9.743242	0 0	+2.196066 0.341645	+1.015896 0.006849	−0.544375 9.735898	−1.088749 0.036928	+1.056964 0.024060	−0.471521 9.673501
OO	−0.553658 9.743242	−1.098033 0.040615	−1.642408 0.215481	−2.196066 0.341645	0 0	−1.180170 0.071945	−2.740441 0.437820	−3.284816 0.516511	−1.139102 0.056563	−2.667587 0.426119
P_1	+0.626512 9.796929	+0.082137 8.914539	−0.462237 9.664865	−1.015896 0.006849	+1.180170 0.071945	0 0	−1.560270 0.193200	−2.104645 0.323179	+0.041069 8.613514	−1.487417 0.172433
Q_1	+2.186782 0.339806	+1.642408 0.215481	+1.098033 0.040615	+0.544375 9.735898	+2.740441 0.437820	+1.560270 0.193200	0 0	−0.544375 9.735898	+1.601339 0.204483	+0.072854 8.862453
2Q	+2.731157 0.436347	+2.186782 0.339806	+1.642408 0.215481	+1.088749 0.036928	+3.284816 0.516511	+2.104645 0.323179	+0.544375 9.735898	0 0	+2.145714 0.331572	+0.617228 9.790446
S_1	+0.585443 9.767485	+0.041069 8.613514	−0.503306 9.701832	−1.056964 0.024060	+1.139102 0.056563	−0.041069 8.613514	−1.601339 0.204483	−2.145714 0.331572	0 0	−1.528486 0.184261
ρ_1	+2.113929 0.325090	+1.569554 0.195776	+1.025179 0.010800	+0.471521 9.673501	+2.667587 0.426119	+1.487417 0.172433	−0.072854 8.862453	−0.617228 9.790446	+1.528486 0.184261	0 0

TABLE 28.—*Component speed differences (b—a) and log (b—a)*—Continued.

SEMIDIURNAL COMPONENTS.

A \ *B*	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	0 0	−0.553658 9.743242	−1.098033 0.040615	−1.642408 0.215481	−2.186782 0.339806	−0.041071 8.613535	−0.082137 8.914539	−0.123204 9.090625	−0.626512 9.796929	−2.113929 0.325090	−1.569554 0.195776	+0.933759 9.970235
L_2	+0.553658 9.743242	0 0	−0.544375 9.735898	−1.088749 0.036928	−1.633124 0.213019	+0.512588 9.709768	+0.471521 9.673501	+0.430454 9.633927	−0.072854 8.862453	−1.560270 0.193200	−1.015896 0.006849	+1.487417 0.172433
M_2	+1.098033 0.040615	+0.544375 9.735898	0 0	−0.544375 9.735898	−1.088749 0.036928	+1.056962 0.024059	+1.015896 0.006849	+0.974829 9.938928	+0.471521 9.673501	−1.015896 0.006849	−0.471521 9.673501	+2.031792 0.307879
N_2	+1.642408 0.215481	+1.088749 0.036928	+0.544375 9.735898	0 0	−0.544375 9.735898	+1.601337 0.204483	+1.560270 0.193200	+1.519204 0.181616	+1.015896 0.006849	−0.471521 9.673501	+0.072854 8.862453	+2.576166 0.410974
2N	+2.186782 0.339806	+1.633124 0.213019	+1.088749 0.036928	+0.544375 9.735898	0 0	+2.145712 0.331571	+2.104645 0.323179	+2.063579 0.314621	+1.560270 0.193200	+0.072854 8.862453	+0.617228 9.790446	+3.120541 0.494230
R_2	+0.041071 8.613535	−0.512588 9.709768	−1.056962 0.024059	−1.601337 0.204483	−2.145712 0.331571	0 0	−0.041067 8.613493	−0.082133 8.914518	−0.585441 9.767483	−2.072858 0.316570	−1.528484 0.184261	+0.974829 9.988928
S_2	+0.082137 8.914539	−0.471521 9.673501	−1.015896 0.006849	−1.560270 0.193200	−2.104645 0.323179	+0.041067 8.613493	0 0	−0.041067 8.613493	−0.544375 9.735898	−2.031792 0.307879	−1.487417 0.172433	+1.015896 0.006849
T_2	+0.123204 9.090625	−0.430454 9.633927	−0.974829 9.988928	−1.519204 0.181616	−2.063579 0.314621	+0.082133 8.914518	+0.041067 8.613493	0 0	−0.503308 0.701834	−1.990725 0.299011	−1.446350 0.160273	+1.056962 0.024059
λ_2	+0.626512 9.796929	+0.072854 8.862453	−0.471521 9.673501	−1.015896 0.006849	−1.560270 0.193200	+0.585441 9.767483	+0.544375 9.735893	+0.503308 9.701834	0 0	−1.487417 0.172433	−0.943042 9.974531	+1.560270 0.193200
μ_2	+2.113929 0.325090	+1.560270 0.193200	+1.015896 0.006849	+0.471521 9.673501	−0.072854 8.862453	+2.072858 0.316570	+2.031792 0.307879	+1.990725 0.299011	+1.487417 0.172433	0 0	+0.544375 9.735898	+3.047687 0.483970
ν_2	+1.569554 0.195776	+1.015896 0.006849	+0.471521 9.673501	−0.072854 8.862453	−0.617228 9.790446	+1.528484 0.184261	+1.487417 0.172433	+1.446350 0.160273	+0.943042 9.974531	−0.544375 9.735898	0 0	+2.503313 0.398515
2SM	−0.933759 0.970235	−1.487417 0.172433	−2.031792 0.307879	−2.576166 0.410974	−3.120541 0.494230	−0.974829 9.988928	−1.015896 0.006849	−1.056962 0.024059	−1.560270 0.193200	−3.047687 0.483970	−2.503313 0.398515	0 0

TABLE 29.—*Elimination factors.*

[Upper line for each component gives the logarithms of the factors; middle line, corresponding natural numbers; lower line, angles in degrees.]

SERIES 14 DAYS. DIURNAL COMPONENTS.

Component sought (*A*).	Disturbing components (*B*, *C*, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	9.7968 .626 269	8.2015 .016 357	9.3150 .207 264	9.7890 .615 93	9.7203 .525 255	8.3017 .020 353	9.0913 .123 261	9.7607 .576 262	8.1357 .014 185
K_1	9.7968 .626 91	....	9.7968 .626 269	8.3839 .024 356	8.3839 .024 4	9.9958 .990 346	9.3150 .207 264	8.3017 .020 353	9.9990 .998 353	9.3344 .216 276
M_1	8.2015 .016 3	9.7968 .626 91	....	9.7890 .615 267	9.3150 .207 96	9.8578 .721 78	8.3839 .024 356	9.3150 .207 264	9.8290 675 85	8.6530 .045 188
O_1	9.3150 .207 96	8.3839 .024 4	9.7890 .615 93	....	8.3826 .024 9	8.7358 .054 171	9.7968 .626 269	8.2015 .016 357	8.1361 .014 178	9.8516 .711 281
OO	9.7890 .615 267	8.3839 .024 356	9.3150 .207 264	8.3826 .024 351	....	8.9571 .091 342	9.0878 .122 260	8.3320 .021 348	8.7710 .059 349	9.1065 .128 272
P_1	9.7203 .525 105	9.9958 .990 14	9.8578 .721 282	8.7358 .054 189	8.9571 .091 18	....	9.3355 .217 278	8.2581 .018 186	9.9990 .998 7	9.3331 .215 290
Q_1	8.3017 .020 7	9.3150 .207 96	8.3839 .024 4	9.7968 .626 91	9.0878 .122 100	9.3355 .217 82	....	9.7968 .626 269	9.3283 .213 89	9.9967 .992 12
2Q	9.0913 .123 99	8.3017 .020 7	9.3150 .207 96	8.2015 .016 3	8.3320 .021 12	8.2581 .018 174	9.7968 .626 91	....	7.1244 .001 0	9.7298 .537 104
S_1	9.7607 .576 98	9.9990 .998 7	9.8290 .675 275	8.1361 .014 182	8.7710 .059 11	9.9990 .998 353	9.3283 .213 271	7.1244 .001 0	....	9.3369 .217 283
ρ_1	8.1357 .014 175	9.3344 .216 84	8.6530 .045 172	9.8516 .711 79	9.1065 .128 88	9.3331 .215 70	9.9967 .992 348	9.7298 .537 256	9.3369 .217 77	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 15 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	9.7534 .567 260	8.9437 .088 342	9.2424 .175 244	8.9063 .081 326	9.9986 .997 353	9.9950 .989 345	9.9892 .975 338	9.6707 .468 247	8.7223 .053 339	9.2966 .198 257	8.8476 .070 168
L_2	9.7534 .567 100	....	9.7627 .579 262	8.9055 .080 344	9.2507 .178 246	9.7927 .620 92	9.8276 .672 85	9.8585 .722 77	9.9961 .991 347	9.3018 .200 259	8.1941 .016 357	9.3301 .214 88
M_2	8.9437 .088 18	9.7627 .579 98	....	9.7627 .579 262	8.9055 .080 344	8.7291 .054 10	8.1941 .016 3	8.4114 .026 175	9.8276 .672 85	8.1941 .016 357	9.8276 .672 275	8.1935 .016 6
N_2	9.2424 .175 116	8.9055 .080 16	9.7627 .579 98	....	9.7627 .579 262	9.2760 .189 108	9.3018 .200 101	9.3204 .209 93	8.1941 .016 3	9.8276 .672 275	9.9961 .991 13	9.0793 .120 104
2N	8.9063 .081 34	9.2507 .178 114	8.9055 .080 16	9.7627 .579 98	....	8.8167 .066 26	8.6888 .049 19	8.4856 .031 11	9.3018 .200 101	9.9961 .991 13	9.6823 .481 111	8.5765 .038 22
R_2	9.9986 .997 7	9.7927 .620 268	8.7291 .054 350	9.2760 .189 252	8.8167 .066 334	....	9.9987 .997 353	9.9950 .989 345	9.7195 .524 255	8.5420 .035 347	9.3168 .207 265	8.4114 .026 175
S_2	9.9950 .989 15	9.8276 .672 275	8.1941 .016 357	9.3018 .200 259	8.6888 .049 341	9.9987 .997 7	....	9.9987 .997 353	9.7627 .579 262	8.1935 .016 354	9.3301 .214 272	8.1941 .016 3
T_2	9.9892 .975 22	9.8585 .722 283	8.4114 .026 185	9.3204 .209 267	8.4856 .031 349	9.9950 .989 15	9.9987 .997 7	....	9.8010 .632 269	7.6684 .005 182	9.3364 .217 280	8.7291 .054 10
λ_2	9.6707 .468 113	9.9961 .991 13	9.8276 .672 275	8.1941 .016 357	9.3018 .200 259	9.7195 .524 105	9.7627 .579 98	9.8010 .632 91	....	9.3301 .214 272	8.7786 .060 190	9.3018 .200 101
μ_2	8.7223 .053 21	9.3018 .200 101	8.9141 .016 3	9.8276 .672 85	9.9961 .991 347	8.5420 .035 13	8.1935 .016 6	7.6684 .005 178	9.3301 .214 88	....	9.7627 .579 98	8.1926 .016 9
ν_2	0.2966 .198 103	8.1941 .016 3	9.8276 .672 85	9.9961 .991 347	9.6823 .481 249	9.3168 .207 95	9.3301 .214 88	9.3364 .217 80	8.7786 .060 170	9.7627 .579 262	....	9.1043 .127 91
2SM	8.8476 .070 192	9.3301 .214 272	8.1935 .016 354	9.0793 .120 256	8.5765 .038 338	8.4114 .026 185	8.1941 .016 357	8.7291 .054 350	9.3018 .200 259	8.1926 .016 351	9.1043 .127 269	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 29 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.6955 .050 351	8.6896 .049 341	8.7199 .052 328	8.8144 .065 13	9.2092 .162 322	8.6937 .049 319	8.6672 .046 310	9.0538 .113 336	8.3224 .021 344
K_1	8.6955 .050 9	....	8.6955 .050 351	8.7517 .056 338	8.7517 .056 22	9.9818 .959 331	8.7199 .052 328	8.6937 .049 319	9.9954 .990 346	8.0542 .011 354
M_1	8.6896 .049 19	8.6955 .050 9	....	8.8144 .065 347	8.7199 .052 32	9.0674 .117 161	8.7517 .056 338	8.7199 .052 328	8.4418 .028 175	7.9579 .009 183
O_1	8.7199 .052 32	8.7517 .056 22	8.8144 .065 13	....	8.7185 .052 44	8.2616 .018 174	8.6955 .050 351	8.6896 .049 341	8.3262 .021 8	8.9810 .096 196
OO	8.8144 .065 347	8.7517 .056 338	8.7199 .052 328	8.7185 .052 316	....	9.0332 .108 309	8.6848 .048 306	8.6504 .045 297	8.9334 .086 324	8.4666 .029 332
P_1	9.2092 .162 38	9.9818 .959 29	9.0674 .117 199	8.2616 .018 186	9.0332 .108 51	....	7.7378 .005 357	8.2260 .017 348	9.9954 .990 14	8.6248 .042 202
Q_1	8.6937 .049 41	8.7199 .052 32	8.7517 .056 22	8.6955 .050 9	8.6848 .048 54	7.7378 .005 3	....	8.6955 .050 351	8.4846 .031 17	9.9857 .968 25
2Q	8.6672 .046 50	8.6937 .049 41	8.7199 .052 32	8.6896 .049 19	8.6504 .045 63	8.2260 .017 12	8.6955 .050 9	....	8.5377 .034 27	9.1825 .152 35
S_1	9.0538 .113 24	9.9954 .990 14	8.4418 .028 185	8.3262 .021 352	8.9334 .086 36	9.9954 .990 346	8.4846 .031 343	8.5377 .034 333	....	8.1807 .015 188
ρ_1	8.3224 .021 16	8.0542 .011 6	7.9579 .009 177	8.9810 .096 164	8.4666 .029 28	8.6248 .042 158	9.9857 .968 335	9.1825 .152 325	8.1807 .015 172	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 29 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.). K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	....	8.8144 .065 347	8.7517 .056 338	8.7199 .052 328	8.6937 .049 319	9.9954 .990 346	9.9818 .959 331	9.9587 .909 317	9.2092 .162 322	8.3224 .021 344	8.0542 .011 354	9.0054 .101 145
L_2	8.8144 .065 13	....	8.6955 .050 351	8.6896 .049 341	8.6798 .048 332	7.9581 .009 178	8.9810 .096 164	9.2842 .192 150	9.9857 .968 335	7.7378 .005 357	8.2616 .018 186	8.6248 .042 158
M_2	8.7517 .056 22	8.6955 .050 9	....	8.6955 .050 351	8.6896 .049 341	8.3262 .021 8	8.2616 .018 174	8.7772 .060 159	8.9810 .096 164	8.2616 .018 186	8.9810 .096 196	8.2588 .018 167
N_2	8.7199 .052 32	8.6896 .049 19	8.6955 .050 9	....	8.6955 .050 351	8.4846 .031 17	7.7378 .005 3	8.3278 .021 169	8.2616 .018 174	8.9810 .096 196	9.9857 .968 25	7.5900 .004 177
2N	8.6937 .049 41	8.6798 .048 28	8.6896 .049 19	8.6955 .050 9	....	8.5377 .034 27	8.2260 .017 12	7.4179 .003 178	7.7378 .005 3	9.9857 .968 25	9.1825 .152 35	7.7379 .005 6
R_2	9.9954 .990 14	7.9581 .009 182	8.3262 .021 352	8.4846 .031 343	8.5377 .034 333	....	9.9954 .990 346	9.9818 .959 331	9.0538 .113 336	7.2754 .002 359	8.1807 015 188	8.7772 .060 159
S_2	9.9818 .959 29	8.9810 .096 196	8.2616 .018 186	7.7378 .005 357	8.2260 .017 348	9.9954 .990 14	....	9.9954 .990 346	8.6955 .050 351	8.2588 .018 193	8.6248 .042 202	8.2616 .018 174
T_2	9.9587 .909 43	9.2842 .192 210	8.7772 .060 201	8.3278 .021 191	7.4179 .003 182	9.9818 .959 29	9.9954 .990 14	....	8.4418 .028 185	8.5780 .038 207	8.8324 .068 217	8.3262 .021 8
λ_2	9.2092 .162 38	9.9857 .968 25	8.9810 .096 196	8.2616 .018 186	7.7378 .005 357	9.0538 .113 24	8.6955 050 9	8.4418 .028 175	....	8.6248 .042 202	8.9640 .092 212	7.7378 .005 3
μ_2	8.3224 .021 16	7.7378 .005 3	8.2616 .018 174	8.9810 .096 164	9.9857 .968 335	7.2754 .002 1	8.2588 .018 167	8.5780 .038 153	8.6248 .042 158	....	8.6955 .050 9	8.2539 .018 161
ν_2	8.0542 .011 6	8.2616 .018 174	8.9810 .096 164	9.9857 .968 335	9.1825 .152 325	8.1807 .015 172	8.6248 .042 158	8.8324 .068 143	8.9640 .092 148	8.6955 .050 351	....	8.5015 .032 151
2SM	9.0054 .101 215	8.6248 .042 202	8.2588 .018 193	7.5900 .004 183	7.7379 .005 354	8.7772 .060 201	8.2616 .018 186	8.3262 .021 352	7.7378 .005 357	8.2539 .018 199	8.5015 .032 209	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 58 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.6896 .049 341	8.6657 .046 322	8.6504 .045 297	8.8039 .064 25	9.1056 .128 284	8.5715 .037 278	8.4713 .030 259	9.0154 .104 313	8.3059 .020 329
K_1	8.6896 .049 19	....	8.6896 .049 341	8.7185 .052 316	8.7185 .052 44	9.9254 .842 303	8.6504 .045 297	8.5715 .037 278	9.9818 .959 331	8.0520 .011 348
M_1	8.6657 .046 38	8.6896 .049 19	....	8.8039 .064 335	8.6504 .045 63	9.0427 .110 142	8.7185 .052 316	8.6504 .045 297	8.4403 .028 170	7.9572 .009 186
O_1	8.6504 .045 63	8.7185 .052 44	8.8039 .064 25	....	8.5737 .037 88	8.2588 .018 167	8.6896 .049 341	8.6657 .046 322	8.3224 .021 16	8.9640 .092 212
OO	8.8039 .064 335	8.7185 .052 316	8.6504 .045 297	8.5737 .037 272	....	8.8349 .068 259	8.4575 .029 253	8.3057 .020 234	8.8391 .069 287	8.4112 .026 303
P_1	9.1056 .128 76	9.9254 .842 57	9.0427 .110 218	8.2588 .018 193	8.8349 .068 101	....	7.7379 .005 354	8.2155 .016 335	9.9818 .959 29	8.5907 .039 225
Q_1	8.5715 .037 82	8.6504 .045 63	8.7185 .052 44	8.6896 .049 19	8.4575 .029 107	7.7379 .005 6	....	8.6896 .049 341	8.4645 .029 35	9.9418 .875 51
2Q	8.4713 .030 101	8.5715 .037 82	8.6504 .045 63	8.6657 .046 38	8.3057 .020 126	8.2155 .016 25	8.6896 .049 19	....	8.4887 .031 53	9.0969 .125 70
S_1	9.0154 .104 47	9.9818 .959 29	8.4403 .028 190	8.3224 .021 344	8.8391 .069 73	9.9818 .959 331	8.4645 .029 325	8.4887 .031 307	....	8.1761 .015 196
ρ_1	8.3059 .020 34	8.0520 .011 12	7.9572 .009 174	8.9640 .092 148	8.4112 .026 57	8.5907 .039 135	9.9418 .875 309	9.0969 .125 290	8.1761 .015 164	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 58 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	....	8.8039 .064 335	8.7185 .052 316	8.6504 .045 297	8.5715 .037 278	9.9818 .959 331	9.9254 .842 303	9.8237 .666 274	9.1056 .128 284	8.3059 .020 329	8.0520 .011 348	8.9185 .083 110
L_2	8.8039 .064 25	....	8.6896 .049 341	8.6657 .046 322	8.6244 .042 303	7.9579 .009 177	8.9640 .092 148	9.2209 .166 120	9.9418 .875 309	7.7379 .005 354	8.2588 .018 193	8.5907 .039 135
M_2	8.7185 .052 44	8.6896 .049 19	....	8.6896 .049 341	8.6657 .046 322	8.3224 .021 16	8.2588 .018 167	8.7480 .056 138	8.9640 .092 148	8.2588 .018 193	8.9640 .092 212	8.2475 .018 154
N_2	8.6504 .045 63	8.6657 .046 38	8.6896 .049 19	....	8.6896 .049 341	8.4645 .029 35	7.7379 .005 6	8.3193 .021 157	8.2588 .018 167	8.9640 .092 212	9.9418 .875 51	7.5898 .004 173
2N	8.5715 .037 82	8.6244 .042 57	8.6657 .046 38	8.6896 .049 19	....	8.4887 .031 53	8.2155 .016 25	7.4165 .003 176	7.7379 .005 6	9.9418 .875 51	9.0969 .125 70	7.7356 .005 12
R_2	9.9818 .959 29	7.9579 .009 183	8.3224 .021 344	8.4645 .029 325	8.4887 .031 307	....	9.9818 .959 331	9.9254 .842 303	9.0154 .104 313	7.2736 .002 357	8.1761 .015 196	8.7480 .056 138
S_2	9.9254 .842 57	8.9640 .092 212	8.2588 .018 193	7.7379 .005 354	8.2155 .016 335	9.9818 .959 29	....	9.9818 .959 331	8.6896 .049 341	8.2475 .018 206	8.5907 .039 225	8.2588 .018 167
T_2	9.8237 .666 86	9.2209 .166 240	8.7480 .056 222	8.3193 .021 203	7.4165 .003 184	9.9254 .842 57	9.9818 .959 29	....	8.4402 .028 190	8.5270 .034 234	8.7366 .055 253	8.3224 .021 16
λ_2	9.1056 .128 76	9.9418 .875 51	8.9640 .092 212	8.2588 .018 193	7.7379 .005 354	9.0154 .104 47	8.6896 .049 19	8.4402 .028 170	....	8.5907 .039 225	8.8933 .078 244	7.7379 .005 6
μ_2	8.3059 .020 31	7.7379 .005 6	8.2588 .018 167	8.9640 .092 148	9.9418 .875 309	7.2736 .002 3	8.2475 .018 154	8.5270 .034 126	8.5907 .039 135	....	8.6896 .049 19	8.2236 .017 141
ν_2	8.0520 .011 12	8.2588 .018 167	8.9640 .092 148	9.9418 .875 309	9.0969 .125 290	8.1761 .015 164	8.5907 .039 135	8.7366 .055 107	8.8933 .078 116	8.6896 .049 341	....	8.4439 .028 122
2SM	8.9185 .083 250	8.5907 .039 225	8.2475 .018 206	7.5898 .004 187	7.7356 .005 348	8.7480 .056 222	8.2588 .018 193	8.3224 .021 344	7.7379 .005 354	8.2286 .017 219	8.4439 .028 233	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 87 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.6798 .048 332	8.6244 .042 303	8.5225 .033 265	8.7857 .061 38	8.9030 .080 246	8.3232 .021 237	7.9841 .010 209	8.9481 .089 289	8.2780 .019 313
K_1	8.6798 .048 28	....	8.6798 .048 332	8.6607 .046 294	8.6607 .046 66	9.8237 .666 274	8.5225 .033 265	8.3232 .021 237	9.9587 .909 317	8.0476 .011 341
M_1	8.6244 .042 57	8.6798 .048 28	....	8.7857 .061 322	8.5225 .033 95	9.0002 .100 123	8.6607 .046 294	8.5225 .033 265	8.4376 .027 165	7.9556 .009 190
O_1	8.5225 .033 95	8.6607 .046 66	8.7857 .061 38	....	8.2641 .018 133	8.2539 .018 161	8.6798 .048 332	8.6244 .042 303	8.3155 .021 23	8.9351 .086 228
OO	8.7857 .061 322	8.6607 .046 294	8.5225 .033 265	8.2641 .018 227	....	8.3377 .022 208	7.8138 .007 199	7.4337 .027 351	8.6579 .045 251	8.3116 .020 275
P_1	8.9030 .080 114	9.8237 .666 86	9.0002 .100 237	8.2539 .018 199	8.3377 .022 152	....	7.7367 .005 351	8.1982 .016 323	9.9587 .909 43	8.5315 .034 247
Q_1	8.3232 .021 123	8.5225 .033 95	8.6607 .046 66	8.6798 .048 28	7.8138 .007 161	7.7367 .005 9	....	8.6798 .048 332	8.4303 .027 52	9.8640 .731 76
2Q	7.9841 .010 151	8.3232 .021 123	8.5225 .033 95	8.6244 .042 57	8.4337 .027 9	8.1982 .016 37	8.6798 .048 28	....	8.4014 .025 80	8.9351 .086 104
S_1	8.9481 .089 71	9.9587 .909 43	8.4376 .027 195	8.3155 .021 337	8.6579 .045 109	9.9587 .909 317	8.4303 .027 308	8.4014 .025 280	....	8.1689 .015 204
ρ_1	8.2780 .019 47	8.0476 .011 19	7.9556 .009 170	8.9351 .086 132	8.3116 .020 85	8.5315 .034 113	9.8640 .731 284	8.9351 .086 256	8.1689 .015 156	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 87 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	....	8.7857 .061 322	8.6607 .046 294	8.5225 .033 265	8.3232 .021 237	9.9587 .909 317	9.8237 .666 274	9.5416 .348 231	8.9030 .080 246	8.2780 .019 313	8.0476 .011 341	8.7538 .057 75
L_2	8.7857 .061 38	....	8.6798 .048 332	8.6244 .042 303	8.5247 .033 275	7.9576 .009 175	8.9351 .086 132	9.1055 .127 89	9.8640 .731 284	7.7367 .005 351	8.2539 .018 199	8.5315 .034 113
M_2	8.6607 .046 66	8.6798 .048 28	....	8.6798 .048 332	8.6244 .042 303	8.3155 .021 23	8.2539 .018 161	8.6976 .050 118	8.9351 .086 132	8.2539 .018 199	8.9351 .086 228	8.2286 .017 141
N_2	8.5225 .033 95	8.6244 .042 57	8.6798 .048 28	....	8.6798 .048 332	8.4303 .027 52	7.7367 .005 9	8.3068 .020 146	8.2539 .018 161	8.9351 .086 228	9.8640 .731 76	7.5883 .004 170
2N	8.3232 .021 123	8.5247 .033 85	8.6244 .042 57	8.6798 .048 28	....	8.4014 .025 80	8.1982 .016 37	7.4165 .003 174	7.7367 .005 9	9.8640 .731 76	8.9351 .086 104	7.7314 .005 18
R_2	9.9587 .909 43	7.9576 .009 185	8.3155 .021 337	8.4303 .027 308	8.4014 .025 280	....	9.9587 .909 317	9.8237 .666 274	8.9481 .089 289	7.2740 .002 356	8.1689 .015 204	8.6976 .050 118
S_2	9.8237 .666 86	8.9351 .086 228	8.2539 .018 199	7.7367 .005 351	8.1982 .016 323	9.9587 .909 43	....	9.9587 .909 317	8.6798 .048 332	8.2286 .017 219	8.5315 .034 247	8.2539 .018 161
T_2	9.5416 .348 129	9.1055 .127 271	8.6976 .050 242	8.3068 .020 214	7.4165 .003 186	9.8237 .666 86	9.9587 .909 43	....	8.4376 .027 195	8.4358 .027 262	8.5521 .036 290	8.3155 .021 23
λ_2	8.9030 .080 114	9.8640 .731 76	8.9351 .086 228	8.2539 .018 199	7.7367 .005 351	8.9481 .089 71	8.6798 .048 28	8.4376 .027 165	....	8.5315 .034 247	8.7629 .058 275	7.7367 .005 9
μ_2	8.2780 .019 47	7.7367 .005 9	8.2539 .018 161	8.9351 .086 132	9.8640 .731 284	7.2740 .002 4	8.2286 .017 141	8.4358 .027 98	8.5315 .034 113	....	8.6798 .048 28	8.1849 .015 122
ν_2	8.0476 .011 19	8.2539 .018 161	8.9351 .086 132	9.8640 .731 284	8.9351 .086 256	8.1689 .015 156	8.5315 .034 113	8.5521 .036 70	8.7629 .058 85	8.6798 .048 332	....	8.3401 .022 93
2SM	8.7538 .057 285	8.5315 .034 247	8.2286 .017 219	7.5883 .004 190	7.7314 .005 342	8.6976 .050 242	8.2539 .018 199	8.3155 .021 337	7.7367 .005 351	8.1849 .015 238	8.3401 .022 267	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 105 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.6704 .047 214	8.5885 .039 248	8.4422 .028 271	8.4953 .031 158	8.8322 .068 291	8.2332 .017 305	7.7808 .006 339	8.3722 .024 342	8.1065 .013 216
K_1	8.6704 .047 146	....	8.6704 .047 214	8.5381 .035 236	8.5381 .035 124	9.7311 .538 257	8.4422 .028 271	8.2332 .017 305	9.9393 .870 308	7.0766 .001 182
M_1	8.5885 .039 112	8.6704 .047 146	....	8.4953 .031 202	8.4422 .028 89	8.8219 .066 42	8.5381 .035 236	8.4422 .028 271	8.9548 .090 94	8.3679 .023 328
O_1	8.4422 .028 89	8.5381 .035 124	8.4953 .031 158	....	8.2803 .019 67	8.1856 .015 20	8.6704 .047 214	8.5885 .039 248	8.6113 .041 72	8.8929 .078 306
OO	8.4953 .031 202	8.5381 .035 236	8.4422 .028 271	8.2803 .019 293	....	8.4500 .028 313	7.9556 .009 327	6.4362 .000 181	7.5174 .003 185	8.1640 .015 239
P_1	8.8322 .068 69	9.7311 .538 103	8.8219 .066 318	8.1856 .015 340	8.4500 .028 47	....	7.8500 .007 194	8.2067 .016 228	9.9393 .870 52	8.4685 .029 286
Q_1	8.2332 .017 55	8.4422 .028 89	8.5381 .035 124	8.6704 .047 146	7.9556 .009 33	7.8500 .007 166	....	8.6704 .047 214	8.2396 .017 38	9.7951 .624 92
2Q	7.7808 .006 21	8.2332 .017 55	8.4422 .028 89	8.5885 .039 112	6.4362 .000 179	8.2067 .016 132	8.6704 .047 146	....	7.1241 .001 4	8.7943 .062 58
S_1	8.3722 .024 18	9.9393 .870 52	8.9548 .090 266	8.6113 .041 288	7.5174 .003 175	9.9393 .870 308	8.2396 .017 322	7.1241 .001 356	....	8.3820 .024 234
ρ_1	8.1065 .013 144	7.0766 .001 178	8.3679 .023 32	8.8929 .078 54	8.1640 .015 121	8.4685 .029 74	9.7951 .624 268	8.7943 .062 302	8.3820 .024 126	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 105 DAYS. SEMIDIURNAL COMPONENTS.

<table>
<tr><th rowspan="2">Component sought (A).</th><th colspan="12">Disturbing components (B, C, etc.).</th></tr>
<tr><th>K_2</th><th>L_2</th><th>M_2</th><th>N_2</th><th>2N</th><th>R_2</th><th>S_2</th><th>T_2</th><th>λ_2</th><th>μ_2</th><th>ν_2</th><th>2SM</th></tr>
<tr><td>K_2</td><td>......
.....
....</td><td>8.4953
.031
202</td><td>8.5381
.035
236</td><td>8.4422
.028
271</td><td>8.2332
.017
305</td><td>9.9392
.069
308</td><td>9.7311
.538
257</td><td>9.1892
.155
205</td><td>8.8322
.068
291</td><td>8.1065
.013
216</td><td>7.0766
.001
182</td><td>8.6847
.048
97</td></tr>
<tr><td>L_2</td><td>8.4953
.031
158</td><td>......
.....
....</td><td>8.6704
.047
214</td><td>8.5885
.039
248</td><td>8.4347
.027
282</td><td>8.9311
.085
106</td><td>8.8929
.078
54</td><td>7.6403
.004
2</td><td>9.7951
.624
268</td><td>7.8500
.007
194</td><td>8.1856
.015
340</td><td>8.4685
.029
74</td></tr>
<tr><td>M_2</td><td>8.5381
.035
124</td><td>8.6704
.047
146</td><td>......
.....
....</td><td>8.6704
.047
214</td><td>8.5885
.039
248</td><td>8.6113
.041
72</td><td>8.1856
.015
20</td><td>8.3896
.025
148</td><td>8.8929
.078
54</td><td>8.1856
.015
340</td><td>8.8929
.078
306</td><td>8.1585
.014
40</td></tr>
<tr><td>N_2</td><td>8.4422
.028
89</td><td>8.5885
.039
112</td><td>8.6704
.047
146</td><td>......
.....
....</td><td>8.6704
.047
214</td><td>8.2395
.017
38</td><td>7.8500
.007
166</td><td>8.4362
.027
114</td><td>8.1856
.015
20</td><td>8.8929
.078
306</td><td>9.7951
.624
92</td><td>7.2638
.002
6</td></tr>
<tr><td>2N</td><td>8.2332
.017
55</td><td>8.4347
.027
78</td><td>8.5885
.039
112</td><td>8.6704
.047
146</td><td>......
.....
....</td><td>7.1241
.001
4</td><td>8.2067
.016
132</td><td>8.3366
.022
80</td><td>7.8500
.007
166</td><td>9.7951
.624
92</td><td>8.7943
.062
58</td><td>7.8368
.007
152</td></tr>
<tr><td>R_2</td><td>9.9392
.869
52</td><td>8.9311
.085
254</td><td>8.6113
.041
288</td><td>8.2395
.017
322</td><td>7.1241
.001
356</td><td>......
.....
....</td><td>9.9392
.869
308</td><td>9.7311
.538
257</td><td>8.3722
.024
342</td><td>8.3410
.022
268</td><td>8.3820
.024
234</td><td>8.3896
.025
148</td></tr>
<tr><td>S_2</td><td>9.7311
.538
103</td><td>8.8929
.078
306</td><td>8.1856
.015
340</td><td>7.8500
.007
194</td><td>8.2067
.016
228</td><td>9.9392
.869
52</td><td>......
.....
....</td><td>9.9392
.869
308</td><td>8.6704
.047
214</td><td>8.1585
.014
320</td><td>8.4685
.029
286</td><td>8.1856
.015
20</td></tr>
<tr><td>T_2</td><td>9.1892
.155
155</td><td>7.6403
.004
358</td><td>8.3896
.025
212</td><td>8.4362
.027
246</td><td>8.3366
.022
280</td><td>9.7311
.538
103</td><td>9.9392
.869
52</td><td>......
.....
....</td><td>8.9548
.090
266</td><td>7.6654
.005
192</td><td>8.0785
.012
338</td><td>8.6113
.041
72</td></tr>
<tr><td>λ_2</td><td>8.8322
.068
69</td><td>9.7951
.624
92</td><td>8.8929
.078
306</td><td>8.1856
.015
340</td><td>7.8500
.007
194</td><td>8.3722
.024
18</td><td>8.6704
.047
146</td><td>8.9548
.090
94</td><td>......
.....
....</td><td>8.4685
.029
286</td><td>8.6609
.046
252</td><td>7.8500
.007
166</td></tr>
<tr><td>μ_2</td><td>8.1065
.013
144</td><td>7.8500
.007
166</td><td>8.1856
.015
20</td><td>8.8929
.078
54</td><td>9.7951
.624
268</td><td>8.3410
.022
92</td><td>8.1585
.014
40</td><td>7.6654
.005
168</td><td>8.4685
.029
74</td><td>......
.....
....</td><td>8.6704
.047
146</td><td>8.1117
.013
60</td></tr>
<tr><td>ν_2</td><td>7.0766
.001
178</td><td>8.1856
.015
20</td><td>8.8929
.078
54</td><td>9.7951
.624
268</td><td>8.7943
.062
302</td><td>8.3820
.024
126</td><td>8.4685
.029
74</td><td>8.0785
.012
22</td><td>8.6609
.046
108</td><td>8.6704
.047
214</td><td>......
.....
....</td><td>8.2581
.018
94</td></tr>
<tr><td>2SM</td><td>8.6847
.048
263</td><td>8.4685
.029
286</td><td>8.1585
.014
320</td><td>7.2638
.002
354</td><td>7.8368
.069
208</td><td>8.3896
.025
212</td><td>8.1856
.015
340</td><td>8.6113
.041
288</td><td>7.8500
.007
194</td><td>8.1117
.013
300</td><td>8.2581
.018
266</td><td>......
.....
...</td></tr>
</table>

TABLE 29.—*Elimination factors*—Continued

SERIES 134 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ
J_1	....	8.4360 .027 205	8.3946 .025 229	8.2695 .019 239	8.0361 .011 170	8.7345 .054 253	8.2094 .016 264	8.0930 .012 288	8.6047 .040 319	7.7771 .006 201
K_1	8.4360 .027 155	....	8.4360 .027 205	8.2628 .018 214	8.2628 .018 146	9.5078 .322 228	8.2695 .019 239	8.2094 .016 264	9.8992 .793 294	7.1819 .002 356
M_1	8.3946 .025 131	8.4360 .027 155	....	8.0361 .011 190	8.2695 .019 121	8.4838 .030 23	8.2628 .018 214	8.2695 .019 239	8.8500 .071 89	8.2196 .017 332
O_1	8.2695 .019 121	8.2628 .018 146	8.0361 .011 170	....	8.1796 .015 111	7.9151 .008 14	8.4360 .027 205	8.3946 .025 229	8.5206 .033 80	8.6697 .047 322
OO	8.0361 .011 190	8.2628 .018 214	8.2695 .019 239	8.1796 .015 249	....	8.4760 .030 262	8.1133 .013 273	7.9812 .010 298	8.2156 .016 328	7.8315 .007 211
P_1	8.7345 .054 107	9.5078 .322 132	8.4838 .030 337	7.9151 .008 346	8.4760 .030 98	....	7.6424 .004 191	7.9951 .010 216	9.8992 .793 66	8.2746 .019 308
Q_1	8.2094 .016 96	8.2695 .019 121	8.2628 .018 146	8.4360 .027 155	8.1133 .013 87	7.6424 .004 169	....	8.4360 .027 205	8.2605 .018 55	9.6387 .435 117
2Q	8.0930 .012 72	8.2094 .016 96	8.2695 .019 121	8.3946 .025 131	7.9812 .010 62	7.9951 .010 144	8.4360 .027 155	....	7.9233 .008 30	8.7610 .058 92
S_1	8.6047 .040 41	9.8992 .793 66	8.8500 .071 271	8.5206 .033 280	8.2156 .016 32	9.8992 .793 294	8.2605 .018 305	7.9233 .008 330	....	8.3143 .021 242
ρ_1	7.7771 .006 159	7.1819 .002 4	8.2196 .017 28	8.6697 .047 38	7.8315 .007 149	8.2746 .019 52	9.6387 .435 243	8.7610 .058 268	8.3143 .021 118	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 134 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	8.0361 .011 190	8.2628 .018 214	8.2695 .019 239	8.2094 .016 264	9.8992 .793 294	9.5078 .322 228	8.9538 .090 342	8.7345 .054 253	7.7771 .006 201	7.1819 .002 356	8.5254 .034 61
L_2	8.0361 .011 170	....	8.4360 .027 205	8.3946 .025 229	8.3215 .021 254	8.8285 .067 104	8.6697 .047 38	8.5871 .039 152	9.6387 .435 243	7.6424 .004 191	7.9151 .008 346	8.2746 .019 52
M_2	8.2628 .018 146	8.4360 .027 155	....	8.4360 .027 205	8.3946 .025 229	8.5206 .033 80	7.9151 .008 14	8.4622 .029 128	8.6697 .047 38	7.9151 .008 346	8.6697 .047 322	7.9028 .008 27
N_2	8.2695 .019 121	8.3946 .025 131	8.4360 .027 155	....	8.4360 .027 205	8.2605 .018 55	7.6424 .004 169	8.3592 .023 103	7.9151 .008 14	8.6697 .047 322	9.6387 .435 117	6.7753 .001 2
2N	8.2094 .016 96	8.3215 .021 106	8.3946 .025 131	8.4360 .027 155	....	7.9233 .008 30	7.9951 .010 144	8.2280 .017 78	7.6424 .004 169	9.6387 .435 117	8.7610 .058 92	7.6344 .004 158
R_2	9.8992 .793 66	8.8285 .067 256	8.5206 .033 280	8.2605 .018 305	7.9233 .008 330	....	9.8992 .793 294	9.5079 .322 228	8.6047 .040 319	8.2346 .017 267	8.3143 .021 242	8.4622 .029 128
S_2	9.5078 .322 132	8.6697 .047 322	7.9151 .008 346	7.6424 .004 191	7.9951 .010 216	9.8992 .793 66	....	9.8992 .793 294	8.4360 .027 205	7.9028 .008 333	8.2746 .019 308	7.9151 .008 14
T_2	8.9538 .090 18	8.5871 .039 208	8.4622 .029 232	8.3592 .023 257	8.2280 .017 282	9.5079 .322 132	9.8992 .793 66	....	8.8500 .071 271	8.0509 .011 219	7.7834 .006 194	8.5206 .033 80
λ_2	8.7345 .054 107	9.6387 .435 117	8.6697 .047 322	7.9151 .008 346	7.6424 .004 191	8.6047 .040 41	8.4360 .027 155	8.8500 .071 89	....	8.2746 .019 308	8.5650 .037 284	7.6424 .004 169
μ_2	7.7771 .006 159	7.6424 .004 169	7.9151 .008 14	8.6697 .047 38	9.6387 .435 243	8.2346 .017 93	7.9028 .008 27	8.0509 .011 141	8.2746 .019 52	....	8.4360 .027 155	7.8820 .008 41
ν_2	7.1819 .002 4	7.9151 .008 14	8.6697 .047 38	9.6387 .435 243	8.7610 .058 268	8.3143 .021 118	8.2746 .019 52	7.7834 .006 166	8.5650 .037 76	8.4360 .027 205	....	8.1118 .013 65
2SM	8.5254 .034 299	8.2746 .019 308	7.9028 .008 333	6.7753 .001 358	7.6344 .004 202	8.4622 .029 232	7.9151 .008 346	8.5206 .033 280	7.6424 .004 191	7.8820 .008 319	8.1118 .013 295	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 163 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.1495 .014 195	8.1341 .014 210	7.9150 .008 207	7.4365 .003 3	8.4234 .027 215	7.9579 .009 223	7.9582 .009 238	8.6570 .045 295	7.0948 .001 185
K_1	8.1495 .014 165	....	8.1495 .014 195	7.7528 .006 192	7.7528 .006 168	9.0723 .118 199	7.9150 .008 207	7.9579 .009 223	9.8470 .703 280	7.5128 .003 350
M_1	8.1341 .014 150	8.1495 .014 165	....	7.4365 .003 357	7.9150 .008 153	7.6604 .005 4	7.7528 .006 192	7.9150 .008 207	8.7629 .058 84	8.0859 .012 335
O_1	7.9150 .008 153	7.7528 .006 168	7.4365 .003 3	....	7.7427 .006 156	7.5513 .004 7	8.1495 .014 195	8.1341 .014 210	8.4422 .028 87	8.3724 .024 338
OO	7.4365 .003 357	7.7528 .006 192	7.9150 .008 207	7.7427 .006 204	....	8.1140 .013 212	7.8343 .007 220	7.8631 .007 235	8.3776 .024 292	6.6248 .000 182
P_1	8.4234 .027 145	9.0723 .118 161	7.6604 .005 356	7.5513 .004 353	8.1140 .013 148	....	7.4230 .003 188	7.7409 .006 203	9.8470 .703 80	7.9852 .010 331
Q_1	7.9579 .009 137	7.9150 .008 153	7.7528 .006 168	8.1495 .014 165	7.8343 .007 140	7.4230 .003 172	....	8.1495 .014 195	8.2410 .017 72	9.3888 .245 142
2Q	7.9582 .009 122	7.9579 .009 137	7.9150 .008 153	8.1341 .014 150	7.8631 .007 125	7.7409 .006 157	8.1495 .014 165	....	8.0589 .011 57	8.5769 .038 127
S_1	8.6570 .045 65	9.8470 .703 80	8.7629 .058 276	8.4422 .028 273	8.3776 .024 68	9.8470 .703 280	8.2410 .017 288	8.0589 .011 57	....	8.2562 .018 250
ρ_1	7.0948 .001 175	7.5128 .003 10	8.0859 .012 25	8.3724 .024 22	6.6248 .000 178	7.9852 .010 29	9.3888 .245 218	8.5769 .038 233	8.2562 .018 110	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 163 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	7.4365 .003 357	7.7528 .006 192	7.9150 .008 207	7.9579 .009 223	9.8470 .703 280	9.0723 .118 199	9.3179 .208 299	8.4234 .027 215	7.0948 .001 185	7.5128 .003 350	8.1450 .014 26
L_2	7.4365 .003 3	....	8.1495 .014 195	8.1341 .014 210	8.1078 .013 226	8.7464 .056 103	8.3724 .024 22	8.7614 .058 122	9.3888 .245 218	7.4230 .003 188	7.5513 004 353	7.9852 .010 29
M_2	7.7528 .006 168	8.1495 .014 165	....	8.1495 .014 195	8.1341 .014 210	8.4422 .028 87	7.5513 .004 7	8.4590 .029 107	8.3724 .024 22	7.5513 .004 353	8.3724 .024 338	7.5483 .004 14
N_2	7.9150 .008 153	8.1341 .014 150	8.1495 .014 165	....	8.1495 .014 195	8.2410 .017 72	7.4230 .003 172	8.2850 .019 92	7.5513 .004 7	8.3724 .024 338	9.3888 .245 142	6.3062 .000 179
2N	7.9579 .009 137	8.1078 .013 134	8.1341 .014 150	8.1495 .014 165	....	8.0588 .011 57	7.7409 .066 157	8.1397 .014 76	7.4230 .003 172	9.3888 .245 142	8.5769 .038 127	7.4186 .003 164
R_2	9.8470 .703 80	8.7464 .056 257	8.4422 .028 273	8.2410 .017 288	8.0588 .011 303	....	9.8470 .703 280	9.0725 .118 199	8.6570 .045 295	8.1488 .014 265	8.2563 .018 250	8.4590 .029 107
S_2	9.0723 .118 161	8.3724 .024 338	7.5513 .004 353	7.4230 .003 188	7.7409 .006 203	9.8470 .703 80	....	9.8470 .703 280	8.1495 .014 195	7.5483 .004 346	7.9852 .010 331	7.5513 .004 7
T_2	9.3179 .208 61	8.7614 .058 238	8.4590 .029 253	8.2850 .019 268	8.1397 .014 284	9.0725 .118 161	9.8470 .703 80	....	8.7629 .058 276	8.1668 .015 246	8.1966 .016 231	8.4422 .028 87
λ_2	8.4234 .027 145	9.3888 .245 142	8.3724 .024 338	7.5513 .004 353	7.4230 .003 188	8.6570 .045 65	8.1495 .014 165	8.7629 .058 84	....	7.9852 .010 331	8.3386 .022 315	7.4230 .003 172
μ_2	7.0948 .001 175	7.4230 .003 172	7.5513 .004 7	8.3724 .024 22	9.3888 .245 218	8.1488 .014 95	7.5483 .004 14	8.1668 .015 114	7.9852 .010 29	....	8.1495 .014 165	7.5426 .003 21
ν_2	7.5128 .003 10	7.5513 .004 7	8.3724 .024 22	9.3888 .245 218	8.5769 .038 233	8.2563 .018 110	7.9852 .010 29	8.1966 .016 129	8.3386 .022 45	8.1495 .014 195	....	7.8424 .007 36
2SM	8.1450 .014 334	7.9852 .010 331	7.5483 .004 346	6.3062 .000 181	7.4186 .003 196	8.4590 .029 253	7.5513 .004 353	8.4422 .028 273	7.4230 .003 188	7.5426 .003 339	7.8424 .007 324	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 192 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	7.6613 .005 186	7.6591 .005 192	7.0355 .001 356	8.0828 .012 16	7.3819 .002 357	6.5151 .009 182	7.0698 .001 187	8.6281 .042 271	7.3308 .002 350
K_1	7.6613 .005 174	....	7.6613 .005 186	7.5891 .004 350	7.5891 .004 10	8.6868 .049 351	7.0355 .001 356	6.5151 .000 182	9.7807 .604 265	7.6468 .004 344
M_1	7.6591 .005 168	7.6613 .005 174	....	8.0828 .012 344	7.0355 .001 4	8.1441 .014 165	7.5891 .004 350	7.0355 .001 356	8.6866 .049 80	7.9586 .009 338
O_1	7.0355 .001 4	7.5891 .004 10	8.0828 .012 16	....	7.5826 .004 20	6.4230 .000 1	7.6613 .005 186	7.6591 .005 192	8.3698 .023 95	7.7679 .006 354
OO	8.0828 .012 344	7.5891 .004 350	7.0355 .001 356	7.5826 .004 340	....	7.8388 .007 341	7.3409 .002 346	7.0344 .001 352	8.3250 .021 256	7.6132 .004 334
P_1	7.3819 .002 3	8.6868 .049 9	8.1441 .014 195	6.4230 .000 359	7.8388 .007 19	....	7.1547 .001 185	7.3491 .002 191	9.7807 .604 95	7.3097 .002 353
Q_1	6.5151 .000 178	7.0355 .001 4	7.5891 .004 10	7.6613 .005 174	7.3409 .002 14	7.1547 .001 175	....	7.6613 .005 186	8.1911 .016 89	8.8560 .072 168
2Q	7.0698 .001 173	6.5151 .000 178	7.0355 .001 4	7.6591 .005 168	7.0344 .001 8	7.3491 .002 169	7.6613 .005 174	....	8.0615 .012 84	8.0931 .012 162
S_1	8.6281 .042 89	9.7807 .604 95	8.6866 .049 280	8.3698 .023 265	8.3250 .021 104	9.7807 .604 265	8.1911 .016 271	8.0615 .012 276	....	8.2024 .016 258
ρ_1	7.3308 .002 10	7.6468 .004 16	7.9586 .009 22	7.7679 .006 6	7.6132 .004 26	7.3097 .002 7	8.8560 .072 192	8.0931 .012 198	8.2024 .016 102	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 192 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	8.0828 .012 344	7.5891 .004 350	7.0355 .001 356	6.5151 .000 182	9.7807 .604 265	8.6868 .049 351	9.2922 .196 256	7.3819 .002 357	7.3308 .002 350	7.6468 .004 344	7.6012 .004 171
L_2	8.0828 .012 16	....	7.6613 .005 186	7.6591 .005 192	7.6554 .005 197	8.6778 .048 101	7.7679 .006 6	8.7615 .058 92	8.8560 .072 192	7.1547 .001 185	6.4230 .000 359	7.3097 .002 7
M_2	7.5891 .004 10	7.6613 .005 174	....	7.6613 .005 186	7.6591 .005 192	8.3698 .023 95	6.4230 .000 1	8.4057 .025 86	7.7679 .006 6	6.4230 .000 359	7.7679 .006 354	6.4265 .000 1
N_2	7.0355 .001 4	7.6591 .005 168	7.6613 .005 174	....	7.6613 .005 186	8.1911 .016 89	7.1547 .001 175	8.2077 .016 80	6.4230 .000 1	7.7679 .006 354	8.8560 .072 168	6.8803 .001 175
2N	6.5151 .000 178	7.6554 .005 163	7.6591 .005 168	7.6613 .005 174	....	8.0615 .012 84	7.3491 .002 169	8.0649 .012 74	7.1547 .001 175	8.8560 .072 168	8.0931 .012 162	7.1525 .001 170
R_2	9.7807 .604 95	8.6778 .048 259	8.3698 .023 265	8.1911 .016 271	8.0615 .012 276	....	9.7807 .604 265	8.6863 .049 351	8.6281 .042 271	8.0768 .012 264	8.2024 .016 258	8.4057 .025 86
S_2	8.6868 .049 9	7.7679 .006 354	6.4230 .000 359	7.1547 .001 185	7.3491 .002 191	9.7807 .604 95	....	9.7807 .604 265	7.6613 .005 186	6.4265 .000 359	7.3097 .002 353	6.4230 .000 1
T_2	9.2922 .196 104	8.7615 .058 268	8.4057 .025 274	8.2077 .016 280	8.0649 .012 286	8.6863 .049 9	9.7807 .604 95	....	8.6866 .049 280	8.0959 .012 273	8.2350 .017 268	8.3698 .023 95
λ_2	7.3819 .002 3	8.8560 .072 168	7.7679 .006 354	6.4230 .000 359	7.1547 .001 185	8.6281 .042 89	7.6613 .005 174	8.6866 .049 80	....	7.3097 .002 353	7.7656 .006 347	7.1547 .001 175
μ_2	7.3308 .002 10	7.1547 .001 175	6.4230 .000 1	7.7679 .006 6	8.8560 .072 192	8.0768 .012 96	6.4265 .000 1	8.0959 .012 87	7.3097 .002 7	....	7.6613 .005 174	6.4253 .000 2
ν_2	7.6468 .004 16	6.4230 .000 1	7.7679 .006 6	8.8560 .072 192	8.0931 .012 198	8.2024 .016 102	7.3097 .002 7	8.2350 .017 92	7.7656 .006 13	7.6613 .005 186	....	7.1202 .001 8
2SM	7.6012 .004 189	7.3097 .002 353	6.4265 .000 359	6.8803 .001 185	7.1525 .001 190	8.4057 .025 274	6.4230 .000 359	8.3698 .023 265	7.1547 .001 185	6.4253 .000 358	7.1202 .001 352	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 221 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	7.4061 .003 356	7.4052 .003 353	7.8848 .008 324	8.2672 .019 28	8.3590 .023 318	7.7969 .006 321	7.7322 .005 317	8.5324 .034 247	7.6535 .005 334
K_1	7.4061 .003 4	....	7.4061 .003 356	8.0179 .010 328	8.0179 .010 32	9.2077 .161 322	7.8848 .008 324	7.7969 .006 321	9.6969 .498 251	7.7209 .005 338
M_1	7.4052 .003 7	7.4061 .003 4	....	8.2672 .019 332	7.8848 .008 36	8.4189 .026 146	8.0179 .010 328	7.8848 .008 324	8.6172 .041 75	7.8313 .007 341
O_1	7.8848 .008 36	8.0179 .010 32	8.2672 .019 28	....	7.9465 .009 64	7.3352 .002 174	7.4061 .003 356	7.4052 .003 353	8.2991 .020 103	7.8800 .008 190
OO	8.2672 .019 332	8.0179 .010 328	7.8848 .008 324	7.9465 .009 296	....	8.2351 .017 290	7.8628 .007 292	7.7946 .006 289	8.0778 .012 219	7.8188 .007 306
P_1	8.3590 .023 42	9.2077 .161 38	8.4189 .026 214	7.3352 .002 186	8.2351 .017 70	....	6.7176 .001 182	6.4350 .000 358	9.6969 .498 109	7.5854 .004 195
Q_1	7.7969 .006 39	7.8848 .008 36	8.0179 .010 32	7.4061 .003 4	7.8628 .007 68	6.7176 .001 178	....	7.4061 .003 356	8.1112 .013 107	8.8310 .068 13
2Q	7.7322 .005 43	7.7969 .006 39	7.8848 .008 36	7.4052 .003 7	7.7946 .006 71	6.4350 .000 2	7.4061 .003 4	....	7.9748 .009 110	8.0073 .010 17
S_1	8.5324 .034 113	9.6969 .498 109	8.6172 .041 285	8.2991 .020 257	8.0778 .012 141	9.6969 .498 251	8.1112 .013 253	7.9748 .009 250	....	8.1495 .014 266
ρ_1	7.6535 .005 26	7.7209 .005 22	7.8313 .007 19	7.8800 .008 170	7.8188 .007 54	7.5854 .004 165	8.8310 .068 347	8.0073 .010 343	8.1495 .014 94	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 221 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	8.2872 .019 332	8.0179 .010 328	7.8848 .008 324	7.7969 .006 321	9.6969 .498 251	9.2077 .161 322	8.9831 .096 213	8.3590 .023 318	7.6535 .005 334	7.7209 .005 338	8.2035 .016 136
L_2	8.2672 .019 28	....	7.4061 .003 356	7.4052 .003 353	7.4037 .003 349	8.6189 .042 99	7.8800 .008 170	8.6448 .044 62	8.8310 .068 347	6.7176 .001 182	7.3352 .002 186	7.5854 .004 165
M_2	8.0179 .010 32	7.4061 .003 4	....	7.4061 .003 356	7.4052 .003 353	8.2991 .020 103	7.3352 .002 174	8.3038 .020 65	7.8800 .008 170	7.3352 .002 186	7.8800 .008 190	7.3333 .002 168
N_2	7.8848 .008 36	7.4052 .003 7	7.4061 .003 4	....	7.4061 .003 356	8.1112 .013 107	6.7176 .001 178	8.1229 .013 69	7.3352 .002 174	7.8800 .008 190	8.8310 .068 13	7.0677 .001 172
2N	7.7969 .006 39	7.4037 .003 11	7.4052 .003 7	7.4061 .003 4	....	7.9748 .009 110	6.4350 .000 2	7.9996 .010 73	6.7176 .001 178	8.8310 .068 13	8.0073 .010 17	6.7183 .001 176
R_2	9.6969 .498 109	8.6189 .042 261	8.2991 .020 257	8.1112 .013 253	7.9748 .009 250	....	9.6970 .498 251	9.2076 .161 322	8.5324 .034 247	8.0145 .010 263	8.1495 .014 266	8.3038 .020 65
S_2	9.2077 .161 38	7.8800 .008 190	7.3352 .002 186	6.7176 .001 182	6.4350 .000 358	9.6970 .498 109	....	9.6970 .498 251	7.4061 .003 356	7.3333 .002 192	7.5854 .004 195	7.3352 .002 174
T_2	8.9831 .096 147	8.6448 .044 298	8.3038 .020 295	8.1229 .013 291	7.9996 .010 287	9.2076 .161 38	9.6970 .498 109	....	8.6172 .041 285	7.9704 .009 301	8.0914 .012 304	8.2991 .020 103
λ_2	8.3590 .023 42	8.8310 .068 13	7.8800 .008 190	7.3352 .002 186	6.7176 .001 182	8.5324 .034 113	7.4061 .003 4	8.6172 .041 75	....	7.5854 .004 195	7.8738 .007 199	6.7176 .001 178
μ_2	7.6535 .005 26	6.7176 .001 178	7.3352 .002 174	7.8800 .008 170	8.8310 .068 347	8.0145 .010 97	7.3333 .002 168	7.9704 .009 59	7.5854 .004 165	....	7.4061 .003 4	7.3294 .002 162
ν_2	7.7209 .005 22	7.3352 .002 174	7.8800 .008 170	8.8310 .068 347	8.0073 .010 343	8.1495 .014 94	7.5854 .004 165	8.0914 .012 56	7.8738 .007 161	7.4061 .003 356	....	7.4945 .003 159
2SM	8.2035 .016 224	7.5854 .004 195	7.3333 .002 192	7.0677 .001 188	6.7183 .001 184	8.3038 .020 295	7.3352 .002 186	8.2991 .020 257	6.7176 .001 182	7.3294 .002 198	7.4945 .003 201	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 250 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	7.9011 .008 347	7.8898 .008 334	8.0302 .011 293	8.3544 .023 41	8.4768 .030 280	7.9350 .009 280	7.8438 .007 267	8.3527 .023 224	7.7796 .006 318
K_1	7.9011 .008 13	....	7.9011 .008 347	8.1489 .014 306	8.1489 .014 54	9.3286 .213 294	8.0302 .011 293	7.9350 .009 280	9.5900 .389 237	7.7661 .006 331
M_1	7.8898 .008 26	7.9011 .008 13	....	8.3544 .023 319	8.0302 .011 67	8.5201 .033 127	8.1489 .014 306	8.0302 .011 293	8.5519 .036 70	7.6982 .005 344
O_1	8.0302 .011 67	8.1489 .014 54	8.3544 .023 41	....	7.9171 .008 108	7.6029 .004 168	7.9011 .008 347	7.8898 .008 334	8.2274 .017 111	8.2405 .017 205
OO	8.3544 .023 319	8.1489 .014 306	8.0302 .011 293	7.9171 .008 252	....	8.1443 .014 239	7.7748 .006 239	7.6181 .004 226	6.8959 .001 183	7.8514 .007 277
P_1	8.4768 .030 80	9.3286 .213 66	8.5201 .033 233	7.6029 .004 192	8.1443 .014 121	....	6.2382 .000 359	7.3397 .002 346	9.5900 .389 123	7.8955 .008 218
Q_1	7.9350 .009 80	8.0302 .011 67	8.1489 .014 54	7.9011 .008 13	7.7748 .006 121	6.2382 .000 1	....	7.9011 .008 347	7.9950 .010 124	9.2133 .163 39
2Q	7.8438 .007 93	7.9350 .009 80	8.0302 .011 67	7.8898 .008 26	7.6181 .004 134	7.3397 .002 14	7.9011 .008 13	....	7.7821 .006 137	8.3852 .024 52
S_1	8.3527 .023 136	9.5900 .389 123	8.5519 .036 290	8.2274 .017 249	6.8959 .001 177	9.5900 .389 237	7.9950 .010 236	7.7821 .006 223	....	8.0954 .012 275
ρ_1	7.7796 .006 42	7.7661 .006 29	7.6982 .005 16	8.2405 .017 155	7.8514 .007 83	7.8955 .008 142	9.2133 .163 321	8.3852 .024 308	8.0954 .012 85	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 250 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	8.3544 .023 319	8.1489 .014 306	8.0302 .011 293	7.9350 .009 280	9.5900 .389 237	9.3286 .213 294	8.4129 .026 350	8.4768 .030 280	7.7796 .006 318	7.7661 .006 331	8.3023 .020 101
L_2	8.3544 .023 41	....	7.9011 .008 347	7.8898 .008 334	7.8703 .007 321	8.5672 .037 98	8.2405 .017 155	8.3634 .023 31	9.2133 .163 321	6.2382 .000 359	7.6029 .004 192	7.8955 .008 143
M_2	8.1489 .014 54	7.9011 .008 13	....	7.9011 .008 347	7.8898 .008 334	8.2274 .017 111	7.6029 .004 168	8.1376 .014 44	8.2405 .017 155	7.6029 .004 192	8.2405 .017 205	7.5928 .004 155
N_2	8.0302 .011 67	7.8898 .008 26	7.9011 .008 13	....	7.9011 .008 347	7.9950 .010 124	6.2382 .000 1	8.0259 .011 58	7.6029 .004 168	8.2405 .017 205	9.2133 .163 39	7.1697 .001 168
2N	7.9350 .009 80	7.8703 .007 39	7.8898 .008 26	7.9011 .008 13	....	7.7821 .006 137	7.3397 .002 14	7.9414 .009 71	6.2382 .000 1	9.2133 .163 39	8.3852 .024 52	6.2381 .000 2
R_2	9.5900 .389 123	8.5672 .037 262	8.2274 .017 249	7.9950 .010 236	7.7821 .006 223	....	9.5901 .389 237	9.3286 .213 294	8.3528 .023 224	7.9596 .009 261	8.0954 .012 275	8.1376 .014 44
S_2	9.3286 .213 66	8.2405 .017 205	7.6029 .004 192	6.2382 .000 359	7.3397 .002 346	9.5901 .389 123	....	9.5901 .389 237	7.9011 .008 347	7.5928 .004 205	7.8955 .008 218	7.6029 .004 168
T_2	8.4129 .026 10	8.3634 .023 329	8.1376 .014 316	8.0259 .011 302	7.9414 .009 289	9.3286 .213 66	9.5901 .389 123	....	8.5519 .036 290	7.7084 .005 328	7.6345 .004 341	8.2274 .017 111
λ_2	8.4768 .030 80	9.2133 .163 39	8.2405 .017 205	7.6029 .004 192	6.2382 .000 359	8.3528 .023 136	7.9011 .008 13	8.5519 .036 70	....	7.8955 .008 218	8.1962 .016 231	6.2382 .000 1
μ_2	7.7796 .006 42	6.2382 .000 1	7.6029 .004 168	8.2405 .017 155	9.2133 .163 321	7.9596 .009 99	7.5928 .004 155	7.7084 .005 32	7.8955 .008 142	....	7.9011 .008 13	7.5759 .004 143
ν_2	7.7661 .006 29	7.6029 .004 168	8.2405 .017 155	9.2133 .163 321	8.3852 .024 308	8.0954 .012 85	7.8955 .008 142	7.6345 .004 19	8.1962 .016 129	7.9011 .008 347	....	7.7671 .006 130
2SM	8.3023 .020 259	7.8955 .008 218	7.5928 .004 205	7.1697 .001 192	6.2381 .000 358	8.1376 .014 316	7.6029 .004 192	8.2274 .017 249	6.2382 .000 359	7.5759 .004 217	7.7671 .006 230	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 279 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.0816 .012 337	8.0469 .011 315	8.0127 .010 261	8.3961 .025 54	8.3841 .024 242	7.8250 .007 239	7.5672 .004 216	7.9987 .010 200	7.8339 .007 303
K_1	8.0816 .012 23	....	8.0816 .012 337	8.1800 .015 284	8.1800 .015 76	9.3172 .208 265	8.0127 .010 261	7.8250 .007 239	9.4495 .282 222	7.7947 .006 325
M_1	8.0469 .011 45	8.0816 .012 23	....	8.3961 .025 306	8.0127 .010 99	8.5477 .035 108	8.1800 .015 284	8.0127 .010 261	8.4890 .031 65	7.5510 .004 348
O_1	8.0127 .010 99	8.1800 .015 76	8.3961 .025 54	....	7.5571 .004 152	7.7343 .005 161	8.0816 .012 337	8.0469 .011 315	8.1523 .014 119	8.3798 .024 221
OO	8.3961 .025 306	8.1800 .015 284	8.0127 .010 261	7.5571 .004 208	....	7.3456 .002 189	6.7358 .001 185	7.1964 .002 342	7.9211 .008 326	7.7771 .006 249
P_1	8.3841 .024 118	9.3172 .208 95	8.5477 .035 252	7.7343 .005 199	7.3456 .002 171	....	6.8592 .001 356	7.5574 .004 334	9.4495 .282 138	7.9990 .010 240
Q_1	7.8250 .007 121	8.0127 .010 99	8.1800 .015 76	8.0816 .012 23	6.7358 .001 175	6.8592 .001 4	....	8.0816 .012 337	7.8251 .007 141	9.3242 .211 64
2Q	7.5672 .004 144	7.8250 .007 121	8.0127 .010 99	8.0469 .011 45	7.1964 .002 18	7.5574 .004 26	8.0816 .012 23	....	7.3460 .002 164	8.4421 .028 86
S_1	7.9987 .010 160	9.4495 .282 138	8.4890 .031 295	8.1523 .014 241	7.9211 .008 34	9.4495 .282 222	7.8251 .007 219	7.3460 .002 196	....	8.0384 .011 283
ρ_1	7.8339 .007 57	7.7947 .006 35	7.5510 .004 12	8.3798 .024 139	7.7771 .006 111	7.9990 .010 120	9.3242 .211 296	8.4421 .028 274	8.0384 .011 77	....

TABLE 29.— *Elimination factors*—Continued.

SERIES 279 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	....	8.3961 .025 306	8.1800 .015 284	8.0127 .010 261	7.8250 .007 239	9.4494 .281 222	9.3172 .208 265	9.0421 .110 308	8.3841 .024 242	7.8339 .007 303	7.7947 .006 325	8.2246 .017 66
L_2	8.3961 .025 54	....	8.0816 .012 337	8.0469 .011 315	7.9866 .010 292	8.5211 .033 96	8.3798 .024 139	6.9057 .001 1	9.3242 .211 296	6.8592 .001 356	7.7343 .005 199	7.9990 .010 120
M_2	8.1800 .015 76	8.0816 .012 23	....	8.0816 .012 337	8.0469 .011 315	8.1523 .014 119	7.7343 .005 161	7.8491 .007 24	8.3798 .024 139	7.7343 .005 199	8.3798 .024 221	7.7105 .005 142
N_2	8.0127 .010 99	8.0469 .011 45	8.0816 .012 23	....	8.0816 .012 337	7.8251 .007 141	6.8592 .001 4	7.9108 .008 46	7.7343 .005 161	8.3798 .024 221	9.3242 .211 64	7.2354 .002 165
2N	7.8250 .007 121	7.9866 .010 68	8.0469 .011 45	8.0816 .012 23	....	7.3463 .002 164	7.8721 .007 66	7.8885 .008 69	6.8592 .001 4	9.3242 .211 64	8.4421 .028 86	6.8588 .001 8
R_2	9.4494 .281 138	8.5211 .033 264	8.1523 .014 241	7.8251 .007 219	7.3463 .002 196	....	9.4496 .282 223	9.3172 .208 265	7.9987 .010 200	7.9102 .008 260	8.0384 .011 283	7.8491 .007 24
S_2	9.3172 .208 95	8.3798 .024 221	7.7343 .005 199	6.8592 .001 356	7.8721 .007 294	9.4496 .282 137	....	9.4496 .282 223	8.0816 .012 237	7.7105 .005 218	7.9990 .010 240	7.7343 .005 161
T_2	9.0421 .110 52	6.9057 .001 359	7.8491 .007 336	7.9108 .008 314	7.8885 .008 291	9.3172 .208 95	9.4496 .282 137	....	8.4891 .031 295	6.8703 .001 355	7.5541 .004 198	8.1523 .014 119
λ_2	8.3841 .024 118	9.3242 .211 64	8.3798 .024 221	7.7343 .005 199	6.8592 .001 356	7.9987 .010 160	8.0816 .012 123	8.4891 .031 65	....	7.9990 .010 240	8.2553 .018 263	6.8592 .001 4
μ_2	7.8339 .007 57	6.8592 .001 4	7.7343 .005 161	8.3798 .024 139	9.3242 .211 296	7.9102 .008 100	7.7105 .005 142	6.8703 .001 5	7.9990 .010 120	....	8.0816 .012 23	7.6697 .005 124
ν_2	7.7947 .006 35	7.7343 .005 161	8.3798 .024 139	9.3242 .211 296	8.4421 .028 274	8.0384 .011 77	7.9990 .010 120	7.5541 .004 162	8.2553 .018 97	8.0816 .012 337	....	7.8266 .007 101
2SM	8.2246 .017 294	7.9990 .010 240	7.7105 .005 218	7.2354 .002 195	6.8588 .001 352	7.8491 .007 336	7.7343 .005 199	8.1523 .014 241	6.8592 .001 356	7.6697 .005 236	7.8266 .007 259	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 297 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.2770 .019 220	8.1622 .015 260	7.9899 .010 266	7.5338 .003 173	8.3896 .025 287	7.7726 .006 306	7.1486 .001 346	8.4204 .026 253	7.5223 .003 206
K_1	8.2770 .019 140	....	8.2770 .019 220	8.0269 .011 227	8.0269 .011 133	9.2565 .181 247	7.9899 .010 266	7.7726 .006 306	9.3360 .217 214	7.3907 .002 346
M_1	8.1622 .015 100	8.2770 .019 140	....	7.5338 .003 187	7.9899 .010 94	8.2044 .016 27	8.0269 .011 227	7.9899 .010 266	7.5392 .003 174	8.1019 .013 306
O_1	7.9899 .010 94	8.0269 .011 133	7.5338 .003 173	....	7.8638 .007 87	7.7467 .006 21	8.2770 .019 220	8.1622 .015 260	7.5336 .003 167	8.4724 .030 300
OO	7.5338 .003 187	8.0269 .011 227	7.9899 .010 266	7.8638 .007 273	....	8.0954 .012 294	7.6320 .004 313	6.7805 .001 353	8.1433 .014 260	7.5129 .003 213
P_1	8.3896 .025 73	9.2565 .181 113	8.2044 .016 333	7.7467 .006 339	8.0954 .012 66	....	7.5300 .003 199	7.8163 .007 239	9.3360 .217 146	8.0286 .011 279
Q_1	7.7726 .006 54	7.9899 .010 94	8.0269 .011 133	8.2770 .019 140	7.6320 .004 47	7.5300 .003 161	....	8.2770 .019 220	7.9031 .008 127	9.3366 .217 80
2Q	7.1486 .001 14	7.7726 .006 54	7.9899 .010 94	8.1622 .015 100	6.7805 .001 7	7.8163 .007 121	8.2770 .019 140	....	7.8741 .007 87	8.2220 .017 40
S_1	8.4204 .026 107	9.3360 .217 146	7.5392 .003 186	7.5336 .003 193	8.1433 .014 100	9.3360 .217 214	7.9031 .008 233	7.8741 .007 273	....	7.8897 .008 312
ρ_1	7.5223 .003 154	7.3907 .002 14	8.1019 .013 54	8.4724 .030 60	7.5129 .003 147	8.0286 .011 81	9.3366 .217 280	8.2220 .017 320	7.8897 .008 48	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 297 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	....	7.5338 .003 187	8.0269 .011 227	7.9899 .010 266	7.7726 .006 306	9.3359 .217 214	9.2565 .181 247	9.1076 .128 281	8.3896 .025 287	7.5223 .003 206	7.3907 .002 346	8.2357 .017 88
L_2	7.5338 .003 173	....	8.2770 .019 220	8.1622 .015 260	7.9326 .009 300	8.1514 .014 27	8.4724 .030 60	8.5711 .037 94	9.3366 .217 280	7.5300 .003 199	7.7467 .006 339	8.0286 .011 81
M_2	8.0269 .011 133	8.2770 .019 140	....	8.2770 .019 220	8.1622 .015 260	7.5339 .003 167	7.7467 .006 21	8.1268 .013 54	8.4724 .030 60	7.7467 .006 339	8.4724 .030 300	7.7179 .005 41
N_2	7.9899 .010 94	8.1622 .015 100	8.2770 .019 140	....	8.2770 .019 220	7.9031 .008 127	7.5300 .003 161	7.4214 .003 14	7.7467 .006 21	8.4724 .030 300	9.3366 .217 80	6.2014 .000 1
2N	7.7726 .006 54	7.9326 .009 60	8.1622 .015 100	8.2770 .019 140	....	7.8741 .007 87	7.8163 .007 121	7.5240 .003 155	7.5300 .003 161	9.3366 .217 80	8.2220 .017 40	7.5050 .003 142
R_2	9.3359 .217 146	8.1514 .014 333	7.5339 .003 193	7.9031 .008 233	7.8741 .007 273	....	9.3362 .217 214	9.2566 .181 247	8.4204 .026 253	7.0150 .001 352	7.8897 .008 312	8.1268 .013 54
S_2	9.2565 .181 113	8.4724 .030 300	7.7467 .006 339	7.5300 .003 199	7.8163 .007 239	9.3362 .217 146	....	9.3362 .217 214	8.2770 .019 220	7.7179 .005 319	8.0286 .011 279	7.7467 .006 21
T_2	9.1076 .128 79	8.5711 .037 266	8.1268 .013 306	7.4214 .003 346	7.5240 .003 205	9.2566 .181 113	9.3362 .217 146	....	7.5385 .003 186	7.8920 .008 285	8.0039 .010 245	7.5339 .003 167
λ_2	8.3896 .025 73	9.3366 .217 80	8.4724 .030 300	7.7467 .006 339	7.5300 .003 199	8.4204 .026 107	8.2770 .019 140	7.5385 .003 174	....	8.0286 .011 279	8.1647 .015 239	7.5300 .003 161
μ_2	7.5223 .003 154	7.5300 .003 161	7.7467 .006 21	8.4724 .030 60	9.3366 .217 280	7.0150 .001 8	7.7179 .005 41	7.8920 .008 75	8.0286 .011 81	....	8.2770 .019 140	7.6680 .005 62
ν_2	7.3907 .002 14	7.7467 .006 21	8.4724 .030 60	9.3366 .217 280	8.2220 .017 320	7.8897 .008 48	8.0286 .011 81	8.0039 .010 115	8.1647 .015 121	8.2770 .019 220	....	7.7984 .006 102
2SM	8.2357 .017 272	8.0286 .011 279	7.7179 .005 319	6.2014 .000 359	7.5050 .003 218	8.1268 .013 306	7.7467 .006 339	7.5339 .003 193	7.5300 .003 199	7.6680 .005 298	7.7984 .006 258	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 326 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.1340 .014 210	8.0698 .012 241	7.8631 .007 235	7.4352 .003 6	8.3392 .022 249	7.8244 .007 265	7.6841 .005 296	8.2809 .019 230	7.0934 .001 190
K_1	8.1340 .014 150	....	8.1340 .014 210	7.7427 .006 204	7.7427 .006 156	9.0470 .111 219	7.8631 .007 235	7.8244 .007 265	9.0723 .118 199	7.5061 .003 340
M_1	8.0698 .012 119	8.1340 .014 150	....	7.4352 .003 354	7.8631 .007 125	7.6587 .005 8	7.7427 .006 204	7.8631 .007 235	7.7472 .006 169	8.0423 .011 310
O_1	7.8631 .007 125	7.7427 .006 156	7.4352 .003 6	....	7.7018 .005 131	7.5483 .004 14	8.1340 .014 210	8.0698 .012 241	7.0956 .001 175	8.3386 .022 315
OO	7.4352 .003 354	7.7427 .006 204	7.8631 .007 235	7.7018 .005 229	....	8.0443 .011 243	7.7204 .005 259	7.6227 .004 290	7.9496 .009 224	6.6245 .000 184
P_1	8.3392 .022 111	9.0470 .111 141	7.6587 .005 352	7.5483 .004 346	8.0443 .011 117	....	7.4186 .003 196	7.7040 .005 227	9.0723 .118 161	7.9254 .008 301
Q_1	7.8244 .007 95	7.8631 .007 125	7.7427 .006 156	8.1340 .014 150	7.7204 .005 101	7.4186 .003 164	....	8.1340 .014 210	7.7258 .005 144	9.2882 .194 105
2Q	7.6841 .005 64	7.8244 .007 95	7.8631 .007 125	8.0698 .012 119	7.6227 .004 70	7.7040 .005 133	8.1340 .014 150	....	7.7948 .006 114	8.3594 .023 75
S_1	8.2809 .019 130	9.0723 .118 161	7.7472 .006 191	7.0956 .001 185	7.9496 .009 136	9.0723 .118 199	7.7258 .005 216	7.7948 .006 246	....	7.7844 .006 321
ρ_1	7.0934 .001 170	7.5061 .003 20	8.0423 .011 50	8.3386 .022 45	6.6245 .000 176	7.9254 .008 59	9.2882 .194 255	8.3594 .023 285	7.7844 .006 39	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 326 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	7.4352 .003 354	7.7427 .006 204	7.8631 .007 235	7.8244 .007 265	9.0720 .118 199	9.0470 .111 219	9.0037 .101 238	8.3392 .022 249	7.0934 .001 190	7.5061 .003 340	8.0971 .013 53
L_2	7.4352 .003 6	....	8.1340 .014 210	8.0698 .012 241	7.9526 .009 271	8.0858 .012 25	8.3386 .022 45	8.4852 .031 64	9.2882 .194 255	7.4186 .003 196	7.5483 .004 346	7.9254 .008 59
M_2	7.7427 .006 156	8.1340 .014 150	....	8.1340 .014 210	8.0698 .012 241	7.0956 .001 175	7.5483 .004 14	7.9190 .008 34	8.3386 .022 45	7.5483 .004 346	8.3386 .022 315	7.5347 .003 28
N_2	7.8631 .007 125	8.0698 .012 119	8.1340 .014 150	....	8.1340 .014 210	7.7259 .005 144	7.4186 .003 164	6.7213 .001 3	7.5483 .004 14	8.3386 .022 315	9.2882 .194 105	6.3062 .000 178
2N	7.8244 .007 95	7.9526 .009 89	8.0698 .012 119	8.1340 .014 150	....	7.7948 .006 114	7.7040 .005 133	7.5123 .003 153	7.4186 .003 .164	9.2882 .194 105	8.3594 .023 75	7.4010 .003 148
R_2	9.0720 .118 161	8.0858 .012 335	7.0956 .001 185	7.7259 .005 216	7.7948 .006 246	....	9.0725 .118 199	9.0472 .112 219	8.2809 .019 230	7.0444 .001 351	7.7843 .006 321	7.9190 .008 34
S_2	9.0470 .111 141	8.3386 .022 315	7.5483 .004 346	7.4186 .003 196	7.7040 .005 227	9.0725 .118 161	....	9.0725 .118 199	8.1340 .014 210	7.5347 .003 332	7.9254 .008 301	7.5483 .004 14
T_2	9.0037 .101 122	8.4852 .031 296	7.9190 .008 326	6.7213 .001 357	7.5123 .003 207	9.0472 .112 141	9.0725 .118 161	....	7.7468 .006 191	7.7359 .005 312	7.9960 .010 282	7.0956 .001 175
λ_2	8.3392 .022 111	9.2882 .194 105	8.3386 .022 315	7.5483 .004 346	7.4186 .003 196	8.2809 .019 130	8.1340 .014 150	7.7568 .006 169	....	7.9254 .008 301	8.1912 .016 271	7.4186 .003 164
μ_2	7.0934 .001 170	7.4186 .003 164	7.5483 .004 14	8.3386 .022 45	9.2882 .194 255	7.0444 .001 9	7.4347 .003 28	7.7359 .005 48	7.9254 .008 59	....	8.1340 .014 150	7.5118 .003 43
ν_2	7.5061 .003 20	7.5483 .004 14	8.3386 .022 45	9.2882 .194 255	8.3594 .023 285	7.7843 .006 39	7.9254 .008 59	7.9960 .010 78	8.1912 .016 89	8.1340 .014 210	....	7.7477 .006 73
2SM	8.0971 .013 307	7.9254 .008 301	7.5347 .003 332	6.3062 .000 182	7.4010 .003 212	7.9190 .008 326	7.5483 .004 346	7.0956 .001 185	7.4186 .003 196	7.5118 .003 317	7.7477 .006 287	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 355 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	7.9464 .009 201	7.9167 .008 222	7.5111 .003 203	7.8888 .008 19	8.0444 .011 211	7.6331 .004 224	7.6506 .004 245	8.0032 .010 206	6.7724 .001 355
K_1	7.9464 .009 159	....	7.9464 .009 201	6.7064 .001 182	6.7064 .001 178	8.4581 .029 190	7.5111 .003 203	7.6331 .004 224	8.4598 .029 185	7.5794 .004 334
M_1	7.9167 .008 138	7.9464 .009 159	....	7.8888 .008 341	7.5111 .003 157	7.7393 .005 169	6.7064 .001 182	7.5111 .003 203	7.8651 .007 164	7.9839 .010 313
O_1	7.5111 .003 157	6.7064 .001 178	7.8888 .008 19	....	6.7060 .001 175	7.2500 .002 8	7.9464 .009 201	7.9167 .008 222	6.7729 .001 3	8.1364 .014 331
OO	7.8888 .008 341	6.7064 .001 182	7.5111 .003 203	6.7060 .001 185	....	7.3914 .002 192	7.3284 .002 206	7.4740 .003 227	7.1838 .002 187	7.3105 .002 336
P_1	8.0444 .011 149	8.4581 .029 170	7.7393 .005 191	7.2500 .002 352	7.3914 .002 168	....	7.2957 .002 193	7.5554 .004 214	8.4598 .029 175	7.7296 .005 324
Q_1	7.6331 .004 136	7.5111 .003 157	6.7064 .001 178	7.9464 .009 159	7.3284 .002 154	7.2957 .002 167	....	7.9464 .009 201	7.4212 .003 162	9.1482 .141 130
2Q	7.6506 .004 115	7.6331 .004 136	7.5111 .003 157	7.9167 .008 138	7.4740 .003 133	7.5554 .004 146	7.9464 .009 159	....	7.5984 .004 141	8.3129 .021 109
S_1	8.0032 .010 154	8.4598 .029 175	7.8651 .007 196	6.7729 .001 357	7.1838 .002 173	8.4598 .029 185	7.4212 .003 198	7.5984 .004 219	....	7.6607 .005 329
ρ_1	6.7724 .001 5	7.5794 .004 26	7.9839 .010 47	8.1364 .014 29	7.3105 .002 24	7.7296 .005 36	9.1482 .141 230	8.3129 .021 251	7.6607 .005 31	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 355 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (*A*).	Disturbing components (*B*, *C*, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM.
K_2	....	7.8888 .008 341	6.7064 .001 182	7.5111 .003 203	7.6331 .004 224	8.4589 .029 185	8.4581 .029 190	8.4553 .029 195	8.0444 .011 211	6.7724 .001 355	7.5794 .004 334	7.6440 .004 18
L_2	7.8888 .008 19	....	7.9464 .009 201	7.9167 .008 222	7.8652 .007 243	8.0217 .011 24	8.1364 .014 29	8.2393 .017 34	9.1482 .141 230	7.2957 .002 193	7.2500 .002 352	7.7296 .005 36
M_2	6.7064 .001 178	7.9464 .009 159	....	7.9464 .009 201	7.9167 .008 222	6.7712 .001 3	7.2500 .002 8	7.4842 .003 13	8.1364 .014 29	7.2500 .002 352	8.1364 .014 331	7.2458 .002 15
N_2	7.5111 .003 157	7.9167 .008 138	7.9464 .009 159	....	7.9464 .009 201	7.4212 .003 162	7.2957 .002 167	7.1008 .001 172	7.2500 .002 8	8.1364 .014 331	9.1482 .141 130	6.7017 .001 174
2N	7.6331 .004 136	7.8652 .007 117	7.9167 .008 138	7.9464 .009 159	....	7.5985 .004 141	7.5554 .004 146	7.5017 .003 151	7.2957 .002 167	9.1482 .141 130	8.3129 .021 109	7.2840 .002 154
R_2	8.4589 .029 175	8.0217 .011 336	6.7712 .001 357	7.4212 .003 198	7.5985 .004 219	....	8.4598 .029 185	8.4586 .029 190	8.0034 .010 206	7.0678 .001 350	7.6606 .005 329	7.4842 .003 13
S_2	8.4581 .029 170	8.1364 .014 331	7.2500 .002 352	7.2957 .002 193	7.5554 .004 214	8.4598 .029 175	....	8.4598 .029 185	7.9464 .009 201	7.2458 .002 345	7.7296 .005 324	7.2500 .002 8
T_2	8.4553 .029 165	8.2393 .017 326	7.4842 .003 347	7.1008 .001 188	7.5017 .003 209	8.4586 .029 170	8.4598 .029 175	....	7.8648 .007 196	7.3738 .002 340	7.7893 .006 319	6.7712 .001 3
λ_2	8.0444 .011 149	9.1482 .141 130	8.1364 .014 331	7.2500 .002 352	7.2957 .002 193	8.0034 .010 154	7.9464 .009 159	7.8648 .007 164	....	7.7296 .005 324	8.0795 .012 303	7.2957 .002 167
μ_2	6.7724 .001 5	7.2957 .002 167	7.2500 .002 8	8.1364 .014 29	9.1482 .141 230	7.0678 .001 10	7.2458 .002 15	7.3738 .002 20	7.7296 .005 36	....	7.9464 .009 159	7.2393 .002 23
ν_2	7.5794 .004 26	7.2500 .002 8	8.1364 .014 29	9.1482 .141 230	8.3129 .021 251	7.6606 .005 31	7.7296 .005 36	7.7893 .006 41	8.0795 .012 57	7.9464 .009 201	....	7.5728 .004 44
2SM	7.6440 .004 342	7.7296 .005 324	7.2458 .002 345	6.7017 .001 186	7.2840 .002 206	7.4842 .003 347	7.2500 .002 352	6.7712 .001 357	7.2957 .002 193	7.2393 .002 337	7.5728 .004 316	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 369 DAYS. DIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).									
	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1	ρ_1
J_1	....	8.3503 .022 290	7.8740 .007 219	7.8760 .008 287	8.3371 .022 112	8.2982 .020 286	7.5509 .004 217	7.4182 .003 326	8.3235 .021 288	5.7099 .000 0
K_1	8.3503 .022 70	....	8.3503 .022 290	6.6332 .000 358	6.6332 .000 2	8.0072 .010 356	7.8760 .008 287	7.5509 .004 217	8.0074 .010 358	7.8892 .008 250
M_1	7.8740 .007 141	8.3503 .022 70	....	8.3371 .022 248	7.8760 .008 73	8.4104 .026 67	6.6332 .000 358	7.8760 .008 287	8.3792 .024 69	7.9045 .008 321
O_1	7.8760 .008 73	6.6332 .000 2	8.3371 .022 112	....	6.6329 .000 4	6.5537 .000 178	8.3503 .022 290	7.8740 .007 219	5.7100 .000 0	8.4169 .026 252
OO	8.3371 .022 248	6.6332 .000 358	7.8760 .008 287	6.6329 .000 356	....	7.0438 .001 354	7.6584 .005 285	7.3523 .002 215	6.8924 .001 356	7.6527 .004 248
P_1	8.2982 .020 74	8.0072 .010 4	8.4104 .026 293	6.5537 .000 182	7.0438 .001 6	....	7.8885 .008 291	7.6024 .004 221	8.0074 .010 2	7.9217 .008 254
Q_1	7.5509 .004 143	7.8760 .008 73	6.6332 .000 2	8.3503 .022 70	7.6584 .005 75	7.8885 .008 69	....	8.3503 .022 290	7.8824 .008 71	9.0329 .108 143
2Q	7.4182 .003 34	7.5509 .004 143	7.8760 .008 73	7.8740 .007 141	7.3523 .002 145	7.6024 .004 139	8.3503 .022 70	....	7.5772 .004 141	8.0586 .011 33
S_1	8.3235 .021 72	8.0074 .010 2	8.3792 .024 291	5.7100 .000 0	6.8924 .001 4	8.0074 .010 358	7.8824 .008 289	7.5772 .004 219	....	7.9055 .008 252
ρ_1	5.7099 .000 0	7.8892 .008 110	7.9045 .008 39	8.4169 .026 108	7.6527 .004 112	7.9217 .008 106	9.0329 .108 217	8.0586 .011 327	7.9055 .008 108	....

TABLE 29.—*Elimination factors*—Continued.

SERIES 369 DAYS. SEMIDIURNAL COMPONENTS.

Component sought (A).	Disturbing components (B, C, etc.).											
	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2	2SM
K_2	....	8.3371 .022 248	6.6332 .000 358	7.8760 .008 287	7.5509 .004 217	8.0074 .010 358	8.0072 .010 356	8.0076 .010 354	8.2982 .020 286	5.7099 .000 0	7.8892 .008 250	7.1088 .001 175
L_2	8.3371 .022 112	....	8.3503 .022 290	7.8740 .007 219	7.6166 .004 329	8.3758 .024 110	8.4169 .026 108	8.4607 .029 106	9.0329 .108 217	7.8885 .008 291	6.5537 .000 182	7.9217 .008 106
M_2	6.6332 .000 2	8.3503 .022 70	....	8.3503 .022 290	7.8740 .007 219	5.7100 .000 0	6.5537 .000 178	6.9049 .001 177	8.4169 .026 108	6.5537 .000 182	8.4169 .026 252	6.5549 .000 177
N_2	7.8760 .008 73	7.8740 .007 141	8.3503 .022 70	....	8.3503 .022 290	7.8824 .008 71	7.8885 .008 69	7.8944 .008 67	6.5537 .000 178	8.4169 .026 252	9.0329 .108 143	7.6658 .005 67
2N	7.5509 .004 143	7.6166 .004 31	7.8740 .007 141	8.3503 .022 70	....	7.5772 .004 141	7.6024 .004 139	7.6268 .004 138	7.8885 .008 69	9.0329 .108 143	8.0586 .011 33	7.4452 .003 138
R_2	8.0074 .010 2	8.3758 .024 250	5.7100 .000 0	7.8824 .008 289	7.5772 .004 219	....	8.0074 .010 358	8.0072 .010 356	8.3235 .021 288	6.1771 .000 181	7.9055 .008 252	6.9049 .001 177
S_2	8.0072 .010 4	8.4169 .026 252	6.5537 .000 182	7.8885 .008 291	7.6024 .004 221	8.0074 .010 2	....	8.0074 .010 358	8.3503 .022 290	6.5549 .000 183	7.9217 .008 254	6.5537 .000 178
T_2	8.0076 .010 6	8.4607 .029 254	6.9049 .001 183	7.8944 .008 293	7.6268 .004 222	8.0072 .010 4	8.0074 .010 2	....	8.3792 .024 291	6.7601 .001 185	7.9377 .009 256	5.7100 .000 0
λ_2	8.2982 .020 74	9.0329 .108 143	8.4164 .026 252	6.5537 .000 182	7.8885 .008 291	8.3235 .021 72	8.3503 .022 70	8.3792 .024 69	....	7.9217 .008 254	7.9044 .008 324	7.8885 .008 69
μ_2	5.7099 .000 0	7.8885 .008 69	6.5537 .000 178	8.4169 .026 108	9.0329 .108 217	6.1771 .000 179	6.5549 .000 177	6.7601 .001 175	7.9217 .008 106	....	8.3503 .022 70	6.5542 .000 175
ν_2	7.8892 .008 110	6.5537 .000 178	8.4169 .026 108	9.0329 .108 217	8.0586 .011 327	7.9055 .008 108	7.9217 .008 106	7.9377 .009 104	7.9044 .008 36	8.3503 .022 290	....	7.6990 .005 105
2SM	7.1088 .001 185	7.9217 .008 254	6.5549 .000 183	7.6658 .005 293	7.4452 .003 222	6.9049 .001 183	6.5537 .000 182	5.7100 .000 0	7.8885 .008 291	6.5542 .000 185	7.6990 .005 255	....

TABLE 30.—*Products of amplitudes and angular functions for Form 245.*

°	1		2		3		4		5		°
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
0	0.000	1.000	0.000	2.000	0.000	3.000	0.000	4.000	0.000	5.000	90
1	.017	1.000	.035	2.000	.052	3.000	.070	3.999	.087	4.999	89
2	.035	0.999	.070	1.999	.105	2.998	.140	3.998	.174	4.997	88
3	.052	.999	.105	1.997	.157	2.996	.209	3.995	.262	4.993	87
4	.070	.998	.140	1.995	.209	2.993	.279	3.990	.349	4.988	86
5	.087	.996	.174	1.992	.261	2.989	.349	3.985	.436	4.981	85
6	.105	.995	.209	1.989	.314	2.984	.418	3.978	.523	4.973	84
7	.122	.993	.244	1.985	.366	2.978	.487	3.970	.609	4.963	83
8	.139	.990	.278	1.981	.418	2.971	.557	3.961	.696	4.951	82
9	.156	.988	.313	1.975	.469	2.963	.626	3.951	.782	4.938	81
10	.174	.985	.347	1.970	.521	2.954	.695	3.939	.868	4.924	80
11	.191	.982	.382	1.963	.572	2.945	.763	3.927	.954	4.908	79
12	.208	.978	.416	1.956	.624	2.934	.832	3.913	1.040	4.891	78
13	.225	.974	.450	1.949	.675	2.923	.900	3.897	1.125	4.872	77
14	.242	.970	.484	1.941	.726	2.911	.968	3.881	1.210	4.852	76
15	.259	.966	.518	1.932	.776	2.898	1.035	3.864	1.294	4.830	75
16	.276	.961	.551	1.923	.827	2.884	1.103	3.845	1.378	4.806	74
17	.292	.956	.585	1.913	.877	2.869	1.169	3.825	1.462	4.782	73
18	.309	.951	.618	1.902	.927	2.853	1.236	3.804	1.545	4.755	72
19	.326	.946	.651	1.891	.977	2.837	1.302	3.782	1.628	4.728	71
20	.342	.940	.684	1.879	1.026	2.819	1.368	3.759	1.710	4.698	70
21	.358	.934	.717	1.867	1.075	2.801	1.433	3.734	1.792	4.668	69
22	.375	.927	.749	1.854	1.124	2.782	1.498	3.709	1.873	4.636	68
23	.391	.920	.781	1.841	1.172	2.762	1.563	3.682	1.954	4.602	67
24	.407	.914	.813	1.827	1.220	2.741	1.627	3.654	2.034	4.568	66
25	.423	.906	.845	1.813	1.268	2.719	1.690	3.625	2.113	4.532	65
26	.438	.899	.877	1.798	1.315	2.696	1.753	3.595	2.192	4.494	64
27	.454	.891	.908	1.782	1.362	2.673	1.816	3.564	2.270	4.455	63
28	.469	.883	.939	1.766	1.408	2.649	1.878	3.532	2.347	4.415	62
29	.485	.875	.970	1.749	1.454	2.624	1.939	3.498	2.424	4.373	61
30	.500	.866	1.000	1.732	1.500	2.598	2.000	3.464	2.500	4.330	60
31	.515	.857	1.030	1.714	1.545	2.572	2.060	3.429	2.575	4.286	59
32	.530	.848	1.060	1.696	1.590	2.544	2.120	3.392	2.650	4.240	58
33	.545	.839	1.089	1.677	1.634	2.516	2.179	3.355	2.723	4.193	57
34	.559	.829	1.118	1.658	1.678	2.487	2.237	3.316	2.796	4.145	56
35	.574	.819	1.147	1.638	1.721	2.457	2.294	3.277	2.868	4.096	55
36	.588	.809	1.176	1.618	1.763	2.427	2.351	3.236	2.939	4.045	54
37	.602	.799	1.204	1.597	1.805	2.396	2.407	3.195	3.009	3.993	53
38	.616	.788	1.231	1.576	1.847	2.364	2.463	3.152	3.078	3.940	52
39	.629	.777	1.259	1.554	1.888	2.331	2.517	3.109	3.147	3.886	51
40	.643	.766	1.286	1.532	1.928	2.298	2.511	3.064	3.214	3.830	50
41	.656	.755	1.312	1.509	1.968	2.264	2.624	3.019	3.280	3.774	49
42	.669	.743	1.338	1.486	2.007	2.229	2.677	2.973	3.346	3.716	48
43	.682	.731	1.364	1.463	2.046	2.194	2.728	2.925	3.410	3.657	47
44	.695	.719	1.389	1.439	2.084	2.158	2.779	2.877	3.473	3.597	46
45	0.707	0.707	1.414	1.414	2.121	2.121	2.828	2.828	3.536	3.536	45
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	
	1		2		3		4		5		

TABLE 30.—*Products of amplitudes and angular functions for Form 245*—Con.

°	6		7		8		9		°
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
0	0.000	6.000	0.000	7.000	0.000	8.000	0.000	9.000	90
1	.105	5.999	.122	6.999	.140	7.999	.157	8.999	89
2	.209	5.996	.244	6.996	.279	7.995	.314	8.995	88
3	.314	5.992	.366	6.990	.419	7.989	.471	8.988	87
4	.419	5.985	.488	6.983	.558	7.980	.628	8.978	86
5	.523	5.977	.610	6.973	.697	7.970	.784	8.966	85
6	.627	5.967	.732	6.962	.836	7.956	.941	8.951	84
7	.731	5.955	.853	6.948	.975	7.940	1.097	8.933	83
8	.835	5.942	.974	6.932	1.113	7.922	1.253	8.912	82
9	.939	5.926	1.095	6.914	1.251	7.902	1.408	8.889	81
10	1.042	5.909	1.216	6.894	1.389	7.878	1.563	8.863	80
11	1.145	5.890	1.336	6.871	1.526	7.853	1.717	8.835	79
12	1.247	5.869	1.455	6.847	1.663	7.825	1.871	8.803	78
13	1.350	5.846	1.575	6.821	1.800	7.795	2.025	8.769	77
14	1.452	5.822	1.693	6.792	1.935	7.762	2.177	8.733	76
15	1.553	5.796	1.812	6.762	2.071	7.727	2.329	8.693	75
16	1.654	5.768	1.929	6.729	2.205	7.690	2.481	8.651	74
17	1.754	5.738	2.047	6.694	2.339	7.650	2.631	8.607	73
18	1.854	5.706	2.163	6.657	2.472	7.608	2.781	8.560	72
19	1.953	5.673	2.279	6.619	2.605	7.564	2.930	8.510	71
20	2.052	5.638	2.394	6.578	2.736	7.518	3.078	8.457	70
21	2.150	5.601	2.509	6.535	2.867	7.469	3.225	8.402	69
22	2.248	5.563	2.622	6.490	2.997	7.417	3.371	8.345	68
23	2.344	5.523	2.735	6.444	3.126	7.364	3.517	8.284	67
24	2.440	5.481	2.847	6.395	3.254	7.308	3.661	8.222	66
25	2.536	5.438	2.958	6.344	3.381	7.250	3.804	8.157	65
26	2.630	5.393	3.069	6.292	3.507	7.190	3.945	8.089	64
27	2.724	5.346	3.178	6.237	3.632	7.128	4.086	8.019	63
28	2.817	5.298	3.286	6.181	3.756	7.064	4.225	7.947	62
29	2.909	5.248	3.394	6.122	3.878	6.997	4.363	7.872	61
30	3.000	5.196	3.500	6.062	4.000	6.928	4.500	7.794	60
31	3.090	5.143	3.605	6.000	4.120	6.857	4.635	7.715	59
32	3.180	5.088	3.709	5.936	4.239	6.784	4.769	7.632	58
33	3.268	5.032	3.812	5.871	4.357	6.709	4.902	7.548	57
34	3.355	4.974	3.914	5.803	4.474	6.632	5.033	7.461	56
35	3.441	4.915	4.015	5.734	4.589	6.553	5.162	7.372	55
36	3.527	4.854	4.115	5.663	4.702	6.472	5.290	7.281	54
37	3.611	4.792	4.213	5.590	4.815	6.389	5.416	7.188	53
38	3.694	4.728	4.310	5.516	4.925	6.304	5.541	7.092	52
39	3.776	4.663	4.405	5.440	5.035	6.217	5.664	6.994	51
40	3.857	4.596	4.500	5.362	5.142	6.128	5.785	6.894	50
41	3.936	4.528	4.592	5.283	5.248	6.038	5.905	6.792	49
42	4.015	4.459	4.684	5.202	5.353	5.945	6.022	6.688	48
43	4.092	4.388	4.774	5.119	5.456	5.851	6.138	6.582	47
44	4.168	4.316	4.863	5.035	5.557	5.755	6.252	6.474	46
45	4.243	4.243	4.950	4.950	5.657	5.657	6.364	6.364	45
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	
	6		7		8		9		

TABLE 31.—*For construction of primary stencils.*

Difference.		Component 2Q.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		1 0	7 21	14 21	21 20*	28 20*	35 20	42 20	49 19*	56 19*	63 19
+23	−1	4	8 4	15 4	22 3*	29 3*	36 3	43 3	50 2*	57 2*	64 2
+22	−2	11	11	11	10*	10*	10	10	9*	9*	9
+21	−3	18	18	18	17*	17*	17	17	16*	16*	16
+20	−4	2 1	9 1	16 1	23 0*	30 0*	37 0	44 0	23*	23*	23
+19	−5	8	8	8	7*	7*	7	7	51 6*	58 6*	65 6
+18	−6	15	15	15	14*	14*	14	14	13*	13*	13
+17	−7	22	22	21*	21*	21*	21	21	20*	20*	20
+16	−8	3 5	10 5	17 4*	24 4*	31 4*	38 4	45 4	52 3*	59 3*	66 3
+15	−9	12	12	11*	11*	11*	11	11	10*	10*	10
+14	−10	19	19	18*	18*	18*	18	18	17*	17*	17
+13	−11	4 2	11 2	18 1*	25 1*	32 1*	39 1	46 1	53 0*	60 0*	67 0
+12	−12	9	9	8*	8*	8	8	8	7*	7*	7
+11	−13	16	16	15*	15*	15	15	15	14*	14*	14
+10	−14	23	23	22*	22*	22	22	22	21*	21*	21
+9	−15	5 6	12 6	19 5*	26 5*	33 5	40 5	47 5	54 4*	61 4*	68 4
+8	−16	13	13	12*	12*	12	12	12	11*	11*	11
+7	−17	20	20	19*	19*	19	19	19	18*	18*	18
+6	−18	6 3	13 3	20 2*	27 2*	34 2	41 2	48 1*	55 1*	62 1*	69 1
+5	−19	10	10	9*	9*	9	9	8*	8*	8*	8
+4	−20	17	17	16*	16*	16	16	15*	15*	15*	15
+3	−21	7 0	14 0	23*	23*	23	23	22*	22*	22*	22
+2	−22	7	7	21 6*	28 6*	35 6	42 6	49 5*	56 5*	63 5*	70 5
+1	−23	14	14	13*	13*	13	13	12*	12*	12*	12

Difference.		Component 2Q.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		70 19	77 19	84 18*	91 18*	98 18	105 18	112 17*	119 17*	126 17	133 17
+23	−1	71 2	78 2	85 1*	92 1*	99 1	106 1	113 0*	120 0*	127 0	134 0
+22	−2	9	9	8*	8*	8	8	7*	7*	7	7
+21	−3	16	16	15*	15*	15	15	14*	14*	14	14
+20	−4	23	23	22*	22*	22	22	21*	21*	21	21
+19	−5	72 6	79 5*	86 5*	93 5*	100 5	107 5	114 4*	121 4*	128 4	135 4
+18	−6	13	12*	12*	12*	12	12	11*	11*	11	11
+17	−7	20	19*	19*	19*	19	19	18*	18*	18	18
+16	−8	73 3	80 2*	87 2*	94 2*	101 2	108 2	115 1*	122 1*	129 1	136 1
+15	−9	10	9*	9*	9*	9	9	8*	8*	8	8
+14	−10	17	16*	16*	16*	16	16	15*	15*	15	15
+13	−11	74 0	23*	23*	23	23	23	22*	22*	22	22
+12	−12	7	81 6*	88 6*	95 6	102 6	109 6	116 5*	123 5*	130 5	137 5
+11	−13	14	13*	13*	13	13	13	12*	12*	12	12
+10	−14	21	20*	20*	20	20	20	19*	19*	19	19
+9	−15	75 4	82 3*	89 3*	96 3	103 3	110 3	117 2*	124 2*	131 2	138 2
+8	−16	11	10*	10*	10	10	10	9*	9*	9	9
+7	−17	18	17*	17*	17	17	16*	16*	16*	16	16
+6	−18	76 1	83 0*	90 0*	97 0	104 0	23*	23*	23*	23	23
+5	−19	8	7*	7*	7	7	111 6*	118 6*	125 6*	132 6	139 6
+4	−20	15	14*	14*	14	14	13*	13*	13*	13	13
+3	−21	22	21*	21*	21	21	20*	20*	20*	20	20
+2	−22	77 5	84 4*	91 4*	98 4	105 4	112 3*	119 3*	126 3	133 3	140 3
+1	−23	12	11*	11*	11	11	10*	10*	10	10	10

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component 2Q.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		140 17	147 16*	154 16*	161 16	168 16	175 15*	182 15*	189 15	196 15	203 15
+23	−1	141 0	23*	23*	23	23	22*	22*	22	22	22
+22	−2	7	148 6*	155 6*	162 6	169 6	176 5*	183 5*	190 5	197 5	204 4*
+21	−3	14	13*	13*	13	13	12*	12*	12	12	11*
+20	−4	20*	20*	20*	20	20	19*	19*	19	19	18*
+19	−5	142 3*	149 3*	156 3*	163 3	170 3	177 2*	184 2*	191 2	198 2	205 1*
+18	−6	10*	10*	10*	10	10	9*	9*	9	9	8*
+17	−7	17*	17*	17*	17	17	16*	16*	16	16	15*
+16	−8	143 0*	150 0*	157 0*	164 0	171 0	23*	23*	23	23	22*
+15	−9	7*	7*	7*	7	7	178 6*	185 6*	192 6	199 6	206 5*
+14	−10	14*	14*	14	14	14	13*	13*	13	13	12*
+13	−11	21*	21*	21	21	21	20*	20*	20	20	19*
+12	−12	144 4*	151 4*	158 4	165 4	172 4	179 3*	186 3*	193 3	200 3	207 2*
+11	−13	11*	11*	11	11	11	10*	10*	10	10	9*
+10	−14	18*	18*	18	18	18	17*	17*	17	17	16*
+9	−15	145 1*	152 1*	159 1	166 1	173 0*	180 0*	187 0*	194 0	201 0	23*
+8	−16	8*	8*	8	8	7*	7*	7*	7	7	208 6*
+7	−17	15*	15*	15	15	14*	14*	14*	14	14	13*
+6	−18	22*	22*	22	22	21*	21*	21*	21	21	20*
+5	−19	146 5*	153 5*	160 5	167 5	174 4*	181 4*	188 4*	195 4	202 4	209 3*
+4	−20	12*	12*	12	12	11*	11*	11*	11	11	10*
+3	−21	19*	19*	19	19	18*	18*	18	18	18	17*
+2	−22	147 2*	154 2*	161 2	168 2	175 1*	182 1*	189 1	196 1	203 1	210 0*
+1	−23	9*	9*	9	9	8*	8*	8	8	8	7*

Difference.		Component 2Q.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		210 14*	217 14*	224 14	231 14	238 13*	245 13*	252 13	259 13	266 13	273 12*
+23	−1	21*	21*	21	21	20*	20*	20	20	19*	19*
+22	−2	211 4*	218 4*	225 4	232 4	239 3*	246 3*	253 3	260 3	267 2*	274 2*
+21	−3	11*	11*	11	11	10*	10*	10	10	9*	9*
+20	−4	18*	18*	18	18	17*	17*	17	17	16*	16*
+19	−5	212 1*	219 1*	226 1	233 1	240 0*	247 0*	254 0	261 0	23*	23*
+18	−6	8*	8*	8	8	7*	7*	7	7	268 6*	275 6*
+17	−7	15*	15*	15	15	14*	14*	14	14	13*	13*
+16	−8	22*	22	22	22	21*	21*	21	21	20*	20*
+15	−9	213 5*	220 5	227 5	234 5	241 4*	248 4*	255 4	262 4	269 3*	276 3*
+14	−10	12*	12	12	12	11*	11*	11	11	10*	10*
+13	−11	19*	19	19	19	18*	18*	18	18	17*	17*
+12	−12	214 2*	221 2	228 2	235 2	242 1*	249 1*	256 1	263 1	270 0*	277 0*
+11	−13	9*	9	9	9	8*	8*	8	8	7*	7*
+10	−14	16*	16	16	15*	15*	15*	15	15	14*	14*
+9	−15	23*	23	23	22*	22*	22*	22	22	21*	21*
+8	−16	215 6*	222 6	229 6	236 5*	243 5*	250 5*	257 5	264 5	271 4*	278 4*
+7	−17	13*	13	13	12*	12*	12*	12	12	11*	11*
+6	−18	20*	20	20	19*	19*	19*	19	19	18*	18*
+5	−19	216 3*	223 3	230 3	237 2*	244 2*	251 2	258 2	265 2	272 1*	279 1*
+4	−20	10*	10	10	9*	9*	9	9	9	8*	8*
+3	−21	17*	17	17	16*	16*	16	16	16	15*	15*
+2	−22	217 0*	224 0	231 0	23*	23*	23	23	23	22*	22*
+1	−23	7*	7	7	238 6*	245 6*	252 6	259 6	266 6	273 5*	280 5*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component 2Q.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		280 12*	287 12	294 12	301 11*	308 11*	315 11	322 11	329 10*	336 10*	343 10*
+23	−1	19*	19	19	18*	18*	18	18	17*	17*	17*
+22	−2	281 2*	288 2	295 2	302 1*	309 1*	316 1	323 1	330 0*	337 0*	344 0*
+21	−3	9*	9	9	8*	8*	8	8	7*	7*	7*
+20	−4	16*	16	16	15*	15*	15	15	14*	14*	14*
+19	−5	23*	23	23	22*	22*	22	22	21*	21*	21
+18	−6	282 6*	289 6	296 6	303 5*	310 5*	317 5	324 5	331 4*	338 4*	345 4
+17	−7	13	13	13	12*	12*	12	12	11*	11*	11
+16	−8	20	20	20	19*	19*	19	19	18*	18*	18
+15	−9	283 3	290 3	297 3	304 2*	311 2*	318 2	325 2	332 1*	339 1*	346 1
+14	−10	10	10	10	9*	9*	9	9	8*	8*	8
+13	−11	17	17	17	16*	16*	16	16	15*	15*	15
+12	−12	284 0	291 0	23*	23*	23*	23	23	22*	22*	22
+11	−13	7	7	298 6*	305 6*	312 6*	319 6	326 6	333 5*	340 5*	347 5
+10	−14	14	14	13*	13*	13*	13	13	12*	12*	12
+9	−15	21	21	20*	20*	20*	20	20	19*	19*	19
+8	−16	285 4	292 4	299 3*	306 3*	313 3*	320 3	327 3	334 2*	341 2*	348 2
+7	−17	11	11	10*	10*	10*	10	10	9*	9*	9
+6	−18	18	18	17*	17*	17	17	17	16*	16*	16
+5	−19	286 1	293 1	300 0*	307 0*	314 0	321 0	328 0	23*	23*	23
+4	−20	8	8	7*	7*	7	7	7	335 6*	342 6*	349 6
+3	−21	15	15	14*	14*	14	14	14	13*	13*	13
+2	−22	22	22	21*	21*	21	21	21	20*	20*	20
+1	−23	287 5	294 5	301 4*	308 4*	315 4	322 4	329 4	336 3*	343 3*	350 3

Difference.		Component 2Q.			Component Q.						
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h*
0		350 10	357 10	364 9*	1 0	10 5	19 13*	28 22*	38 7*	47 16	57 1
+23	−1	17	17	16*	5*	14	23	29 8	16*	48 1*	10*
+22	−2	351 0	358 0	23*	15	23*	20 8*	17	39 2	11	19*
+21	−3	7	7	365 6*	2 0	11 9	18	30 2*	11*	20	58 5
+20	−4	14	14	13*	9*	18*	21 3	12	21	49 5*	14*
+19	−5	21	21	20*	19	12 3*	12*	21*	40 6	15	59 0
+18	−6	352 4	359 4	366 3*	3 4*	13	22	31 6*	15*	50 0*	9
+17	−7	11	11	10*	13*	22*	22 7*	16	41 1	9*	18*
+16	−8	18	18	17*	23	13 8	16*	32 1*	10*	19	60 4
+15	−9	353 1	360 1	367 0*	4 8*	17	23 2	11	19*	51 4*	13
+14	−10	8	8	7*	17*	14 2*	11*	20	42 5	14	22*
+13	−11	15	14*	14*	5 3	12	20*	33 5*	14*	23	61 8
+12	−12	22	21*	21*	12*	21*	24 6	15	23*	52 8*	17*
+11	−13	354 5	361 4*	268 4*	22	15 6*	15*	34 0*	43 9	18	62 2*
+10	−14	12	11*	11*	6 7	16	25 1	9*	18*	53 3*	12
+9	−15	19	18*	18*	16*	16 1*	10	19	44 4	12*	21*
+8	−16	355 2	362 1*	369 1*	7 2	11	19*	35 4*	13	22	63 7
+7	−17	9	8*	8*	11*	20	26 5	13*	22*	54 7*	16
+6	−18	16	15*	15*	20*	17 5*	14*	23	45 8	16*	64 1*
+5	−19	23	22*	22*	8 6	15	23*	36 8*	17*	55 2	11
+4	−20	356 6	363 5*	370 5*	15*	18 0	27 9	18	46 2*	11*	20*
+3	−21	13	12*		9 1	9*	18*	37 3	12	21	65 5*
+2	−22	20	19*		10	19	28 4	12*	21*	56 6	15
+1	−23	357 3	364 2*		19*	19 4*	13	22	47 7	15*	66 0*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component Q.																			
Hour.		*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*
0		66	9*	75	18*	85	3*	94	12	103	21	113	6	122	14*	131	23*	141	8	150	17
+23	−1		19	76	4		12*		21*	104	6*		15	123	0	132	9		17*	151	2*
+22	−2	67	4*		13*		22	95	7		15*	114	0*		9*		18	142	3		12
+21	−3		14		22*	86	7*		16*	105	1		10		18*	133	3*		12*		21
+20	−4		23	77	8		17	96	1*		10*		19*	124	4		13		21*	152	6*
+19	−5	68	8*		17*	87	2		11		20	115	4*		13*		22*	143	7		16
+18	−6		18	78	3		11*		20*	106	5		14		23	134	7*		16*	153	1*
+17	−7	69	3*		12		21	97	6		14*		23*	125	8		17	144	2		10*
+16	−8		12*		21*	88	6*		15	107	0	116	8*		17*	135	2*		11		20
+15	−9		22	79	7		15*	98	0*		9*		18	126	3		11*		20*	154	5*
+14	−10	70	7*		16	89	1		10		18*	117	3*		12*		21	145	6		14*
+13	−11		17	80	1*		10*		19	108	4		13		21*	136	6*		15*	155	0
+12	−12	71	2		11		20	99	4*		13*		22	127	7		16	146	0*		9*
+11	−13		11*		20*	90	5		14		23	118	7*		16*	137	1		10		19
+10	−14		21	81	5*		14*		23*	109	8		17	128	2		10*		19*	156	4
+9	−15	72	6*		15	91	0	100	8*		17*	119	2*		11		20	147	5		13*
+8	−16		15*	82	0*		9		18	110	3		11*		20*	138	5*		14		23
+7	−17	73	1		10		18*	101	3*		12		21	129	6		14*		23*	157	8*
+6	−18		10*		19	92	4		13		21*	120	6*		15	139	0	148	9		17*
+5	−19		19*	83	4*		13*		22	111	7		16	130	0*		9*		18	158	3
+4	−20	74	5		14		22*	102	7*		16*	121	1		10		19	149	3*		12*
+3	−21		14*		23*	93	8		17	112	1*		10*		19*	140	4		13		22
+2	−22	75	0	84	8*		17*	103	2*		11		20	131	4*		13*		22*	159	7
+1	−23		9		18	94	3		11*		20*	122	5*		14		23	150	7*		16*

Difference.		Component Q.																			
Hour.		*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*	*d.*	*h.*
0		160	2	169	10*	178	19*	188	4*	197	13	206	22	216	6*	225	15*	235	0*	244	9
+23	−1		11		20	179	5		13*		22*	207	7*		16	226	1		9*		18*
+22	−2		20*	170	5*		14		23	198	8		16*	217	1*		10*		19	245	4
+21	−3	161	6		15		23*	189	8*		17	208	2		11		19*	236	4*		13*
+20	−4		15*	171	0	180	9		18	199	2*		11*		20	227	5		14		22*
+19	−5	162	0*		9*		18*	190	3		12		21	218	5*		14*		23	246	8
+18	−6		10		19	181	3*		12*		21*	209	6		15	228	0	237	8*		17*
+17	−7		19*	172	4		13		22	200	6*		15*	219	0*		9		18	247	2*
+16	−8	163	5		13*		22*	191	7		16	210	1		9*		18*	238	3*		12
+15	−9		14		23	182	8		16*	201	1*		10		19	229	4		12*		21*
+14	−10		23*	173	8*		17	192	2		11		19	220	4*		13		22	248	7
+13	−11	164	9		17*	183	2*		11*		20	211	5		14		22*	239	7*		16
+12	−12		18*	174	3		12		20*	202	5*		14*		23	230	8		17	249	1*
+11	−13	165	3*		12*		21*	193	6		15		23*	221	8*		17*	240	2		11
+10	−14		13		22	184	6*		15*	203	0*	212	9		18	231	2*		11*		20*
+9	−15		22*	175	7		16	194	1		9*		18*	222	3		12		21	250	5*
+8	−16	166	7*		16*	185	1*		10		19	213	4		12*		21*	241	6		15
+7	−17		17	176	2		10*		19*	204	4*		13		22	232	7		15*	251	0*
+6	−18	167	2*		11*		20	195	5		13*		22*	223	7*		16	242	1		10
+5	−19		12		20*	186	5*		14*		23	214	8		16*	233	1*		10*		19
+4	−20		21	177	6		15		23*	205	8*		17*	224	2		11		19*	252	4*
+3	−21	168	6*		15*	187	0	196	9		18	215	2*		11*		20*	243	5		14
+2	−22		16	178	1		9*		18*	206	3		12		21	234	5*		14*		23*
+1	−23	169	1*		10		19	197	3*		12*		21*	225	6		15	244	0	253	8*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component Q.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		253 18	263 3	272 11*	281 20*	291 5	300 14	309 23	319 7*	328 16*	338 1*
+23	−1	254 3*	12	21	282 6	14*	23*	310 8	17	329 2	10*
+22	−2	12*	21*	273 6*	15	292 0	301 9	17*	320 2*	11	20
+21	−3	22	264 7	15*	283 0*	9*	18	311 3	12	20*	339 5*
+20	−4	255 7*	16*	274 1	10	18*	302 3*	12*	21	330 6	15
+19	−5	17	265 1*	10*	19*	293 4	13	21*	321 6*	15*	340 0
+18	−6	256 2	11	20	284 4*	13*	22	312 7	16	331 0*	9*
+17	−7	11*	20*	275 5	14	23	303 7*	16*	322 1	10	19
+16	−8	21	266 5*	14*	23*	294 8	17	313 2	10*	19*	341 4
+15	−9	257 6*	15	276 0	285 8*	17*	304 2*	11	20	332 5	13*
+14	−10	15*	267 0*	9*	18	295 3	11*	20*	323 5*	14	23
+13	−11	258 1	10	18*	286 3*	12*	21	314 6	14*	23*	342 8*
+12	−12	10*	19	277 4	13	21*	305 6*	15*	324 0	333 9	17*
+11	−13	20	268 4*	13*	22	296 7	16	315 0*	9*	18*	343 3
+10	−14	259 5	14	23	287 7*	16*	306 1	10	19	334 3*	12*
+9	−15	14*	23*	278 8	17	297 1*	10*	19*	325 4	13	22
+8	−16	260 0	269 8*	17*	288 2*	11	20	316 4*	13*	22*	344 7
+7	−17	9	18	279 3	11*	20*	307 5*	14	23	335 7*	16*
+6	−18	18*	270 3*	12	21	298 6	14*	23*	326 8*	17	345 2
+5	−19	261 4	13	21*	289 6*	15	308 0	317 9	17*	336 2*	11*
+4	−20	13*	22	280 7	16	299 0*	9	18	327 3	12	20*
+3	−21	22*	271 7*	16*	290 1	10	19*	318 3*	12*	21	346 6
+2	−22	262 8	17	281 1*	10*	19*	309 4	13	21*	337 6*	15*
+1	−23	17*	272 2	11	20	300 4*	13*	22*	328 7	16	347 0*

Difference.		Component Q.			Component ρ.						
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		347 10	356 19	366 3*	1 0	10 15*	20 11	30 6*	40 2	49 21*	59 17
+23	−1	19*	357 4*	13	5*	11 1	20*	16	12	50 7*	60 3
+22	−2	348 5	13*	22*	15*	11	21 6*	31 2	21*	17	12*
+21	−3	14	23	367 8	2 1*	21	16*	12	41 7*	51 3	22*
+20	−4	23*	358 8*	17	11	12 6*	22 2	21*	17	12*	61 8*
+19	−5	349 9	18	368 2*	21	16*	12	32 7*	42 3	22*	18
+18	−6	18*	359 3	12	3 6*	13 2*	22	17*	13	52 8*	62 4
+17	−7	350 3*	12*	21*	16*	12	23 7*	33 3	22*	18	13*
+16	−8	13	22	369 6*	4 2*	22	17*	13	43 8*	53 4	23*
+15	−9	22*	360 7	16	12	14 7*	24 3	22*	18*	14	63 9*
+14	−10	351 8	16*	370 1*	22	17*	13	34 8*	44 4	23*	19
+13	−11	17	361 2	....	5 8	15 3*	23	18*	14	54 9*	64 5
+12	−12	352 2*	11*	....	17*	13	25 8*	35 4	23*	19	15
+11	−13	12	20*	....	6 3*	23	18*	14	45 9*	55 5	65 0*
+10	−14	21	362 6	....	13	16 9	26 4*	36 0	19*	15	10*
+9	−15	353 6*	15*	....	23	18*	14	9*	46 5	56 0*	20
+8	−16	16	363 1	....	7 9	17 4*	27 0	19*	15	10*	66 6
+7	−17	354 1*	10	....	18*	14	9*	37 5*	47 1	20*	16
+6	−18	10*	19*	....	8 4*	18 0	19*	15	10*	57 6	67 1*
+5	−19	20	364 5	....	14*	10	28 5*	38 1	20*	16	11*
+4	−20	355 5*	14*	....	9 0	19*	15	10*	48 6	58 2	21*
+3	−21	15	23*	....	10	19 5*	29 1	20*	16	11*	68 7
+2	−22	356 0	365 9	....	19*	15*	11	39 6*	49 2	21*	17
+1	−23	9*	18*	....	10 5*	20 1	20*	16	11*	59 7	69 2*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component ρ.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		69 12*	79 8	89 3*	98 23	108 18*	118 14	128 9*	138 5	148 1	157 20*
+23	−1	22*	18	13*	99 9	109 4*	119 0	19*	15	10*	158 6
+22	−2	70 8	80 3*	23	18*	14*	10	129 5*	139 1	20*	16
+21	−3	18	13*	90 9	100 4*	110 0	19*	15	10*	149 6	159 1*
+20	−4	71 4	23*	19	14*	10	120 5*	130 1	20*	16	11*
+19	−5	13*	81 9	91 4*	101 0	19*	15	11	140 6*	150 2	21*
+18	−6	23*	19	14*	10	111 5*	121 1	20*	16	11*	160 7
+17	−7	72 9	82 5	92 0*	20	15*	11	131 6*	141 2	21*	17
+16	−8	19	14*	10	102 5*	112 1	20*	16	11*	151 7*	161 3
+15	−9	73 5	83 0*	20	15*	11	122 6*	132 2	21*	17	12*
+14	−10	14*	10	93 5*	103 1*	21	16*	12	142 7*	152 3	22*
+13	−11	74 0*	20	15*	11	113 6*	123 2	21*	17	12*	162 8
+12	−12	10*	84 6	94 1*	21	16*	12	133 7*	143 3	22*	18
+11	−13	20	15*	11	104 6*	114 2	21*	17*	13	153 8*	163 4
+10	−14	75 6	85 1*	21	16*	12	124 7*	134 3	22*	18	13*
+9	−15	15*	11*	95 7	105 2*	22	17*	13	144 8*	154 4	23*
+8	−16	76 1*	21	16*	12	115 7*	125 3	22*	18	14	164 9*
+7	−17	11*	86 7	96 2*	22	17*	13	135 8*	145 4	23*	19
+6	−18	21	16*	12	106 8	116 3*	23	18*	14	155 9*	165 5
+5	−19	77 7	87 2*	22	17*	13	126 8*	136 4	23*	19	14*
+4	−20	17	12*	97 8	107 3*	23	18*	14	146 9*	156 5	166 0*
+3	−21	78 2*	22	17*	13	117 8*	127 4*	137 0	19*	15	10*
+2	−22	12*	88 8	98 3*	23	18*	14	9*	147 5	157 0*	20
+1	−23	22	18	13*	108 9	118 4*	128 0	19*	15	10*	167 6

Difference.		Component ρ.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		167 16	177 11*	187 7	197 2*	206 22	216 17*	226 13	236 8*	246 4	255 23*
+23	−1	168 1*	21	16*	12	207 7*	217 3*	23	18*	14	256 9*
+22	−2	11*	178 7	188 2*	22	17*	13	227 8*	237 4	23*	19
+21	−3	21	17	12*	198 8	208 3*	23	18*	14	247 9*	257 5
+20	−4	169 7	179 2*	22	17*	13	218 8*	228 4	238 0	19*	15
+19	−5	17	12*	189 8	199 3*	23	18*	14	9*	248 5	258 0*
+18	−6	170 2*	22	17*	13*	209 9	219 4*	229 0	19*	15	10*
+17	−7	12*	180 8	190 3*	23	18*	14	9*	239 5	249 0*	20
+16	−8	22*	18	13*	200 9	210 4*	220 0	19*	15	10*	259 6
+15	−9	171 8	181 3*	23	18*	14	10	230 5*	240 1	20*	16
+14	−10	18	13*	191 9	201 4*	211 0	19*	15	10*	250 6	260 1*
+13	−11	172 4	23*	19	14*	10	221 5*	231 1	20*	16	11*
+12	−12	13*	182 9	192 4*	202 0	19*	15	10*	241 6*	251 2	21*
+11	−13	23*	19	14*	10	212 5*	222 1	20*	16	11*	261 7
+10	−14	173 9	183 4*	193 0*	20	15*	11	232 6*	242 2	21*	17
+9	−15	19	14*	10	203 5*	213 1	20*	16	11*	252 7	262 3
+8	−16	174 5	184 0*	20	15*	11	223 6*	233 2	21*	17	12*
+7	−17	14*	10	194 5*	204 1	20*	16*	12	243 7*	253 3	22*
+6	−18	175 0*	20	15*	11	214 6*	224 2	21*	17	12*	263 8
+5	−19	10*	185 6	195 1*	21	16*	12	234 7*	244 3	22*	18
+4	−20	20	15*	11	205 6*	215 2	21*	17	13	254 8*	264 4
+3	−21	176 6	186 1*	21	16*	12	225 7*	235 3	22*	18	13*
+2	−22	15*	11	196 7	206 2*	22	17*	13	245 8*	255 4	23*
+1	−23	177 1*	21	16*	12	216 7*	226 3	22*	18	13*	265 9*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component ρ.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		265 19	275 14*	285 10	295 5*	305 1	314 20*	324 16	334 12	344 7*	354 3
+23	−1	266 5	276 0*	20	15*	11	315 6*	325 2	21*	17	12*
+22	−2	14*	10	286 6	296 1*	21	16*	12	335 7*	345 3	22*
+21	−3	267 0*	20	15*	11	306 6*	316 2	21*	17	12*	355 8*
+20	−4	10*	277 6	287 1*	21	16*	12	326 7*	336 3	22*	18
+19	−5	20	15*	11	297 6*	307 2*	22	17*	13	346 8*	356 4
+18	−6	268 6	278 1*	21	16*	12	317 7*	327 3	22*	18	13*
+17	−7	16	11*	288 7	298 2*	22	17*	13	337 8*	347 4	23*
+16	−8	269 1*	21	16*	12	308 7*	318 3	23	18*	14	357 9*
+15	−9	11*	279 7	289 2*	22	17*	13	328 8*	338 4	23*	19
+14	−10	21	16*	12*	299 8	309 3*	23	18*	14	348 9*	358 5
+13	−11	270 7	280 2*	22	17*	13	319 8*	329 4	23*	19	15
+12	−12	17	12*	290 8	300 3*	23	18*	14	339 9*	349 5	359 0*
+11	−13	271 2*	22	17*	13	310 9	320 4*	330 0	19*	15	10*
+10	−14	12*	281 8	291 3*	23	18*	14	9*	340 5	350 0*	20
+9	−15	22*	18	13*	301 9	311 4*	321 0	19*	15	10*	360 6
+8	−16	272 8	282 3*	23	18*	14	9*	331 5*	341 1	20*	16
+7	−17	18	13*	292 9	302 4*	312 0	19*	15	10*	351 6	361 1*
+6	−18	273 3*	23*	19	14*	10	322 5*	332 1	20*	16	11*
+5	−19	13*	283 9	293 4*	303 0	19*	15	10*	342 6	352 2	21*
+4	−20	23*	19	14*	10	313 5*	323 1	20*	16	11*	362 7
+3	−21	274 9	284 4*	294 0	19*	15*	11	333 6*	343 2	21*	17
+2	−22	19	14*	10	304 5*	314 1	20*	16	11*	353 7	363 2*
+1	−23	275 5	285 0*	20	15*	11	324 6*	334 2	21*	17	12*

Difference.		Component ρ.	Component O.								
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		363 22*	1 0	14 22*	29 3	43 7*	57 12	71 16*	85 21	100 2	114 6*
+23	−1	364 8	8	15 12*	17	21*	58 2	72 7	86 11*	16	20*
+22	−2	18	22	16 2*	30 7	44 12	16*	21	87 1*	101 6	115 11
+21	−3	365 4	2 12	17	21*	45 2	59 6*	73 11	16	20*	116 1
+20	−4	13*	3 2*	17 7	31 11*	16	21	74 1*	88 6	102 10*	15
+19	−5	23*	16*	21	32 2	46 6*	60 11	15*	20	103 1	117 5*
+18	−6	366 9	4 7	18 11*	16	20*	61 1	75 6	89 10*	15	19*
+17	−7	19	21	19 1*	33 6	47 11	15*	20	90 0*	104 5	118 10
+16	−8	367 5	5 11	16	20*	48 1	62 5*	76 10	15	19*	119 0
+15	−9	14*	6 1*	20 6	34 10*	15	20	77 0*	91 5	105 9*	14
+14	−10	368 0*	15*	20	35 1	49 5*	63 10	14*	19	106 0	120 4*
+13	−11	10*	7 6	21 10*	15	19*	64 0	78 5	92 9*	14	18*
+12	−12	20	20	22 0*	36 5	50 9*	14*	19	23*	107 4	121 8*
+11	−13	369 6	8 10	14*	19*	51 0	65 4*	79 9	93 13*	18*	23
+10	−14	15*	9 0*	23 5	37 9*	14	18*	23*	94 4	108 8*	122 13
+9	−15	370 1*	14*	19	23*	52 4*	66 9	80 13*	18	22*	123 3*
+8	−16	………	10 4*	24 9*	38 14	18*	23	81 3*	95 8*	109 13	17*
+7	−15	………	19	23*	39 4	53 8*	67 13*	18	22*	110 3	124 7*
+6	−18	………	11 9	25 13*	18*	23	68 3*	82 8	96 12*	17*	22
+5	−19	………	23*	26 4	40 8*	54 13	17*	22*	97 3	111 7*	125 12
+4	−20	………	12 13*	18	22*	55 3*	69 8	83 12*	17	21*	126 2*
+3	−21	………	13 3*	27 8*	41 13	17*	22	84 2*	98 7*	112 12	16*
+2	−22	………	18	22*	42 3	56 7*	70 12*	17	21*	113 2	127 6*
+1	−23	………	14 8	28 12*	17*	22	71 2*	85 7	99 11*	16	21

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component O.									
Hours.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		128 11	142 15*	156 20	171 1	185 5*	199 10	213 14*	227 19	242 0	256 4*
+23	−1	129 1	143 6	157 10*	15	19*	200 0	214 5	228 9*	14	18*
+22	−2	15*	20	158 0*	172 5	186 10	14*	19	23*	243 4	257 9
+21	−3	130 5*	144 10	15	19*	187 0	201 4*	215 9	229 14	18*	23
+20	−4	20	145 0*	159 5	173 9*	14	19	23*	230 4	244 8*	258 13
+19	−5	131 10	14*	19	174 0	188 4*	202 9	216 13*	18	23	259 3*
+18	−6	132 0	146 5	160 9*	14	18*	23	217 4	231 8*	245 13	17*
+17	−7	14*	19	23*	175 4	189 9	203 13*	18	22*	246 3	260 8
+16	−8	133 4*	147 9	161 14	18*	23	204 3*	218 8	232 13	17*	22
+15	−9	19	23*	162 4	176 8*	190 13	18	22*	233 3	247 7*	261 12
+14	−10	134 9	148 13*	18	22*	191 3*	205 8	219 12*	17	21*	262 2*
+13	−11	23	149 3*	163 8*	177 13	17*	22	220 2*	234 7*	248 12	16*
+12	−12	135 13*	18	22*	178 3	192 7*	206 12*	17	21*	249 2	263 6*
+11	−13	136 3*	150 8	164 12*	17*	22	207 2*	221 7	235 11*	16*	21
+10	−14	17*	22*	165 3	179 7*	193 12	16*	21*	236 2	250 6*	264 11
+9	−15	137 8	151 12*	17	21*	194 2*	208 7	222 11*	16	20*	265 1*
+8	−16	22	152 2*	166 7*	180 12	16*	21	223 1*	237 6*	251 11	15*
+7	−17	138 12*	17	21*	181 2	195 6*	209 11*	16	20*	252 1	266 5*
+6	−18	139 2*	153 7	167 11*	16*	21	210 1*	224 6	238 10*	15*	20
+5	−19	16*	21*	168 2	182 6*	196 11	15*	20*	239 1	253 5*	267 10
+4	−20	140 7	154 11*	16	20*	197 1*	211 6	225 10*	15	19*	268 0*
+3	−21	21	155 1*	169 6*	183 11	15*	20	226 0*	240 5	254 10	14*
+2	−22	141 11*	16	20*	184 1	198 5*	212 10	15	19*	255 0	269 4*
+1	−23	142 1*	156 6	170 10*	15	20	213 0*	227 5	241 9*	14	19

Difference.		Component O.								Component 2N.	
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		270 9	284 13*	298 18	312 23	327 3*	341 8	355 12*	369 17	1 0	14 23*
+23	−1	23	285 4	299 8*	313 13	17*	22	356 3	370 7*	8	15 14
+22	−2	271 13*	18	22*	314 3	328 8	342 12*	17	....	22	16 4
+21	−3	272 3*	286 8	300 13	17*	22	343 2*	357 7	....	2 12*	18*
+20	−4	18	22*	301 3	315 7*	329 12	17	21*	....	3 2*	17 8*
+19	−5	273 8	287 12*	17	22	330 2*	344 7	358 11*	....	17	23
+18	−6	22	288 3	302 7*	316 12	16*	21	359 2	....	4 7	18 13
+17	−7	274 12*	17	21*	317 2	331 7	345 11*	16	....	21*	19 3*
+16	−8	275 2*	289 7	303 11*	16*	21	346 1*	360 6	....	5 11*	18
+15	−9	16*	21*	304 2	318 6*	332 11	15*	20*	....	6 2	20 8
+14	−10	276 7	290 11*	16	20*	333 1*	347 6*	361 10*	....	16	22*
+13	−11	21	291 1*	305 6*	319 11	15*	20	362 0*	....	7 6*	21 12*
+12	−12	277 11*	16	20*	320 1	334 5*	348 10*	15	....	20*	22 3
+11	−13	278 1*	292 6	306 10*	15*	20	349 0*	363 5	....	8 11	17
+10	−14	15*	20*	307 1	321 5*	335 10	14*	19*	....	9 1	23 7*
+9	−15	279 6	293 10*	15	19*	336 0*	350 5	364 9*	....	15*	21*
+8	−16	20	294 0*	308 5*	322 10	14*	19	23*	....	10 5*	24 12
+7	−17	280 10*	15	19*	323 0	337 4*	351 9*	365 14	....	20	25 2
+6	−18	281 0*	295 5	309 9*	14*	19	23*	366 4	....	11 10	16*
+5	−19	14*	19*	310 0	324 4*	338 9	352 13*	18	....	12 0*	26 6*
+4	−20	282 5	296 9*	14	18*	23	353 4	367 8*	....	14*	21
+3	−21	19	23*	311 4	325 9	339 13*	18	22*	....	13 5	27 11
+2	−22	283 9	297 14	18*	23	340 3*	354 8	368 13	....	19	28 1*
+1	−23	23*	298 4	312 8*	326 13	18	22*	369 3	....	14 9*	15*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component 2N.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		29 6	43 12	57 18	72 0	86 6	100 12*	114 18*	129 0*	143 6*	157 12*
+23	−1	20	44 2	58 8*	14*	20*	101 2*	115 8*	15	21	158 3
+22	−2	30 10*	16*	22*	73 4*	87 10*	17	23	130 5	144 11	17
+21	−3	31 0*	45 6*	59 13	19	88 1	102 7	116 13	19*	145 1*	159 7*
+20	−4	15	21	60 3	74 9	15	21*	117 3*	131 9*	15*	21*
+19	−5	32 5	46 11	17	23*	89 5*	103 11*	17*	132 0	146 6	160 12
+18	−6	19*	47 1*	61 7*	75 13*	20	104 2	118 8	14	20	161 2*
+17	−7	33 9	15*	22	76 4	90 10	16	22	133 4*	147 10*	16*
+16	−8	34 0	48 6	62 12	18	91 0*	105 6*	119 12*	18*	148 0*	162 7
+15	−9	14	20	63 2*	77 8*	14*	20*	120 2*	134 9	15	21
+14	−10	35 4*	49 10*	16*	22*	92 5	106 11	17	23	149 5	163 11*
+13	−11	18*	50 0*	64 7	78 13	19	107 1	121 7	135 13*	19*	164 1*
+12	−12	36 9	15	21	79 3	93 9*	15*	21*	136 3*	150 9*	16
+11	−13	23	51 5	65 11*	17*	23*	108 5*	122 11*	18	151 0	165 6
+10	−14	37 13*	19*	66 1*	80 7*	94 14	20	123 2	137 8	14	20*
+9	−15	38 3*	52 9*	16	22	95 4	109 10	16	22*	152 4*	166 10*
+8	−16	18	53 0	67 6	81 12	18*	110 0*	124 6*	138 12*	18*	167 1
+7	−17	39 8	14	20*	82 2*	96 8*	14*	20*	139 3	153 9	15
+6	−18	22*	54 4*	68 10*	16*	23	111 5	125 11	17	23	168 5*
+5	−19	40 12*	19	69 1	83 7	97 13	19	126 1*	140 7*	154 13*	19*
+4	−20	41 3	55 9	15	21	98 3*	112 9	15*	21*	155 3*	169 10
+3	−21	17	23*	70 5*	84 11*	17*	23	127 6	141 12	18	170 0
+2	−22	42 7*	56 13*	19*	85 1*	99 8	113 14	20	142 2	156 8	14*
+1	−23	21*	57 4	71 10	16	22	114 4	128 10*	16*	22*	171 4*

Difference.		Component 2N.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		171 19	186 1	200 7	214 13	228 19	243 1*	257 7*	271 13*	285 19*	300 1*
+23	−1	172 9	15	21*	215 3*	229 9*	15*	21*	272 4	286 10	16
+22	−2	23*	187 5*	201 11*	17*	23*	244 6	258 12	18	287 0	301 6
+21	−3	173 13*	19*	202 2	216 8	230 14	20	259 2	273 8*	14*	20*
+20	−4	174 4	188 10	16	22	231 4	245 10*	16*	22*	288 4*	302 10*
+19	−5	18	189 0	203 6*	217 12*	18*	246 0*	260 6*	274 13	19	303 1
+18	−6	175 8*	14*	20*	218 2*	232 9	15	21	275 3	289 9	15*
+17	−7	22*	190 4*	204 11	17	23	247 5	261 11	17*	23*	304 5*
+16	−8	176 13	19	205 1	219 7	233 13*	19*	262 1*	276 7*	290 13*	20
+15	−9	177 3	191 9	15*	21*	234 3*	248 9*	15*	22	291 4	205 10
+14	−10	17*	23*	206 5*	220 11*	18	249 0	263 6	277 12	18	306 0*
+13	−11	178 7*	192 13*	20	221 2	235 8	14	20	278 2*	292 8*	14*
+12	−12	22	193 4	207 10	16	22*	250 4*	264 10*	16*	22*	307 5
+11	−13	179 12	18	208 0*	222 6*	236 12*	18*	265 0*	279 7	293 13	19
+10	−14	180 2*	194 8*	14*	20*	237 3	251 9	15	21	294 3	308 9*
+9	−15	16*	22*	209 5	223 11	17	23	266 5	280 11*	17*	23*
+8	−16	181 7	195 13	19	224 1	238 7*	252 13*	19*	281 1*	295 7*	309 14
+7	−17	21	196 3	210 9*	15*	21*	253 3*	267 10	16	22	310 4
+6	−18	182 11*	17*	23*	225 5*	239 12	18	268 0	282 6	296 12	18*
+5	−19	183 1*	197 8	211 14	20	240 2	254 8	14*	20*	297 2*	311 8*
+4	−20	16	22	212 4	226 10	16*	22*	269 4*	283 10*	16*	23
+3	−21	184 6	198 12*	18*	227 0*	241 6*	255 12*	19	284 1	298 7	312 13
+2	−22	20*	199 2*	213 8*	14*	21	256 3	270 9	15	21	313 3*
+1	−23	185 10*	17	23	228 5	242 11	17	23*	285 5*	299 11*	17*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component 2N.				Component μ.					
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		314 8	328 14	342 20	357 2	1 0	15 11*	30 6	45 0*	59 19	74 13
+23	−1	22	329 4	343 10*	16*	8	16 2*	21	15	60 9*	75 4
+22	−2	315 12*	18*	344 0*	358 6*	23	17*	31 11*	46 6	61 0*	18*
+21	−3	316 2*	330 8*	15	21	2 13*	17 8	32 2*	21	15	76 9*
+20	−4	17	23	345 5	359 11	3 4*	23	17	47 11*	62 6	77 0*
+19	−5	317 7	331 13	19*	360 1*	19	18 13*	33 8	48 2*	20*	15
+18	−6	21*	332 3*	346 9*	15*	4 10	19 4*	22*	17	63 11*	78 6
+17	−7	318 11*	17*	347 0	361 6	5 0*	19	34 13*	49 8	64 2	20*
+16	−8	319 2	333 8	14	20	15*	20 10	35 4	22*	17	79 11*
+15	−9	16	22	348 4*	362 10*	6 6*	21 0*	19	50 13*	65 7*	80 2*
+14	−10	320 6*	334 12*	18*	363 0*	21	15*	36 10	51 4	22*	17
+13	−11	20*	335 2*	349 9	15	7 12	22 6	37 0*	19	66 13*	81 7*
+12	−12	321 11	17	23	364 5	8 2*	21	15*	52 9*	67 4	22*
+11	−13	322 1	336 7	350 13*	19*	17*	23 11*	38 6	53 0*	19	82 13
+10	−14	15*	21*	351 3*	365 9*	9 8	24 2*	21	15	68 9*	83 4
+ 9	−15	323 5*	337 11*	18	366 0	23	17	39 11*	54 6	69 0*	18*
+8	−16	20	338 2	352 8	14	10 13*	25 8	40 2*	20*	15	84 9
+7	−17	324 10	16*	22*	367 4*	11 4*	22*	17	55 11*	70 6	85 0
+6	−18	325 0*	339 6*	353 12*	18*	19	26 13*	41 8	56 2	20*	15
+5	−19	14*	21	354 3	368 9	12 10	27 4*	22*	17	71 11*	86 5*
+4	−20	326 5	340 11	17	23	13 0*	19	42 13*	57 8	72 2	20*
+3	−21	19	341 1*	355 7*	369 13*	15*	28 10	43 4	22*	17	87 11*
+2	−22	327 9*	15*	21*	370 3*	14 6	29 0*	19	58 13*	73 7*	88 2
+1	−23	23*	342 6	356 12	....	21	15*	44 9*	59 4	22*	17

Difference.		Component μ.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		89 7*	104 2	118 20*	133 14*	148 9	163 3*	177 22	192 16	207 10*	222 5
+23	−1	22*	16*	119 11	134 5*	149 0	18	178 12*	193 7	208 1*	19*
+22	−2	90 13	105 7*	120 2	20	14*	164 9	179 3*	21*	16	223 10*
+21	−3	91 4	22	16*	135 11	150 5*	23*	18	194 12*	209 7	224 1
+20	−4	18*	106 13	121 7*	136 1*	20	165 14*	180 9	195 3	21*	16
+19	−5	92 9*	107 4	22	16*	151 11	166 5	23*	18	210 12*	225 6*
+18	−6	93 0	18*	122 13	137 7*	152 1*	20	181 14*	196 8*	211 3	21*
+17	−7	15	108 9*	123 3*	22	16*	167 11	182 5	23*	18	226 12
+16	−8	94 5*	109 0	18*	138 13	153 7	168 1*	20	197 14*	212 8*	227 3
+15	−9	20*	15	124 9	139 3*	22	16*	183 10*	198 5	23*	18
+14	−10	95 11	110 5*	125 0	18*	154 12*	169 7	184 1*	20	213 14	228 8*
+13	−11	96 2	20*	14*	140 9	155 3*	22	16	199 10*	214 5	23*
+12	−12	17	111 11	126 5*	141 0	18	170 12*	185 7	200 1*	19*	229 14
+11	−13	97 7*	112 2	20*	14*	156 9	171 3*	21*	16	215 10*	230 5
+10	−14	22*	16*	127 11	142 5*	157 0	18	186 12*	201 7	216 1	19*
+9	−15	98 13	113 7*	128 2	20	14*	172 9	187 3	21*	16	231 10*
+8	−16	99 4	22	16*	143 11	158 5*	23*	18	202 12*	217 7	232 1
+7	−17	18*	114 13	129 7*	144 1*	20	173 14*	188 9	203 3	21*	16
+6	−18	100 9*	115 3*	22	16*	159 11	174 5	23*	18	218 12*	233 6*
+5	−19	101 0	18*	130 13	145 7	160 1*	20	189 14*	204 8*	219 3	21*
+4	−20	15	116 9	131 3*	22	16*	175 10*	190 5	23*	18	234 12
+3	−21	102 5*	117 0	18*	146 12*	161 7	176 1*	20	205 14	220 8*	235 3
+2	−22	20*	15	132 9*	147 3*	22	16	191 10*	206 5	23*	17*
+1	−23	103 11	118 5*	133 0	18*	162 12*	177 7	192 1*	19*	221 14	236 8*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference. Hour.		Component μ. d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.
0		236 23	251 17*	266 12	281 6*	296 0*	310 19	325 13*	340 8	355 2	369 20*
+23	−1	237 14	252 8*	267 2*	21	15*	311 10	326 4	22*	17	370 11*
+22	−2	238 5	23	17*	282 12	297 6	312 0*	19	341 13*	356 7*	....
+21	−3	19*	253 14	268 8*	283 2*	21	15*	327 9*	342 4	22*	....
+20	−4	239 10*	254 4*	23	17*	298 12	313 6	328 0*	19	357 13	....
+19	−5	240 1	19	269 14	284 8	299 2*	21	15*	343 9*	358 4	....
+18	−6	16	255 10	270 4*	23	17*	314 11*	329 6	344 0*	19	....
+17	−7	241 6*	256 1	19*	285 13*	300 8	315 2*	21	15	359 9*	....
+16	−8	21*	15*	271 10	286 4*	23	17	330 11*	345 6	360 0*	....
+15	−9	242 12	257 6*	272 1	19	301 13*	316 8	331 2*	20*	15	....
+14	−10	243 3	21*	15*	287 10	302 4*	22*	17	346 11*	361 6	....
+13	−11	17*	258 12	273 6*	288 1	19	317 13*	332 8	347 2	20*	....
+12	−12	244 8*	259 3	21	15*	303 10	318 4*	22	17	362 11*	....
+11	−13	23	17*	274 12	289 6*	304 0*	19	333 13*	348 8	363 2	....
+10	−14	245 14	260 8*	275 2*	21	15*	319 10	334 4	22*	17	....
+9	−15	246 4*	23	17*	290 12	305 6	320 0*	19	349 13*	364 7*	....
+8	−16	19*	261 14	276 8	291 2*	21	15*	335 9*	350 4	22*	....
+7	−17	247 10	262 4*	23	17*	306 11*	321 6	336 0*	19	365 13	....
+6	−18	248 1	19*	277 13*	292 8	307 2*	21	15	351 9*	366 4	....
+5	−19	16	263 10	278 4*	23	17	322 11*	337 6	352 0*	18*	....
+4	−20	249 6*	264 1	19*	293 13*	308 8	323 2*	20*	15	367 9*	....
+3	−21	21*	15*	279 10	294 4*	23	17	338 11*	353 6	368 0	....
+2	−22	250 12	265 6*	280 1	19	309 13*	324 8	339 2*	20*	15	....
+1	−23	251 3	21	15*	295 10	310 4*	22*	17	354 11*	369 6	....

Difference. Hour.		Component N. d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.
0		1 0	19 20*	39 2	58 7*	77 13	96 18*	116 0	135 5*	154 11	173 16*
+23	−1	10*	20 16	21*	59 2*	78 8	97 13*	19	136 0*	155 6	174 11*
+22	−2	2 5*	21 11	40 16*	22	79 3*	98 9	117 14*	20	156 1*	175 6*
+21	−3	3 1	22 6*	41 11*	60 17	22*	99 4	118 9*	137 15	20*	176 2
+20	−4	20	23 1*	42 7	61 12*	80 18	23*	119 5	138 10*	157 15*	21
+19	−5	4 15*	20*	43 2	62 7*	81 13	100 18*	120 0	139 5*	158 11	177 16*
+18	−6	5 10*	24 16	21*	63 3	82 8*	101 14	19*	140 0*	159 6	178 11*
+17	−7	6 5*	25 11	44 16*	22	83 3*	102 9	121 14*	20	160 1*	179 7
+16	−8	7 1	26 6*	45 12	64 17*	23	103 4	122 9*	141 15	20*	180 2
+15	−9	20	27 1*	46 7	65 12*	84 18	23*	123 5	142 10*	161 16	21*
+14	−10	8 15*	21	47 2*	66 8	85 13	104 18*	124 0	143 5*	162 11	181 16
+13	−11	9 10*	28 16	21*	67 3	86 8*	105 14	19*	144 1	163 6*	182 12
+12	−12	10 6	29 11*	48 17	22	87 3*	106 9	125 14*	20	164 1*	183 7
+11	−13	11 1	30 6*	49 12	68 17*	23	107 4*	126 10	145 15*	21	184 2
+10	−14	20*	31 2	50 7	69 12*	88 18	23*	127 5	146 10*	165 16	21*
+9	−15	12 15*	21	51 2*	70 8	89 13*	108 19	128 0*	147 6	166 11	185 16*
+8	−16	13 11	32 16	21*	71 3	90 8*	109 14	19*	148 1	167 6*	186 12
+7	−17	14 6	33 11*	52 17	22*	91 4	110 9*	129 15	20	168 1*	187 7
+6	−18	15 1	34 6*	53 12	72 17	23	111 4*	130 10	149 15*	21	188 2*
+5	−19	20*	35 2	54 7*	73 13	92 18*	23*	131 5	150 10*	169 16	21*
+4	−20	16 15*	21	55 2*	74 8	93 13*	112 19	132 0*	151 6*	170 11*	189 17
+3	−21	17 11	36 16*	22	75 3*	94 8*	113 14	19*	152 1	171 6*	190 12
+2	−22	18 6	37 11*	56 17	22*	95 4	114 9*	133 15	20*	172 2	191 7*
+1	−23	19 1*	38 7	57 12*	76 17*	23	115 4*	134 10	153 15*	21	192 2*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component N.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		192 21*	212 3	231 8*	250 14	269 19*	289 1	308 6*	327 12	346 17*	365 23
+23	−1	193 17	22*	232 4	251 9*	270 15	20	309 1*	328 7	347 12*	366 18
+22	−2	194 12	213 17*	23	252 4*	271 10	290 15*	21	329 2*	348 8	367 13*
+21	−3	195 7*	214 13	233 18*	253 0	272 5	291 10*	310 16	21*	349 3	368 8*
+20	−4	196 2*	215 8	234 13*	19	273 0*	292 6	311 11*	330 17	22*	369 4.
+19	−5	22	216 3*	235 9	254 14	19*	293 1	312 6*	331 12	350 17*	23
+18	−6	197 17	22*	236 4	255 9*	274 15	20*	313 2	332 7*	351 13	370 18
+17	−7	198 12*	217 18	23	256 4*	275 10	294 15*	21	333 2*	352 8	....
+16	−8	199 7*	218 13	237 18*	257 0	276 5*	295 11	314 16*	21*	353 3	....
+15	−9	200 3	219 8	238 13*	19	277 0*	296 6	315 11*	334 17	22*	....
+14	−10	22	220 3*	239 9	258 14*	20	297 1*	316 6*	335 12	354 17*	....
+13	−11	201 17	22*	240 4	259 9*	278 15	20*	317 2	336 7*	355 13	....
+12	−12	202 12*	221 18	23*	260 5	279 10*	298 15*	21	337 2*	356 8	....
+11	−13	203 7*	222 13	241 18*	261 0	280 5*	299 11	318 16*	22	367 3*	....
+10	−14	204 3	223 8*	242 14	19*	281 0*	300 6	319 11*	338 17	22*	....
+9	−15	22	224 3*	243 9	262 14*	20	301 1*	320 7	339 12*	358 18	....
+8	−16	205 17*	23	244 4*	263 9*	282 15	20*	321 2	340 7*	359 13	....
+7	−17	206 12*	225 18	23*	264 5	283 10*	302 16	21*	341 3	360 8*	....
+6	−18	207 8	226 13*	245 18*	265 0	284 5*	303 11	322 16*	22	361 3*	....
+5	−19	208 3	227 8*	246 14	19*	285 1	304 6*	323 12	342 17*	22*	....
+4	−20	22*	228 3*	247 9	266 14*	20	305 1*	324 7	343 12*	362 18	....
+3	−21	209 17*	23	248 4*	267 10	286 15*	21	325 2*	344 7*	363 13	....
+2	−22	210 12*	229 18	23*	268 5	287 10*	306 16	21*	345 3	364 8*	....
+1	−23	211 8	230 13*	249 19	269 0*	288 6	307 11	326 16*	22	365 3*	....

Difference.		Component ν.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		1 0	20 18*	40 23	61 3	81 7	101 11	121 15	141 19	161 23	182 3
+23	−1	11	21 15	41 19	23	82 3	102 7	122 11	142 15*	162 19*	23*
+22	−2	2 7	22 11	42 15	62 19	23	103 3*	123 7*	143 11*	163 15*	183 19*
+21	−3	3 3	23 7	43 11*	63 15*	83 19*	23*	124 3*	144 7*	164 11*	184 15*
+20	−4	23*	24 3*	44 7*	64 11*	84 15*	104 19*	23*	145 4	165 8	185 12
+19	−5	4 19*	23*	45 3*	65 7*	85 12	105 16	125 20	146 0	166 4	186 8
+18	−6	5 15*	25 19*	46 0	66 4	86 8	106 12	126 16	20	167 0	187 4
+17	−7	6 12	26 16	20	67 0	87 4	107 8	127 12	147 16*	20*	188 0*
+16	−8	7 8	27 12	47 16	20	88 0*	108 4*	128 8*	148 12*	168 16*	20*
+15	−9	8 4	28 8	48 12*	68 16*	20*	109 0*	129 4*	149 8*	169 12*	189 16*
+14	−10	9 0*	29 4*	49 8*	69 12*	89 16*	20*	130 0*	150 5	170 9	190 13
+13	−11	20*	30 0*	50 4*	70 8*	90 13	110 17	21	151 1	171 5	191 9
+12	−12	10 16*	21	51 1	71 5	91 9	111 13	131 17	21	172 1	192 5
+11	−13	11 13	31 17	21	72 1	92 5	112 9	132 13	152 17*	21*	193 1*
+10	−14	12 9	32 13	52 17	21	93 1*	113 5*	133 9*	153 13*	173 17*	21*
+9	−15	13 5	33 9*	53 13*	73 17*	21*	114 1*	134 5*	154 9*	174 13*	194 17*
+8	−16	14 1*	34 5*	54 9*	74 13*	94 17*	21*	135 1*	155 6	175 10	195 14
+7	−17	21*	35 1*	55 5*	75 9*	95 14	115 18	22	156 2	176 6	196 10
+6	−18	15 17*	22	56 2	76 6	96 10	116 14	136 18	22	177 2	197 6*
+5	−19	16 14	36 18	22	77 2	97 6	117 10	137 14	157 18*	22*	198 2*
+4	−20	17 10	37 14	57 18	22	98 2*	118 6*	138 10*	158 14*	178 18*	22*
+4	−21	18 6	38 10*	58 14*	78 18*	22*	119 2*	139 6*	159 10*	179 14*	199 19
+2	−22	19 2*	39 6*	59 10*	79 14*	99 18*	22*	140 3	160 7	180 11	200 15
+1	−23	22*	40 2*	60 6*	80 10*	100 15	120 19	23	161 3	181 7	201 11

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component ν.								
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		202 7*	222 11*	242 15*	262 19*	282 23*	303 3	323 7*	343 11*	363 16
+23	−1	203 3*	223 7*	243 11*	263 15*	283 19*	23	324 4	344 8	364 12
+22	−2	23*	224 3*	244 7*	264 12	284 16	304 20	325 0	345 4	365 8
+21	−3	204 20	225 0	245 4	265 8	285 12	305 16	20	346 0	366 4*
+20	−4	205 16	20	246 0	266 4	286 8	306 12*	326 16*	20*	367 0*
+19	−5	206 12	226 16	20	267 0*	287 4*	307 8*	327 12*	347 16*	20*
+18	−6	207 8*	227 12*	247 16*	20*	288 0*	308 4*	328 8*	348 12*	368 17
+17	−7	208 4*	228 8*	248 12*	268 16*	20*	309 1	329 5	349 9	369 13
+16	−8	209 0*	229 4*	249 8*	269 13	289 17	21	330 1	350 5	370 9
+15	−9	21	230 1	250 5	270 9	290 13	310 17	21	351 1	....
+14	−10	210 17	21	251 1	271 5	291 9	311 13*	331 17*	21*	....
+13	−11	211 13	231 17	21*	272 1*	292 5*	312 9*	332 13*	352 17*	....
+12	−12	212 9*	232 13*	252 17*	21*	293 1*	313 5*	333 9*	353 13*	....
+11	−13	213 5*	233 9*	253 13*	273 17*	21*	314 2	334 6	354 10	....
+10	−14	214 1*	234 5*	254 10	274 14	294 18	22	335 2	355 6	....
+9	−15	22	235 2	255 6	275 10	295 14	315 18	22	356 2	....
+8	−16	215 18	22	256 2	276 6	296 10	316 14*	336 18*	22*	....
+7	−17	216 14	236 18	22*	277 2*	297 6*	317 10*	337 14*	357 18*	....
+6	−16	217 10*	237 14*	257 18*	22*	298 2*	318 6*	338 10*	358 14*	....
+5	−19	218 6*	238 10*	258 14*	278 18*	22*	319 3	339 7	359 11	....
+4	−20	219 2*	239 6*	259 11	279 15	299 19	23	340 3	360 7	....
+3	−21	23	240 3	260 7	280 11	300 15	320 19	23	361 3	....
+2	−22	220 19	23	261 3	281 7	301 11	321 15*	341 19*	23*	....
+1	−23	221 15	241 19	23*	282 3	302 7*	322 11*	342 15*	362 19*	....

Difference.		Component 2MK.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		1 0	22 7	44 0	65 17	87 10	109 3	130 20	152 13	174 6	195 23
+23	−1	11*	23 4*	21*	66 14*	88 7*	110 0*	131 17*	153 10*	175 4	196 21
+22	−2	2 9*	24 2*	45 19*	67 12*	89 5*	22*	132 15*	154 8*	176 1*	197 18*
+21	−3	3 7	25 0	46 17	68 10	90 3	111 20	133 13	155 6	23	198 16
+20	−4	4 4*	22	47 15	69 8	91 1	112 18	134 11	156 4	177 21	199 14
+19	−5	5 2*	26 19*	48 12*	70 5*	22*	113 15*	135 8*	157 1*	178 18*	200 11*
+18	−6	6 0	27 17	49 10	71 3	92 20	114 13	136 6*	23*	179 16*	201 9*
+17	−7	22	28 15	50 8	72 1	93 18	115 11	137 4	158 21	180 14	202 7
+16	−8	7 19*	29 12*	51 5*	22*	94 15*	116 8*	138 1*	159 18*	181 11*	203 4*
+15	−9	8 17*	30 10*	52 3*	73 20*	95 13*	117 6*	23*	160 16*	182 9*	204 2*
+14	−10	9 15	31 8	53 1	74 18	96 11	118 4	139 21	161 14	183 7	205 0
+13	−11	10 12*	32 5*	22*	75 16	97 9	119 2	140 19	162 12	184 5	22
+12	−12	11 10*	33 3*	54 20*	76 13*	98 6*	23*	141 16*	163 9*	185 2*	206 19*
+11	−13	12 8	34 1	55 18	77 11	99 4	120 21	142 14	164 7	186 0*	207 17*
+10	−14	13 6	23	56 16	78 9	100 2	121 19	143 12	165 5	22	208 15
+9	−15	14 3*	35 20*	57 13*	79 6*	23*	122 16*	144 9*	166 2*	187 19*	209 12*
+8	−16	15 1	36 18*	58 11*	80 4*	101 21*	123 14*	145 7*	167 0*	188 17*	210 10*
+7	−17	23	37 16	59 9	81 2	102 19	124 12	146 5	22	189 15	211 8
+6	−18	16 20*	38 13*	60 6*	23*	103 16*	125 10	147 3	168 20	190 13	212 6
+5	−19	17 18*	39 11*	61 4*	82 21*	104 14*	126 7*	148 0*	169 17*	191 10*	213 3*
+4	−20	18 16	40 9	62 2	83 19	105 12	127 5	22	170 15	192 8	214 1
+3	−21	19 14	41 7	63 0	84 17	106 10	128 3	149 20	171 13	193 6	23
+2	−22	20 11*	42 4*	21*	85 14*	107 7*	129 0*	150 17*	172 10*	194 3*	215 20*
+1	−23	21 9	43 2	64 19	86 12*	108 5*	22*	151 15*	173 8*	195 1*	216 18*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component 2MK.								Component MN.	
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		217 16	239 9	261 2	282 19	304 12	326 5	347 22	369 15	1 0	23 20
+23	−1	218 14	240 7	262 0	283 17	305 10	327 3	348 20	370 13	12*	24 19*
+22	−2	219 11*	241 4*	21*	284 14*	306 7*	328 0*	349 17*	....	2 11*	25 18*
+21	−3	220 9	242 2	263 19*	285 12*	307 5*	22*	350 15*	....	3 11	26 18
+20	−4	221 7	243 0	264 17	286 10	308 3	329 20	351 13	....	4 10*	27 17
+19	−5	222 4*	21*	265 14*	287 7*	309 0*	330 17*	352 10*	....	5 9*	28 16*
+18	−6	223 2*	244 19*	266 12*	288 5*	22*	331 15*	353 8*	....	6 9	29 16
+17	−7	224 0	245 17	267 10	289 3	310 20	332 13	354 6	....	7 8	30 15
+16	−8	22	246 15	268 8	290 1	311 18	333 11	355 4	....	8 7*	31 14*
+15	−9	225 19*	247 12*	269 5*	22*	312 15*	334 8*	356 1*	....	9 6*	32 13*
+14	−10	226 17	248 10	270 3	291 20	313 13*	335 6*	23*	....	10 6	33 13
+13	−11	227 15	249 8	271 1	292 18	314 11	336 4	357 21	....	11 5*	34 12*
+12	−12	228 12*	250 5*	22*	293 15*	315 8*	337 1*	358 18*	....	12 4*	35 11*
+11	−13	229 10*	251 3*	272 20*	294 13*	316 6*	23*	359 16*	....	13 4	36 11
+10	−14	230 8	252 1	273 18	295 11	317 4	338 21	360 14	....	14 3	37 10
+9	−15	231 5*	22*	274 16	296 9	318 2	339 19	361 12	....	15 2*	38 9*
+8	−16	232 3*	253 20*	275 13*	297 6*	23*	340 16*	362 9*	....	16 2	39 8*
+7	−17	233 1	254 18	276 11	298 4	319 21	341 14	363 7*	....	17 1	40 8
+6	−18	23	255 16	277 9	299 2	320 19	342 12	364 5	....	18 0*	41 7*
+5	−19	234 20*	256 13*	278 6*	23*	321 16*	343 9*	365 2*	....	23*	42 6*
+4	−20	235 18*	257 11*	279 4*	300 21*	322 14*	344 7*	366 0*	....	19 23	43 6
+3	−21	236 16	256 9	280 2	301 19	323 12	345 5	22	....	20 22	44 5
+2	−22	237 13*	259 6*	23*	302 16*	324 10	346 3	367 20	....	21 21*	45 4*
+1	−23	238 11*	260 4*	281 21*	303 14*	325 7*	347 0*	368 17*	....	22 21	46 4

Difference.		Component MN.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		47 3	70 10	93 17	117 0	140 7	163 14	186 21	210 4	233 11	256 18
+23	−1	48 2*	71 9*	94 16*	23	141 6	164 13	187 20	211 3	234 10	257 17
+22	−2	49 1*	72 8*	95 15*	118 22*	142 5*	165 12*	188 19*	212 2*	235 9*	258 16*
+21	−3	50 1	73 8	96 15	119 22	143 5	166 12	189 18*	213 1*	236 8*	259 15*
+20	−4	51 0	74 7	97 14	120 21	144 4	167 11	190 18	214 1	237 8	260 15
+19	−5	23*	75 6*	98 13*	121 20*	145 3*	168 10*	191 17*	215 0*	238 7*	261 14
+18	−6	52 23	76 6	99 12*	122 19*	146 2*	169 9*	192 16*	23*	239 6*	262 13*
+17	−7	53 22	77 5	100 12	123 19	147 2	170 9	193 16	216 23	240 6	263 13
+16	−8	54 21*	78 4*	101 11*	124 18*	148 1	171 8	194 15	217 22	241 5	264 12
+15	−9	55 20*	79 3*	102 10*	125 17*	149 0*	172 7*	195 14*	218 21*	242 4*	265 11*
+14	−10	56 20	80 3	103 10	126 17	150 0	173 7	196 14	219 20*	243 3*	266 10*
+13	−11	57 19	81 2	104 9	127 16	23	174 6	197 13	220 20	244 3	267 10
+12	−12	58 18*	82 1*	105 8*	128 15*	151 22*	175 5*	198 12*	221 19*	245 2*	268 9*
+11	−13	59 18	83 1	106 8	129 14*	152 21*	176 4*	199 11*	222 18*	246 1*	269 8*
+10	−14	60 17	84 0	107 7	130 14	153 21	177 4	200 11	223 18	247 1	270 8
+9	−15	61 16*	23*	108 6*	131 13*	154 20*	178 3	201 10	224 17	248 0	271 7
+8	−16	62 15*	85 22*	109 5*	132 12*	155 19*	179 2*	202 9*	225 16*	23*	272 6*
+7	−17	63 15	86 22	110 5	133 12	156 19	180 2	203 9	226 16	249 22*	273 5*
+6	−18	64 14*	87 21	111 4	134 11	157 18	181 1	204 8	227 15	250 22	274 5
+5	−19	65 13*	88 20*	112 3*	135 10*	158 17*	182 0*	205 7*	228 14*	251 21*	275 4*
+4	−20	66 13	89 20	113 3	136 10	159 16*	23*	206 6*	229 13*	252 20*	276 3*
+3	−21	67 12	90 19	114 2	137 9	160 16	183 23	207 6	230 13	253 20	277 3
+2	−22	68 11*	91 18*	115 1*	138 8*	161 15*	184 22*	208 5*	231 12	254 19	278 2
+1	−23	69 10*	92 17	116 0*	139 7*	162 14*	185 21*	209 4*	232 11*	255 18*	279 1*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component MN.				Component M.					
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		280 0*	303 7*	326 14*	349 21*	1 0	29 22*	59 11*	89 0	118 13	148 1*
+23	−1	281 0	304 7	327 14	350 21	15*	31 4	60 17	90 5*	119 18*	149 7
+22	−2	23*	305 6*	328 13*	351 20	2 21	32 10	61 22*	91 11	121 0	150 12*
+21	−3	282 22*	306 5*	329 12*	352 19*	4 2*	33 15*	63 4	92 17	122 5*	151 18
+20	−4	283 22	307 5	330 12	353 19	5 8	34 21	64 9*	93 22*	123 11	153 0
+19	−5	284 21	308 4	331 11	354 18	6 13*	36 2*	65 15	95 4	124 16*	154 5*
+18	−6	285 20*	309 3*	332 10*	355 17*	7 19	37 8	66 20*	96 9*	125 22	155 11
+17	−7	286 20	310 2*	333 9*	356 16*	9 0*	38 13*	68 2	97 15	127 3*	156 16*
+16	−8	287 19	311 2	334 9	357 16	10 6	39 19	69 7*	98 20*	128 9	157 22
+15	−9	288 18*	312 1*	335 8*	358 15*	11 12	41 0*	70 13	100 2	129 14*	159 3*
+14	−10	289 17*	313 0*	336 7*	359 14*	12 17*	42 6	71 19	101 7*	130 20	160 9
+13	−11	290 17	314 0	337 7	360 14	13 23	43 11*	73 0*	102 13	132 2	161 14*
+12	−12	291 16	23	338 6	371 13	15 4*	44 17	74 6	103 18*	133 7*	162 20
+11	−13	292 15*	315 22*	339 5*	362 12*	16 10	45 22*	75 11*	105 0	134 13	164 1*
+10	−14	293 15	316 22	340 5	363 11*	17 15*	47 4	76 17	106 5*	135 18*	165 7
+9	−15	294 14	317 21	341 4	364 11	18 21	48 9*	77 22*	107 11	137 0	166 12*
+8	−16	295 13*	318 20*	342 3*	365 10*	20 2*	49 15	79 4	108 16*	138 5*	167 18
+7	−17	296 12*	319 19*	343 2*	366 9*	21 8	50 20*	80 9*	109 22	139 11	168 23*
+6	−18	297 12	320 19	344 2	367 9	22 13*	51 2*	81 15	111 3*	140 16*	170 5
+5	−19	298 11*	321 18	345 1	368 8	23 19	53 8	82 20*	112 9*	141 22	171 10*
+4	−20	299 10*	322 17*	346 0*	369 7*	25 0*	54 13*	84 2	113 15	143 3*	172 16*
+3	−21	300 10	323 17	347 0	370 7	26 6	55 19	85 7*	114 20*	144 9	173 22
+2	−22	301 9	324 16	23	....	27 11*	57 0*	86 13	116 2	145 14*	175 3*
+1	−23	302 8*	325 15*	348 22*	....	28 17	58 6	87 18*	117 7*	146 20	176 9

Difference.		Component M.							Component MK.		
Hours.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		177 14*	207 3	236 16	266 4*	295 17*	325 6	354 19	1 0	46 5*	92 9*
+23	−1	178 20	208 8*	237 21*	267 10	296 23	326 11*	356 0*	2 0	48 3*	94 7*
+22	−2	180 1*	209 14	239 3	268 15*	298 4*	327 17	357 6	3 22	50 2	96 6
+21	−3	181 7	210 19*	240 8*	269 21	299 10	328 22*	358 11*	5 20	52 0	98 4
+20	−4	182 12*	212 1	241 14	271 2*	300 15*	330 4	359 17	7 18*	53 22	100 2
+19	−5	183 18	213 7	242 19*	272 8	301 21	331 9*	360 22*	9 16*	55 20*	102 0*
+18	−6	184 23*	214 12*	244 1	273 14	303 2*	332 15	362 4	11 14*	57 18*	103 22*
+17	−7	186 5	215 18	245 6*	274 19*	304 8	333 21	363 9*	13 13	59 16*	105 20*
+16	−8	187 10*	216 23*	246 12	276 1	305 13*	335 2*	364 15	15 11	61 15	107 18*
+15	−9	188 16	218 5	247 17*	277 6*	306 19	336 8	365 20*	17 9	63 13	109 17
+14	−10	189 21*	219 10*	248 23	278 12	308 0*	337 13*	367 2	19 7*	65 11	111 15
+13	−11	191 3	220 16	250 4*	279 17*	309 6	338 19	368 7*	21 5*	67 9*	113 13
+12	−12	192 9	221 21*	251 10	280 23	310 11*	340 0*	369 13	23 3*	69 7*	115 11*
+11	−13	193 14*	223 3	252 16	282 4*	311 17	341 6	370 18*	25 2	71 5*	117 9*
+10	−14	194 20	224 8*	253 21*	283 10	312 23	342 11*	....	27 0	73 4	119 7*
+9	−15	196 1*	225 11	255 3	284 15*	314 4*	343 17	....	28 22	75 2	121 6
+8	−16	197 7	226 19*	256 8*	285 21	315 10	344 22*	....	30 20*	77 0	123 4
+7	−17	198 12*	228 1	257 14	287 2*	316 15*	346 4	....	32 18*	78 22*	125 2
+6	−18	199 18	229 6*	258 19*	288 8	317 21	347 9*	....	34 16*	80 20*	127 0*
+5	−19	200 23*	230 12	260 1	289 13*	319 2*	348 15	....	36 14*	82 18*	128 22*
+4	−20	202 5	231 17*	261 6*	290 19	320 8	349 20*	....	38 13	84 17	130 20*
+3	−21	203 10*	232 23*	262 12	292 0*	321 13*	351 2	....	40 11	86 15	132 19
+2	−22	204 16	234 5	263 17*	293 6*	322 19	352 7*	....	42 9	88 13	134 17
+1	−23	205 21*	235 10*	264 23	294 12	324 0*	353 13*	....	44 7*	90 11*	136 15

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component MK.						Component λ.			
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		138 13*	184 17	230 21	277 1	323 5	369 9	1 0	55 0	110 2*	165 5
+23	−1	140 11*	186 15*	232 19*	278 23	325 3	371 7	2 4*	57 7	112 9*	167 12
+22	−2	142 9*	188 13*	234 17*	280 21*	327 1	....	4 11*	59 14	114 16*	169 19*
+21	−3	144 8	190 11*	236 15*	282 19*	328 23*	....	6 18*	61 21	117 0	172 2*
+20	−4	146 6	192 10	238 14	284 17*	330 21*	....	9 1*	64 4*	119 7	174 9*
+19	−5	148 4	194 8	240 12	286 16	332 19*	....	11 8*	66 11*	121 14	176 16*
+18	−6	150 2*	196 6	242 10	288 14	334 18	....	13 16	68 18*	123 21	178 23*
+17	−7	152 0*	198 4*	244 8	290 12	336 16	....	15 23	71 1*	126 4	181 7
+16	−8	153 22*	200 2*	246 6*	292 10*	338 14	....	18 6	73 8*	128 11*	183 14
+15	−9	155 21	202 0*	248 4*	294 8*	340 12*	....	20 13	75 16	130 18*	185 21
+14	−10	157 19	203 23	250 2*	296 6*	342 10*	....	22 20*	77 23	133 1*	188 4
+13	−11	159 17	205 21	252 1	298 5	344 8*	....	25 3*	80 6	135 8*	190 11*
+12	−12	161 15*	207 19	253 23	300 3	346 7	....	27 10*	82 13	137 15*	192 18*
+11	−13	163 13*	209 17*	255 21	302 1	348 5	....	28 17*	84 20	139 23	195 1*
+10	−14	165 11*	211 15*	257 19*	303 23*	350 3	....	32 0*	87 3*	142 6	197 8*
+9	−15	167 10	213 13*	259 17*	305 21*	352 1*	....	34 8	89 10*	144 13	199 15*
+8	−16	169 8	215 12	261 15*	307 19*	353 23*	....	36 15	91 17*	146 20	201 23
+7	−17	171 6	217 10	263 14	309 18	355 21*	....	38 22	94 0*	149 3*	204 6
+6	−18	173 4*	219 8	265 12	311 16	357 20	....	41 5	96 8	151 10*	206 13
+5	−19	175 2*	221 6*	267 10	313 14	359 18	....	43 12*	98 15	153 17*	208 20
+4	−20	177 0*	223 4*	269 8*	315 12	361 16	....	45 19*	100 22	156 0*	211 3
+3	−21	178 22*	225 2*	271 6*	317 10*	363 14*	....	48 2*	103 5	158 7*	213 10*
+2	−22	180 21	227 1	273 4*	319 8*	365 12*	....	50 9*	105 12	160 15	215 17*
+1	−23	182 19	228 23	275 3	321 6*	367 10*	....	52 16*	107 19*	162 22	218 0*

Difference.		Component λ.			Component MS.						
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*h. h.*
0		220 7*	275 10*	330 13	1 0	58 20*	117 22	176 23*	236 1	295 2*	354 4
+23	−1	222 15	277 17*	332 20	2 6*	61 7*	120 9	179 10*	238 12	297 13*	356 15
+22	−2	224 22	280 0*	335 3	4 17*	63 19	122 20*	181 21*	240 23	300 0*	359 2
+21	−3	227 5	282 7*	337 10	7 4*	66 6	125 7*	184 9	243 10*	302 11*	361 13
+20	−4	229 12	284 14*	339 17*	9 15*	68 17	127 18*	186 20	245 21*	304 23	364 0*
+19	−5	231 19	286 22	342 0*	12 2*	71 4	130 5*	189 7	248 8*	307 10	366 11*
+18	−6	234 2*	289 5	344 7*	14 13*	73 15	132 16*	191 18	250 19*	309 21	368 22*
+17	−7	236 9*	291 12	346 14*	17 0*	76 2	135 3*	194 5	253 6*	312 8	371 9*
+16	−8	238 16*	293 19	348 22	19 11*	78 13	137 14*	196 16	255 17*	314 19	....
+15	−9	240 23*	296 2*	351 5	21 23	81 0	140 1*	199 3	258 4*	317 6	....
+14	−10	243 7	298 9*	353 12	24 10	83 11*	142 13	201 14	260 15*	319 17	....
+13	−11	245 14	300 16*	355 19	26 21	85 22*	145 0	204 1*	263 3	322 4	....
+12	−12	247 21	302 23*	358 2	29 8	88 9*	147 11	206 12*	265 14	324 15*	....
+11	−13	250 4	305 6*	360 9*	31 19	90 20*	149 22	208 23*	268 1	327 2*	....
+10	−14	252 11	307 14	362 16*	34 6	93 7*	152 9	211 10*	270 12	329 13*	....
+9	−15	254 18*	309 21	364 23*	36 17	95 18*	154 20	213 21*	272 23	332 0*	....
+8	−16	257 1*	312 4	367 6*	39 4	98 5*	157 7	216 8*	275 10	334 11*	....
+7	−17	259 8*	314 11	369 14	41 15*	100 16*	159 18	218 19*	277 21	336 22*	....
+6	−18	261 15*	316 18*	371 21	44 2*	103 4	162 5*	221 6*	280 8	339 9*	....
+5	−19	263 22*	319 1*	....	46 13*	105 15	164 16*	223 18	282 19*	341 20*	....
+4	−20	266 6	321 8*	....	49 0*	108 2	167 3*	226 5	285 6*	344 8	....
+3	−21	268 13	323 15*	....	51 11*	110 13	169 14*	228 16	287 17*	346 19	....
+2	−22	270 20	325 22*	....	53 22*	113 0	172 1*	231 3	290 4*	349 6	....
+1	−23	273 3	328 6	....	56 9*	115 11	174 12*	233 14	292 15*	351 17	....

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component L.						Component P.		Component T.
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		1 0	63 8	126 23	190 14	254 5	317 20	1 0	358 16	1 0
+23	−1	2 8*	65 23*	129 14*	193 5*	256 20*	320 11*	8 15*	373 21	16 6
+22	−2	5 0	68 15	132 6	195 21	259 12	323 3	23 20*	....	46 16*
+21	−3	7 16	71 7	134 22	198 12*	262 3*	325 18*	39 2	....	77 3
+20	−4	10 7*	73 22*	137 13*	201 4*	264 19*	328 10*	54 7	....	107 13*
+19	−5	12 23	76 14	140 5	203 20	267 11	331 2	69 12*	....	138 0
+18	−6	15 14*	79 5*	142 20*	206 11*	270 2*	333 17*	84 17*	....	168 10*
+17	−7	18 6*	81 21*	145 12*	209 3	272 18	336 9	99 23	....	198 21
+16	−8	20 22	84 13	148 4	211 19	275 10	339 1	115 4	....	229 7*
+15	−9	23 13*	87 4*	150 19*	214 10*	278 1*	341 16*	130 9*	....	259 18
+14	−10	26 5	89 20	153 11	217 2	280 17	344 8	145 14*	....	290 4*
+13	−11	28 21	92 12	156 2*	219 17*	283 8*	346 23*	160 20	....	320 15
+12	−12	31 12*	95 3*	158 18*	222 9*	286 0*	349 15*	176 1	....	351 1*
+11	−13	34 4	97 19	161 10	225 1	288 16	352 7	191 6*	....	381 12
+10	−14	36 19*	100 10*	164 1*	227 16*	291 7*	354 22*	206 11*	....	....
+9	−15	39 11*	103 2*	166 17	230 8	293 23	357 14	221 17	....	....
+8	−16	42 3	105 18	169 9	233 0	296 15	360 6	236 22	....	....
+7	−17	44 18*	108 9*	172 0*	235 15*	299 6*	362 21*	252 3*	....	....
+6	−18	47 10	111 1	174 16	238 7	301 22	365 13	267 8*	....	....
+5	−19	50 2	113 17	177 7*	240 22*	304 13*	368 4*	282 13*	....	....
+4	−20	52 17*	116 8*	179 23*	243 14*	307 5*	370 20*	297 19	....	....
+3	−21	55 9	119 0	182 15	246 6	309 21	....	313 0	....	....
+2	−22	58 0*	121 15*	185 6*	248 21*	312 12*	....	328 5*	....	....
+1	−23	60 16*	124 7*	187 22	251 13	315 4	....	343 10*	....	....

Difference.		Component R.	Component K.		Component 2SM.						
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		1 0	1 0	358 16	1 0	29 22*	59 11*	89 0	118 13	148 1*	177 14*
+1	−23	16 6	8 15*	373 21	15*	31 4	60 17	90 5*	119 18*	149 7	178 20
+2	−22	46 16*	23 20*	....	2 21	32 10	61 22*	91 11	121 0	150 12*	180 1*
+3	−21	77 3	39 2	....	4 2*	33 15*	63 4	92 17	122 5*	151 18	181 7
+4	−20	107 13*	54 7	....	5 8	34 21	64 9*	93 22*	123 11	153 0	182 12*
+5	−19	138 0	69 12*	....	6 13*	36 2*	65 15	95 4	124 16*	154 5*	183 18
+6	−18	168 10*	84 17*	....	7 19	37 8	66 20*	96 9*	125 22	155 11	184 23*
+7	−17	198 21	99 23	....	9 0*	38 13*	68 2	97 15	127 3*	156 16*	186 5
+8	−16	229 7*	115 4	....	10 6	39 19	69 7*	98 20*	128 9	157 22	187 10*
+9	−15	259 18	130 9*	....	11 12	41 0*	70 13	100 2	129 14*	159 3*	188 16
+10	−14	290 4*	145 14*	....	12 17*	42 6	71 19	101 7*	130 20	160 9	189 21*
+11	−13	320 15	160 20	....	13 23	43 11*	73 0*	102 13	132 2	161 14*	191 3
+12	−12	351 1*	176 1	....	15 4*	44 17	74 6	103 18*	133 7*	162 20	192 9
+13	−11	381 12	191 6*	....	16 10	45 22*	75 11*	105 0	134 13	164 1*	193 14*
+14	−10	....	206 11*	....	17 15*	47 4	76 17	106 5*	135 18*	165 7	194 20
+15	−9	....	221 17	....	18 21	48 9*	77 22*	107 11	137 0	166 12*	196 1*
+16	−8	....	236 22	....	20 2*	49 15	79 4	108 16*	138 5*	167 18	197 7
+17	−7	....	252 3*	....	21 8	50 20*	80 9*	109 22	139 11	168 23*	198 12*
+18	−6	....	267 8*	....	22 13*	52 2*	81 15	111 3*	140 16*	170 5	199 18
+19	−5	....	282 13*	....	23 19	53 8	82 20*	112 9*	144 22	171 10*	200 23*
+20	−4	....	297 19	....	25 0*	54 13*	84 2	113 15	143 3*	172 16*	202 5
+21	−3	....	313 0	....	26 6	55 19	85 7*	114 20*	144 9	173 22	203 10*
+22	−2	....	328 5*	....	27 11*	57 0*	86 13	116 2	145 14*	175 3*	204 16
+23	−1	....	343 10*	....	28 17	58 6	87 18*	117 7*	146 20	176 9	205 21*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component 2SM.						Component J.			
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		207 3	236 16	266 4*	295 17*	325 6	354 19	1 0	26 3	51 18	77 8*
+1	−23	208 8*	237 21*	267 10	296 23	326 11*	356 0*	13*	27 4*	52 19*	78 10*
+2	−22	209 14	239 3	268 15*	298 4*	327 17	357 6	2 15	28 6	53 21	79 12
+3	−21	210 19*	240 8*	269 21	299 10	328 22*	358 11*	3 17	29 7*	54 22*	80 13*
+4	−20	212 1	241 14	271 2*	300 15*	330 4	359 17	4 18*	30 9*	56 0*	81 15
+5	−19	213 7	242 19*	272 8	301 21	331 9*	360 22*	5 20	31 11	57 2	82 17
+6	−18	214 12*	244 1	273 14	303 2*	332 15	362 4	6 21*	32 12*	58 3*	83 18*
+7	−17	215 18	245 6*	274 19*	304 8	333 21	363 9*	7 23*	33 14	59 5	84 20
+8	−16	216 23*	246 12	276 1	305 13*	335 2*	364 15	9 1	34 16	60 6*	85 21*
+9	−15	218 5	247 17*	277 6*	306 19	336 8	365 20*	10 2*	35 17*	61 8*	86 23*
+10	−14	219 10*	248 23	278 12	308 0*	337 13*	367 2	11 4	36 19	62 10	88 1
+11	−13	220 16	250 4*	279 17*	309 6	338 19	368 7*	12 6	37 20*	63 11*	89 2*
+12	−12	221 21*	251 10	280 23	310 11*	340 0*	369 13	13 7*	38 22*	64 13	90 4
+13	−11	223 3	252 16	282 4*	311 17	341 6	370 18*	14 9	40 0	65 15	91 6
+14	−10	224 8*	253 21*	283 10	312 23	342 11*	....	15 10*	41 1*	66 16*	92 7*
+15	−9	225 14	255 3	284 15*	314 4*	343 17	....	16 12*	42 3	67 18	93 9
+16	−8	226 19*	256 8*	285 21	315 10	344 22*	....	17 14	43 5	68 19*	94 10*
+17	−7	228 1	257 14	287 2*	316 15*	346 4	....	18 15*	44 6*	69 21*	95 12*
+18	−6	229 6*	258 19*	288 8	317 21	347 9*	....	19 17	45 8	70 23	96 14
+19	−5	230 12	260 1	289 13*	319 2*	348 15	....	20 18*	46 9*	72 0*	97 15*
+20	−4	231 17*	261 6*	290 19	320 8	349 20*	....	21 20*	47 11*	73 2	98 17
+21	−3	232 23*	262 12	292 0*	321 13*	351 2	....	22 22	48 13	74 4	99 18*
+22	−2	234 5	263 17*	293 6*	322 19	352 7*	....	23 23*	49 14*	75 5*	100 20*
+23	−1	235 10*	264 23	294 12	324 0*	353 13*	....	25 1	50 16	76 7	101 22

Difference.		Component J.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		102 23*	128 14*	154 5*	179 20*	205 11*	231 2	256 17	282 8	307 23	333 14
+1	−23	104 1	129 16	155 7	180 22	206 13	232 4	257 18*	283 9*	309 0*	334 15*
+2	−22	105 3	130 18	156 8*	181 23*	207 14*	233 5*	258 20*	284 11*	310 2	335 17
+3	−21	106 4*	131 19*	157 10*	183 1	208 16	234 7	259 22	285 13	311 4	336 18*
+4	−20	107 6	132 21	158 12	184 3	209 18	235 8*	260 23*	286 14*	312 5*	337 20*
+5	−19	108 7*	133 22*	159 13*	185 4*	210 19*	236 10*	262 1	287 16	313 7	338 22
+6	−18	109 9*	135 0*	160 15	186 6	211 21	237 12	263 3	288 18	314 8*	339 23*
+7	−17	110 11	136 2	161 17	187 7*	212 22*	238 13*	264 4*	289 19*	315 10*	341 1
+8	−16	111 12*	137 3*	162 18*	188 9*	214 0*	239 15	265 6	290 21	316 12	342 3
+9	−15	112 14	138 5	163 20	189 11	215 2	240 17	266 7*	291 22*	317 13*	343 4*
+10	−14	113 16	139 6*	164 21*	190 12*	216 3*	241 18*	267 9*	293 0*	318 15	344 6
+11	−13	114 17*	140 8*	165 23*	191 14	217 5	242 20	268 11	294 2	319 17	345 7*
+12	−12	115 19	141 10	167 1	192 16	218 6*	243 21*	269 12*	295 3*	320 18*	346 9*
+13	−11	116 20*	142 11*	168 2*	193 17*	219 8*	244 23*	270 14	296 5	321 20	347 11
+14	−10	117 22*	143 13	169 4	194 19	220 10	246 1	271 16	297 6*	322 21*	348 12*
+15	−9	119 0	144 15	170 6	195 20*	221 11*	247 2*	272 17*	298 8*	323 23*	349 14
+16	−8	120 1*	145 16*	171 7*	196 22*	222 13	248 4	273 19	299 10	325 1	350 16
+17	−7	121 3	146 18	172 9	198 0	223 15	249 6	274 20*	300 11*	326 2*	351 17*
+18	−6	122 5	147 19*	173 10*	199 1*	224 16*	250 7*	275 22*	301 13	327 4	352 19
+19	−5	123 6*	148 21*	174 12*	200 3	225 18	251 9	277 0	302 15	328 6	353 20*
+20	−4	124 8	149 23	175 14	201 5	226 19*	252 10*	278 1*	303 16*	329 7*	354 22*
+21	−3	123 9*	151 0*	176 15*	202 6*	227 21*	253 12*	279 3	304 18	330 9	356 0
+22	−2	126 11*	152 2	177 17	203 8	228 23	254 14	280 5	305 19*	331 10*	357 1*
+23	−1	127 13	153 4	178 18*	204 9*	230 0*	255 15*	281 6*	306 21*	332 12*	358 3

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Comp. J.	Component OO.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*h. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*h. h.*	*d. h.*
0		359 5	1 0	13 22	27 2	40 6*	53 10*	66 14*	79 18*	92 22*	106 2*
+1	−23	360 6*	7*	14 11*	15*	19*	23*	67 3*	80 7*	93 11*	15*
+2	−22	361 8	20*	15 0*	28 4*	41 8*	54 12*	16*	20*	94 1	107 5
+3	−21	362 9*	2 9*	13*	17*	22	55 2	68 6	81 10	14	18
+4	−20	363 11*	23	16 3	29 7	42 11	15	19	23	95 3	108 7
+5	−19	364 13	3 12	16	20	43 0	56 4	69 8	82 12	16*	20*
+6	−18	365 14*	4 1	17 5	30 9*	13*	17*	21*	83 1*	96 5*	109 9*
+7	−17	366 16	14*	18*	22*	44 2*	57 6*	70 10*	14*	18*	22*
+8	−16	367 18	5 3*	18 7*	31 11*	15*	19*	23*	84 3*	97 8	110 12
+9	−15	368 19*	16*	20*	32 1	45 5	58 9	71 13	17	21	111 1
+10	−14	369 21	6 6	19 10	14	18	22	72 2	85 6	98 10	14
+11	−13	370 22*	19	23	33 3	46 7	59 11	15	19	23*	112 3*
+12	−12	....	7 8	20 12	16*	20*	60 0*	73 4*	86 8*	99 12*	16*
+13	−11	....	21*	21 1*	34 5*	47 9*	13*	17*	21*	100 1*	113 5*
+14	−10	....	8 10*	14*	18*	22*	61 2*	74 6*	87 11	15	19
+15	−9	....	23*	22 3*	35 8	48 12	16	20	88 0	101 4	114 8
+16	−8	....	9 13	17	21	49 1	62 5	75 9	13	17	21
+17	−7	....	10 2	23 6	36 10	14	18	22	89 2*	102 6*	115 10*
+18	−6	....	15	19	23*	50 3*	63 7*	76 11*	15*	19*	23*
+19	−5	....	11 4*	24 8*	37 12*	16*	20*	77 0*	90 4*	103 8*	116 12*
+20	−4	....	17*	21*	38 1*	51 5*	64 9*	13*	18	22	117 2
+21	−3	....	12 6*	25 10*	15	19	23	78 3	91 7	104 11	15
+22	−2	....	20	26 0	39 4	52 8	65 12	16	20	105 0	118 4
+23	−1	....	13 9	13	17	21	66 1	79 5	92 9*	13*	17*

Difference.		Component OO.									
Hour.		*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*	*d. h.*
0		119 6*	132 10*	145 14*	158 18*	171 22*	185 2*	198 6*	211 11	224 15	237 19
+1	−23	19*	23*	146 4	159 8	172 12	16	20	212 0	225 4	238 8
+2	−22	120 9	133 13	17	21	173 1	186 5	199 9	13	17	21
+3	−21	22	134 2	147 6	160 10	14	18	22	213 2*	226 6*	239 10*
+4	−20	121 11	15	19*	23*	174 3*	187 7*	200 11*	15*	19*	23*
+5	−19	122 0*	135 4*	148 8*	161 12*	16*	20*	201 0*	214 4*	227 8*	240 12*
+6	−18	13*	17*	21*	162 1*	175 5*	188 9*	14	18	22	241 2
+7	−17	123 2*	136 6*	149 11	15	19	23	202 3	215 7	228 11	15
+8	−16	16	20	150 0	163 4	176 8	189 12	16	20	229 0	242 4
+9	−15	124 5	137 9	13	17	21	190 1	203 5*	216 9*	13*	17*
+10	−14	18	22	151 2*	164 6*	177 10*	14*	18*	22*	230 2*	243 6*
+11	−13	125 7*	138 11*	15*	19*	23*	191 3*	204 7*	217 11*	15*	19*
+12	−12	20*	139 0*	152 4*	165 8*	178 12*	16*	21	218 1	231 5	244 9
+13	−11	126 9*	13*	18	22	179 2	192 6	205 10	14	18	22
+14	−10	23	140 3	153 7	166 11	15	19	23	219 3	232 7	245 11
+15	−9	127 12	16	20	167 0	180 4	193 8	206 12*	16*	20*	246 0*
+16	−8	128 1	141 5	154 9*	13*	17*	21*	207 1*	220 5*	233 9*	13*
+17	−7	14*	18*	22*	168 2*	181 6*	194 10*	14*	18*	22*	247 2*
+18	−6	129 3*	142 7*	155 11*	15*	19*	23*	208 4	221 8	234 12	16
+19	−5	16*	20*	156 1	169 5	182 9	195 13	17	21	235 1	248 5
+20	−4	130 6	143 10	14	18	22	196 2	209 6	222 10	14	18
+21	−3	19	23	157 3	170 7	183 11	15	19*	23*	236 3*	249 7*
+22	−2	131 8	144 12*	16*	20*	184 0*	197 4*	210 8*	223 12*	16*	20*
+23	−1	21*	145 1*	158 5*	171 9*	13*	17*	21*	224 1*	237 5*	250 9*

TABLE 31.—*For construction of primary stencils*—Continued.

Difference.		Component OO.									
Hour.		d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.	d. h.
0		250 23	264 3	277 7	290 11	303 15	316 19	329 23	343 3	356 7	369 11
+1	−23	251 12	16	20	291 0	304 4	317 8*	330 12*	16*	20*	370 0*
+2	−22	252 1	265 5*	278 9*	13*	17*	21*	331 1*	344 5*	357 9*	....
+3	−21	14*	18*	22*	292 2*	305 6*	318 10*	14*	18*	22*	....
+4	−20	253 3*	266 7*	279 11*	15*	19*	319 0	332 4	345 8	358 12	....
+5	−19	16*	21	280 1	293 5	306 9	13	17	21	359 1	....
+6	−18	254 6	267 10	14	18	22	320 2	333 6	346 10	14	....
+7	−17	19	23	281 3	294 7	307 11	15*	19*	23*	360 3*	....
+8	−16	255 8	268 12*	16*	20*	308 0*	321 4*	334 8*	347 12*	16*	....
+9	−15	21*	269 1*	282 5*	295 9*	13*	17*	21*	348 1*	361 5*	....
+10	−14	256 10*	14*	18*	22*	309 2*	322 7	335 11	15	19	....
+11	−13	23*	270 4	283 8	296 12	16	20	336 0	349 4	362 8	....
+12	−12	257 13	17	21	297 1	310 5	323 9	13	17	21	....
+13	−11	258 2	271 6	284 10	14	18	22*	337 2*	350 6*	363 10*	....
+14	−10	15*	19*	23*	298 3*	311 7*	324 11*	15*	19*	23*	....
+15	−9	259 4*	272 8*	285 12*	16*	20*	325 0*	338 4*	351 8*	364 12*	....
+16	−8	17*	21*	286 1*	299 5*	312 9*	14	18	22	365 2	....
+17	−7	260 7	273 11	15	19	23	326 3	339 7	352 11	15	....
+18	−6	20	274 0	287 4	300 8	313 12	16	20	353 0	366 4	....
+19	−5	261 9	13	17	21	314 1	327 5*	340 9*	13*	17*	....
+20	−4	22*	275 2*	288 6*	301 10*	14*	18*	22*	354 2*	367 6*	....
+21	−3	262 11*	15*	19*	23*	315 3*	328 7*	341 11*	15*	19*	....
+22	−2	263 0*	276 4*	289 8*	302 12*	17	21	342 1	355 5	368 9	....
+23	−1	14	18	22	303 2	316 6	329 10	14	18	22	....

TABLE 32.—*Divisors for primary stencil sums.*

COMPONENT J.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	30	59	87	106	134	164	192	221	250	279	298	326	355	370
1	31	59	89	106	135	164	193	222	250	280	298	327	356	369
2	28	58	86	104	134	162	192	220	250	278	296	326	354	369
3	30	59	88	106	135	165	192	222	251	280	299	326	356	370
4	29	59	88	104	135	163	193	222	250	280	297	327	355	369
5	28	59	87	105	134	163	193	221	251	278	297	326	355	370
6	30	57	88	106	134	165	192	222	250	280	298	326	356	369
7	28	58	87	104	134	163	193	221	250	279	297	327	354	369
8	29	58	88	106	134	164	193	222	251	279	298	326	356	371
9	29	57	87	105	134	163	192	222	250	280	297	326	355	369
10	28	58	86	104	134	162	193	220	250	278	297	326	354	368
11	30	59	88	107	134	164	193	223	251	280	299	327	357	370
12	29	57	87	104	134	162	191	221	250	279	296	326	354	368
13	28	58	85	104	133	162	191	220	250	278	297	325	354	368
14	30	58	88	106	134	164	192	223	250	280	297	327	356	369
15	29	58	87	105	135	162	192	220	251	279	296	327	355	369
16	28	58	86	105	133	163	191	220	250	279	297	325	355	369
17	30	57	87	105	134	163	192	221	250	280	296	326	355	368
18	28	58	86	104	134	162	192	220	250	278	296	325	355	369
19	29	58	87	106	133	163	191	221	249	280	297	325	356	369
20	29	57	87	104	134	162	191	220	249	279	296	326	354	368
21	28	58	85	104	133	162	191	219	249	277	296	325	354	369
22	30	58	88	106	134	164	192	222	249	279	298	326	356	369
23	28	57	86	104	134	161	191	219	249	277	295	325	353	368

COMPONENT K.

Series.	14	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.															
0	15	30	59	88	106	135	164	193	221	250	279	297	326	355	369
1	14	30	59	88	106	135	164	193	222	251	279	297	326	355	369
2	14	29	59	88	106	135	164	193	222	251	280	298	327	355	369
3	14	29	59	88	106	135	164	193	222	251	280	298	327	356	370
4	14	29	57	87	105	134	163	192	221	250	279	297	326	355	369
5	14	29	58	88	105	134	163	192	221	250	279	297	326	355	369
6	14	29	58	87	106	135	163	192	221	250	279	297	326	355	369
7	14	29	58	87	105	135	164	193	221	250	279	296	325	354	368
8	14	29	58	87	105	135	164	193	222	251	280	298	327	355	369
9	14	29	58	87	105	134	164	193	222	251	280	298	327	356	370
10	14	29	57	86	104	133	163	192	221	250	279	297	326	355	369
11	14	29	58	87	105	133	162	192	221	250	279	297	326	355	369
12	14	29	58	87	105	134	163	192	221	250	279	297	326	355	369
13	14	29	58	87	105	134	163	192	222	250	279	297	326	355	369
14	14	29	58	87	105	134	163	192	222	251	280	297	326	355	369
15	13	28	57	86	104	133	162	191	220	250	279	297	326	355	368
16	14	29	58	86	104	133	162	191	220	249	279	297	326	355	369
17	14	29	58	87	105	133	162	191	220	249	279	297	326	355	369
18	14	29	58	87	105	134	163	191	220	249	278	297	326	355	369
19	14	29	58	87	105	134	163	192	221	250	278	297	326	355	369
20	14	29	58	87	105	134	163	192	221	250	279	297	326	355	369
21	14	28	57	86	104	133	162	191	220	249	278	296	325	355	369
22	14	29	58	86	104	133	162	191	220	249	278	296	325	355	369
23	14	29	58	87	105	134	162	191	220	249	278	296	325	354	369

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT L.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	59	87	105	133	163	191	221	250	279	297	326	355	369
1	29	59	87	106	134	164	192	222	251	279	297	326	355	369
2	29	58	87	106	134	163	192	221	250	280	298	326	356	370
3	30	58	87	105	134	163	192	221	250	279	298	326	356	370
4	30	58	88	106	135	164	192	222	250	279	297	326	355	370
5	29	58	88	106	134	164	192	222	250	280	298	327	356	369
6	29	57	86	105	133	163	191	221	249	279	297	325	355	368
7	30	59	88	106	135	164	193	222	250	279	298	326	356	369
8	30	58	88	105	135	164	193	222	251	280	298	327	357	370
9	29	57	87	104	133	163	191	221	250	279	296	326	355	369
10	30	58	87	105	134	164	192	221	249	279	296	326	354	368
11	29	58	87	105	134	162	192	222	250	280	297	326	355	369
12	29	58	87	104	134	162	192	221	250	279	297	326	355	369
13	29	58	88	105	135	163	192	220	250	279	296	326	354	368
14	29	58	88	105	134	163	193	221	250	280	297	327	355	370
15	28	58	86	105	134	163	192	221	250	279	297	327	355	369
16	28	58	86	104	134	162	191	220	249	278	296	325	353	367
17	28	57	86	104	134	162	192	220	250	278	297	326	355	369
18	29	58	87	105	134	162	192	220	250	278	296	326	355	369
19	29	58	87	105	135	163	192	221	250	279	297	326	354	369
20	28	58	86	105	134	163	192	221	250	279	297	327	355	369
21	28	58	86	104	132	162	191	219	249	277	296	324	354	368
22	29	58	87	105	134	163	193	221	251	279	297	325	355	369
23	29	58	87	105	134	163	193	221	251	279	298	326	355	370

COMPONENT M.

Series.	15	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.															
0	15	29	59	87	105	135	164	192	222	250	279	297	325	355	369
1	15	29	57	87	105	134	163	192	221	250	279	296	326	354	369
2	15	28	58	86	105	134	162	192	221	250	279	296	325	354	369
3	16	29	59	88	107	135	165	193	222	251	281	299	328	357	371
4	16	30	58	87	106	135	164	193	222	251	280	297	326	355	370
5	15	28	57	86	104	134	163	192	221	250	278	296	325	354	368
6	15	29	58	87	106	134	163	192	222	250	280	297	326	355	369
7	16	29	58	87	105	134	163	192	221	250	279	296	326	354	369
8	16	29	59	87	106	135	164	193	221	251	280	298	326	355	370
9	15	29	58	87	106	135	165	193	223	251	280	298	327	357	371
10	15	29	57	87	105	134	163	192	221	250	279	296	326	354	368
11	15	28	57	86	104	133	162	192	221	250	278	296	325	354	369
12	15	29	58	87	105	133	162	191	220	250	280	297	326	355	368
13	15	30	59	88	105	134	163	192	221	250	279	298	327	355	369
14	15	29	58	87	105	134	163	192	220	250	278	297	326	356	369
15	14	29	58	87	104	134	163	192	222	250	279	298	326	356	369
16	15	29	57	87	104	133	162	191	220	249	278	296	326	354	368
17	15	29	59	87	105	134	162	192	220	250	279	298	326	355	369
18	14	29	58	87	105	133	163	191	220	249	278	297	326	355	368
19	15	30	58	88	105	135	163	192	221	250	279	297	326	356	369
20	14	28	57	86	103	133	162	191	220	249	277	296	325	354	368
21	14	29	58	87	105	133	162	192	221	250	280	298	327	356	369
22	15	30	59	88	105	134	163	192	221	249	279	298	327	355	369
23	15	29	58	87	105	134	163	192	220	250	278	296	325	355	369

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT N.

Series.	15	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.															
0......	16	29	58	87	105	134	163	191	220	250	279	297	327	356	370
1......	16	29	58	88	106	135	165	194	223	252	281	299	327	357	370
2......	15	29	57	87	105	133	162	191	220	248	278	296	324	354	367
3......	16	30	58	88	106	134	163	192	221	249	279	297	326	355	370
4......	16	30	58	87	105	135	164	193	223	252	282	299	328	357	371
5......	15	30	59	88	106	134	164	192	222	250	279	297	326	355	369
6......	15	29	58	87	105	133	163	191	221	249	278	296	324	354	367
7......	15	29	58	87	105	133	163	191	220	250	279	298	326	357	370
8......	14	29	58	88	107	135	164	194	223	251	281	299	327	356	370
9......	15	30	58	88	105	134	163	192	221	249	279	297	325	354	368
10......	15	30	58	88	105	134	163	191	221	249	279	297	326	356	370
11......	15	30	58	86	106	135	165	193	224	252	281	299	328	357	371
12......	15	28	59	87	106	134	164	192	220	250	278	297	325	355	368
13......	15	28	58	86	104	133	161	191	219	249	277	295	324	354	368
14......	14	28	57	86	104	133	161	191	220	250	279	297	326	354	369
15......	14	29	58	88	105	135	164	194	222	251	280	298	327	355	370
16......	15	29	58	86	104	134	162	191	220	249	277	295	325	353	368
17......	15	28	58	86	104	134	162	191	220	249	278	296	327	355	370
18......	15	28	58	87	105	134	164	193	222	252	280	298	327	356	371
19......	15	29	59	87	105	134	163	192	220	250	278	296	325	354	367
20......	14	28	57	86	104	133	161	191	219	249	277	295	325	353	367
21......	14	28	57	86	103	133	161	192	220	249	279	297	326	354	368
22......	16	30	59	88	106	137	165	194	223	252	281	298	328	356	370
23......	15	29	58	86	104	133	162	191	220	249	277	295	325	353	367

COMPONENT 2N.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0............	28	58	86	105	135	163	193	222	251	280	299	327	357	371
1............	30	58	88	106	135	165	194	223	252	281	299	329	357	371
2............	28	58	87	105	134	164	193	222	250	279	297	325	353	368
3............	30	59	88	106	136	164	193	221	251	280	298	326	356	370
4............	29	57	86	104	132	161	190	220	249	278	295	325	353	368
5............	28	58	86	105	134	163	192	222	251	280	298	326	356	369
6............	30	58	88	106	135	164	194	222	252	281	298	328	356	370
7............	29	59	88	106	135	165	193	223	251	280	297	325	354	368
8............	29	59	88	106	135	163	192	220	249	279	296	325	355	368
9............	29	57	86	104	133	162	191	220	250	278	296	326	354	369
10............	29	58	87	106	135	164	193	223	251	280	298	327	357	370
11............	29	58	87	106	135	164	194	222	251	280	298	326	355	369
12............	29	58	88	106	135	165	193	221	249	277	295	325	354	368
13............	29	59	87	105	134	162	190	219	248	278	296	325	354	368
14............	29	57	86	104	133	161	191	220	250	278	297	326	355	370
15............	29	58	87	105	133	163	192	222	250	280	298	327	356	370
16............	29	58	87	104	134	163	192	221	251	279	297	325	354	368
17............	29	58	88	105	134	163	192	220	249	278	296	326	355	369
18............	29	59	87	104	132	161	189	219	248	278	296	325	354	368
19............	29	57	86	103	133	161	191	220	249	278	297	326	355	369
20............	30	59	88	106	134	164	193	222	251	280	299	328	357	371
21............	28	58	87	104	134	163	192	221	250	279	297	325	354	367
22............	30	58	87	106	135	163	192	220	249	278	296	326	355	369
23............	28	56	85	103	131	161	189	219	248	277	295	325	354	368

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT O.

Series.	14	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hours															
0	13	29	58	87	106	135	164	192	222	251	279	298	327	355	369
1	14	29	59	88	105	134	164	192	221	251	280	298	327	355	369
2	14	28	57	86	105	133	162	192	221	250	279	296	325	354	368
3	14	30	57	87	105	134	164	193	221	251	280	297	326	356	370
4	14	29	58	87	106	135	163	193	222	250	280	297	325	354	369
5	14	29	59	87	105	135	163	192	222	251	280	297	326	355	369
6	14	29	58	87	105	134	164	193	222	251	279	297	326	355	369
7	14	28	58	87	105	135	164	192	222	251	280	297	327	355	369
8	14	29	58	88	106	134	164	193	221	250	278	296	325	355	368
9	15	30	58	87	106	134	163	193	221	250	279	297	326	355	369
10	14	29	58	87	105	135	164	193	221	249	279	297	326	356	370
11	14	30	59	88	107	136	164	192	222	251	280	299	327	356	370
12	14	29	59	87	105	135	163	192	221	250	279	297	327	355	369
13	13	28	57	87	104	132	161	189	219	248	276	295	324	253	367
14	14	29	58	87	105	133	163	192	220	250	279	297	327	356	369
15	14	29	58	87	105	133	162	192	221	250	280	297	326	355	370
16	14	30	58	87	104	134	163	192	221	250	279	298	325	355	369
17	14	29	58	86	104	133	161	191	220	248	277	296	325	354	369
18	13	28	58	87	104	134	163	191	221	250	279	297	327	355	369
19	14	29	58	88	104	133	163	192	221	250	278	297	326	355	368
20	15	29	58	87	105	134	163	192	220	250	279	296	326	355	369
21	14	29	58	87	105	133	163	192	220	249	279	297	326	356	370
22	15	30	57	86	105	134	162	191	221	250	279	298	326	355	369
23	14	28	58	86	104	134	162	192	221	249	279	297	326	355	369

COMPONENT OO.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	58	86	104	134	163	192	221	250	280	298	326	355	369
1	30	60	88	107	136	164	193	221	250	279	297	326	355	369
2	29	57	86	103	133	162	192	220	250	280	297	327	355	369
3	31	60	89	107	137	166	194	223	251	281	298	327	355	370
4	30	58	87	104	132	162	191	220	249	278	297	326	355	369
5	29	59	88	106	135	166	194	223	251	280	298	326	355	369
6	28	58	86	104	132	161	190	219	249	277	297	325	355	368
7	29	58	88	105	135	165	194	223	251	280	298	327	355	369
8	29	59	88	105	134	163	191	220	249	278	297	326	355	369
9	29	58	87	105	134	163	193	223	251	280	298	326	355	369
10	28	58	87	105	133	162	191	219	248	277	296	325	355	368
11	28	57	87	104	134	162	193	222	251	280	299	327	355	369
12	29	58	88	106	135	163	193	221	250	278	296	326	355	369
13	29	57	87	104	133	162	192	221	250	280	297	328	356	370
14	30	59	88	107	135	164	192	222	250	278	296	325	354	369
15	28	57	85	104	132	162	191	220	250	279	297	327	356	369
16	29	58	87	106	135	164	193	222	251	279	297	326	354	369
17	29	57	86	104	133	161	190	220	249	278	296	326	355	369
18	30	58	88	106	135	165	193	224	252	281	298	327	356	370
19	28	57	85	104	132	161	189	218	248	277	295	323	354	368
20	29	58	87	106	135	164	193	222	252	280	298	326	356	369
21	28	58	86	104	133	161	190	218	248	277	295	324	354	368
22	29	57	87	105	135	163	193	222	251	281	298	327	356	370
23	29	58	87	105	134	163	191	220	249	278	295	325	354	369

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT P.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	58	87	105	135	164	193	222	251	280	298	327	356	369
1	29	58	87	105	134	163	192	221	250	279	297	297	354	368
2	29	58	87	105	134	163	192	222	251	280	298	327	355	369
3	29	59	88	106	135	164	193	222	251	280	298	327	356	370
4	29	58	87	105	134	164	193	222	251	280	297	326	355	369
5	29	58	87	105	134	163	192	221	250	279	296	325	354	368
6	29	58	87	105	134	163	192	221	251	279	297	326	355	369
7	29	58	88	106	135	164	193	222	251	279	297	326	356	370
8	29	58	87	105	134	163	192	221	249	278	296	325	354	368
9	29	58	87	105	134	164	193	221	250	279	297	326	355	369
10	29	58	87	105	134	163	192	220	249	279	297	326	355	369
11	29	58	88	106	135	164	192	221	250	279	297	326	356	370
12	29	58	87	105	134	163	191	220	249	278	296	325	354	368
13	29	58	87	105	134	162	192	221	250	279	297	326	355	369
14	30	59	88	106	135	163	192	221	250	280	298	327	356	370
15	29	58	87	105	133	162	191	220	249	278	296	325	354	368
16	29	58	87	106	134	163	192	221	250	279	297	326	355	370
17	29	58	87	104	133	162	192	221	250	279	297	326	355	369
18	30	59	87	105	134	163	192	221	250	279	298	327	356	370
19	29	58	86	104	133	162	191	220	249	278	296	325	354	368
20	29	57	86	104	134	163	192	221	250	279	297	326	355	369
21	29	57	86	104	133	162	191	221	250	279	297	326	355	369
22	28	57	86	104	133	162	191	220	249	278	296	325	354	368
23	28	58	87	105	134	163	192	221	250	279	298	327	356	370

COMPONENT Q.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	59	88	106	136	164	194	222	250	280	297	326	355	368
1	29	58	86	104	133	162	191	221	250	280	298	327	357	370
2	29	59	88	106	135	165	193	222	251	280	298	326	354	368
3	28	56	86	103	132	161	190	220	249	278	297	326	354	369
4	30	59	89	107	136	166	195	225	253	282	299	328	356	370
5	29	58	87	105	133	162	191	219	249	277	296	325	254	369
6	30	59	88	107	136	165	195	224	254	281	300	328	356	371
7	30.	58	87	104	133	162	191	219	248	277	295	324	354	369
8	28	58	87	105	135	164	194	223	251	280	298	326	356	369
9	29	59	88	106	135	163	192	221	248	278	296	325	355	369
10	28	58	86	104	134	163	192	221	250	280	298	327	355	370
11	29	58	88	106	134	164	192	220	249	277	295	324	353	368
12	29	57	86	104	133	163	191	220	250	279	297	327	356	370
13	30	59	89	107	136	165	192	221	250	278	296	325	354	369
14	29	58	87	104	133	161	191	220	250	279	297	327	356	371
15	30	59	88	107	136	164	194	222	251	280	297	326	355	368
16	29	58	86	104	133	161	190	219	248	278	296	325	355	368
17	29	59	87	106	135	164	193	223	251	280	298	326	355	368
18	28	57	85	103	131	160	188	218	247	277	295	324	354	367
19	29	58	87	105	134	164	193	223	252	281	299	328	356	370
20	29	57	86	104	132	161	190	218	247	276	294	324	353	367
21	30	57	87	105	134	164	193	222	252	281	299	328	356	370
22	29	58	87	105	134	162	191	220	249	277	295	325	354	368
23	27	56	85	103	133	162	192	221	251	280	298	327	357	370

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT 2Q.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	25	50	83	113	142	167	192	217	242	279	309	334	359	371
1	25	59	101	116	141	166	191	216	255	293	308	333	358	370
2	36	77	102	117	142	167	192	233	269	293	309	334	359	371
3	39	64	89	104	129	154	196	230	255	279	295	320	345	366
4	25	50	75	90	115	159	192	217	242	266	282	307	355	370
5	25	50	75	90	136	167	192	217	242	266	282	332	358	370
6	25	50	83	113	142	167	192	217	241	277	309	334	358	370
7	25	60	102	117	142	167	192	217	254	293	309	334	358	370
8	36	76	101	116	141	166	191	232	267	292	308	333	357	369
9	39	64	89	104	129	154	197	230	255	280	296	320	345	365
10	25	50	75	90	115	159	191	215	240	265	281	305	353	369
11	25	50	75	90	136	167	192	216	241	266	283	331	358	370
12	25	50	83	113	142	167	192	216	241	277	307	332	357	369
13	25	60	101	117	142	167	191	216	254	293	308	333	358	370
14	37	77	101	117	142	167	191	231	268	293	308	333	358	370
15	38	63	87	103	128	153	194	229	254	279	294	319	344	364
16	25	50	74	90	115	159	191	216	241	266	281	306	354	370
17	25	49	74	90	136	165	190	215	240	265	280	330	357	369
18	25	49	81	113	142	166	191	216	241	278	308	333	358	370
19	25	58	101	117	142	166	191	216	254	292	307	332	357	369
20	36	76	101	117	141	166	191	231	268	293	308	333	358	370
21	37	62	87	103	127	152	194	229	254	279	294	319	344	364
22	24	49	74	90	114	158	191	216	241	266	281	306	354	370
23	24	49	74	90	135	166	191	216	241	266	281	331	358	370

COMPONENT R.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	30	59	88	106	135	164	193	222	251	280	298	327	356	370
1	29	59	88	106	135	164	193	222	251	280	298	326	355	369
2	29	58	88	106	135	164	193	222	251	279	297	326	355	369
3	29	58	87	105	135	164	193	221	250	279	297	326	355	369
4	29	58	87	105	134	163	192	221	250	279	297	326	355	369
5	29	58	86	104	133	162	192	221	250	279	297	326	355	369
6	28	57	86	104	133	162	191	221	250	279	297	326	355	369
7	29	58	87	105	134	163	192	221	251	280	298	327	356	370
8	29	58	87	105	134	163	192	221	250	280	298	327	356	370
9	29	58	87	105	134	163	192	221	250	279	298	327	356	370
10	29	58	87	105	134	163	192	221	250	279	297	327	356	370
11	29	58	87	105	134	163	192	221	250	279	297	326	356	370
12	29	58	87	105	134	163	192	221	250	279	297	326	354	368
13	29	58	87	105	134	163	192	221	250	279	296	325	354	368
14	29	58	87	105	134	163	192	221	249	278	296	325	354	368
15	29	58	87	105	134	163	191	220	249	278	296	325	354	368
16	29	58	87	105	133	162	191	220	249	278	296	325	354	368
17	29	57	86	104	133	162	191	220	249	278	296	325	354	368
18	29	58	87	105	134	163	192	221	250	279	297	326	355	369
19	29	58	87	105	134	163	192	221	250	279	297	326	355	369
20	29	58	87	105	134	163	192	221	250	279	297	326	355	369
21	29	58	87	105	134	163	192	221	250	279	297	326	355	369
22	29	58	87	105	134	163	192	221	250	279	297	326	355	369
23	29	58	87	105	134	163	192	221	250	279	297	326	355	369

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TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT T.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	58	88	106	135	164	193	222	251	280	298	327	356	370
1	29	58	87	105	134	163	192	221	250	279	297	326	355	369
2	29	58	87	105	134	163	192	221	250	279	297	326	355	369
3	29	58	87	105	134	163	192	221	250	279	297	326	355	369
4	29	58	87	105	134	163	193	222	251	280	298	328	357	371
5	30	59	88	106	135	164	193	222	251	280	298	327	356	370
6	29	58	87	105	134	163	192	221	250	279	297	326	355	369
7	29	58	87	105	134	163	192	221	250	279	297	326	355	369
8	29	58	87	105	134	163	192	221	250	279	297	326	355	369
9	29	58	87	105	135	164	193	222	251	281	299	328	357	371
10	29	58	87	105	134	163	192	221	250	279	297	326	355	369
11	29	58	87	105	134	163	192	221	250	279	297	326	355	369
12	29	58	87	105	134	163	192	221	250	279	297	326	354	368
13	29	58	87	105	134	163	192	221	250	279	297	325	355	369
14	29	59	88	106	135	164	193	223	252	281	298	327	356	370
15	29	58	87	105	134	163	192	221	250	278	296	325	354	368
16	29	58	87	105	134	163	192	221	249	278	296	325	354	368
17	29	58	87	105	134	163	192	220	249	278	296	325	354	368
18	29	58	87	105	134	163	191	220	249	278	297	326	355	369
19	29	58	87	105	134	163	192	221	250	279	297	326	355	369
20	29	58	87	105	133	162	191	220	249	278	296	325	354	368
21	29	58	86	104	133	162	191	220	249	278	296	325	354	368
22	29	57	86	104	133	162	191	220	249	278	296	325	354	368
23	28	57	86	104	133	162	191	220	250	279	297	326	355	369

COMPONENT λ.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	58	89	107	135	164	194	223	252	280	298	330	358	372
1	29	57	87	106	134	162	191	221	250	278	296	325	355	369
2	29	57	86	104	134	162	191	219	250	278	296	324	354	369
3	31	59	88	105	136	165	194	222	252	282	300	328	357	371
4	31	59	88	105	134	164	193	221	250	279	298	326	355	369
5	29	59	88	105	134	162	193	221	250	278	297	326	355	369
6	29	58	88	105	134	162	193	221	250	278	296	326	355	369
7	29	57	88	106	135	163	192	223	252	280	298	326	358	371
8	29	57	86	104	134	162	191	219	250	278	296	324	354	368
9	30	58	87	104	135	163	192	220	250	279	297	325	354	367
10	31	60	88	106	135	166	195	223	252	282	301	329	358	371
11	28	59	87	105	134	162	193	221	249	278	297	326	355	368
12	28	57	87	105	134	162	191	221	249	278	296	326	355	368
13	28	57	87	105	134	162	190	221	249	278	296	324	354	368
14	28	57	85	105	134	163	191	220	251	280	298	326	355	371
15	29	58	86	104	134	163	191	220	249	279	296	325	353	367
16	30	59	87	105	133	164	192	221	249	280	297	326	354	368
17	28	60	88	106	134	164	194	223	251	280	299	329	357	371
18	28	57	87	105	133	162	191	221	249	278	295	326	354	368
19	28	57	86	105	133	162	190	221	249	278	295	324	354	368
20	28	57	85	104	133	162	190	219	249	278	295	324	353	368
21	29	58	86	104	134	164	192	221	250	281	298	327	355	370
22	30	59	87	105	133	164	192	221	249	279	297	326	354	368
23	28	58	87	105	133	163	192	221	249	277	296	326	354	368

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT μ.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	29	59	89	105	135	163	192	223	252	280	299	326	356	369
1	30	61	88	107	135	164	194	223	252	282	298	327	356	369
2	30	57	88	105	134	164	193	221	250	280	296	326	355	369
3	27	57	87	104	134	163	190	219	249	276	296	325	353	368
4	30	60	87	106	135	162	192	222	249	279	298	326	356	369
5	30	57	86	106	133	163	193	220	250	280	297	327	356	370
6	27	56	86	103	133	163	190	220	250	278	297	326	354	369
7	29	59	88	106	136	163	193	223	251	280	299	326	355	369
8	30	59	87	107	134	164	194	222	250	279	296	326	356	369
9	29	57	87	104	134	163	191	219	249	279	296	326	354	369
10	28	58	88	105	134	163	191	221	251	278	298	326	355	369
11	30	59	86	105	134	162	192	222	249	279	297	326	356	369
12	29	57	86	105	133	163	193	220	250	280	297	327	356	369
13	28	57	87	104	134	164	191	221	251	279	297	326	353	369
14	29	59	88	106	136	163	193	222	250	278	298	325	355	368
15	30	59	87	107	134	164	193	222	250	280	297	327	357	370
16	29	57	87	104	133	162	191	219	249	278	296	326	354	369
17	28	57	86	103	133	162	190	220	249	277	297	325	354	368
18	29	59	86	106	135	163	193	222	250	280	298	327	356	369
19	30	57	87	106	134	164	193	221	251	281	298	327	356	370
20	27	57	87	104	134	163	191	221	250	277	296	325	353	369
21	30	60	88	106	136	164	193	222	250	279	297	326	356	369
22	30	58	87	105	132	162	192	220	249	279	295	325	356	369
23	28	56	85	101	131	161	190	219	249	278	295	325	352	369

COMPONENT ν.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	31	59	86	103	135	165	193	221	249	283	300	327	355	368
1	28	56	83	103	134	161	189	216	250	278	295	322	351	367
2	28	56	89	107	135	162	190	224	252	280	297	324	358	371
3	28	60	89	106	134	161	195	222	250	278	295	329	357	370
4	33	62	90	107	135	167	196	223	251	280	302	329	357	370
5	30	57	85	102	135	164	192	219	249	281	299	326	354	367
6	28	55	83	104	134	161	189	217	250	277	295	322	352	369
7	28	55	90	107	135	162	191	224	252	279	296	325	358	371
8	28	61	89	106	134	161	195	222	250	277	295	329	357	370
9	34	62	90	107	134	169	197	224	252	282	302	330	358	371
10	29	56	84	101	134	162	190	217	248	279	296	324	351	365
11	28	55	85	107	134	162	190	219	251	278	295	323	353	371
12	28	56	89	106	133	161	190	223	251	278	295	326	356	370
13	29	62	90	107	134	164	195	223	251	278	298	330	357	371
14	32	60	88	105	134	167	194	222	250	281	300	328	355	369
15	27	55	83	101	133	161	188	216	247	278	295	323	350	365
16	27	55	86	107	134	162	189	221	250	278	295	323	355	371
17	27	58	88	106	133	161	192	223	250	278	295	327	356	369
18	30	62	89	107	134	165	195	223	250	278	299	330	357	370
19	31	59	86	103	134	166	193	221	248	282	299	327	354	367
20	27	55	82	101	133	161	188	216	249	278	295	322	350	366
21	27	55	87	106	134	162	189	222	250	278	295	322	356	369
22	27	59	88	105	133	160	193	223	250	278	295	328	357	370
23	31	62	89	106	134	165	195	223	250	279	300	328	356	369

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT ρ.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	30	59	89	107	135	164	193	222	251	279	297	326	355	369
1	29	59	88	105	134	164	193	222	251	280	299	328	356	372
2	28	57	87	105	134	162	191	220	249	278	295	324	353	367
3	29	58	87	106	135	165	194	224	252	281	299	328	357	371
4	30	58	87	106	135	163	192	221	250	279	297	326	355	370
5	29	58	87	106	134	163	192	220	250	278	296	325	354	368
6	28	58	87	106	136	165	193	223	252	282	299	328	357	371
7	29	58	87	104	134	163	192	221	249	278	296	325	354	369
8	29	58	87	105	135	165	194	222	251	280	298	326	355	370
9	29	58	87	105	133	162	192	222	251	280	298	327	357	371
10	29	57	86	104	133	162	191	220	249	278	296	325	353	366
11	28	58	87	105	134	163	193	223	252	280	298	327	356	369
12	29	58	86	104	133	162	190	219	249	279	297	326	355	369
13	30	59	88	106	135	163	192	221	250	280	297	326	355	368
14	29	58	87	104	134	163	193	221	250	280	299	328	357	370
15	28	57	86	104	132	162	190	219	248	276	295	324	354	367
16	30	59	88	106	135	164	193	222	250	279	298	327	355	369
17	28	57	86	104	133	161	191	220	250	279	298	327	356	370
18	29	58	87	104	133	162	191	220	248	277	295	325	354	367
19	30	58	87	106	135	164	193	222	251	280	297	326	356	369
20	28	57	86	104	132	161	190	219	249	277	295	325	354	368
21	30	59	87	105	134	163	191	220	249	278	296	324	353	368
22	29	58	88	105	135	164	193	222	251	281	298	328	357	371
23	29	58	86	104	133	162	191	219	248	277	295	323	352	367

COMPONENT MK.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	30	59	88	105	135	164	192	222	251	279	297	325	355	368
1	29	58	88	106	135	163	192	222	251	280	298	327	356	369
2	29	58	88	105	134	164	192	221	249	278	297	326	355	369
3	30	58	86	104	133	163	191	221	250	278	296	325	355	368
4	29	58	87	106	134	163	192	222	251	280	298	326	356	369
5	29	58	87	105	134	164	192	220	250	279	298	327	356	369
6	30	58	86	105	134	164	193	221	250	279	297	326	356	369
7	30	58	87	105	133	163	192	221	251	279	297	326	355	369
8	30	59	88	106	135	164	193	221	251	280	299	327	355	369
9	28	57	86	105	134	164	192	220	249	278	296	325	354	369
10	29	58	86	104	133	163	192	221	251	279	297	326	355	369
11	29	59	88	106	134	162	192	221	250	279	298	326	354	369
12	28	58	86	105	134	163	192	220	250	279	297	326	355	369
13	29	58	86	105	133	162	192	221	250	278	297	326	355	369
14	29	59	88	106	134	163	193	222	250	280	297	326	355	370
15	29	59	87	106	135	163	192	221	250	280	297	327	355	369
16	28	57	86	105	133	162	192	220	249	278	296	326	355	369
17	29	59	87	104	134	163	193	222	250	279	296	325	354	369
18	29	58	88	105	134	162	191	220	249	279	296	326	354	368
19	28	57	87	105	135	163	193	221	250	279	297	327	356	370
20	29	57	86	103	133	162	191	221	249	278	296	325	354	369
21	29	58	88	105	134	162	191	221	250	280	297	326	355	369
22	28	57	87	105	135	163	191	221	250	280	297	327	355	369
23	29	57	87	104	134	163	192	221	249	278	297	325	355	370

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT 2MK.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	30	59	87	106	134	164	193	221	251	280	298	326	355	369
1	29	59	87	106	134	164	193	221	250	280	298	327	356	370
2	29	59	87	106	134	163	192	221	250	279	297	325	355	368
3	29	58	86	105	133	163	193	222	251	280	298	326	355	369
4	30	59	87	105	134	164	192	221	250	279	297	326	355	369
5	29	59	88	106	135	164	192	222	251	279	298	327	357	370
6	29	58	86	104	134	163	191	221	250	278	297	325	354	368
7	30	59	87	105	135	164	192	221	251	280	299	327	356	370
8	30	58	87	105	134	163	192	221	250	279	296	326	355	368
9	29	57	87	104	134	164	192	222	251	279	297	326	356	369
10	30	58	88	105	135	164	192	221	251	279	297	326	355	369
11	30	59	88	106	135	164	193	222	251	280	297	327	356	370
12	29	57	87	105	134	162	192	221	249	278	296	326	356	369
13	29	57	87	104	134	162	191	221	249	278	296	325	354	368
14	29	57	86	104	133	162	191	220	249	279	297	326	355	369
15	29	58	87	105	134	162	192	221	249	279	296	326	355	369
16	28	57	87	105	135	163	192	222	250	279	297	326	354	369
17	28	57	86	104	133	162	191	220	249	278	296	325	353	368
18	29	59	88	106	135	163	193	222	250	280	298	328	356	371
19	28	58	87	105	134	162	192	221	249	278	296	325	354	368
20	28	57	87	104	133	162	191	220	250	279	297	326	355	369
21	29	58	87	105	133	163	192	220	250	279	297	326	354	369
22	28	58	87	106	134	163	193	221	250	279	297	326	355	370
23	28	57	87	104	133	162	191	219	249	278	296	325	354	368

COMPONENT MN.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	269
Hour.														
0	28	56	85	104	134	163	193	223	253	283	301	328	356	370
1	30	60	90	109	139	166	194	222	250	277	296	325	355	370
2	28	56	84	101	129	158	188	218	248	278	297	326	355	369
3	30	60	91	109	139	168	198	226	254	281	299	326	355	370
4	30	59	87	104	132	159	187	217	248	277	296	325	355	369
5	28	57	88	106	136	165	195	225	256	283	301	328	356	369
6	30	61	90	109	136	164	192	220	247	277	295	325	355	369
7	28	56	83	101	130	160	190	221	250	280	298	327	355	368
8	30	61	90	109	138	168	196	224	251	279	296	325	355	369
9	29	57	84	102	129	157	187	218	247	277	295	325	355	369
10	30	60	89	108	137	167	198	228	255	283	300	328	356	369
11	31	61	89	107	134	162	190	218	247	277	295	325	356	370
12	28	55	84	102	132	162	193	222	252	282	299	327	355	368
13	30	59	89	107	137	165	193	220	248	276	294	324	355	369
14	28	55	83	100	128	159	189	218	248	278	296	327	355	368
15	30	59	89	107	137	168	198	225	253	281	298	326	356	370
16	30	58	86	103	131	159	187	216	246	276	294	325	355	369
17	28	56	86	104	135	165	195	224	254	282	299	327	355	368
18	29	59	89	107	135	163	190	218	246	276	295	325	354	369
19	27	55	83	100	131	161	190	220	250	280	299	328	355	369
20	29	59	89	108	138	168	195	223	251	279	296	325	354	369
21	28	56	84	101	129	157	186	216	246	276	295	325	354	369
22	28	58	88	107	137	167	196	226	254	282	299	327	354	369
23	29	59	88	105	133	161	188	216	246	276	295	325	354	369

TABLE 32.—*Divisors for primary stencil sums*—Continued.

COMPONENT MS.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	30	59	88	106	135	164	192	222	250	279	297	326	354	369
1	30	58	88	106	134	164	192	221	250	279	296	326	355	369
2	29	58	87	105	134	163	192	222	250	280	298	327	355	369
3	30	58	88	107	135	165	194	223	252	281	298	328	356	370
4	29	58	87	105	134	163	191	221	249	279	296	325	354	368
5	30	58	88	105	134	164	192	221	250	280	297	327	356	370
6	29	58	88	105	135	164	194	223	252	281	299	328	356	371
7	30	58	87	105	134	162	192	220	250	278	296	326	354	368
8	29	58	87	104	134	162	191	220	249	278	296	326	355	369
9	29	57	87	104	133	162	192	220	250	279	297	326	355	369
10	30	59	88	106	136	164	193	222	251	279	298	327	355	370
11	30	58	88	105	134	163	192	220	250	278	296	326	354	368
12	28	58	87	104	134	162	192	221	250	279	298	326	356	370
13	28	57	86	105	134	163	193	221	251	279	297	325	355	369
14	29	59	87	105	135	163	192	221	250	278	297	325	354	369
15	29	58	87	105	134	163	192	220	250	278	296	325	355	369
16	28	58	86	104	134	163	193	222	251	280	299	327	356	371
17	29	58	87	106	135	163	193	221	251	279	297	326	355	369
18	28	58	86	104	133	162	190	220	248	278	296	324	354	367
19	28	57	86	104	132	162	191	220	249	279	297	326	356	369
20	29	59	87	106	134	164	192	222	250	279	298	326	355	369
21	29	58	86	105	133	162	191	220	249	278	296	325	354	367
22	28	58	86	104	133	162	190	220	248	278	296	325	355	368
23	28	57	86	105	133	163	192	221	250	280	297	326	356	369

COMPONENT 2SM.

Series.	29	58	87	105	134	163	192	221	250	279	297	326	355	369
Hour.														
0	28	57	87	106	136	164	192	220	250	280	299	329	356	369
1	30	60	88	106	133	163	193	223	252	280	297	325	355	370
2	28	56	86	105	135	165	193	220	249	279	297	327	356	370
3	30	60	89	107	135	163	193	223	253	281	298	326	355	370
4	28	55	84	103	133	163	191	219	247	276	294	324	353	367
5	30	60	90	107	135	163	193	223	253	282	299	326	355	370
6	28	56	84	103	133	163	192	220	248	277	295	325	355	370
7	30	60	90	109	137	164	193	223	253	283	300	328	356	370
8	29	57	85	103	133	163	193	221	249	277	295	325	355	370
9	29	59	89	108	137	165	193	222	252	282	300	328	356	370
10	30	59	86	104	133	163	193	223	251	279	295	325	355	370
11	28	57	87	106	136	164	192	220	249	279	298	327	355	369
12	30	59	87	104	132	161	191	221	249	277	295	323	353	367
13	28	57	87	105	135	164	191	219	249	279	298	328	356	369
14	30	60	88	105	133	162	192	222	251	279	297	325	355	369
15	27	55	85	103	133	163	191	219	247	277	296	326	355	368
16	30	60	89	106	134	162	192	222	252	281	298	326	355	369
17	28	56	84	102	132	162	191	219	247	276	295	325	355	368
18	30	60	90	108	135	163	192	222	252	282	300	328	355	369
19	29	57	85	102	132	162	192	220	248	276	295	325	355	369
20	29	59	89	107	135	163	190	220	250	280	298	326	354	367
21	29	57	85	102	132	162	192	221	249	276	295	325	355	369
22	28	58	88	106	135	163	191	220	250	280	299	327	355	368
23	30	58	86	103	132	162	192	222	250	278	295	325	355	369

TABLE 33.—*For construction of secondary stencils.*

Component A.	J				S				L			
Component B.	OO		2SM		K and P		R and T		MS		λ	
Page.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.
		+		−		±		±		−		−
1	0–23	3	0–23	0	0–23	0	0–23	0	0–23	0	0–23	0
2	10– 3	9	0–23	1	0–23	1	0–23	0	0–23	0	0–23	1
3	16– 4	15	0–23	2	0–23	1	0–23	1	17–21	0	0–23	1
4	23– 5	21	0–23	3	0–23	2	0–23	1	0–23	1	0–23	1
5	5– 6	3	0–23	4	0–23	2	0–23	1	0–23	1	0–23	2
6	0–23	10	0–23	5	0– 1	2	0–23	1	0–23	1	0–23	2
7	19–12	16	0–23	6	0–23	3	0–15	1	0–23	1	0–23	3
8	1–12	22	1–11	6	0–23	3	0–23	2	0–23	2	0–23	3
9	8–13	4	0–23	7	0–23	4	0–23	2	0–23	2	0–23	3
10	14	10	0–23	8	0–23	4	0–23	2	0–23	2	0–23	4
11	0–23	17	0–23	9	0–23	5	0–23	2	0–23	2	0–23	4
12	3–20	23	0–23	10	0–23	5	0–23	3	0–23	2	0–23	5
13	10–21	5	0–23	11	0–23	6	0–23	3	0–23	3	0–23	5
14	16–22	11	0–23	12	0–23	6	0–23	3	0–23	3	12–20	5
15	23	17	0–23	13	0–23	7	0–23	3	0–23	3	0–23	6
16	6– 4	0	6– 3	13	0–23	7	0–23	4	0–23	3	0–23	6
17	12– 5	6	0–23	14	0–23	8	0–23	4	0–23	3	0–23	7
18	19– 6	12	0–23	15	0–23	8	0–23	4	0–23	4	0–23	7
19	1– 7	18	0–23	16	0– 8	8	0–23	4	0–23	4	0–23	8
20	8	0	0–23	17	0–23	9	0–23	4	0–23	4	0–23	8
21	0–23	7	0–23	18	0–23	9	0–23	5	0–23	4	0–23	8
22	21–14	13	0–23	19	0–23	10	0–23	5	0–23	4	0–23	9
23	4–14	19	4– 9	19	0–23	10	0–23	5	0–23	5	0–23	9
24	10–15	1	0–23	20	0–23	11	0–23	5	0–23	5	0–23	10
25	0–23	8	0–23	21	0–23	11	0–23	6	0–23	5	0–23	10
26	23–21	14	0–23	22	0–23	12	0–23	6	0–23	5	0–23	10
27	6–22	20	0–23	23	0–23	12	0–23	6	0–23	5	0–23	11
28	12–23	2	0–23	0	0–23	13	0–23	6	0–23	6	0–23	11
29	19– 0	8	0–23	1	0–23	13	0–23	7	0–23	6	0–23	12
30	1	14	0–23	2	0–23	14	0–23	7	0–23	6	0–23	12
31	8– 6	21	8– 1	2	0–23	14	0–23	7	0–23	6	0–23	12
32	15– 7	3	0–23	3	0–15	14	0–23	7	0–23	6	0–23	13
33	21– 8	9	0–23	4	0–23	15	0–23	7	0–23	7	0–23	13
34	4– 9	15	0–23	5	0–23	15	0–23	8	0–23	7	0–23	14
35	0–23	22	0–23	6	0–23	16	0–23	8	0–23	7	0–23	14
36	17–15	4	0–23	7	0–23	16	0–23	8	0–23	7	2–21	14
37	23–15	10	0–23	8	0–23	17	0–23	8	0–23	7	0–23	15
38	6–16	16	6– 8	8	0–23	17	0–23	9	0–23	8	0–23	15
39	12–17	22	0–23	9	0–23	18	0–23	9	0–23	8	0–23	16
40	0–23	5	0–23	10	0–23	18	0–23	9	0–23	8	0–23	16
41	2–23	11	0–23	11	0–23	19	0–23	9	0–23	8	13–15	16
42	8– 0	17	0–23	12	0–23	19	0–23	10	0–23	8	0–23	17
43	15– 1	23	0–23	13	0–23	20	0–23	10	0–23	9	0–23	17
44	21– 2	5	0–23	14	0–23	20	0–23	10	0–23	9	0–23	18
45	0–23	12	0–23	15	0–23	20	0–23	10	0–23	9	0–23	18
46	10– 8	18	10–23	15	0–23	21	0–23	10	0–23	9	0–23	19
47	17– 9	0	0–23	16	0–23	21	0–23	11	0–23	9	0–23	19
48	23–10	6	0–23	17	0–23	22	0–23	11	0–23	10	0–23	19
49	6–11	12	0–23	18	0–23	22	0–23	11	0–23	10	0–23	20
50	0–23	19	0–23	19	0–23	23	0–23	11	0–23	10	0–23	20
51	19–16	1	0–23	20	0–23	23	0–23	12	0–23	10	0–23	21
52	2–17	7	0–23	21	0–23	0	0–23	12	8–16	10	0–23	21
(53)	7–14	12	0–23	21	0–23	0	0–23	12	0–23	11	0–23	21

TABLE 33.—*For construction of secondary stencils*—Continued.

Component A	L		M		N				O			
Component B	MK		MN		2MK		ν		μ		2N	
Page.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.
		−		−		+		+		+		+
1	23–10	0	0–23	1	27–0	0	0–23	0	0–23	0	0–23	0
2	20– 8	1	0–23	2	11–23	1	0–23	1	0–23	1	0–23	0
3	17– 5	2	0–23	4	2–14	2	0–23	1	0–23	1	0–23	0
4	15– 3	3	0–23	5	17– 6	3	0–23	1	0–23	2	0–23	0
5	12– 1	4	0–23	7	9–21	4	0–23	2	0–23	2	0–23	0
6	9–22	5	0–23	8	0–13	5	0–23	2	7– 8	2	0–23	0
7	7–20	6	0–23	10	15– 4	6	0–23	3	0–23	3	0–23	0
8	4–17	7	5– 0	11	6–19	7	0–23	3	0–23	3	0–23	0
9	2–15	8	0–23	13	22–11	8	0–23	3	0–23	4	0–23	0
10	23–12	9	18– 8	14	13– 2	9	0–23	4	0–23	4	0–23	0
11	20–10	10	0–23	16	4–18	10	0–23	4	0–23	5	0–23	1
12	18– 7	11	7–15	17	20– 9	11	0–23	5	0–23	5	0–23	1
13	15– 5	12	0–23	19	11– 1	12	0–23	5	0–23	6	0–23	1
14	12– 2	13	19–22	20	2–16	13	2–10	5	0–23	6	0–23	1
15	10– 0	14	0–23	22	17– 2	14	0–23	6	0–23	7	0–23	1
16	7–21	15	0–23	0	9–23	15	0–23	6	0–23	7	0–23	1
17	4–19	16	0–23	1	0–15	16	0–23	7	0–23	8	0–23	1
18	2–17	17	0–23	3	15– 6	17	0–23	7	0–23	8	0–23	1
19	23–14	18	0–23	4	6–21	18	0–23	8	21– 5	8	0–23	1
20	21–12	19	0–23	6	22–13	19	0–23	8	0–23	9	0–23	1
21	18– 9	20	0–23	7	13– 4	20	0–23	8	0–23	9	0–23	1
22	15– 7	21	0–23	9	4–20	21	0–23	9	0–23	10	0–23	1
23	13– 5	22	0–23	10	19–11	22	0–23	9	0–23	10	0–23	1
24	10– 2	23	0–23	12	11– 3	23	0–23	10	0–23	11	0–23	1
25	7– 0	0	0–23	13	2–18	0	0–23	10	0–23	11	0–23	1
26	5–21	1	0–23	15	17–10	1	0–23	10	0–23	12	0–23	1
27	2–19	2	0–23	16	8– 1	2	0–23	11	0–23	12	0–23	1
28	23–16	3	0–23	18	0–16	3	0–23	11	0–23	13	0–23	1
29	21–14	4	6– 0	19	15– 8	4	0–23	12	0–23	13	0–23	1
30	18–11	5	0–23	21	6–23	5	0–23	12	0–23	14	0–23	2
31	15– 9	6	19– 7	22	22–15	6	0–23	12	0–23	14	0–23	2
32	13– 6	7	0–23	0	13– 6	7	0–23	13	11– 4	14	0–23	2
33	10– 4	8	7–15	1	4–22	8	0–23	13	0–23	15	0–23	2
34	8– 1	9	0–23	3	19–13	9	0–23	14	0–23	15	0–23	2
35	5–23	10	20–22	4	11– 5	10	0–23	14	0–23	16	0–23	2
36	2–21	11	0–23	6	2–20	11	2–20	14	0–23	16	0–23	2
37	0–18	12	0–23	8	17–12	12	0–23	15	0–23	17	0–23	2
38	21–16	13	0–23	9	8– 3	13	0–23	15	0–23	17	0–23	2
39	18–13	14	0–23	11	0–18	14	0–23	16	0–23	18	0–23	2
40	16–11	15	0–23	12	15–10	15	0–23	16	0–23	18	0–23	2
41	13– 8	16	0–23	14	6– 1	16	6– 9	16	0–23	19	0–23	2
42	10– 6	17	0–23	15	21–17	17	0–23	17	0–23	19	0–23	2
43	8– 4	18	0–23	17	13– 8	18	0–23	17	0–23	20	0–23	2
44	5– 1	19	0–23	18	4– 0	19	0–23	18	0–23	20	0–23	2
45	3–23	20	0–23	20	19–15	20	0–23	18	1–23	20	0–23	2
46	0–20	21	0–23	21	10– 6	21	0–23	19	0–23	21	0–23	2
47	21–18	22	0–23	23	2–22	22	0–23	19	0–23	21	0–23	2
48	19–15	23	18–16	0	17–13	23	0–23	19	0–23	22	0–23	2
49	16–13	0	0–23	2	8– 5	0	0–23	20	0–23	22	0–23	3
50	13–10	1	6–23	3	0–20	1	0–23	20	0–23	23	0–23	3
51	11– 8	2	0–23	5	15–12	2	0–23	21	0–23	23	0–23	3
52	8– 5	3	19– 7	6	6– 3	3	0–23	21	0–23	0	0–23	3
(53)	0–23	4	0–23	8	0–23	4	0–23	21	0–23	0	0–23	3

TABLE 33.—*For construction of secondary stencils*—Continued.

Component A	O									
Component B	ρ		Q		2Q					
Page.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.	Component A, hours.	Difference, hours.
		—		—		—		—		—
1	18– 1	2	0–23	3	18–22	5	23–11	6	12–17	7
2	0–23	8	6– 3	9	6– 8	17	9–20	18	21– 5	19
3	18–15	13	18–12	15	18– 6	6	7–17	7	....	....
4	7–19	18	7–22	21	7–16	18	17– 5	19	6	20
5	19–22	23	19– 8	3	19– 1	6	2–14	7	15–18	8
6	0–23	5	7–18	9	7–11	18	12– 0	19	1– 6	20
7	19–12	10	19– 3	15	19–21	6	22–10	7	11–18	8
8	7–16	15	7–13	21	7–19	19	20– 6	20	....	....
9	19	20	19–23	3	19– 5	7	6–18	8	....	....
10	8– 5	2	8	9	8–15	19	16– 3	20	4– 7	21
11	20– 9	7	0–23	16	20– 0	7	1–13	8	14–19	9
12	8–13	12	8– 5	22	8–10	19	11–23	20	0– 7	21
13	0–23	18	20–15	4	20	7	21– 8	8	9–19	9
14	8– 2	23	8– 1	10	8–18	20	19– 7	21	....	....
15	20– 6	4	20–10	16	20– 4	8	5–17	9	18–19	10
16	9	9	9–20	22	9–14	20	15– 2	21	3– 8	22
17	21–19	15	21– 6	4	21–23	8	0–12	9	13–20	10
18	9–23	20	9–15	10	9	20	10–22	21	23– 8	22
19	21– 3	1	21– 1	16	21– 7	9	8–20	10	....	....
20	0–23	7	9–11	22	9–17	21	18– 6	22	7– 8	23
21	21–16	12	0–23	5	21– 3	9	4–16	10	17–20	11
22	10–20	17	10– 8	11	10–12	21	13– 1	22	2– 9	23
23	22– 0	22	22–17	17	22	9	23–11	10	12–21	11
24	0–23	4	10– 3	23	10–21	22	22– 9	23	....	....
25	22–13	9	22–13	5	22– 6	10	7–19	11	20–21	12
26	10–17	14	10–22	11	10–16	22	17– 5	23	6– 9	0
27	22– 6	19	22– 8	17	22– 2	10	3–14	11	15–21	12
28	10– 6	1	10–18	23	10–11	22	12– 0	23	1– 9	0
29	23–10	6	23– 3	5	23–10	11	11–22	12	....	....
30	11–14	11	11–13	11	11–19	23	20– 8	0	9–10	1
31	0–23	17	23	17	23– 5	11	6–18	12	19–22	13
32	11– 3	22	0–23	0	11–15	23	16– 4	0	5–10	10
33	23– 7	3	23–20	6	23– 0	11	1–13	12	14–22	13
34	11	8	11– 5	12	11–23	0	0–10	1	....	....
35	0–20	14	0–15	18	0– 9	12	10–21	13	22–23	14
36	12– 0	19	12– 1	0	12–18	0	19– 7	1	8–11	2
37	0– 4	0	0–10	6	0– 4	12	5–17	13	18–23	14
38	0–23	6	12–20	12	12–14	0	15– 2	1	3–11	2
39	0–17	11	0– 6	18	0–12	13	13–23	14	....	....
40	12–21	16	12–15	0	12–22	1	23–11	2	....	....
41	1	21	1	6	1– 7	13	8–20	14	21– 0	15
42	13–10	3	0–23	13	13–17	1	18– 6	2	7–12	3
43	1–14	8	1–22	19	1– 3	13	4–16	14	17– 0	15
44	13–16	13	13– 8	1	13	1	14– 1	2	2–12	3
45	0–23	19	1–17	7	1–11	14	12– 0	15	....	....
46	13– 7	0	13– 3	13	13–21	2	22– 9	3	10–12	4
47	2–11	5	2–13	19	2– 6	14	7–19	15	20– 1	16
48	14–15	10	14–22	1	14–16	2	17– 5	3	6–13	4
49	2– 0	16	2– 8	7	2	14	3–15	15	16– 1	16
50	14– 4	21	14–18	3	14– 0	3	1–13	4	....	....
51	2– 8	2	2– 3	19	2–10	15	11–23	16	0– 1	17
52	0–23	8	0–23	2	14–20	3	21– 8	4	9–13	5
(53)	4–16	12	4–23	7	4	13	5–16	14	17– 3	15

Table 34.—*For summation of long-period components.*

ASSIGNMENT OF DAILY SUMS FOR COMPONENT Mf.

Component division.	Days of series.													
0	1	28	55	82*	110	137	164*	192	219	246	274	301	328	356
1	2	29	56	84	111	138	166	193	220	248*	275	302	330*	357
2	3	30	57*	85	112	139	167	194	221	249	276	303	331	358
3	4	31	59	86	113	141*	168	195	223*	250	277	304*	332	359
4	5	32	60	87	114	142	169	196	224	251	278	306	333	360
5	6	34*	61	88	115*	143	170	197*	225	252	279	307	334	361
6	7	35	62	89	117	144	171	199	226	253	281*	308	335	363*
7	8*	36	63	90*	118	145	172	200	227	254	282	309	336	364
8	10	37	64	92	119	146	174*	201	228	256*	283	310	337*	365
9	11	38	65	93	120	147	175	202	229	257	284	311	339	366
10	12	39	67*	94	121	149*	176	203	230*	258	285	312*	340	367
11	13	40	68	95	122	150	177	204	232	259	286	314	341	368
12	14	42*	69	96	123*	151	178	205*	233	260	287	315	342	369
13	15	43	70	97	125	152	179	207	234	261	289*	316	343	....
14	16*	44	71	98	126	153	180	208	235	262	290	317	344	....
15	18	45	72	100*	127	154	182*	209	236	263*	291	318	345*	....
16	19	46	73	101	128	155	183	210	237	265	292	319	347	....
17	20	47	75*	102	129	156*	184	211	238*	266	293	320	348	....
18	21	48	76	103	130	158	185	212	240	267	294	322*	349	....
19	22	49*	77	104	131*	159	186	213	241	268	295	323	350	....
20	23	51	78	105	133	160	187	215*	242	269	297*	324	351	....
21	24	52	79	106	134	161	188	216	243	270	298	325	352	....
22	26*	53	80	108*	135	162	189*	217	244	271*	299	326	353	....
23	27	54	81	109	136	163	191	218	245	273	300	327	355*	....

ASSIGNMENT OF DAILY SUMS FOR COMPONENT MSf.

Component division.	Days of series.												
0	1	30	60*	89	119	148	178	207	237	266	296	325	355
1	2	31	61	90	120	149*	179	208*	238	268*	297	327*	356
2	3	33*	62	92*	121	151	180	210	239	269	298	328	357
3	4	34	63	93	122	152	181*	211	240*	270	300*	329	359*
4	5*	35	65*	94	124*	153	183	212	242	271	301	330	360
5	7	36	66	95	125	154	184	213*	243	272*	302	332*	361
6	8	37*	67	96*	126	156*	185	215	244	274	303	333	362
7	9	39	68	98	127	157	186	216	245	275	304*	334	364*
8	10	40	69*	99	128*	158	188*	217	247*	276	306	335	365
9	12*	41	71	100	130	159	189	218	248	277	307	336*	366
10	13	42	72	101*	131	160*	190	220*	249	279*	308	338	367
11	14	44*	73	103	132	162	191	221	250	280	309	339	368*
12	15	45	74	104	133*	163	192*	222	252*	281	311*	340	....
13	17*	46	76*	105	135	164	194	223	253	282	312	341	....
14	18	47	77	106	136	165*	195	224*	254	284*	313	343*	....
15	19	49*	78	108*	137	167	196	226	255	285	314	344	....
16	20	50	79	109	138	168	197*	227	256*	286	316*	345	....
17	21*	51	80*	110	140*	169	199	228	258	287	317	346	....
18	23	52	82	111	141	170	200	229	259	288*	318	348*	....
19	24	53*	83	112*	142	172*	201	231*	260	290	319	349	....
20	25	55	84	114	143	173	202	232	261	291	320*	350	....
21	26	56	85*	115	144*	174	204*	233	263*	292	322	351	....
22	28*	57	87	116	146	175	205	234	264	293	323	352*	....
23	29	58	88	117*	147	176*	206	236*	265	295*	324	354	....

TABLE 34.—*For summation of long-period components*—Continued.

ASSIGNMENT OF DAILY SUMS FOR COMPONENT Mm.

Component division.	Days of series.													
0	1	28	56	83	111	138	166	193	221	249*	276	304	331	359
1	2	29	57	84	112	139*	167	195*	222	250	277	305	332	360
2	3	30	58	85*	113	141	168	196	223	251	278	306	333*	361
3	4	32*	59	87	114	142	169	197	224	252	280*	307	335	362
4	5	33	60	88	115	143	170*	198	226*	253	281	308	336	363
5	6	34	61	89	116*	144	172	199	227	254	282	309	337	364*
6	7	35	63*	90	118	145	173	200	228	255	283	311*	338	366
7	9*	36	64	91	119	146	174	201*	229	257*	284	312	339	367
8	10	37	65	92	120	147*	175	203	230	258	285	313	340	368
9	11	38	66	94*	121	149	176	204	231	259	286	314	342*	369
10	12	40*	67	95	122	150	177	205	232*	260	288*	315	343	...
11	13	41	68	96	123	151	178*	206	234	261	289	316	344	...
12	14	42	69	97	125*	152	180	207	235	262	290	317	345	...
13	15*	43	71*	98	126	153	181	208	236	263*	291	319*	346	...
14	17	44	72	99	127	154	182	209*	237	265	292	320	347	...
15	18	45	73	100	128	156*	183	211	238	266	293	321	348	...
16	19	46*	74	102*	129	157	184	212	239	267	294*	322	350*	...
17	20	48	75	103	130	158	185	213	240*	268	296	323	351	...
18	21	49	76	104	131	159	187*	214	242	269	297	324	352	...
19	22	50	77*	105	133*	160	188	215	243	270	298	325*	353	...
20	23*	51	79	106	134	161	189	216	244	271*	299	327	354	...
21	25	52	80	107	135	162	190	218*	245	273	300	328	355	...
22	26	53	81	108*	136	164*	191	219	246	274	301	329	356*	...
23	27	54*	82	110	137	165	192	220	247	275	302*	330	358	...

ASSIGNMENT OF DAILY SUMS FOR COMPONENT Sa.

Component division.	Days of series.	Component division.	Days of series.
0	1–8 359–369	12	176–190
1	9–23	13	191–205
2	24–38	14	206–221
3	39–53	15	222–236
4	54–69	16	237–251
5	70–84	17	252–266
6	85–99	18	267–282
7	100–114	19	283–297
8	115–129	20	298–312
9	130–145	21	313–327
10	146–160	22	328–342
11	161–175	23	343–358

TABLE 35.—*Products* $\left(a\frac{S}{15}\right)$ *for Form 444.*

Component.	Time meridian in hours = S÷15.							
	1.000	2.000	3.000	4.000	5.000	5.500	6.000	6.500
	Products, in degrees.							
M_2	28.98	57.97	86.95	115.94	144.92	159.41	173.90	188.40
S_2	30.00	60.00	90.00	120.00	150.00	165.00	180.00	195.00
N_2	28.44	58.88	85.32	113.76	142.20	156.42	170.64	184.86
K_1	15.04	30.08	45.12	60.16	75.21	82.73	90.25	97.77
M_4	57.97	115.94	173.90	231.87	289.84	318.83	347.81	16.79
O_1	13.94	27.89	41.83	55.77	69.72	76.69	83.66	90.63
M_6	86.95	173.90	260.86	347.81	74.76	118.24	161.71	205.19
$(MK)_3$	44.03	88.05	132.08	176.10	220.13	242.14	264.15	286.16
S_4	60.00	120.00	180.00	240.00	300.00	330.00	0.00	30.00
$(MN)_4$	57.42	114.85	172.27	229.70	287.12	315.83	344.54	13.25
ν_2	28.51	57.03	85.54	114.05	142.56	156.82	171.08	185.33
S_6	90.00	180.00	270.00	0.00	90.00	135.00	180.00	225.00
μ_2	27.97	55.94	83.90	111.87	139.84	153.83	167.81	181.79
$(2N)_2$	27.90	55.79	83.69	111.58	139.48	153.42	167.37	181.32
$(OO)_1$	16.14	32.28	48.42	64.56	80.70	88.77	96.83	104.90
λ_2	29.46	58.91	88.37	117.82	147.28	162.01	176.73	191.46
S_1	15.00	30.00	45.00	60.00	75.00	82.50	90.00	97.50
M_1	14.50	28.99	43.49	57.99	72.48	79.73	86.98	94.23
J_1	15.59	31.17	46.76	62.34	77.93	85.72	93.51	101.31
Mm	0.54	1.09	1.63	2.18	2.72	2.99	3.27	3.54
Ssa	0.08	0.16	0.25	0.33	0.41	0.45	0.49	0.53
Sa	0.04	0.08	0.12	0.16	0.21	0.23	0.25	0.27
MSf	1.02	2.03	3.05	4.06	5.08	5.59	6.10	6.60
Mf	1.10	2.20	3.29	4.39	5.49	6.04	6.59	7.14
ρ_1	13.47	26.94	40.41	53.89	67.36	74.09	80.83	87.56
Q_1	13.40	26.80	40.20	53.59	66.99	73.69	80.39	97.09
T_2	29.96	59.92	89.88	119.84	149.79	164.77	179.75	194.73
R_2	30.04	60.08	90.12	120.16	150.21	165.23	180.25	195.27
$(2Q)_1$	12.85	25.71	38.56	51.42	64.27	70.70	77.13	83.55
P_1	14.96	29.92	44.88	59.84	74.80	82.27	89.75	97.23
$(2SM)_2$	31.02	62.03	93.05	124.06	155.08	170.59	186.10	201.60
M_3	43.48	86.95	130.43	173.90	217.38	239.12	260.86	282.60
L_2	29.53	59.06	88.59	118.11	147.64	162.41	177.17	191.94
$(2MK)_3$	42.93	85.85	128.78	171.71	214.64	236.10	257.56	279.03
K_2	30.08	60.16	90.25	120.33	150.41	165.45	180.49	195.53
M_8	115.94	231.87	347.81	103.75	219.68	277.65	335.62	33.59
$(MS)_4$	58.98	117.97	176.95	235.94	294.92	324.41	353.90	23.40

TABLE 35.—*Products* $\left(a\frac{S}{15}\right)$ *for Form 444*—Continued.

Component.	7.000	8.000	9.000	10.000	10.500	11.000	11.500	12.000
	Time meridian in hours $=S \div 15$. Products in degrees.							
M_2	202.89	231.87	260.86	289.84	304.33	318.83	333.32	347.81
S_2	210.00	240.00	270.00	300.00	315.00	330.00	345.00	0.00
N_2	199.08	227.52	255.96	284.40	298.62	312.84	327.06	341.28
K_1	105.29	120.33	135.37	150.41	157.93	165.45	172.97	180.49
M_4	45.78	103.75	161.71	219.68	248.67	277.65	306.63	335.62
O_1	97.60	111.54	125.49	139.43	146.40	153.37	160.34	167.32
M_6	248.67	335.62	62.57	149.52	193.00	236.48	279.95	323.43
$(MK)_3$	308.18	352.20	36.23	80.25	102.26	124.28	146.29	168.30
S_4	60.00	120.00	180.00	240.00	270.00	300.00	330.00	0.00
$(MN)_4$	41.97	99.39	156.81	214.24	242.95	271.66	300.37	329.09
ν_2	199.59	228.10	256.61	285.13	299.38	313.64	327.89	342.15
S_6	270.00	0.00	90.00	180.00	225.00	270.00	315.00	0.00
μ_2	195.78	223.75	251.71	279.68	293.67	307.65	321.63	335.62
$(2N)_2$	195.27	223.16	251.06	278.95	292.90	306.85	320.80	334.74
$(OO)_1$	112.97	129.11	145.25	161.39	169.46	177.53	185.60	193.67
λ_2	206.19	235.65	265.10	294.56	309.28	324.01	338.74	353.47
S_1	105.00	120.00	135.00	150.00	157.50	165.00	172.50	180.00
M_1	101.48	115.97	130.47	144.97	152.22	159.46	166.71	173.96
J_1	109.10	124.68	140.27	155.85	163.65	171.44	179.23	187.03
Mm	3.81	4.35	4.90	5.44	5.72	5.99	6.26	6.53
Ssa	0.57	0.66	0.74	0.82	0.86	0.90	0.94	0.99
Sa	0.29	0.33	0.37	0.41	0.43	0.45	0.47	0.49
MSf	7.11	8.13	9.14	10.16	10.67	11.17	11.68	12.19
Mf	7.69	8.78	9.88	10.98	11.53	12.08	12.63	13.18
ρ_1	94.30	107.77	121.24	134.72	141.45	148.19	154.92	161.66
Q_1	93.79	107.19	120.59	133.99	140.69	147.39	154.08	160.78
T_2	209.71	239.67	269.63	299.59	314.57	329.55	344.53	359.51
R_2	210.29	240.33	270.37	300.41	315.43	330.45	345.47	0.49
$(2Q)_1$	89.98	102.83	115.69	128.54	134.97	141.40	147.82	154.25
P_1	104.71	119.67	134.63	149.59	157.07	164.55	172.03	179.51
$(2SM)_2$	217.11	248.13	279.14	310.16	325.67	341.17	356.68	12.19
M_3	304.33	347.81	31.29	74.76	96.50	118.24	139.98	161.71
L_2	206.70	236.23	265.76	295.28	310.05	324.81	339.58	354.34
$(2MK)_3$	300.49	343.42	26.34	69.27	90.73	112.20	133.66	155.13
K_2	210.57	240.66	270.74	300.82	315.86	330.90	345.94	0.99
M_8	91.55	207.49	323.43	79.36	137.33	195.30	253.27	311.24
$(MS)_4$	52.89	111.87	170.86	229.84	259.33	288.83	318.32	347.81

TABLE 36.—*Angle differences for Form 445.*

Component.	Jan. 1, 0h, to Feb. 1, 0h.		Feb. 1, 0h, to Dec. 31, 24h.				Jan. 1, 0h, to Dec. 31, 24h.			
			Common year.		Leap year.		Common year.		Leap year.	
	°	°	°	°	°	°	°	°	°	°
M_2	+324.2	− 35.8	+136.6	−223.4	+112.2	−247.8	+100.8	−259.2	+ 76.4	− 283.6
S_2	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0
N_2	+279	− 81	+93	−267	+ 56	−304	+ 12	− 348	+335	− 25
K_1	+ 31	−329	+329	− 31	+330	− 30	+ 0	− 0	+ 1	− 359
M_4	+288	− 72	+274	− 86	+225	−135	+202	−158	+153	− 207
O_1	+294	− 66	+167	−193	+142	−218	+101	−259	+ 76	− 284
M_6	+253	−107	+ 49	−311	+336	− 24	+302	− 58	+229	− 131
$(MK)_3$	+355	− 5	+106	−254	+ 82	−278	+101	−259	+ 77	− 283
S_4	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0
$(MN)_4$	+243	−117	+230	−130	+168	−192	+113	−247	+ 51	− 309
ν_2	+333	− 27	+317	− 43	+281	− 79	+290	− 70	+254	− 106
S_6	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0
μ_2	+288	− 72	+274	− 86	+225	−135	+202	−158	+153	− 207
$(2N)_2$	+234	−126	+ 49	−311	+359	− 1	+283	− 77	+233	− 127
$(OO)_1$	+127	−233	+131	−229	+159	−201	+258	−102	+286	− 74
λ_2	+315	− 45	+316	− 44	+303	− 57	+271	− 89	+258	− 102
S_1	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0	+ 0	− 0
M_1	+342	− 18	+248	−112	+236	−124	+230	−130	+218	− 142
J_1	+ 76	−284	+ 12	−348	+ 27	−333	+ 88	−272	+103	− 257
Mm	+ 45	−315	+ 44	−316	+ 57	−303	+ 89	−271	+102	− 258
Ssa	+ 61	−299	+299	− 61	+300	− 60	+ 0	− 0	+ 1	− 359
Sa	+ 31	−329	+329	− 31	+330	− 30	+ 0	− 0	+ 1	− 359
MSf	+ 36	−324	+223	−137	+248	−112	+259	−101	+284	− 76
Mf	+ 97	−263	+162	−198	+188	−172	+259	−101	+285	− 75
ρ_1	+303	− 57	+348	− 12	+311	− 49	+291	− 69	+254	− 106
Q_1	+249	−111	+123	−237	+ 85	−275	+ 12	−348	+334	− 26
T_2	+329	− 31	+ 31	−329	+ 30	−330	+ 0	− 0	+259	− 1
R_2	+ 31	−329	+329	− 31	+330	− 30	+ 0	− 0	+ 1	− 359
$(2Q)_1$	+204	−156	+ 80	−280	+ 28	−332	+284	− 76	+232	− 128
P_1	+329	− 31	+ 31	−329	+ 30	−330	+ 0	− 0	+359	− 1
$(2SM)_2$	+ 36	−324	+223	−137	+248	−112	+259	−101	+284	− 76
M_3	+306	− 54	+ 25	−335	+348	− 12	+331	− 29	+294	− 66
L_2	+ 9	−351	+180	−180	+169	−191	+189	−171	+178	− 182
$(2MK)_3$	+258	−102	+304	− 56	+254	−106	+202	−158	+152	− 208
K_2	+ 61	−299	+299	− 61	+300	− 60	+ 0	− 0	+ 1	− 359
M_8	+217	−143	+186	−174	+ 89	−271	+ 43	−317	+306	− 54
$(MS)_4$	+324	− 36	+137	−223	+112	−248	+101	−259	+ 76	− 284

TABLE 37.—*U. S. Coast and Geodetic Survey tide-predicting machine No. 2.*

GENERAL GEARS AND CONNECTING SHAFTS.

Gears and shafts.	Face or diameter.	Number of teeth.	Pitch.	Period of rotation.	Remarks.
	Inches.			*Dial hours.*	
S-1	0.56	....	....	4	Hand crank shaft for operating machine.
G-1	0.56	40	24	4	Spur gear on shaft 1.
G-2	0 50	120	24	12	Spur-stud gear.
G-3	0.50	120	24	12	Spur gear on shaft 2.
S-2	0.50	....	....	12	Short horizontal shaft.
G-4	0.41	72	24	12	Bevel gear on shaft 2.
G-5	0 41	72	24	12	Bevel gear on shaft 3.
S-3	0.50	....	....	12	Diagonal shaft connecting with front component section.
G-6	0.38	75	30	12	Bevel gear on shaft 3.
G-7	0.38	75	30	12	Bevel gear on shaft 4.
S-4	0.38	....	....	12	Short vertical shaft through desk top.
G-8	0.38	75	30	12	Bevel gear on shaft 4.
G-9	0.38	75	30	12	Bevel gear on shaft 5.
S-5	0.38	....	....	12	Short horizontal shaft.
G-10	0.27	75	30	12	Bevel gear on shaft 5.
G-11	0.27	75	30	12	Bevel gear on shaft 6.
S-6	0.38	....	....	12	Main vertical shaft of dial case.
G-12	0.17	60	48	12	Releasable bevel gear on shaft 6.
G-13	0.17	120	48	24	Bevel gear on shaft 7.
S-7	0.15	....	....	24	Intermediate shaft to hour hand.
G-14	0.17	84	48	24	Bevel gear on shaft 7.
G-15	0.17	84	48	24	Bevel gear on shaft 8.
S-8	0.15	....	....	24	Hour-hand shaft.
G-16	0.17	180	48	12	Releasable bevel gear on shaft 6.
G-17	0.17	60	48	4	Bevel gear on shaft 9.
S-9	0.15	....	....	4	Intermediate shaft to minute hand.
G-18	0.17	240	48	4	Bevel gear on shaft 9.
G-19	0.17	60	48	1	Bevel gear on shaft 10.
S-10	0.15	....	....	1	Minute-hand shaft.
G-20	0.17	60	48	12	Releasable bevel gear on shaft 6.
G-21	0.17	120	48	24	Bevel gear on shaft 11.
S-11	0.15	....	....	24	Intermediate shaft to day dial.
G-22	....	1	....	24	Worm screw, 0.56 inch diameter, 18 threads to inch on shaft 11.
G-23	....	366	....	24 × 366	Worm wheel, 6.47 inch diameter, on shaft 12.
S-12	0.31	....	....	24 × 366	Day dial shaft.
G-24	0.25	46	40	12	Spur gear at top of shaft 6.
G-25	0.25	60	40	....	Spur-stud gear.
G-26	0.25	60	40	....	Spur-stud gear connected with gear 25 by ratchet wheel and pawl.
G-27	0.25	46	40	12	Spur gear at lower end of feeding roller.
G-28	0.41	72	24	12	Bevel gear on shaft 3.
G-29	0.41	72	24	12	Bevel gear on shaft 13.
S-13	0.44	....	....	12	Main vertical shaft of front component section.
G-30	0.38	110	30	12	Spur gear on shaft 13.
G-31	0 38	110	30	12	Spur stud gear.
G-32	0.38	110	30	12	Spur stud gear on shaft 14.
S-14	0.38	....	....	12	Front vertical shaft of rear component section.
G-33	0.28	75	30	12	Bevel gear on shaft 14.
G-34	0.28	75	30	12	Bevel gear on shaft 15.
S-15	0.50	....	....	12	Main connecting horizontal shaft of rear component section.
G-35	0.28	75	30	12	Bevel gear on shaft 15.
G-36	0.28	75	30	12	Bevel gear on shaft 16.
S-16	0.38	....	....	12	Rear vertical shaft of rear component section.

TABLE 38.—*U. S. Coast and Geodetic Survey tide-predicting machine No. 2.*

COMPONENT GEARS AND MAXIMUM AMPLITUDE SETTINGS.

Component.	Theoretical speed per hour.	Teeth in gear wheels. Vertical shafts. I	Teeth in gear wheels. Intermediate shafts. II	Teeth in gear wheels. Intermediate shafts. III	Teeth in gear wheels. Component shafts. IV	Gear speed per dial hour.	Error per year.	Maximum amplitude settings of cranks.
	°					°	°	*Units.*
J_1	15.5854433	107	90	52	119	15.5854342	−0.08	1.4
K_1	15.0410686	61	73	51	85	15.0410959	+ .24	11.0
K_2	30.0821372	122	80	96	146	30.0821918	+ .48	3.9
L_2	29.5284788	104	61	56	97	29.5284773	− .01	2.4
*M_1	14.4920521	103	85	59	148	14.4920509	− .01	1.0
M_2	28.9841042	103	74	59	85	28.9841017	− .02	20.0
M_3	43.4761563	86	62	70	67	43.4761675	+ .10	1.4
M_4	57.9682084	118	74	103	85	57.9682035	− .04	4.0
M_6	86.9523126	140	62	86	67	86.9523351	+ .20	1.0
M_8	115.9364168	118	37	103	85	115.9364070	+ .09	0.4
N_2	28.4397296	65	46	53	79	28.4397358	+ .05	6.0
2N	27.8953548	68	58	46	58	27.8953627	+ .07	1.0
O_1	13.9430356	92	89	58	129	13.9430363	+ .01	9.0
OO	16.1391016	134	131	71	135	16.1391009	− .01	0.8
P_1	14.9589314	91	73	50	125	14.9589041	− .24	4.8
Q_1	13.3986609	84	88	51	109	13.3986656	+ .04	3.0
2Q	12.8542862	127	114	50	130	12.8542510	− .31	0.6
R_2	30.0410686	85	50	43	73	30.0410959	+ .24	0.4
S_1	15.0000000	63	75	50	84	15.0000000	.00	2.0
S_2	30.0000000	70	70	70	70	30.0000000	.00	9.8
S_4	60.0000000	75	45	60	50	60.0000000	.00	1.0
S_6	90.0000000	90	48	80	50	90.0000000	.00	0.4
T_2	29.9589314	81	50	45	73	29.9589041	− .24	1.0
λ_2	29.4556254	131	65	57	117	29.4556213	− .04	0.4
μ_2	27.9682084	125	82	74	121	27.9681516	− .50	1.2
ν_2	28.5125830	89	69	70	95	28.5125858	+ .02	2.0
ρ_1	13.4715144	69	70	41	90	13.4714286	− .75	0.8
MK	44.0251728	120	81	105	106	44.0251572	− .14	1.9
2MK	42.9271398	81	52	79	86	42.9271020	− .33	1.4
MN	57.4238338	135	42	53	89	57.4237560	− .68	0.7
MS	58.9841042	118	61	62	61	58.9841440	− .35	2.0
2SM	31.0158958	69	47	50	71	31.0158825	− .12	1.4
Mf	1.0980330	84	45	1	51	1.0980392	+ .05	4.0
MSf	1.0158958	149	80	1	55	1.0159091	+ .12	2.0
Mm	0.5443747	93	41	1	125	0.5443902	+ .14	3.0
Sa	0.0410686	51	149 125	1 60	 120	0.0410738	+ .05	8.0
Ssa	0.0821372	51	149	1	125	0.0821477	+ .09	3.0

*Designed for one-half of speed of M_2.

TABLE 39.—*Synodic periods of components.*

DIURNAL COMPONENTS.

	J_1	K_1	M_1	O_1	OO	P_1	Q_1	2Q	S_1
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
K_1	27.555								
M_1	13.777	27.555							
O_1	9.133	13.661	27.555						
OO	27.093	13.661	9.133	6.830					
P_1	23.942	182.621	32.451	14.765	12.710				
Q_1	6.859	9.133	13.661	27.555	5.474	9.614			
2Q	5.492	6.859	9.133	13.777	4.566	7.127	27.555		
S_1	25.622	365.243	29.803	14.192	13.168	365.243	9.367	6.991	
ρ_1	7.096	9.557	14.632	31.812	5.623	10.085	205.892	24.302	9.814

SEMIDIURNAL COMPONENTS.

	K_2	L_2	M_2	N_2	2N	R_2	S_2	T_2	λ_2	μ_2	ν_2
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
L_2	27.093										
M_2	13.661	27.555									
N_2	9.133	13.777	27.555								
2N	6.859	9.185	13.777	27.555							
R_2	365.225	29.263	14.192	9.367	6.991						
S_2	182.621	31.812	14.765	9.614	7.127	365.259					
T_2	121.748	34.847	15.387	9.874	7.269	182.630	365.259				
λ_2	23.942	205.892	31.812	14.765	9.614	25.622	27.555	29.803			
μ_2	7.096	9.614	14.765	31.812	205.892	7.236	7.383	7.535	10.085		
ν_2	9.557	14.765	31.812	205.892	24.302	9.814	10.085	10.371	15.906	27.555	
2SM	16.064	10.085	7.383	5.823	4.807	15.387	14.765	14.192	9.614	4.922	5.992

TABLE 40.—*Day of the common year corresponding to day of month.*

[For leap year increase all numbers after February 29 by one day.]

Day of month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

Part III.—TIDAL HARMONIC CONSTANTS.

TIDAL HARMONIC CONSTANTS.

The tidal harmonic constants given on the following pages have been compiled from various sources, which are indicated by the references at the bottom of each column. All amplitudes have been reduced to feet, and the epochs have been referred to the local meridians. Values inclosed in parentheses have been inferred.

The combined length of the series, together with the first and last year of the observations from which the constants were derived, is indicated for each station. In combining the results from several series of observations at any place the usual practice has been to take separately the direct means of the amplitudes and epochs.

A more precise method was used for combining the results for the components Mf, MSf, and Mm as derived from the different series of observations at the stations in India, where observations covering periods of many years have been analyzed. This method consists of the use of the following formulas:

$$\text{Mean amplitude of component } A = \sqrt{\left(\frac{1}{n}\,\Sigma H_a \cos \kappa_a\right)^2 + \left(\frac{1}{n}\,\Sigma H_a \sin \kappa_a\right)^2}$$

and

$$\text{Mean epoch of component } A = \tan^{-1} \frac{\Sigma H_a \sin \kappa_a}{\Sigma H_a \cos \kappa_a}$$

n being the number of individual results combined and H_a and κ_a the amplitude and epoch, respectively, of any component A as derived from each series of observations.

The sources from which the constants have been compiled, together with the corresponding reference number used in the compilation, are given below. The cooperation of all those who have so courteously furnished the harmonic constants for various ports is very much appreciated by the U. S. Coast and Geodetic Survey. It is hoped that this cooperation will be continued, and all persons who may secure additional constants for any station are invited to send a copy of the same to the Director, U. S. Coast and Geodetic Survey, Washington, D. C.

References.

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(2) Proceedings of the Royal Society of London, vol. 45, 1888–89.
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(5) Resultater af Vanstands-Observationer paa den Norske Kyst, Hefte VI, 1904.
(6) Bihang till Kongl. Svenska Vetenskaps-Akademiens Hadlinger, vol. 15, part I, No. 11, 1889–90. (There is probably an error of 180° in the kappas of the diurnal components which has not been corrected.)

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(8) Tables des Marees des Colonies Francaises de L'Atlantique, pour 1923.
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ARCTIC REGIONS.

Component.	Jan Mayen Island (71° 00′ N., 8° 28′ W.).		Greenland. Nennortolik (60° 08′ N., 45° 16′ W.).		Godthaab, Davis Strait (64° 12′ N., 51° 44′ W.).		Port Foulke (78° 18′ N., 73° 00′ W.).		Rensselaer (78° 37′ N., 70° 53′ W.).		Polaris Bay (81° 36′ N., 61° 40′ W.).		Cape Bryant (80° 21′ N., 55° 30′ W.).		Grant Land. Cape Sheridan (82° 27′ N., 61° 21′ W.).		Fort Conger[1] (81° 44′ N., 64° 44′ W.).		Point Aldrich (83° 07′ N., 69° 44′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1							(0.059)	(208)	(0.048)	(215)	(0.023)	(264)	(0.018)	(298)	(0.009)	(307)			(0.010)	(326)
K_1	0.105	97	0.62	114	0.69	127	1.046	187	0.851	193	0.403	246	0.323	286	0.157	298	0.280	222	0.171	311
K_2	0.117	18			0.43	227	(0.414)	(5)	(0.406)	(12)	(0.225)	(33)	(0.063)	(47)	0.104	348	0.300	17	(0.044)	(284)
L_2	0.041	357			0.13	291	(0.102)	(351)	(0.094)	(4)	0.063	34	(0.012)	(18)	0.025	329	0.066	18	(0.011)	(265)
M_1							(0.052	(166)	(0.046)	(172)	(0.020)	(227)	(0.016)	(274)	(0.009)	(288)	0.009	276	(0.010)	(296)
M_2	1.319	328	2.88	161	4.46	193	3.640	322	3.374	333	1.795	352	0.420	4	0.803	303	1.962	335	0.377	230
M_3																	0.032	235		
M_4	0.004	358					0.048	108	0 058	185	0.017	31	0.018	320	0.013	354	0.018	322	0.009	285
M_6	0.017	270					0.060	166	0.039	142	0.006	118	0.008	274	0.008	183			0.004	184
M_8									0.018	145										
N_2	0.281	300			0.86	188	0.669	293	0.703	303	0.353	326	0.079	350	0.142	276	0.378	309	0.063	194
$2N$	0.037	271					(0.089)	(264)	(0.093)	(273)	(0.047)	(300)	(0.010)	(336)	(0.019)	(248)			(0.008)	(159)
O_1	0.196	49	0.36	74	0.30	81	0.407	145	0.421	150	0.151	209	0.135	262	0.088	279	0.092	199	0.108	281
OO							(0.032)	(229)	(0.026)	(237)	(0.012)	(283)	(0.010)	(311)	(0.005)	(316)			(0.005)	(341)
P_1	0.035	97			0.23	125	(0.346)	(187)	(0.282)	(193)	(0.133)	(246)	(0.107)	(286)	0.053	296	0.077	233	(0.057)	(311)
Q_1							(0.079)	(124)	(0.082)	(128)	0.019	260	(0.026)	(249)	0.014	267	0.003	102	0.014	266
$2Q$							(0.011)	(103)	(0.011)	(107)	(0.004)	(172)	(0.004)	(237)	(0.002)	(260)			(0.003)	(251)
R_2							(0.012)	(5)	(0.012)	(12)	(0.007)	(33)	(0.002)	(47)	(0.003)	(351)			(0.001)	(284)
S_1																	0.020	66		
S_2	0.430	18	1.24	203	1.54	229	1.521	5	1.494	12	0 827	33	0.232	47	0.378	351	0.889	19	0.164	284
S_4									0.051	346					0.004	133			0.004	104
S_6									0.020	329										
T_2							(0.090)	(5)	(0.088)	(12)	(0.049)	(33)	(0.014)	(47)	0.034	36			(0.010)	(284)
λ_2							(0.026)	(342)	(0.024)	(351)	(0.013)	(11)	(0.003)	(24)	(0 006)	(325)			(0.003)	(255)
μ_2	.032	278					(0.087)	(279)	(0.081)	(295)	0.058	299	(0.010)	(320)	0.017	238	0.043	288	(0.009)	(176)
ν_2							(0.130)	(297)	(0.136)	(307)	(0.068)	(330)	(0.015)	(352)	0.032	284	0.021	326	(0.012)	(199)
ρ_1							(0.015)	(127)	(0.016)	(131)	(0.006)	(193)	(0.005)	(251)	(0.003)	(271)			(0.004)	(268)
Series	1883		1882		1883		1860–61		1853–54		1871–72		1909		1905–09		1881–82		1908	
Length	104½ days.				47 days.		58 days.		116 days.		174 days.		29 days.		220 days.		369 days.		29 days.	
Reference	(1)		(2)		(2)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long period components see p. 403.

ARCTIC REGIONS—Continued.

Component.	Baffin Land.				North Devon, Beechey Island, (74° 43′ N., 91° 54′ W.).		Grinnell Land, Penny Strait, (76° 52′ N., 97° 00′ W.).		North Somerset, Port Leopold, (73° 50′ N., 90° 20′ W.).		Bellot Strait, Port Kennedy, (72° 01′ N., 94° 15′ W.).		Melville Island, Winter Harbor, (74° 47′ N., 111° 00′ W.).		Alaska.[1]				Siberia,[2] Pitlekaj, (67° 03′ N., 173° 30′ W.).	
	Kingua Fiord, (66° 36′ N., 67° 20′ W.).		Bowdoin Harbor, (64° 24′ N., 77° 52′ W.)												Flaxman Is., (70° 11′ N., 145° 50′ W.).		Point Barrow, (71° 18′ N., 156° 40′ W.).			
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			(0.015)	(154)			(0.017)	(304)			(0.066)	(278)	(0.012)	(336)	0.004	349	(0.004)	(330)		
K_1	0.27	32	0.270	144	0.901	243	0.307	274	0.899	216	1.180	245	0.219	267	0.077	7	0.054	347	0.038	233
K_2	0.76	199	(0.633)	(3)	0.151	54	(0.061)	(32)	0.175	29	(0.162)	(49)	(0.193)	(83)	0.010	62	(0.018)	(16)	0.009	60
L_2	0.16	167	0.244	342	0.080	47	(0.018)	(18)	0.044	3	(0.050)	(54)	(0.034)	(72)	0.006	18	(0.004)	(1)	0.002	34
M_1			0.009	309					0.045	230	(0.063)	(212)			0.006	26	(0.004)	(3)		
M_2	7.43	159	6.808	305	1.996	347	0.661	0	2.001	338	1.802	356	1.208	34	0.218	354	0.165	336	0.083	4
M_3			0.059	204							0.103	119								
M_4			0.178	94	0.024	268	0.005	62	0.015	202	0.094	214	0.004	97	0.007	274	0.003	319	0.005	144
M_6			0.095	322			0.002	96			0.060	164	0.005	283	0.004	141	0.003	106	0.009	3
M_8			0.004	104							0.020	21								
N_2	1.20	144	1.360	276	0.429	315	0.126	342	0.420	306	0.278	299	0.168	355	0.030	331	0.028	312	0.016	334
2N			(0.181)	(247)			(0.017)	(324)			(0.037)	(241)	(0.022)	(316)	0.004	307	(0.004)	(287)	0.002	304
O_1	0.88	47	0.201	123	0.488	162	0.148	213	0.443	164	0.578	178	0.104	130	0.088	45	0.053	20	0.042	243
OO			(0.008)	164			(0.010)	(335)			(0.037)	(312)	(0.007)	(45)	0.002	330	(0.002)	(313)		
P_1	0.84	38	0.145	154	0.215	222	(0.102)	(274)	0.216	218	(0.391)	(245)	(0.073)	(267)	0.026	7	(0.018)	(347)	0.012	233
Q_1			0.020	117			(0.029)	(183)			(0.112)	(145)	(0.020)	(61)	0.029	50	(0.010)	(36)		
2Q			(0.005)	(103)			(0.004)	(153)			(0.015)	(112)	(0.003)	(353)	0.023	82	(0.001)	(53)		
R_2			(0.019)	(3)			(0.002)	(32)			(0.005)	(49)	(0.006)	(83)	0.001	37	(0.001)	(16)		
S_1			0.028	186					0.031	27							0.006	237	0.006	58
S_2	2.67	202	2.326	3	0.686	34	0.226	32	0.643	29	0.595	49	0.709	83	0.094	37	0.065	16	0.031	60
S_4			0.017	156					0.007	257	0.024	22								
S_6			0.014	288							0.015	9								
T_2			(0.137)	(3)			(0.013)	(32)			(0.035)	(49)	(0.042)	(83)	0.006	37	(0.004)	(16)		
λ_2			(0.048)	(332)			(0.005)	(15)			(0.013)	(21)	(0.008)	(56)	0.002	14	(0.001)	(354)		
μ_2			(0.163)	(248)			(0.016)	(328)			(0.043)	(303)	(0.029)	(344)	0.005	311	(0.004)	(297)	0.002	308
ν_2			(0.264)	(280)			(0.024)	(344)			(0.054)	(306)	(0.033)	(0)	0.006	334	(0.005)	(315)		
ρ_1			(0.008)	(114)			(0.006)	(187)			(0.022)	(150)	(0.004)	(71)	0.003	61	(0.002)	(34)		
Series	1883		1922		1858–59		1853		1848–49		1859		1820		1906		1883		1878–79	
Length	6 weeks.		29 days.		119 days.		29 days.		9 months.		29 days.		29 days.		58 days.		104½ days.		162½ days.	
Reference	(2)		(1)		(3)		(1)		(3)		(1)		(1)		(1)		(1)		(1)	

[1] For other stations in Alaska see pp. 336–340.

[2] For other stations in Siberia see p. 340.

ARCTIC REGIONS—Continued.

Component.	Franz Josef Land.				Spitzbergen.						Russia.[1]		Norway.[2]							
	Teplitz Bay (81° 47′ N., 57° 59′ E.).		Cape Flora (79° 57′ N., 49° 59′ E.).		Treurenberg (80° 00′ N., 16° 52′ E.).		Mossel Bay (79° 53′ N., 16° 04′ E.).		Port Virgo (79° 43′ N., 10° 52′ E.).		Ekaterinskaya[3] (69° 13′ N., 33° 27′ E.).		Vardo[3] (70° 20′ N., 31° 06′ E.).		Fineide[3] (67° 17′ N., 15° 30′ E.).		Kabelvaag[3] (68° 13′ N., 14° 30′ E.).		Bodo[3] (67° 17′ N., 14° 23′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1					(0.013)	(191)			(0.005)	(138)										
K_1	0.101	26	0.224	30	0.240	270	0.233	65	0.090	215	0.430	294	0.384	286	0.261	250	0.344	212	0.340	208
K_2					(0.094)	(150)	0.124	118	0.267	91	0.320	232	0.266	204	0.126	100	0.292	37	0.287	36
L_2	0.019	197	0.015	297	(0.026)	(126)	0.045	191	(0.044)	(63)			1.181	229	0.125	63	0.066	35	0.059	7
M_1					(0.011)	(170)			(0.005)	(294)										
M_2	0.508	178	0.435	279	0.916	98	1.151	74	1.363	38	3.810	191	3.291	164	1.736	57	2.979	4	2.840	356
M_3					0.018	268														
M_4	0.005	357	0.006	189	0.032	127			0.006	168			0.039	202	0.039	61	0.141	323	0.162	292
M_6	0.004	265	0.008	162	0.038	61			0.016	107					0.039	179				
M_8					0.006	280														
N_2	0.097	155	0.083	245	0.234	71	0.215	42	0.250	13	0.810	162	0.717	130	0.341	36	0.610	340	0.568	334
2N					(0.031)	(44)			(0.033)	(348)										
O_1	0.042	49	0.073	47	0.071	70	0.090	239	0.040	12	0.090	97	0.097	92	0.085	102	0.128	54	0.128	32
OO					(0.007)	(110)			(0.003)	(59)										
P_1					(0.079)	(270)	0.072	63	(0.030)	(215)	0.110	287	0.115	282	0.074	236	0.090	202	0.095	194
Q_1					0.033	63			(0.008)	(90)	0.080	49			0.046	32			0.056	333
2Q					(0.002)	(228)			(0.001)	(168)										
R_2					(0.003)	(150)			(0.002)	(70)			0.036	176			0.056	350		
S_1													0.016	182	0.025	141	0.039	130		
S_2	0.208	229	0.145	333	0.347	150	0.432	121	0.259	70	1.110	235	0.919	208	0.504	106	1.078	44	0.981	35
S_4					0.016	199														
S_6					0.001	270														
T_2					(0.020)	(150)			(0.015)	(70)			0.043	212			0.089	82		
λ_2					(0.006)	(122)			(0.010)	(53)										
μ_2					(0.022)	(47)			(0.033)	(349)			0.100	109	0 108	154	0.066	296	0.105	290
ν_2					(0.045)	(75)			(0.048)	(17)			0.144	138	0.054	32	0.166	342	0.141	310
ρ_1					(0.003)	(139)			(0.002)	(80)										
Series	1904		1904		1900		1872–73		1897				1881–1892		1896–1898		1884–1890		1896–1900	
Length	58 days.		104½ days.		104½ days.		104 days.		29 days.				2 years.		2 years.		2 years.		2 years.	
Reference	(1)		(1)		(1)		(6)		(1)		(66)		(5)		(5)		(5)		(5)	

[1] See also page 402.

[2] See also page 399.

[3] For compound and long-period components see page 403

BRITISH AMERICA.

Component.	Hudson Strait.										East coast.									
	Port Laperriere, Digges Is., (62° 34′ N., 78° 01′ W.).		Port Boncherville, Nottingham, I., (63° 12′ N., 77° 28′ W.).		Stuparts Bay, (61° 35′ N., 71° 32′ W.).		Ashe Inlet, (62° 33′ N., 70° 35′ W.).		Port Burwell, Ungava Bay, (60° 25′ N., 64° 46′ W.).		Forteau Bay,[1] Belle Isle Strait, (51° 27′ N., 56° 23′ W.).		St. Johns,[1] Newfoundland, (47° 34′ N., 52° 41′ W.).		S. W. Point,[1] Anticosti, Is., (49° 24′ N., 63° 36′ W.).		Father Point,[1] St. Lawrence R., (48° 31′ N., 68° 28′ W.).		Quebec,[1] St. Lawrence R., (46° 49′ N., 71° 11′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1											0.021	158			0.039	223	0.048	210	0.028	321
K_1	0.14	64	0.22	91	0.47	103	0.52	108	0.48	114	0.341	184	0.248	108	0.592	207	0.772	208	0.735	273
K_2	0.34	316	0.48	321	0.83	289	1.08	296	0.64	305	0.144	311	0.120	259	0.126	85	0.400	102	0.446	235
L_2											0.018	241	0.020	211	0.047	36	0.088	90	0.475	222
M_1											0.011	202			0.028	207	0.048	186	0.039	278
M_2	3.09	257	4.74	260	9.02	227	11.00	234	7.12	263	1.338	293	1.172	210	1.658	41	4.173	62	5.846	186
M_3											0.021	4	0.039	75	0.005	239	0.017	354	0.043	341
M_4											0.062	64	0.020	48	0.035	297	0.042	88	0.899	284
M_6											0.021	62	0.020	344	0.039	258	0.019	115	0.222	262
M_8											0.004	112	0.006	346	0.008	47	0.009	158	0.156	10
N_2											0.272	267	0.232	195	0.361	21	0.886	35	0.966	158
2N											0.038	242			0.049	29	0.121	28	0.178	138
O_1	0.04	126	0.25	17	0.31	6	0.21	349	0.19	157	0.274	166	0.229	77	0.564	181	0.712	184	0.686	248
OO													(0.010)	(140)						
P_1	0.05	64	0.07	91	0.16	103	0.17	108	0.16	114	0.106	184	0.083	86	0.207	211	0.263	206	0.166	284
Q_1											0.040	148	(0.045)	(61)	0.102	153	0.110	152	0.101	225
2Q													(0.006)	(45)						
R_2													(0.004)	(256)						
S_1											0.017	151			0.029	248	0.050	223	0.049	256
S_2	1.24	316	1.77	321	3.05	289	3.98	296	2.33	305	0.462	315	0.480	254	0.481	81	1.368	103	1.375	235
S_4											0.016	62	0.004	349	0.005	322	0.009	75	0.045	47
S_6													0.003	342						
T_2													(0.029)	(252)						
λ_2													(0.008)	(230)						
μ_2											0.028	226	(0.028)	(165)	0.054	15	0.178	9	0.340	313
ν_2											0.061	252	(0.045)	(197)	0.072	5	0.165	26	0.315	168
ρ_1													(0.087)	(53)						
Series	1886		1886		1886		1886		1885		1898–1904		1880		1894–1898		1897–1917		1894–1914	
Length	2 weeks.		1 month.		2 weeks.		1 month.		2 weeks.		5 years.		236 days.		4 years.		15 years.		14 years.	
Reference	(2)		(2)		(2)		(2)		(2)		(7)		(1)		(7)		(7)		(7)	

[1] For compound and long period components see p. 403.

BRITISH AMERICA AND UNITED STATES.

Component.	British America, East Coast—Continued.								Maine.						Massachusetts.					
	Charlottetown,[1] Prince Edward Is. (46° 13′ N., 63° 08′ W.).		St. Paul Is.,[1] Cabot Strait (47° 13′ N., 60° 09′ W.).		Halifax,[1] Nova Scotia (44° 39′ N., 63° 35′ W.).		St. John,[1] New Brunswick (45° 16′ N., 66° 03′ W.).		Eastport[1] (44° 54′ N., 66° 59′ W.).		Pulpit Harbor[1] (44° 09′ N., 68° 53′ W.).		Portland[1] (43° 39′ N., 70° 15′ W.).		Boston,[1] Commonwealth Pier No. 5 (42° 21′ N., 71° 03′ W.).		Cape Cod Canal, east entrance (41° 46′ N., 70° 30′ W.).		Cape Cod Canal, west entrance (41° 44′ N., 70° 37′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet*	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*
J_1	0.049	265	0.019	236	0.032	74	0.033	128	...	...	0.018	109	(0.026)	(142)	(0.025)	(142)	(0.026)	(144)	(0.013)	(92)
K_1	0.831	264	0.275	236	0.335	58	0.498	128	0.480	129	0.457	129	0.462	132	0.449	134	0.462	136	0.241	99
K_2	0.199	6	0.089	284	0.136	252	0.449	4	0.369	2	0.212	356	0.189	358	0.350	21	(0.165)	(4)	(0.110)	(246)
L_2	0.101	296	0.025	232	0.063	242	0.596	5	0.392	342	0.239	10	0.183	22	0.264	15	(0.125)	(5)	(0.050)	(242)
M_1	0.039	242	0.018	217	0.016	40	0.025	114	...	...	0.021	135	0.013	115	0.023	117	(0.030)	(127)	(0.015)	(107)
M_2	2.383	296	1.009	245	2.090	221	9.791	326	8.576	326	4.899	320	4.372	324	4.371	330	4.468	331	1.797	224
M_3	0.021	334	0.008	107	...	...	0.020	208	...	...	0.005	189	0.005	186	0.008	299	...	...	...	...
M_4	0.063	48	0.017	184	0.112	17	0.119	150	0.208	180	0.023	137	0.033	79	0.072	107	0.082	81	0.351	130
M_6	0.044	199	0.004	234	0.011	70	0.097	179	0.171	242	0.128	58	0.047	73	0.123	232	0.174	241	0.039	218
M_8	0.012	294	0.003	89	...	...	0.016	157	...	...	0.015	330	0.015	308	0.028	19	...	...	...	...
N_2	0.514	266	0.210	222	0.470	199	2.009	295	1.725	298	1.049	288	0.949	292	0.995	300	0.913	297	0.412	206
2N	0.109	221	0.029	186	0.061	187	0.312	239	...	...	...	...	(0.126)	(261)	0.115	287	(0.121)	(264)	(0.055)	(188)
O_1	0.747	233	0.305	205	0.151	28	0.372	109	0.377	111	0.365	108	0.353	111	0.348	117	0.365	119	0.164	114
OO	...	...	...	...	...	...	...	...	...	...	...	...	(0.014)	(153)	(0.014)	(151)	(0.014)	(153)	(0.007)	(84)
P_1	0.243	269	0.093	236	0.112	55	0.162	130	0.144	134	0.153	131	0.138	130	0.158	135	(0.153)	(136)	(0.080)	(99)
Q_1	0.115	201	0.054	169	0.019	67	0.061	95	0.059	99	0.061	95	0.062	79	0.070	110	(0.071)	(110)	(0.032)	(122)
2Q	...	...	...	...	...	...	...	...	...	...	...	...	(0.009)	(90)	(0.009)	(100)	(0.009)	(102)	(0.004)	(129)
R_2	...	...	...	...	...	...	...	...	...	...	0.035	207	(0.005)	(0)	(0.006)	(5)	(0.005)	(4)	(0.003)	(246)
S_1	0.026	323	0.025	265	0.024	24	0.037	106	...	...	0.016	74	0.024	89	0,017	76	...	...	...	...
S_2	0.609	4	0.325	286	0.464	253	1.638	4	1.399	6	0.777	355	0.699	0	0.699	5	0.608	4	0.404	246
S_4	0.005	145	0.004	145	0.022	319	0.006	204	...	...	0.004	342	0.003	185	0.003	210	0.009	212	0.055	21
S_6	...	...	...	...	...	...	...	...	...	...	...	...	0.005	109	0.007	190	...	...	...	...
T_2	...	...	...	...	...	...	...	...	...	...	0.113	34	(0.041)	(0)	0.221	351	(0.036)	(4)	(0.024)	(246)
λ_2	...	...	...	...	...	...	...	...	...	...	0.086	3	0.077	347	0.046	16	(0.031)	(346)	(0.013)	(234)
μ_2	0.114	288	0.041	211	0.066	201	0.109	88	0.067	78	0.050	226	0.020	201	0.045	271	(0.106)	(298)	(0.043)	(202)
ν_2	0.109	253	0.040	209	0.117	213	0.491	306	0.413	299	0.244	292	0.220	300	0.218	310	(0.177)	(302)	(0.080)	(208)
ρ_1	...	...	...	...	...	...	...	...	...	...	...	...	0.013	102	(0.013)	(110)	(0.014)	(112)	(0.006)	(121)
Series	1907–1919		1895–1918		1895–1906		1894–1915		1862–1863		1871–1875		1864–1916		1922–1923		1913		1913	
Length	10 years.		19 years.		9 years.		20 years.		369 days.		5 years.		2 years.		369 days.		58 days.		58 days.	
Reference	(7)		(7)		(7)		(7)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long period components see p. 403.

UNITED STATES, EAST COAST.

Component.	Rhode Island.						Connecticut.				New York.									
	Newport,[1] Fort Adams (41° 29′ N., 71° 20′ W.).		Bristol[1] (41° 40′ N., 71° 16′ W.).		Providence[1] (41° 49′ N., 71° 24′ W.).		New London,[1] Fort Trumbull (41° 21′ N., 72° 06′ W.).		New London,[1] Naval Station (41° 24′ N., 72° 06′ W.).		Willets Point,[1] U.S.E. Wharf (40° 48′ N., 73° 46′ W.).		Fort Hamilton[1] (40° 36′ N., 74° 02′ W.).		New York,[1] Governors I. (40° 41′ N., 74° 01′ W.).		New York,[1] The Battery (40° 42′ N., 74° 01′ W.).		Albany,[1] Hudson R. (42° 39′ N., 73° 45′ W.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																	(0.018)	(106)	(0.011)	(284)
K_1	0.209	96	0.208	94	0.237	99	0.249	112	0.225	109	0.339	119	0.322	104	0.325	106	0.327	106	0.203	281
K_2	0.098	239	0.130	241	0.120	247	0.065	285	0.072	279	0.146	359	0.140	240	0.118	255	0.107	255	0.053	210
L_2	0.016	210	0.021	173	0.076	226	0.057	339	0.028	357	0.300	3	0.103	232	0.129	249	0.077	248	0.134	172
M_1	0.008	70					0.002	300	0.008	169	0.020	166	0.008	105	0.016	104	0.011	205	0.016	333
M_2	1.661	218	1.896	223	2.019	228	1.136	274	1.157	278	3.649	329	2.210	221	2.153	231	2.112	233	1.018	172
M_3													0.026	202			0.033	198	0.014	244
M_4	0.179	120	0.292	135	0.344	150	0.064	62	0.077	79	0.096	211	0.029	339	0.087	332	0.055	333	0.130	254
M_6	0.011	127	0.036	245	0.087	265	0.039	134	0.043	164	0.210	84	0.052	35	0.076	89	0.071	81	0.034	171
M_8													0.013	80			0.012	86	0.023	245
N_2	0.365	200	0.421	206	0.492	208	0.266	247	0.243	253	0.744	304	0.478	204	0.496	211	0.487	213	0.188	154
2N							(0.035)	(220)	(0.032)	(228)							(0.065)	(193)	(0.025)	(136)
O_1	0.164	124	0.158	131	0.158	118	0.181	137	0.168	138	0.198	150	0.172	98	0.161	104	0.176	106	0.143	275
OO																	(0.010)	(106)	(0.006)	(286)
P_1	0.069	115	0.090	94	0.089	103	0.074	113	0.097	121	0.091	134	0.098	106	0.105	104	0.102	106	0.090	265
Q_1	0.047	116			0.034	103	0.023	132	(0.033)	(152)			0.031	87	(0.031)	(103)	0.046	138	0.015	283
2Q																	(0.005)	(106)	0.004	270
R_2																	(0.003)	(259)	0.001	203
S_1			0.027	110	0.045	57							0.040	64			0.049	67	0.088	184
S_2	0.384	237	0.435	245	0.440	253	0.214	288	0.216	290	0.644	352	0.445	248	0.413	257	0.416	259	0.124	203
S_4													0.038	70			0.043	79	0.009	286
S_6													0.004	141			0.005	186	0.004	124
T_2	0.023	237					0.013	288	(0.012)	(290)			0.110	157	0.073	183	(0.025)	(259)	0.033	255
λ_2	0.012	233					(0.008)	(281)	(0.008)	(284)			0.043	197	0.025	186	(0.015)	(245)	(0.007)	(186)
μ_2	0.078	199					0.042	191	(0.028)	(226)			0.061	235	0.063	217	(0.051)	(208)	0.075	305
ν_2	0.060	204	0.034	225	0.073	239	0.043	257	(0.056)	(295)	0.112	312	0.095	203	0.093	241	(0.094)	(216)	0.034	177
ρ_1																	(0.007)	(106)	(0.005)	(273)
Series	1892–93		1890–91		1886–87		1882–83		1899–1900		1891–1894		1900–1904		1876–1878		1920–21		1914–15	
Length	369 days.		369 days.		369 days.		369 days.		369 days.		2 years.		2 years.		3 years.		369 days.		369 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long period components see pp. 403–404.

UNITED STATES, EAST COAST—Continued.

Component.	New Jersey.				Pennsylvania.				Delaware, Breakwater Harbor [1] (38° 48′ N., 75° 06′ W.).		Virginia.								District of Columbia, Washington [1] Navy Yard (38° 52′ N., 77° 00′ W.).	
	Sandy Hook [1] (40° 27′ N., 74° 00′ W.).		Atlantic City,[1] Million Dollar Pier (39° 21′ N., 74° 26′ W.).		Philadelphia, Washington Ave. (39° 56′ N., 75° 09′ W.).		Philadelphia,[1] Chestnut St. (39° 57′ N., 75° 09′ W.).				Old Point Comfort [1] (37° 00′ N., 76° 19′ W.).		Richmond,[1] James River 37° 32′ N., 77° 25′ W.).		Stingray Light [1] (37° 34′ N., 76° 16′ W.).		Great Wicomico Light (37° 48′ N., 76° 16′ W.).			
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.019)	(104)	(0.019)	(115)			(0.020)	(225)	(0.019)	(132)			(0.011)	(227)					(0.007)	(257)
K_1	0.333	102	0.338	107	0.354	214	0.316	218	0.340	125	0.186	119	0.202	238	0.086	133	0.078	157	0.155	272
K_2	0.123	243	0.107	232	0.070	97	0.091	78	0.099	272	0.062	277	0.061	173	(0.023)	(325)	(0.023)	(357)	0.071	253
L_2	0.110	203	0.054	174	0.304	45	0.210	61	0.076	278	0.064	270	0.216	148	(0.016)	(331)	(0.017)	(353)	0.112	262
M_1	0.016	119	0.016	119			0.025	329	0.010	109			0.018	238	(0.006)	(162)	(0.006)	(176)	0.008	88
M_2	2.219	218	1.912	207	2.462	43	2.367	49	1.942	240	1.220	248	1.723	122	0.529	296	0.507	337	1.421	226
M_3			0.024	179			0.018	195	0.012	213			0.026	136						
M_4	0.026	336	0.025	272	0.366	359	0.368	7	0.035	229	0.039	244	0.211	140	0.008	171	0.033	191	0.083	355
M_6	0.054	353	0.018	353	0.123	194	0.112	206	0.019	261	0.016	191	0.089	95	0.006	117	0.013	306	0.021	82
M_8			0.002	274			0 069	156	0.003	348			0.034	122						
N_2	0.503	201	0.449	190	0.407	20	0.388	28	0.433	218	0.269	226	0.317	97	0.112	261	0.114	322	0.294	200
2N	(0.067)	(184)	(0.050)	(173)			(0.052)	(7)	0.057	170			(0.042)	(72)	(0.015)	(226)	(0.015)	(307)	(0.055)	(188)
O_1	0.172	98	0.251	91	0.264	195	0.252	203	0.260	112	0.138	143	0.157	262	0.075	190	0.087	194	0.100	292
OO	(0.010)	(105)	(0.010)	(123)			(0.011)	(233)	(0.011)	(139)			(0.006)	(215)					(0.004)	(244)
P_1	0.105	105	0.112	99	0.073	193	0.098	209	0.104	124	0.064	114	0.031	240	(0.028)	(133)	(0.026)	(157)	0.031	274
Q_1	0.032	110	0.037	90	0.040	197	(0.049)	(195)	0.035	104	0.044	130	(0.030)	(273)	(0.015)	(219)	(0.017)	(213)	0.015	307
2Q	(0.004)	(95)	(0.007)	(75)			(0.007)	(188)	(0.007)	(98)			(0.004)	(285)					(0.002)	(317)
R_2	(0.003)	(246)	(0.003)	(231)			(0.003)	(88)	(0.003)	(264)			(0.002)	(160)					(0.002)	(268)
S_1	0.032	222	0.039	38					0.034	82			0.100	120						
S_2	0.426	246	0.389	231	0.337	82	0.315	88	0.375	264	0.227	269	0.246	150	0.083	325	0.085	357	0.201	270
S_4			0.004	261			0.006	344	0.008	309			0.018	223						
S_6			0.003	3			0.007	22	0.002	63			0.002	229						
T_2	(0.025)	(246)	0.092	238			(0.019)	(88)	0.071	296			(0.014)	(160)	(0.005)	(325)	(0.005)	(357)	(0.026)	(330)
λ_2	(0.016)	(231)	(0.013)	(218)			(0.017)	(67)	0.044	298			(0.012)	(139)	(0.004)	(309)	(0.004)	(347)	(0.073)	(258)
μ_2	0.068	226	0.062	190			0.120	171	0.054	203	(0.029)	(228)	(0.041)	(84)	(0.013)	(266)	(0.012)	(318)		
ν_2	0.096	199	0.076	186	0.140	23	0.147	22	0.096	223	(0.054)	(228)	(0.062)	(100)	(0.022)	(265)	(0.022)	(324)	(0.036)	(196)
ρ_1	(0.005)	(273)	(0.010)	(84)			(0.010)	(196)	(0.010)	(106)			(0.006)	(272)					(0.003)	(303)
Series	1876–1888		1914–1915		1891–1892		1901–1902		1919–1920		1865–1877		1903–1904		1898		1898		1858–1894	
Length	8 years.		369 days.		393 days.		2 years.		369 days.		2 years.		369 days.		29 days.		29 days.		2 years.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 404.

UNITED STATES, EAST COAST—Continued.

Component.	District of Columbia—Continued. Washington,[1] 7th St. Wharf, (38° 52′ N., 77° 01′ W.).		Maryland. Holland Island Bar Light, (38° 04′ N., 76° 06′ W.).		Drum Point Light, (38° 19′ N., 76° 25′ W.).		Sharp Island Light, (38° 38′ N., 76° 23′ W.).		Thomas Point Shoal Light, (38° 54′ N., 76° 26′ W.).		Love Point Light, (39° 03′ N., 76° 17′ W.).		Seven Foot Knoll Light, (39° 09′ N., 76° 25′ W.)		Baltimore,[1] Fells Point, (39° 17′ N., 76° 35′ W.).		Baltimore,[1] Fort McHenry, (39° 16′ N., 76° 35 W.).		Pooles Island Light, (39° 17′ N., 75° 16′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.010)	(262)															(0.012)	(290)		
K_1	0.152	272	0.092	201	0.087	240	0.146	272	0.206	268	0.252	275	0.274	284	0.129	299	0.221	296	0.276	293
K_2	0.074	268	(0.029)	(33)	(0.021)	(59)	(0.016)	(126)	(0.014)	(127)	(0.021)	(210)	(0.024)	(220)	0.034	242	0.024	202	(0.026)	(259)
L_2	0.117	251	(0.020)	(35)	(0.013)	(58)	(0.015)	(110)	(0.011)	(134)	(0.016)	(277)	(0.013)	(205)	0.032	249	0.017	218	(0.017)	(232)
M_1	0.020	346	(0.007)	(207)	(0.007)	(252)	(0.010)	(272)	(0.011)	(283)	(0.015)	(288)	(0.013)	(298)	0.024	170	0.014	130	(0.016)	(306)
M_2	1.373	229	0.707	12	0.555	39	0.582	80	0.367	119	0.501	168	0.438	185	0.572	190	0.474	191	0.572	212
M_3	0.009	99																		
M_4	0.074	358	0.022	284	0.019	354	0.031	91	0.015	62	0.004	177	0.022	43	0.011	329	0.023	304	0.006	304
M_6	0.031	54	0.022	69	0.016	142	0.038	239	0.009	21	0.004	212	0.010	217	0.006	185	0.008	225	0.012	314
M_8	0.010	159																		
N_2	0.241	205	0.138	349	0.089	19	0.102	51	0.078	103	0.112	159	0.092	165	0.092	163	0.098	171	0.114	192
2N	(0.032)	(181)	(0.018)	(326)	(0.012)	(0)	(0.014)	(31)	(0.010)	(88)	(0.015)	(149)	(0.012)	(145)			(0.013)	(150)	(0.15)	(173)
O_1	0.121	291	0.094	214	0.111	264	0.129	272	0.100	297	0.177	301	0.092	312	0.112	321	0.172	306	0.162	319
OO	(0.005)	(253)															(0.007)	(285)		
P_1	0.057	273	(0.030)	(201)	(0.029)	(240)	(0.048)	(272)	(0.068)	(268)	(0.083)	(275)	(0.091)	(284)	0.051	314	0.075	284	(0.091)	(293)
Q_1	(0.024)	(301)	(0.018)	(220)	(0.022)	(276)	(0.025)	(272)	(0.019)	(312)	(0.034)	(314)	(0.018)	(326)			0.033	267	(0.031)	(331)
2Q	(0.003)	(310)															(0.004)	(316)		
R_2	(0.002)	(272)															(0.001)	(217)		
S_1																	0.047	228		
S_2	0.201	272	0.107	33	0.078	59	0.060	126	0.051	127	0.076	210	0.087	220	0.075	225	0.084	217	0.095	259
S_4	0.004	251																		
S_6	0.001	258																		
T_2	(0.012)	(272)	(0.006)	(33)	(0.005)	(59)	(0.004)	(126)	(0.003)	(127)	(0.005)	(210)	(0.005)	(220)			(0.005)	(217)	(0.006)	(259)
λ_2	(0.010)	(249)	(0.005)	(22)	(0.004)	(48)	(0.004)	(102)	(0.003)	(123)	(0.004)	(188)	(0.003)	(201)			(0.003)	(203)	(0.004)	(234)
μ_2	(0.033)	(185)	(0.017)	(351)	(0.013)	(18)	(0.014)	(34)	(0.009)	(110)	(0.012)	(126)	(0.011)	(150)			0.003.	97	(0.014)	(165)
ν_2	0.052	226	(0.027)	(352)	(0.017)	(22)	(0.020)	(55)	(0.015)	(105)	(0.022)	(160)	(0.018)	(168)			0.022	181	(0.022)	(195)
ρ_1	(0.005)	(299)															0.007	310		
Series	1899–1900		1898		1898		1898		1898		1898		1898		1845–1846		1907–1908		1898	
Length	365 days.		29 days.		29 days.		29 days.		29 days.		29 days.		29 days.		369 days.		369 days.		29 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 404.

UNITED STATES, EAST COAST—Continued.

Component.	Maryland—Continued. Elk River Entrance (39° 26′ N., 76° 59′ W.).		North Carolina, Wilmington,[1] Cape Fear R. (34° 14′ N., 77° 57′ W.).		South Carolina, Charleston,[1] Customhouse Wharf (32° 46′ N., 79° 56′ W.).		Georgia. Tybee Light,[1] Savannah River (32° 02′ N., 80° 51′ W.).		Georgia. Savannah,[1] Fort Jackson (32° 05′ N., 81° 02′ W.).		Georgia. Savannah,[1] Water Works (32° 05′ N., 81° 05′ W.).		Georgia. Quarantine Station, Sapelo Sound (31° 32′ N., 81° 12′ W.).		Florida. Fernandina,[1] Fort Clinch (30° 41′ N., 81° 28′ W.).		Florida. Fernandina,[1] Desoto St. (30° 41′ N., 81° 28′ W.).		Florida. Key West,[1] Fort Taylor (24° 33′ N., 81° 48′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet	Deg	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1			(0.010)	(167)					(0.018)	(140)	(0.017)	(149)	(0.014)	(41)			(0.020)	(126)		
K_1	0.338	307	0.173	168	0.338	126	0.341	114	0.314	142	0.311	149	0.176	69	0.339	120	0.345	127	0.274	274
K_2	(0.046)	(284)	0.032	339	0.090	238	0.154	246	0.109	289	0.086	286	(0.175)	(253)	0.156	275	0.133	267	0.049	281
L_2	(0.027)	(273)	0.111	300	0.132	235	0.135	198	0.259	206	0.291	206	(0.081)	(231)	0.284	206	0.146	222	0.023	277
M_1	(0.020)	(322)	0.004	261	0.020	106			0.028	166	0.030	176	(0.013)	(97)			0.013	137		
M_2	1.012	246	1.123	289	2.378	217	3.219	210	3.018	243	3.002	250	3.461	219	2.837	223	2.854	228	0.565	260
M_3			0.018	298					0.036	326	0.039	342					0.045	299		
M_4	0.033	8	0.206	139	0.123	296	0.058	287	0.220	14	0.271	33	0.092	332	0.070	59	0.032	295	0.036	235
M_6	0.012	62	0.047	240	0.033	305	0.021	286	0.088	79	0.098	110	0.028	340	0.028	2	0.032	8	0.011	181
M_8			0.037	80					0.017	175	0.023	207					0.004	334		
N_2	0.184	219	0.176	266	0.538	200	0.677	190	0.603	237	0.584	246	0.556	207	0.623	203	0.585	213	0.123	232
$2N$	(0.025)	(192)	(0.023)	(242)	(0.072)	(183)			(0.080)	(232)	(0.078)	(242)	(0.074)	(195)			(0.078)	(197)	(0.016)	(204)
O_1	0.203	337	0.159	171	0.247	126	0.245	120	0.254	147	0.245	150	0.181	125	0.238	126	0.252	129	0.294	273
OO			(0.005)	(166)					(0.010)	(137)	(0.010)	(149)	(0.008)	(13)			(0.011)	(125)		
P_1	(0.112)	(307)	0.043	186	0.111	125	0.118	114	0.100	141	0.098	154	(0.058)	(69)	0.119	118	0.110	125	0.091	273
Q_1	(0.039)	(352)	0.034	152	0.049	122	0.060	122	0.043	167	0.050	149	(0.035)	(153)			0.055	133	0.058	271
$2Q$			(0.004)	(173)					(0.007)	(152)	(0.006)	(150)	(0.005)	(181)			(0.007)	(131)		
R_2			(0.001)	(313)					(0.003)	(275)	0.003	290	(0.005)	(253)			0.004	258		
S_1			0.048	134	0.052	99			0.095	98	0.095	96					0.052	90		
S_2	0.169	284	0.132	313	0.407	246	0.586	235	0.411	275	0.406	290	0.643	253	0.479	245	0.509	258	0.172	280
S_4			0.010	211					0.022	122	0.023	172					0.028	12		
S_6			0.002	189					0.004	9	0.004	0								
T_2	(0.010)	(284)	0.055	348	(0.024)	(246)			0.169	292	(0.147)	(351)	(0.038)	(253)			(0.030)	(258)		
λ_2	(0.007)	(264)	0.008	300	(0.017)	(230)			0.126	270	0.150	261	(0.024)	(235)			(0.020)	(242)		
μ_2	(0.024)	(208)	0.047	58	0.063	245	(0.077)	(184)	0.119	328	0.167	325	(0.083)	(186)			0.082	273		
ν_2	(0.036)	(222)	0.068	243	0.123	193	0.118	200	0.164	196	0.157	208	(0.108)	(209)	0.121	206	0.117	210	0.024	235
ρ_1			0.006	172					(0.010)	(149)	(0.009)	(150)	(0.007)	(150)			(0.010)	(130)		
Series	1898		1908–1909		1859–1903		1889–1890		1914–1915		1914–1915		1902		1860–1861		1899–1900		1857–1858	
Length	29 days.		369 days.		2 years.		369 days.		369 days.		369 days.		29 days.		369 days.		369 days.		369 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 404.

UNITED STATES, GULF COAST.

Component.	Florida—Continued. Key West,[1] Curry's Wharf (24° 34′ N., 81° 48′ W.).		Tortugas, (24° 38′ N., 82° 53′ W.).		Cedar Keys, (29° 08′ N., 83° 02′ W.).		St. Marks Light (30° 04′ N., 84° 11′ W.).		Pensacola,[1] Warrington Navy Yard (30° 21′ N., 87° 16′ W.).		Alabama, Mobile Point Light, Fort Morgan, (30° 14′ N., 88° 01′ W.).		Mississippi. Biloxi, (30° 24′ N., 88° 54′ W.).		Cat Island,[1] (30° 14′ N., 89° 10′ W.).		Louisiana, Port Eads[1] (29° 01′ N., 89° 10′ W.).		Texas, Galveston,[1] Fort Point (29° 20′ N., 94° 46′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.016)	(281)													0.035	297			(0.022)	(319)
K_1	0.283	279	0.371	275	0.534	314	0.577	319	0.411	320	0.384	318	0.568	319	0.525	325	0.439	293	0.386	315
K_2	0.048	300	0.043	293	0.134	55	0.129	63	0.006	20			0.041	346	0.028	288	0.002	229	0.006	106
L_2	0.022	273	0.010	318									0.020	330	0.012	33			0.013	151
M_1	0.015	287							0.016	268			0.024	299	0.007	26	0.023	266	0.016	298
M_2	0.555	274	0.478	278	1.061	24	1.122	44	0.062	317	0.072	301	0.112	11	0.116	11	0.059	316	0.308	108
M_3	0.005	178																		
M_4	0.030	308	0.010	297	0.054	276			0.008	318	0.016	331	0.019	138			0.006	91	0.008	226
M_6	0.014	113	0.004	183	0.012	90			0.001	359			0.003	205			0.001	46	0.003	14
M_8	0.002	230																		
N_2	0.019	256	0.092	266	0.162	23	0.151	27	0.008	318			0.034	32	0.026	33	0.022	341	0.074	91
2N	(0.014)	(239)	(0.012)	(254)															(0.010)	(74)
O_1	0.286	275	0.365	272	0.492	309	0.508	308	0.408	310	0.369	308	0.514	309	0.479	315	0.407	295	0.358	309
OO	(0.009)	(283)																	(0.012)	(322)
P_1	0.091	281	0.111	273	0.161	314	0.172	320	0.121	324			0.153	313	0.156	321	0.141	294	0.115	306
Q_1	0.064	262	(0.072)	(270)					0.073	292			0.118	288	0.091	307	0.088	277	0.073	296
2Q	(0.007)	(271)																	(0.009)	(303)
R_2	(0.001)	(298)																	(0.001)	(111)
S_1	0.022	310													0.044	10	0.008	249		
S_2	0.170	298	0.166	291	0.419	51	0.444	73	0.026	315	0.035	313	0.091	32	0.068	24	0.038	298	0.094	111
S_4	0.007	6																		
S_6	0.001	229																		
T_2	0.026	312																	(0.006)	(111)
λ_2	0.003	263																	(0.002)	(109)
μ_2	0.014	205	(0.011)	(265)					(0.001)	(319)									(0.007)	(104)
ν_2	0.021	257	(0.018)	(268)															(0.014)	(93)
ρ_1	(0.011)	(274)																	(0.014)	(306)
Series	1914–15		1860–61		1892–93		1860–61		1859–60		1850–51		1882–83		1848		1895–96		1903–04	
Length	369 days.		369 days.		369 days.		369 days.		369 days.		369 days.		369 days.		369 days.		369 days.		369 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(3)		(1)		(1)	

[1] For compound and long-period components see pp. 404–405.

UNITED STATES, GULF COAST TO WEST INDIES.

Component.	Texas—Continued. Galveston,[1] Doswell's Wharf (29° 19′ N., 94° 47′ W.).		Texas—Continued. Galveston,[1] 20th St. (29° 19′ N., 94° 48′ W.).		Mexico. Tampico (22° 16′ N., 97° 49′ W.).		Mexico. Vera Cruz (19° 12′ N., 96° 8′ W.).		Mexico. Campeche (19° 50′ N., 90° 32′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1			(0.028)	(328)						
K_1	0.346	321	0.361	323	0.347	293	0.539	282	0.874	314
K_2	0.018	132	0.013	172	0.014	34	0.018	17	0.098	208
L_2	0.014	175	0.011	227	(0.002)	(68)			0.062	104
M_1			0.014	328					0.048	245
M_2	0.224	124	0.259	119	0.080	63	0.202	75	0.723	90
M_3			0.004	21						
M_4	0.002	128	0.005	222	0.004	63	0.009	247	0.035	40
M_6	0.004	29	0.002	358			0.002	337	0.008	72
M_8			0.001	334						
N_2	0.053	111	0.060	93	(0.015)	(57)	0.059	67	0.138	78
$2N$			(0.008)	(67)						
O_1	0.333	312	0.338	313	0.278	291	0.626	320	0.600	300
OO			0.016	333						
P_1	0.129	319	0.111	315	(0.115)	(293)	(0.178)	(285)		
Q_1	0.066	341	0.082	296						
$2Q$			(0.009)	(303)						
R_2			(0.001)	(121)						
S_1			0.026	281						
S_2	0.043	134	0.084	121	0.027	73	0.065	355	0.221	117
S_4			0.006	34						
S_6			0.001	16						
T_2			0.016	96						
λ_2			(0.002)	(120)						
μ_2			0.007	36	(0.002)	(52)				
ν_2	0.010	113	0.012	114						
ρ_1			(0.013)	(309)						
Series	1852–53		1908–09		1891–92		1857		1900	
Length	369 days.		369 days.		369 days.		87 days.		105 days.	
Reference	(1)		(1)		(1)		(1)		(1)	

Component.	Canal Zone, Cristobal (9° 21′ N., 79° 55′ W.).		Bahamas, Nassau[1] (25° 05′ N., 77° 21′ W.).		Haiti, Port au Prince (18° 34′ N., 72° 22′ W.).		Porto Rico. Ponce (17° 59′ N., 66° 40′ W.).		Porto Rico. San Juan (18° 29′ N. 66° 07′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1	(0.019)	(162)	0.017	119			(0.014)	(191)	(0.019)	(163)
K_1	0.337	161	0.285	120	0.227	150	0.237	186	0.270	162
K_2	0.021	159	0.065	246	0.067	324	(0.006)	(264)	0.027	224
L_2	0.019	49	0.046	247	(0.016)	(256)	(0.001)	(40)	(0.016)	(261)
M_1	0.019	139	0.014	102	(0.014)	(345)	0.015	180	0.014	175
M_2	0.268	6	1.242	213	0.487	246	0.034	280	0.487	246
M_3	0.009	209	0.007	154						
M_4	0.016	137	0.017	65	0.008	67	0.007	57	0.007	84
M_6	0.003	139	0.006	279	0.008	330	0.001	58	0.007	308
M_8	0.003	94								
N_2	0.087	329	0.303	191	0.107	236	0.009	160	0.113	232
$2N$	(0.012)	(290)	(0.040)	(168)	(0.014)	(226)	(0.001)	(41)	(0.015)	(218)
O_1	0.196	160	0.214	124	0.132	135	0.176	175	0.238	161
OO	(0.010)	(162)	(0.009)	(117)			(0.008)	(197)	(0.010)	(163)
P_1	0.112	165	0.087	122	(0.082)	(158)	(0.078)	(186)	0.089	162
Q_1	0.031	158	0.038	118			(0.034)	(169)	0.046	161
$2Q$	(0.005)	(160)	(0.006)	(128)			(0.005)	(164)	0.006	160
R_2			(0.002)	(237)					(0.001)	(267)
S_1	0.016	92	0.010	172					0.007	233
S_2	0.044	197	0.210	237	0.125	275	0.021	264	0.074	267
S_4	0.002	340	0.004	319						
S_6	0.002	330	0.003	104						
T_2	(0.003)	(197)	(0.012)	(237)			(0.001)	(264)	(0.004)	(267)
λ_2	0.005	166	(0.009)	(225)					(0.003)	(256)
μ_2	0.006	71	(0.028)	(203)	0.012	217	(0.001)	(296)	(0.012)	(225)
ν_2	0.018	305	0.068	189			(0.002)	(176)	(0.022)	(234)
ρ_1	(0.007)	(160)	(0.008)	(126)			(0.007)	(170)	0.009	161
Series	1922–23		1903–4		1906		1899		1899	
Length	369 days.		369 days.		58 days.		87 days.		191½ days.	
Reference	(1)		(1)		(1)		(1)		(1)	

[1] For compound and long period components see p. 405.

WEST INDIES AND SOUTH AMERICA.[1]

Component.	Culebra Island, Great Harbor, Camp Roosevelt (18° 18′ N., 65° 17′ W.).		Virgin Islands, St. Thomas[2] Harbor (18° 20′ N., 64° 56′ W.).		St. Lucia, Port Castries (14° 01′ N., 61° 00′ W.).		French Guiana, Isles du Salut (5° 17′ N., 52° 35′ W.).		Brazil.											
									Itaqui,[2] Maranhao. (2° 35′ S., 44° 24′ W.).		Camocim (2° 55′ S., 40° 52′ W.).		Ceara (3° 41′ S., 38° 34′ W.).		Pernambuco,[2] Recife Arsenal (8° 04′ S., 34° 53′ W.).		Rio de Janeiro[2] Arsenal (22° 54′ S., 43° 10′ W.).		Rio Grande do Sul[2] (32° 07′ S., 52° 04′ W.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																	0.011	315		
K_1	0.250	162	0.295	171	(0.069)	(134)	0.328	199	0.312	265	0.361	23	0.187	36	0.102	64	0.209	148	0.098	294
K_2	(0.012)	(266)					0.262	142	0.568	246	0.295	179	0.220	152	0.249	148	0.182	86	0.026	22
L_2															0.056	155	0.052	77		
M_1															0.013	208	0.019	159		
M_2	0.293	241	0.124	208	0.246	63	2.592	118	7.385	188	3.573	177	3.041	142	2.503	125	1.070	87	0.157	268
M_3															0.016	132	0.026	204		
M_4	0.017	40							0.262	189			0.092	323	0.013	274	0.180	91	0.180	183
M_6	0.009	331															0.006	172		
M_8																	0.001	219		
N_2	0.048	223							1.158	147	0.728	173	0.607	142	0.482	113	0.120	133	0.184	257
2N																	(0.026)	(175)		
O_1	0.186	155	0.243	153	0.056	116	0.230	181	0.614	73	0.446	258	0.066	242	0.167	142	0.365	87	0.354	113
OO																	0.006	206		
P_1	(0.083)	(162)	0.078	176			0.098	199	0.105	265	0.118	23	0.062	36	0.023	65	0.067	147	0.033	294
Q_1													0.013	242	0.043	112	0.102	60		
2Q																	(0.010)	(27)		
R_2															0.010	124	(0.007)	(110)		
S_1			0.011	244											0.046	65	0.034	108		
S_2	0.043	266	0.031	243	0.127	107	0.919	142	2.080	246	1.083	179	0.804	152	0.912	148	0.564	97	0.098	22
S_4													0.003	338	0.003	343	0.009	34		
S_6															0.003	349				
T_2															0.089	166	0.034	132		
λ_2																	0.016	23		
μ_2	0.014	244							0.568	275					0.085	111	0.054	111		
ν_2																	0.020	112		
ρ_1																	(0.014)	(61)		
Series	1902		1872–1875		1888												1906–1913			
Length	29 days.		3 years.		29 days.												3 years.			
Reference	(1)		(3)		(1)		(8)		(9)		(9)		(9)		(9)		(1), (9)		(9)	

[1] For British Guiana see p. 402.

[2] For compound and long-period components see p. 405.

SOUTH AMERICA.

Component.	Uruguay, Montevideo (34° 53′ S., 56° 12′ W.).		Argentina. Buenos Aires[1] (34° 36 S., 58° 22′ W.).		Mar del Plata[1] (38° 05′ S., 57° 32′ W.).		Puerto Quequer[1] (38° 33′ S., 58° 43′ W.).		Puerto Belgrano,[1] Bahia Blanca (38° 53′ S., 62° 06′ W.).		Faro de Recalada, Bahia Blanca (39° 00′ S., 61° 16′ W.).		Bahia Anegada (40° 02′ S., 62° 09′ W.).		Muelle San Blas (40° 33′ S., 62° 14′ W.).		Faro Segunda Barranca (40° 47′ S., 62° 16′ W.).		Barra de Rio Negro (41° 00′ S., 62° 48′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.002)	(348)			0.024	224	0.020	215	0.039	102										
K_1	0.049	318	0.253	18	0.463	106	0.387	76	0.677	43	0.313	15	0.688	13	0.672	340	0.658	334	0.66	310
K_2	(0.011)	(318)	0.014	344	0.066	237	0.066	247	0.137	276	0.085	214	0.104	212	0.049	120	0.068	75	0.23	68
L_2	(0.009)	(74)	0.048	220	0.088	195	0.072	195	0.663	209										
M_1	(0.002)	(287)			0.036	126	0.023	30	0.057	200										
M_2	0.186	34	0.814	185	1.236	171	1.316	163	4.723	139	2.644	88	3.117	91	2.634	33	2.623	351	4.43	323
M_3					0.054	116	0.036	102	0.082	46										
M_4	0.034	146	0.073	252	0.135	273	0.207	297	0.327	101										
M_6	0.012	333	0.018	292	0.019	338	0.036	159	0.028	221										
M_8			0.007	146																
N_2	0.064	354	0.341	149	0.328	131	0.213	111	0.726	41										
2N	(0.009)	(314)																		
O_1	0.019	256	0.448	211	0.597	5	0.410	357	0.495	341	0.389	305	0.603	310	0.360	281	0.419	278	0.30	255
OO	(0.001)	(19)																		
P_1	(0.016)	(318)	0.123	20	0.177	93	0.115	58	0.190	14	0.104	15	0.230	13	0.228	340	0.228	334	0.23	310
Q_1	(0.004)	(225)	0.085	124	0.072	283	0.069	342	0.096	300										
2Q			(0.012)	(45)																
R_2					0.069	303	0.010	154	0.067	120										
S_1					0.085	19	0.419	86	0.223	84										
S_2	0.040	318	0.167	266	0.233	247	0.220	248	0.770	278	0.322	214	0.387	212	0.177	120	0.024	75	0.82	68
S_4							0.003	78	0.030	108										
S_6					0.016	217	0.010	151	0.007	300										
T_2	0.002	318			0.020	176	0.026	214	0.111	282										
λ_2	0.001	359																		
μ_2	0.004	111	(0.020)	(103)	0.020	259	0.066	214	0.484	223										
ν_2	0.012	359	(0.067)	(152)	0.074	95	0.070	151	0.319	85										
ρ_1	0.001	229																		
Series	1843		1893–1894		1915		1912		1905–1908		1908		1919		1918		1918		1916	
Length	162½ days.		369 days.		1year.		1 year.		3 years.		2 months.		2 months.		6 months.		2 months.		15 days.	
Reference	(1)		(1)		(10)		(10)		(10)		(10)		(10)		(10)		(10)		(10)	

[1] For compound and long-period components see p. 405.

SOUTH AMERICA—Continued.

Argentina—Continued.

Component.	San Antonio[1] (40° 49′ S., 64° 54′ W.).		Puerto Piramides (42° 35′ S., 64° 16′ W.).		Puerto Madryn (42° 46′ S., 65° 01′ W.).		Fondeadero, Punta Nenfas (42° 58′ S., 64° 19′ W.).		Bahia Cruz, Caleta Truco (44° 27′ S., 65° 20′ W.).		Puerto Santa Elena (44° 31′ S., 67° 42′ W.).		Isla Leones (45° 03′ S., 65° 38′ W.).		Bahia Bustamante (45° 06′ S., 66° 43′ W.).		Comodoro Rivadavia[1] (45° 52′ S., 67° 29′ W.).		Puerto Deseado[1] (47° 45′ S., 65° 55′ W.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.006	32															0.144	106	0.026	203
K_1	0.646	302	0.35	204	0.59	231	0.46	232	0.50	213	0.54	192	0.65	192	0.886	179	0.579	185	0.741	138
K_2	0.548	19	0.36	246	0.38	266	0.43	252	0.23	239	0.35	216	0.19	115	0.351	194	0.170	164	0.285	59
L_2	0.666	316															0.241	185	0.456	40
M_1	0.177	298															0.066	337	0.034	82
M_2	10.312	302	5.85	183	6.23	193	6.00	193	4.75	153	5.35	139	6.46	122	5.922	100	6.854	89	5.838	5
M_3	0.121	157															0.128	271	0.080	320
M_4	0.167	268															0.360	173	0.291	294
M_6	0.364	249															0.132	112	0.073	41
M_8																				
N_2	2.156	260															0.960	46	1.430	322
2N																				
O_1	0.338	228	0.55	120	0.26	155	0.62	120	0.05	130	0.38	113	0.39	103	0.396	96	0.349	81	0.643	58
OO																				
P_1	0.187	300	0.11	204	0.20	231	0.16	232	0.17	213	0.18	192	0.22	192	0.029	179	0.161	161	0.222	150
Q_1	0.066	326															0.049	20	0.095	24
2Q																				
R_2	0.023	350															0.013	209	0.074	28
S_1	0.082	76															0.062	224	0.099	135
S_2	2.146	17	1.31	246	1.39	266	1.54	252	0.85	239	1.27	216	0.71	115	1.283	194	1.379	185	1.122	300
S_4	0.020	4															0.021	322	0.006	165
S_6	0.187	350															0.097	295	0.004	159
T_2	0.138	18															0.088	179	0.031	32
λ_2																				
μ_2	0.213	359															0.125	199	0.051	214
ν_2	0.564	291															0.411	59	0.462	196
ρ_1																				
Series	1912		1916		1916–1917		1916		1917		1916–1917		1916		1915		1913		1913	
Length	1 year.		2 months.		6 months.		15 days.		15 days.		3 months.		15 days.		15 days.		1 year.		1 year.	
Reference	(10)		(10)		(10)		(10)		(10)		(10)		(10)		(10)		(10)		(10)	

[1] For compound and long-period components see p. 405.

SOUTH AMERICA AND PANAMA CANAL ZONE.

Component.	Argentina—Continued. Puerto San Julian (49° 15′ S., 67° 41′ W.).		Argentina—Continued. Puerto Santa Cruz (50° 07′ S., 68° 25′ W.).		Argentina—Continued. Puerto Gallegos (51° 37′ S., 69° 00′ W.).		Port Louis, Falkland Is. (51° 29′ S., 58° 00′ W.).		South Georgia Is. (54° 31′ S., 36° 01′ W.).		Chile. Cape Horn, Hermite Is (55° 51′ S., 67° 33′ W.).		Chile. Cape Horn,[1] Orange Bay (55° 31′ S., 68° 05′ W.).		Chile. Pollo Island, Smith Channel (52° 23′ S., 73° 41′ W.).		Chile. Valparaiso[1] (33° 02′ S., 71° 38′ W.).		Canal Zone, Naos Island[1] (8° 55′ N., 79° 32′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																	(0.028)	(351)		
K_1	0.78	89	0.921	72	0.755	63	0.358	37	0.17	52	0.563	55	0.707	36	0.820	41	0.499	330	0.440	340
K_2	0.62	351	0.928	330	0.951	312	0.170	206	0.11	233	0.061	148	0.064	128	0.131	11	0.142	288	0.392	142
L_2							0.095	135	0.04	209	0.045	138	0.052	109			0.041	229	0.226	167
M_1							0.024	79					0.020	350			0.021	287		
M_2	9.27	300	12.132	277	12.008	254	1.544	157	0.74	213	2.017	105	1.931	104	1.508	31	1.410	279	5.928	87
M_3							0.018	83												
M_4							0.068	357	0.01	308	0.095	216	0.016	197			0.007	147	0.218	358
M_6							0.012	76			0.034	333	0.017	313			0.004	107	0.041	276
M_8							0.010	193												
N_2							0.335	130	0.16	199	0.311	72	0.491	66			0.359	248	1.297	54
2N													(0.065)	(27)			(0.048)	(217)		
O_1	0.67	35	0.721	21	0.656	16	0.451	4	0.33	18	0.412	345	0.587	347	0.590	335	0.328	286	0.135	344
OO																	(0.015)	(14)		
P_1	0.26	89	0.298	72	0.262	63	0.141	87	0.05	50	0.186	55	0.175	30	0.262	41	0.161	322	0.123	342
Q_1											0.080	310	(0.114)	(323)			(0.064)	(264)	0.032	36
2Q																	(0.009)	(242)		
R_2																	(0.004)	(300)		
S_1							0.289	25					0.013	19						
S_2	2.28	351	3.406	330	3.510	312	0.492	195	0.38	236	0.224	148	0.302	134	0.525	11	0.466	300	1.656	144
S_4							0.007	64	0.004	39							0.003	59		
S_6																	0.003	60		
T_2													0.085	260			(0.027)	(300)		
λ_2													(0.014)	(118)			(0.010)	(289)	0.033	281
μ_2													(0.046)	(74)			(0.034)	(259)	0.185	33
ν_2											0.060	76	(0.095)	(71)			(0.069)	(252)	0.151	59
ρ_1																	(0.012)	(267)		
Series	1916		1916		1915–16		1842		1883		1842		1882–83		1904		1892–93		1882–83	
Length	2 months.		1 month.		3 months.		1 year.		8 months.		29 days.		369 days.		60 days.		369 days.		369 days.	
Reference	(10)		(10)		(10)		(3)		(2)		(1)		(1)		(11)		(1)		(1)	

[1] For compound and long-period components see p. 405.

PANAMA CANAL ZONE TO UNITED STATES, WEST COAST.

Component.	Canal Zone—Continued. Balboa [1] (8° 57′ N., 79° 34′ W.).		Mexico. Mazatlan [1] (23° 11′ N., 106° 27′ W.).		Mexico. Magdalena Bay, Lower California (24° 38′ N., 112° 09′ W.).		Mexico. San Juanico Bay, Lower California (26° 15′ N., 112° 28′ W.).		Mexico. Ballenas Bay, Lower California (26° 43′ N., 113° 34′ W.).		California. San Diego [1] (32° 42′ N., 117° 14′ W.).		California. Morro (35° 22′ N., 120° 51′ W.).		California. San Francisco,[1] Fort Point (37° 49′ N., 122° 29′ W.).		California. San Francisco,[1] Presidio (37° 48′ N., 122° 27′ W.).		California. Sausalito [1] (37° 50′ N., 120° 28′ W.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.025)	(336)									(0.062)	(101)	(0.048)	(117)			(0.068)	(114)		
K_1	0.443	343	0.642	72	0.79	71	0.41	93	0.43	90	1.080	95	1.001	111	1.218	106	1.208	106	1.592	110
K_2	0.401	142	0.212	248	0.27	253	0.28	252	0.29	275	0.202	265	0.103	290	0.116	327	0.120	329	0.094	336
L_2	0.138	108			0.19	241	0.08	318	0.36	335	0.045	256	0.050	308	0.073	0	0.055	353	0.039	353
M_1	0.011	359	0.022	20							0.039	92	0.041	132	0.044	83	0.039	104	0.040	65
M_2	6.000	89	1.077	265	1.59	244	1.72	246	2.14	261	1.703	276	1.227	308	1.696	331	1.773	330	1.570	337
M_3	0.037	130									0.012	357	0.022	346			0.013	332		
M_4	0.214	3	0.014	294							0.026	190	0.053	171	0.086	32	0.077	25	0.033	55
M_6	0.030	296	0.012	30							0.010	107	0.013	254	0.012	342	0.009	22	0.021	338
M_8	0.012	305									0.003	124	0.007	106			0.006	64		
N_2	1.260	58	0.241	254	0.39	246	0.34	247	0.70	202	0.408	256	0.260	284	0.364	304	0.376	304	0.333	310
2N	0.164	25									0.047	232	(0.035)	(260)			0.041	276		
O_1	0.128	355	0.453	75	0.56	77	0.29	55	0.17	86	0.697	79	0.608	99	0.766	88	0.756	89	0.717	94
OO	(0.014)	(330)									(0.034)	(109)	(0.026)	(123)			(0.038)	(123)		
P_1	0.135	344	0.256	69	0.26	71	0.13	93	0.14	90	0.354	93	0.274	108	0.368	104	0.377	104	0.371	109
Q_1	0.020	39									0.131	69	0.107	99	0.124	83	0.128	82	0.124	82
2Q	(0.003)	(8)									(0.018)	(62)	(0.016)	(87)			(0.020)	(72)		
R_2	(0.013)	(146)									(0.006)	(271)	(0.003)	(304)			(0.003)	(335)		
S_1	0.026	59									0.027	197					0.020	147		
S_2	1.616	146	0.743	254	1.01	253	1.02	252	1.07	275	0.696	274	0.320	304	0.382	335	0.404	335	0.354	348
S_4	0.077	89									0.005	183	0.009	177			0.002	246		
S_6	0.003	145									0.004	107	0.006	148			0.002	112		
T_2	0.216	245									0.035	29	(0.019)	(304)			0.064	194		
λ_2	0.031	92									0.022	232	(0.009)	(307)			0.027	335		
μ_2	0.197	35									0.026	245	0.025	174			0.029	224	0.049	218
ν_2	0.235	60									0.066	257	0.065	285			0.073	311	0.044	297
ρ_1	(0.005)	(1)									(0.026)	(71)	(0.023)	(94)			(0.029)	(82)		
Series	1912–1917		1878–79		1894		1893		1890		1869–1871, 1917		1919		1863–1870		1904–1913		1889–90	
Length	3 years.		369 days.		1 month.		51 days.		36 days.		4 years.		163 days.		4 years.		6 years.		369 days.	
Reference	(1)		(1)		(12)		(12)		(62)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see pp. 405–406.

UNITED STATES AND BRITISH AMERICA, WEST COAST.

Component.	California—Continued.				Washington.				British Columbia.											
	Humboldt Bay,[1] South Jetty Landing (40° 45′ N., 124° 14′ W.).		Oregon, Astoria[1] (46° 11′ N., 123° 50′ W.).		Port Townsend[1] (48° 07′ N., 122° 45′ W.).		Seattle,[1] Madison St. (47° 37′ N., 122° 20′ W.).		Victoria,[1] Vancouver Is. (48° 25′ N., 123° 24′ W.).		Sand Heads,[1] Fraser River (49° 07′ N., 123° 16′ W.).		Vancouver,[1] Burrand Inlet (49° 18′ N., 123° 07′ W.).		Whaletown, Georgia Strait (50° 07′ N., 125° 04′ W.).		Seymour Narrows (50° 08′ N., 125° 23′ W.).		Chatham Point, Discovery Strait (50° 15′ N., 125° 28′ W.).	
	H	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*	*H*	*κ*
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.070)	(124)					(0.151)	(167)	0.111	173	0.175	198	0.138	220	(0.170)	(174)			(0.119)	(158)
K_1	1.244	115	1.316	129	2.511	148	2.697	156	2.078	146	2.790	162	2.704	175	3.043	163	2.946	147	2.120	144
K_2	0.126	350	0.220	24	0.157	131	0.272	157	0.064	94	0.203	174	0.221	184	(0.222)	(174)	(0.169)	(100)	(0.286)	(77)
L_2	0.052	4	0.157	11	0.104	151	0.188	188	0.045	185	0.079	178	0.143	170	(0.093)	(174)			(0.085)	(80)
M_1	0.035	100	0.052	152	0.108	162	0.084	145	0.062	154	0.100	137	0.117	201	(0.170)	(151)			(0.117)	(130)
M_2	2.063	338	2.971	9	2.217	106	3.494	128	1.217	70	2.911	144	2.784	165	3.314	145	2.934	71	3.023	53
M_3	0.004	224					0.036	151	0.030	266	0.010	146	0.026	128						
M_4	0.036	161	0.100	317	0.131	290	0.070	70	0.065	326	0.026	164	0.053	174			0.363	253		
M_6	0.020	312	0.034	106	0.033	233	0.036	304	0.048	195	0.027	61	0.027	132			0.140	132		
M_8	0.001	69					0.008	8			0.005	225								
N_2	0.415	313	0.586	346	0.471	75	0.686	97	0.290	41	0.606	115	0.557	140	0.687	117	0.589	37	0.665	27
2N	(0.055)	(287)					(0.091)	(66)	0.049	50	0.101	92	0.068	141	(0.091)	(89)			(0.088)	(0)
O_1	0.772	99	0.784	114	1.454	127	1.502	133	1.208	124	1.531	139	1.450	151	1.676	140	1.620	137	1.139	116
OO	(0.039)	(132)					(0.084)	(178)							(0.094)	(186)			(0.066)	(172)
P_1	0.407	113	0.374	126	0.800	147	0.834	152	0.633	144	0.874	162	0.835	176	(1.007)	(163)	(0.975)	(147)	(0.702)	(144)
Q_1	0.134	91	0.129	111	0.237	119	0.246	128	0.210	113	0.261	132	0.243	154	(0.325)	(129)			(0.221)	(102)
2Q	(0.020)	(82)					(0.039)	(111)							(0.044)	(118)			(0.030)	(88)
R_2	(0.004)	(358)					(0.007)	(154)							(0.006)	(174)			(0.008)	(77)
S_1	0.020	274					0.051	257	0.075	264	0.090	262	0.086	295						
S_2	0.493	358	0.767	39	0.546	130	0.846	154	0.342	86	0.716	173	0.651	199	0.816	174	0.622	100	1.053	77
S_4	0.004	246					0.006	129												
S_6	0.003	141					0.002	108												
T_2	0.080	58	(0.045)	(39)	0.076	151	0.159	139							(0.048)	(174)			(0.062)	(77)
λ_2	0.021	345	0.050	14	0.032	166	(0.024)	(140)							(0.023)	(159)			(0.021)	(64)
μ_2	0.025	284	0.022	129	0.081	352	0.109	357	0.084	354	0.065	50	0.032	330	(0.080)	(117)			(0.073)	(29)
ν_2	0.089	316	0.170	322	0.094	84	0.149	113	0.066	37	0.136	126	0.117	144	(0.133)	(121)			(0.129)	(30)
ρ_1	(0.029)	(92)					(0.057)	(124)							(0.064)	(130)			(0.043)	(103)
Series	1911–12		1874–75		1874–1876		1899–1900		1895–1920		1895–1920		1902–1917		1916–17		1897		1900	
Length	369 days.		2 years.		3 years.		2 years.		14 years.		12 years.		12 years.		162½ days.		29 days.		40 days.	
Reference	(1)		(1)		(1)		(1)		(7)		(7)		(7)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 406.

BRITISH AMERICA AND ALASKA.

Component.	British Columbia—Continued.								Southeast Alaska.											
	Clayoquot,[1] Vancouver Is. (49° 09′ N., 125° 55′ W.).		Wadhams,[1] Rivers Inlet, (51° 24′ N., 127° 38′ W.).		Prince Rupert,[1] Chatham Sound, (54° 19′ N., 130° 19′ W.).		Port Simpson,[1] Chatham Sound, (54° 33′ N., 130° 27′ W.).		Craig,[1] (55° 29′ N., 133° 09′ W.).		Ketchikan,[1] (55° 21′ N., 131° 32′ W.).		Port Alice, Dividson Inlet, (55° 48′ N., 133° 36′ W.).		Sitka,[1] (57° 03′ N., 135° 20′ W.).		Sergius Narrows, Peril Strait, (57° 24′ N., 135° 38′ W.).		Granite Cove, Cross Sound, (58° 12′ N., 136° 24′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.077	129	0.097	133	0.098	153	0.110	146	(0.082)	(135)	(0.092)	(137)								
K_1	1.288	114	1.553	123	1.685	129	1.660	129	1.468	128	1.648	129	1.433	124	1.504	125	1.580	130	1.452	126
K_2	0.257	8	0.329	14	0.546	30	0.552	28	0.294	18	0.506	29			0.320	22	0.457	49		
L_2	0.103	2	0.112	11	0.188	16	0.166	36	0.105	34	0.139	8			0.109	28				
M_1	0.043	122	0.063	143	0.067	104	0.062	119	0.052	119	0.065	145			0.029	150			0.073	103
M_2	3.257	347	4.143	353	6.383	6	6.108	6	3.719	2	6.138	7	4.043	1	3.591	3	4.932	12	4.007	6
M_3	0.009	236	0.016	270	0.065	303	0.051	294	0.008	269										
M_4	0.050	340	0.021	316	0.029	223	0.044	192	0.006	132	0.065	123	0.048	41	0.013	140	0.100	230	0.036	204
M_6	0.016	14	0.008	252	0.009	81	0.008	244	0.007	152	0.007	32	0.018	257	0.002	94	0.046	89	0.029	48
M_8			0.007	334	0.011	90			0.011	137	0.004	275								
N_2	0.650	320	0.850	329	1.249	341	1.230	341	0.771	338	1.241	342	0.821	337	0.758	335	1.056	348	0.767	337
2N	0.101	279	0.160	360	0.184	316	0.170	313	0.112	312	0.140	319								
O_1	0.816	100	0.932	107	1.012	114	0.995	112	0.881	113	1.014	114	0.894	110	0.905	110	1.034	111	0.941	114
OO									(0.046)	(143)	(0.051)	(144)								
P_1	0.385	113	0.499	121	0.542	127	0.526	125	0.446	126	0.510	125			0.450	124				
Q_1	0.141	94	0.169	103	0.174	100	0.183	107	0.157	107	0.174	101			0.157	98			0.169	92
2Q									(0.023)	(98)	(0.026)	(98)								
R_2									(0.009)	(32)	(0.016)	(38)								
S_1	0.033	287	0.062	256	0.069	272	0.034	226	0.028	220	0.021	280								
S_2	0.931	17	1.293	23	2.074	38	1.990	38	1.187	32	2.014	38	1.297	34	1.145	34	1.656	45	1.288	38
S_4			0.012	94	0.008	235	0.011	220	0.004	19	0.013	223								
S_6									0.002	128	0.002	317								
T_2									0.107	142	0.144	193			(0.068)	(34)				
λ_2									0.015	341	0.015	348								
μ_2	0.052	290	0.096	303	0.137	336	0.143	331	0.071	318	0.141	327			0.085	321			0.056	295
ν_2	0.152	344	0.195	335	0.232	26	0.312	339	0.146	338	0.248	349			0.142	343				
ρ_1									(0.033)	(106)	(0.039)	(107)								
Series / Length / Reference	1905–1917, 11 years. (7)		1906–1910, 5 years. (7)		1906–1918, 10 years. (7)		1902–1917, 10 years. (7)		1917–18, 369 days. (1)		1920–21, 369 days. (1)		1904, 29 days. (1)		1893–94, 369 days. (1)		1897, 162½ days. (1)		1901, 29 days. (1)	

[1] For compound and long-period components see p. 406.

ALASKA.

Component.	Southeast Alaska—Continued.								Copper River Delta.				Prince William Sound.							
	Port Althorp, Cross Sound (58° 07′ N., 136° 17′ W.).		Hooniah, Port Frederick, Icy Strait (58° 07′ N., 135° 26′ W.).		Juneau,[1] Gastineau Channel, Stephens Passage (58° 18′ N., 134° 24′ W.).		Skagway,[1] Lynn Canal (59° 27′ N., 135° 18′ W.).		Kokinhenic Is. (60° 18′ N., 145° 03′ W.).		Pete Dahl Slough (60° 23′ N., 145° 24′ W.).		Cape Whitshed, Orca Inlet (60° 28′ N., 145° 55′ W.).		Orca, Orca Inlet (60° 35′ N., 145° 41′ W.).		Camp April, Orca Bay (60° 32′ N., 146° 00′ W.).		Rocky Point, Valdez Arm (60° 57′ N., 146° 42′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1					(0.094)	(137)	(0.096)	(138)												
K_1	1.478	119	1.711	130	1.674	130	1.708	131	0.411	157	1.573	137	1.514	130	1.528	130	1.471	124	1.554	117
K_2	0.307	35	0.328	63	0.627	41	0.666	41	(0.076)	(51)	(0.286)	(46)	(0.424)	(44)	(0.437)	(40)	(0.417)	(32)		
L_2	0.102	16	0.082	92	0.161	39	0.172	13	(0.038)	(35)	(0.092)	(28)	(0.117)	(33)	(0.127)	(21)	(0.132)	(21)		
M_1	0.077	109	0.080	56	0.042	121	0.049	122	(0.027)	(168)	(0.087)	(129)	(0.092)	(124)	(0.090)	(122)	(0.088)	(117)		
M_2	3.613	354	5.973	14	6.510	13	6.647	14	1.116	12	3.516	13	4.421	8	4.515	358	4.542	356	4.458	359
M_3					0.033	264	0.077	305												
M_4	0.018	329	0.069	218	0.116	181	0.133	216	0.319	13	0.188	296	0.363	231	0.167	138	0.061	138		
M_6	0.058	326	0.016	20	0.020	105	0.029	336	0.052	346	0.084	355	0.143	11	0.087	30	0.023	129		
M_8					0.003	340	0.005	331												
N_2	0.701	331	1.121	341	1.280	348	1.306	349	0.261	348	0.637	358	0.804	344	0.877	335	0.908	331		
$2N$	0.093	309			(0.170)	(324)	(0.174)	(324)	0.035	325	0.085	343	0.107	319	0.117	311	0.121	306		
O_1	0.654	99	0.983	111	0.998	115	1.023	116	0.344	178	0.840	121	1.059	118	0.984	115	0.977	110	1.050	124
OO					(0.052)	(145)	(0.053)	(146)												
P_1	0.489	119	0.486	123	(0.497)	(129)	(0.565)	(131)	(0.136)	(157)	(0.521)	(137)	(0.501)	(130)	(0.506)	(130)	(0.487)	(124)		
Q_1	0.127	89			0.174	115	0.198	101	0.067	189	(0.163)	(113)	(0.205)	(112)	(0.191)	(107)	(0.190)	(104)		
$2Q$					(0.026)	(100)	(0.027)	(102)												
R_2					0.018	44	(0.018)	(48)												
S_1					0.034	281	0.017	29												
S_2	1.127	35	2.028	48	2.218	44	2.232	48	0.278	51	1.051	46	1.560	44	1.605	40	1.533	32	1.501	52
S_4					0.022	212														
S_6					0.004	327														
T_2	0.067	35			(0.177)	(295)	(0.132)	(48)	(0.016)	(51)	(0.062)	(46)	(0.092)	(44)	(0.095)	(40)	(0.090)	(32)		
λ_2	0.025	13			0.041	28	0.110	347	(0.008)	(30)	(0.025)	(28)	(0.031)	(25)	(0.032)		(0.032)	(13)		
μ_2	0.087	312	0.170	269	0.127	338	0.154	347	(0.027)	(333)	(0.084)	(339)	(0.106)	(333)	(0.108)	(315)	(0.109)	(320)		
ν_2	0.136	334			0.244	350	0.304	354	(0.051)	(352)	(0.124)	(0)	(0.156)	(347)	(0.170)	(338)	(0.176)	(334)		
ρ_1					(0.038)	(109)	(0.039)	(110)												
Series	1901		1901		1911–12		1908–9		1898		1898		1899		1898		1900		1902	
Length	15 days.		104½ days.		369 days.		369 days.		29 days.		29 days.		29 days.		29 days.		29 days.		29 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 406.

ALASKA—Continued.

Component.	Prince William Sound—Con. Port Valdez (61° 07′ N., 146° 27′ W.).		Cook Inlet. Seldovia (59° 26′ N., 151° 43′ W.).		Cook Inlet. Chinulna Point (60° 30′ N., 151° 17′ W.).		Cook Inlet. Anchorage,[1] Knik Arm (61° 14′ N., 149° 55′ W.).		Kodiak Island, Kodiak [1] (57° 47′ N., 152° 24′ W.).		Sannak Islands, Peterson Bay (54° 24′ N., 162° 38′ W.).		Aleutian Islands. Tigalda Bay, Tigalda Is. (54° 05′ N., 165° 10′ W.).		Aleutian Islands. Unalga Bay, Unalga Is. (54° 00′ N., 166° 11′ W.).		Aleutian Islands. Dutch Harbor, Unalaska Is. (53° 54′ N., 166° 32′ W.).		Aleutian Islands. Kashega Bay, Unalaska Is. (53° 28′ N., 167° 05′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			(0.099)	(134)	(0.119)	(152)	(0.122)	(198)												
K_1	1.657	123	1.768	126	2.120	148	2.182	190	1.330	139	1.364	124	1.088	146	1.058	148	1.062	152	1.130	151
K_2	(0.414)	(25)	0.844	61	(0.858)	(115)	0.566	196	0.301	39	(0.198)	(18)	(0.075)	(5)	(0.034)	(304)	0.019	350	(0.030)	(91)
L_2	(0.125)	(20)	0.153	14	0.188	119	0.625	205	0.106	358	(0.054)	(7)	(0.028)	(74)	(0.043)	(143)	0.045	161	(0.020)	(93)
M_1	(0.095)	(117)	0.095	114	0.084	204	0.146	229	0.060	150	(0.077)	(111)	(0.062)	(140)	(0.064)	(139)	0.064	147	(0.067)	(140)
M_2	4.514	354	7.229	23	8.205	81	11.950	167	3.228	8	1.922	355	0.384	60	0.611	105	0.862	111	0.713	96
M_3			0.081	252	0.027	357	0.041	268	0.006	119										
M_4	0.090	141	0.094	206	0.449	36	0.935	195	0.038	97	0.053	290	0.026	265	0.042	280	0.009	280	0.024	15
M_6	0.029	190	0.072	19	0.323	304	0.583	206	0.032	239	0.063	4	0.007	83	0.043	203	0.005	238	0.013	235
M_8			0.015	241	0.028	227	0.152	229	0.004	0										
N_2	0.862	327	1.514	355	1.769	48	1.980	135	0.676	342	(0.373)	(342)	0.196	47	0.294	67	0.310	62	0.138	98
$2N$	0.115	301	0.210	324	(0.235)	(15)	0.563	65			(0.050)	(330)	0.026	33			0.042	12	0.018	100
O_1	0.970	111	1.170	111	1.208	139	1.288	173	0.897	122	0.773	97	0.635	134	0.718	131	0.723	142	0.743	129
OO			(0.055)	(141)	(0.066)	(157)	(0.067)	(207)												
P_1	(0.548)	(123)	0.596	124	(0.702)	(148)	0.603	185	0.444	134	(0.451)	(124)	(0.360)	(146)	(0.350)	(148)	0.352	152	(0.374)	(151)
Q_1	(0.188)	(105)	0.243	116	(0.234)	(135)	0.225	167	0.161	112	(0.150)	(83)	(0.123)	(128)	(0.139)	(123)	0.140	137	(0.144)	(118)
$2Q$			(0.030)	(100)	(0.031)	(131)	(0.033)	(156)												
R_2			(0.022)	(57)	(0.025)	(115)	0.025	215												
S_1			0.079	126	0.127	305			0.021	32										
S_2	1.522	25	2.762	57	3.155	115	3.108	215	1.077	41	0.726	18	2.769	5	0.126	304	0.071	350	0.111	91
S_4			0.010	279	0.050	142	0.030	245												
S_6			0.010	181	0.017	250	0.021	93												
T_2	(0.090)	(25)	(0.163)	(57)	(0.186)	(115)	0.353	173	(0.064)	(41)	(0.043)	(18)	(0.016)	(5)	(0.008)	(304)	0.004	350	(0.007)	(91)
λ_2	(0.032)	(8)	(0.051)	(39)	(0.057)	(97)	0.084	189			(0.014)	(6)	(0.003)	(35)	(0.004)	(197)	0.006	222	(0.005)	(94)
μ_2	(0.108)	(323)	0.269	339	(0.197)	(46)	0.558	274	0.067	322	(0.046)	(332)	(0.009)	(115)	(0.015)	(266)	0.021	233	(0.017)	(100)
ν_2	(0.167)	(331)	0.288	7	(0.343)	(52)	0.734	129	0.123	350	(0.072)	(344)	(0.038)	(48)	(0.057)	(72)	0.060	69	(0.027)	(97)
ρ_1			(0.044)	(104)	(0.046)	(136)	0.049	165												
Series	1901		1908–1913		1910		1914–1918		1885–86		1901		1901		1901		1901		1901	
Length	29 days.		267 days.		29 days.		163 days.		369 days.		15 days.		29 days.		29 days.		134 days.		15 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see pp. 406–407.

ALASKA, BERING SEA.

Component.	Pribilof Islands, St. Paul I. (57° 08′ N., 170° 18′ W.).		Nushagak Bay. Protection Point, (58° 30′ N., 158° 41′ W.).		Nushagak Bay. Clark Point, (59° 50′ N., 158° 33′ W.).		Kuskokwim Bay. Goodnews Bay, South Spit, (59° 02′ N., 161° 55′ W.).		Kuskokwim Bay. Goodnews Bay North Spit, (59° 04′ N., 161° 47′ W.).		Kuskokwim Bay. Apokak, (60° 08′ N., 162° 17′ W.).		Yukon River Delta. Kwiklokchun (62° 34′ N., 164° 51′ W.).		Yukon River Delta. Avogon, (62° 37′ N., 164° 51′ W.).		Norton Sound. St. Michael, (63° 29′ N., 162° 02′ W.).		Norton Sound. Nome, (64° 30′ N., 165° 26′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.053)	(165)	(0.157)	(270)	(0.160)	(276)	(0.109)	(308)	(0.106)	(315)	(0.119)	(2)	(0.037)	(236)	(0.27)	(234)			(0.023)	(44)
K_1	0.938	158	2.808	258	2.851	263	1.954	293	1.896	300	2.120	345	0.655	218	0.488	221	1.354	297	0.407	1
K_2	0.012	311	(0.001)	(117)	(0.029)	(149)	(0.041)	(269)	(0.042)	(328)	0.311	113	(0.014)	(217)	0.035	207	(0.033)	(338)	(0.011)	(156)
L_2	(0.023)	(168)	0.340	27	0.196	85	(0.073)	(257)	0.320	294	0.471	336			(0.015)	(150)	(0.026)	(292)	0.023	104
M_1	0.041	103	0.170	295	0.124	259	0.052	336	0.048	342	0.091	16	0.040	219	(0.031)	(207)	(0.076)	(272)	0.062	271
M_2	0.839	122	5.900	23	6.983	33	2.622	198	2.680	208	4.082	302	0.006	78	0.535	94	0.554	235	0.316	71
M_3	0.010	17									0.092	63			0.069	328				
M_4	0.011	85	0.208	261	0.227	272			0.138	139	0.268	166			0.100	119	0.042	150	0.006	192
M_6	0.013	117	0.074	342	0.076	107			0.096	320	0.127	227			0.019	123	0.018	266	0.007	260
M_8	0.002	240									0.020	146			0.003	210				
N_2	0.289	77	1.450	330	1.934	340	0.560	138	0.522	133	1.018	231	0.002	35	0.154	38	0.179	178	0.176	356
2N	(0.038)	(31)	(0.193)	(276)	(0.257)	(288)	(0.074)	(78)	(0.070)	(58)	(0.135)	(160)			(0.020)	(342)			(0.023)	(282)
O_1	0.642	145	1.755	232	1.703	235	1.241	263	1.322	268	1.339	312	0.461	183	0.378	194	0.761	247	0.189	274
OO	(0.029)	(171)	(0.087)	(283)	0.088	290	(0.061)	(323)	(0.058)	(331)	(0.066)	(19)	(0.020)	(253)	(0.015)	(247)			(0.013)	(88)
P_1	(0.310)	(158)	(0.930)	(258)	(0.944)	(263)	(0.647)	(293)	(0.628)	(300)	(0.702)	(345)	(0.217)	(218)	(0.162)	(221)	(0.448)	(297)	(0.135)	(1)
Q_1	(0.125)	(138)	(0.340)	(219)	(0.330)	(221)	(0.241)	(248)	(0.257)	(252)	0.258	310	(0.089)	(166)	(0.073)	(181)	(0.150)	(228)	(0.037)	(231)
2Q	(0.017)	(132)	(0.046)	(206)	(0.044)	(208)	(0.032)	(233)	(0.034)	(236)	(0.035)	(279)	(0.012)	(148)	(0.010)	(168)			(0.005)	(188)
R_2					(0.001)	(149)	(0.001)	(269)	(0.001)	(327)	(0.003)	(54)								
S_1											0.096	286								
S_2	0.055	224	0.005	117	0.018	149	0.149	269	0.156	327	0.429	54	0.050	217	0.050	267	0.121	338	0.042	156
S_4	0.005	136									0.014	280			0.010	4				
S_6	0.003	0									0.010	232			0.004	113				
T_2	(0.003)	(224)			(0.006)	(149)	(0.009)	(269)	(0.009)	(327)	(0.025)	(54)	(0.003)	(217)	(0.003)	(267)	(0.007)	(338)	(0.002)	(156)
λ_2	(0.006)	(169)	(0.041)	(67)	(0.049)	(87)	(0.018)	(231)	(0.019)	(264)	(0.029)	(354)			(0.004)	(174)	(0.004)	(282)	(0.002)	(110)
μ_2	(0.020)	(20)	(0.142)	(289)	(0.168)	(276)	(0.063)	(126)	(0.120)	(50)	(0.098)	(189)			(0.013)	(280)	(0.013)	(130)	(0.008)	(347)
ν_2	(0.056)	(83)	(0.281)	(337)	(0.375)	(347)	(0.109)	(146)	(0.102)	(143)	0.185	86			(0.030)	(45)	(0.035)	(186)	(0.034)	(6)
ρ_1	(0.024)	(139)	(0.067)	(221)	(0.065)	(223)	(0.047)	(250)	(0.050)	(254)	(0.051)	(298)	(0.018)	(168)	(0.014)	(183)			(0.007)	(237)
Series	1872		1910		1909		1912		1913		1914		1898		1899		1891–1899		1900	
Length	87 days.		29 days.		29 days.		29 days.		58 days.		87 days.		29 days.		29 days.		145 days.		29 days.	
Reference	(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)		(1)	

ALASKA, SIBERIA AND JAPAN.

Component.	Alaska,[1] Port Clarence, (65° 13′ N., 166° 24′ W.).		Siberia.[1] Nagaeva Bay, Tausk Bay (59° 37′ N., 150° 40′ E.).		Siberia.[1] Langr Island, Gulf of Amur (53° 19′ N., 141° 26′ E.).		Siberia.[1] Castries Bay, Gulf of Tartar (51° 26′ N., 140° 52′ E.).		Japan, Hokushu Island. Tomari, Kunashira (43° 46′ N., 145° 29′ E.).		Japan, Hokushu Island. Shakotan, Shikotanjima (43° 52′ N., 146° 49′ E.).		Japan, Hokushu Island. Tarakusima (43° 38′ N., 146° 20′ E.).		Japan, Hokushu Island. Suishojima (43° 22′ N., 145° 52′ E.).		Japan, Hokushu Island. Nemuro (43° 27′ N., 145° 40′ E.).		Japan, Hokushu Island. Hanasaki[2] (43° 17′ N., 145° 35′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																			0.042	170
K_1	0.248	115	1.71	229	1.31	275	0.23	330	0.85	160	0.584	157	0.685	149	0.671	171	0.678	165	0.687	177
K_2	(0.008)	(346)	0.39	289	0.07	222	0.23	325	0.12	149	0.107	135	0.125	147	0.117	144	0.146	155	0.114	152
L_2	(0.021)	(294)																	0.039	130
M_1	(0.013)	(201)																	0.034	198
M_2	0.474	213	4.00	238	0.92	181	2.41	284	0.94	108	0.810	103	0.802	102	1.009	110	0.998	103	0.900	116
M_3																			0.015	131
M_4	0.097	301																	0.011	129
M_6	0.028	212																	0.002	155
M_8	0.010	298																		
N_2	0.144	133	0.56	222	0.23	96	0.56	247											0.114	89
2N	(0.019)	(53)																		
O_1	0.121	287	1.15	203	1.15	246	0.23	323	0.70	142	0.489	155	0.513	125	0.750	157	0.555	121	0.718	164
OO	(0.005)	(303)																		
P_1	(0.082)	(115)	0.56	229	0.46	275	0.10	330	0.28	160	0.195	157	0.228	149	0.223	171	0.226	165	0.229	177
Q_1	(0.023)	(12)	0.23	203	0.23	246	0.03	323											0.161	151
2Q	(0.003)	(98)																		
R_2	(0.001)	(346)																	0.029	75
S_1																			0.038	17
S_2	0.029	346	1.48	289	0.20	222	0.76	325	0.43	149	0.393	135	0.457	147	0.429	144	0.536	155	0.402	160
S_4																			0.003	231
S_6																			0.002	249
T_2	(0.002)	(346)																	0.043	162
λ_2	(0.003)	(275)																		
ν_2	(0.011)	(81)																	0.017	131
μ_2	(0.028)	(144)																	0.028	86
ρ_1	(0.005)	(1)																		
Series	1900		1913		1911–12		1911				1887		1887		1886		1886		1897–1902	
Length	29 days.		1 month.		4 months.		3 months.				2 months.		3 months.		1 month.		1 month.		5 years.	
Reference	(1)		(13)		(13)		(13)		(14)		(15)		(15)		(15)		(15)		(16)	

[1] For additional stations in Alaska and Siberia see p. 320.

[2] For compound and long-period components see p. 407.

JAPAN.

Hokushu Island.

Component.	Kiritappu (43° 03′ N., 145° 10′ E.).		Atsukeshi (43° 02′ N., 144° 51′ E.).		Kusuri (42° 58′ N., 144° 22′ E.).		Mororan (42° 20′ N., 141° 07′ E.).		Suttsu (42° 47′ N., 140° 16′ E.).		Iwanai (42° 59′ N., 140° 33′ E.).		Raigishi (43° 20′ N., 140° 24′ E.).		Otaru[1] (43° 13′ N., 141° 01′ E.).		Hamamashi (43° 36′ N., 141° 23′ E.).		Rumoye (43° 56′ N., 141° 39′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1															0.007	25				
K_1	0.68	152	0.765	149	0.765	156	0.790	153	0.15	342	0.17	331	0.17	145	0.155	353	0.16	339	0.17	326
K_2	0.12	144	0.115	149	0.110	156	0.151	138	0.01	158	0.02	155	0.02	139	0.016	136	0.01	153	0.01	157
L_2															0.009	144				
M_1															0.015	216				
M_2	0.92	105	0.981	107	0.808	106	1.133	103	0.16	116	0.18	118	0.15	112	0.144	117	0.15	108	0.14	125
M_3															0.007	218				
M_4															0.004	216				
M_6															0.001	353				
M_8																				
N_2															0.037	88				
2N																				
O_1	0.62	161	0.538	150	0.541	133	0.684	149	0.16	346	0.14	322	0.15	324	0.151	332	0.18	321	0.17	334
OO																				
P_1	0.22	152	0.255	149	0.255	156	0.263	153	0.05	342	0.05	331	0.06	145	0.045	354	0.05	339	0.05	326
Q_1															0.032	313				
2Q																				
R_2															0.009	39				
S_1															0.015	47				
S_2	0.43	144	0.423	149	0.403	156	0.520	138	0.06	158	0.07	155	0.08	139	0.070	149	0.06	153	0.07	157
S_4															0.002	51				
S_6															0.001	153				
T_2															0.010	196				
λ_2																				
μ_2															0.011	36				
ν_2															0.007	356				
ρ_1																				
Series			1892		1892		1890								1902–03					
Length			7 months.		1 month.		4 months.								2 years.					
Reference	(14)		(15)		(15)		(15)		(14)		(14)		(14)		(16)		(14)		(14)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Hokushu Island—Continued.						Honshu Island.					
	Tomamae (44° 19′ N., 141° 39′ E.).		Oshidomari, Rishiri Is. (45° 14′ N., 141° 14′ E.).		Wakanai (45° 25′ N., 141° 40′ E.).		Asadoko, Aomori Bay (40° 57′ N., 140° 58′ E.).		Moura. Aomori Bay (40° 57′ N., 140° 52′ E.).		Ominato, Aomori Bay (41° 15′ N., 141° 09′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1												
K_1	0.15	334	0.17	344	0.19	0	0.20	167	0.178	145	0.185	157
K_2	0.02	159	0.01	156	0.02	156	0.09	140	0.077	134	0.081	134
L_2												
M_1												
M_2	0.15	133	0.09	136	0.07	81	0.59	105	0.580	105	0.655	104
M_3												
M_4												
M_6												
M_8												
N_2												
2N												
O_1	0.17	324	0.18	338	0.16	322	0.11	155	0.084	140	0.138	142
OO												
P_1	0.05	334	0.05	344	0.06	0	0.05	167	0.059	145	0.062	157
Q_1												
2Q												
R_2												
S_1												
S_2	0.08	159	0.06	156	0.07	156	0.31	140	0.286	134	0.297	134
S_4												
S_6												
T_2												
λ_2												
μ_2												
ν_2												
ρ_1												
Series									1888		1889	
Length									1 month.		3 months.	
Reference	(14)		(14)		(14)		(14)		(15)		(15)	

Component.	Honshu Island.							
	Ohatake, (41° 25′ N., 141° 10′ E.).		Ayukawa,[1] (38° 18′ N., 141° 31′ E.).		Orinohama (38° 23′ N., 141° 26′ E.).		Hirakata (36° 51′ N., 140° 48′ E.).	
	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.039	181				
K_1	0.59	144	0.780	170	0.77	156	0.72	159
K_2	(0.12)	(144)	0.126	148	(0.14)	(152)	(0.13)	(145)
L_2			0.042	140				
M_1			0.029	176				
M_2	0.89	108	1.023	115	1.11	114	0.97	115
M_3			0.020	114				
M_4			0.008	118				
M_6			0.002	314				
M_8								
N_2			0.146	102				
2N								
O_1	0.48	142	0.623	152	0.66	152	0.56	156
OO								
P_1	(0.23)	(144)	0.240	167	(0.26)	(156)	(0.24)	(159)
Q_1			0.134	143				
2Q								
R_2			0.030	59				
S_1			0.025	31				
S_2	0.42	144	0.471	152	0.52	152	0.48	145
S_4			0.003	212				
S_6			0.002	176				
T_2			0.029	195				
λ_2								
μ_2			0.019	127				
ν_2			0.028	109				
ρ_1								
Series			1894–1906					
Length			5 years.					
Reference	(14)		(16)		(14)		(14)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Honshu Island—Continued.																			
	Choshi Kawaguchi, (35° 44′ N., 140° 50′ E.).		Katsu-ura, (35° 10′ N., 140° 17′ E.).		Otohama, (34° 55′ N., 139° 56′ E.).		Tateyama, Sagami Sea, (34° 59′ N., 139° 51′ E.).		Sagami Daiichi Kaiho, Tokyo Bay, (35° 19′ N., 139° 46′ E.).		Shinangawa, Tokyo Bay, (35° 37′ N., 139° 45′ E.).		Kanagawa, Tokyo Bay, (35° 28′ N., 139° 39′ E.).		Yokohama,[1] Tokyo Bay, (35° 27′ N., 139° 38′ E.).		Yokosuka, Tokyo Bay, (35° 18′ N., 139° 39′ E.).		Hashirimitzu, Tokyo Bay, (35° 15′ N., 139° 44′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1															0.042	195				
K_1	0.63	174	0.78	166	0.69	172	0.730	161	0.81	165	0.71	169	0.83	164	0.817	180	0.77	164	0.77	169
K_2	(0.06)	(173)	(0.14)	(170)	0.15	180	0.161	174	0.19	180	(0.20)	(191)	(0.22)	(181)	0.201	181	(0.19)	(181)	0.18	181
L_2															0.051	171				
M_1															0.033	196				
M_2	0.67	133	1.19	138	1.10	143	1.178	147	1.46	149	1.60	159	1.45	140	1.531	154	1.43	152	1.36	150
M_3															0.035	161				
M_4															0.049	97				
M_6															0.005	103				
M_8																				
N_2															0.227	148				
2N																				
O_1	0.44	166	0.56	154	0.60	155	0.602	156	0.58	158	0.61	154	0.63	160	0.632	159	0.61	137	0.64	158
OO																				
P_1	(0.21)	(174)	(0.26)	(166)	0.24	172	0.244	161	0.27	165	(0.25)	(169)	(0.27)	(164)	0.270	177	(0.26)	(164)	0.26	169
Q_1															0.132	152				
2Q																				
R_2															0.014	2				
S_1															0.022	86				
S_2	0.23	173	0.52	170	0.53	180	0.593	174	0.69	180	0.74	191	0.80	181	0.746	185	0.69	181	0.66	181
S_4															0.005	140				
S_6															0.003	71				
T_2															0.045	166				
λ_2																				
μ_2															0.049	179				
ν_2															0.060	144				
ρ_1																				
Series							1891								1900–1905					
Length							2 months.								6 years.					
Reference	(14)		(14)		(14)		(15)		(14)		(14)		(14)		(16)		(14)		(14)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Honshu Island—Continued.

Component.	Uraganishi-uraga, Tokyo Bay (35° 15′ N., 139° 44′ E.).		Aburatsubo,[1] Kawatsu Bay, (35° 10′ N., 139° 37′ E.).		Shimoda, Sagami Sea (34° 40′ N., 138° 57′ E.).		Tago, Suruga Bay (34° 48′ N., 138° 47′ E.).		Yeno-ura, Suruga Bay (35° 3′ N., 138° 54′ E.).		Shimitzu, Suruga Bay (35° 1′ N., 138° 31′ E.).		Sakushima, Mie Bay (34° 44′ N., 137° 2′ E.).		Yokka-ichi, Mie Bay (34° 57′ N., 136° 38′ E.).		Toba, Mie Bay (34° 29′ N., 136° 50′ E.).		Matoya, Totomi Sea (34° 22′ N., 136° 52′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.041	186																
K_1	0.78	163	0.751	180	0.79	169	0.74	182	0.618	167	0.615	168	1.099	167	0.778	166	0.734	172	0.638	172
K_2	(0.16)	(177)	0.144	177	(0.16)	(186)	(0.19)	(186)	0.180	191	0.155	198	0.232	204	0.259	204	0.190	179	0.175	199
L_2			0.066	186																
M_1			0.038	161																
M_2	1.24	146	1.155	152	1.29	162	1.33	167	1.326	170	1.291	170	1.711	177	2.130	176	1.683	174	1.412	170
M_3			0.015	150																
M_4			0.009	104																
M_6			0.003	50																
M_8																				
N_2			0.195	150																
2N																				
O_1	0.61	154	0.589	160	0.64	163	0.50	170	0.446	161	0.505	160	0.653	164	0.549	177	0.574	165	0.518	170
OO																				
P_1	(0.26)	(163)	0.256	178	(0.26)	(169)	(0.25)	(182)	0.206	167	0.205	168	0.366	167	0.259	166	0.244	172	0.213	172
Q_1			0.125	153																
2Q																				
R_2			0.035	168																
S_1			0.029	50																
S_2	0.60	177	0.549	182	0.59	186	0.69	186	0.662	191	0.571	198	0.852	204	0.951	204	0.699	179	0.644	199
S_4			0.004	172																
S_6			0.002	201																
T_2			0.056	192																
λ_2																				
μ_2			0.031	139																
ν_2			0.013	113																
ρ_1																				
Series			1895–1904						1890		1890		1888		1888		1888		1888	
Length			5 years.						3 months.		2 months.		2 months.		1 month.		4 months.		2 months.	
Reference	(14)		(16)		(14)		(14)		(15)		(15)		(15)		(15)		(15)		(15)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Honshu Island—Continued.																			
	Hamashima, Totomi Sea (34° 18′ N., 136° 45′ E.).		Kushimoto,[1] Kii Channel (33° 28′ N., 135° 46′ E.).		Hii, Kii Channel (33° 55′ N., 135° 6′ E.).		Wakanoura, Kii Channel (34° 11′ N., 135° 11′ E.).		Osaka, Inland Sea (34° 39′ N., 135° 26′ E.).		Kobe,[1] Inland Sea (34° 41′ N., 135° 11′ E.).		Akashi, Inland Sea (34° 39′ N., 134° 59′ E.).		Shikama, Inland Sea (34° 47′ N., 134° 41′ E.).		Jeshima, Inland Sea (34° 40′ N., 134° 31′ E.).		Naoshima, (Miyanoura), Inland Sea (34° 27′ N., 134° 0′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.040	207							0.038	228								
K_1	0.695	170	0.720	188	0.70	177	0.75	189	0.88	195	0.838	205	0.83	212	1.02	220	0.90	221	0.99	222
K_2	0.180	194	0.186	195	0.20	203	0.18	225	0.17	227	0.147	230	0.08	245	0.10	306	0.10	309	0.20	355
L_2			0.052	174							0.041	325								
M_1			0.032	153							0.029	239								
M_2	1.589	185	1.498	174	1.52	181	1.40	185	1.01	215	1.001	212	0.44	257	0.89	319	0.95	340	2.22	319
M_3			0.017	201							0.026	233								
M_4			0.003	198							0.039	59								
M_6			0.003	104							0.041	234								
M_8																				
N_2			0.276	171							0.209	206								
$2N$																				
O_1	0.534	171	0.548	166	0.55	172	0.57	165	0.65	180	0.630	181	0.62	194	0.85	205	0.70	209	0.74	177
OO																				
P_1	0.232	170	0.245	183	0.24	177	0.25	189	0.29	195	0.263	200	0.28	212	0.34	220	0.30	222	0.33	222
Q_1			0.116	158							0.123	171								
$2Q$																				
R_2			0.020	123							0.026	195								
S_1			0.019	10							0.032	68								
S_2	0.659	194	0.672	198	0.73	203	0.68	225	0.62	227	0.569	229	1.31	245	0.37	306	0.38	309	0.73	355
S_4			0.003	147							0.003	167								
S_6			0.002	160							0.002	43								
T_2			0.054	194							0.049	238								
λ_2																				
μ_2			0.041	169							0.147	164								
ν_2			0.061	160							0.038	205								
ρ_1																				
Series	1888		1897–1905								1900–1906									
Length	3 months.		5 years.								6 years.									
Reference	(15)		(16)		(14)		(14)		(14)		(16)		(14)		(14)		(14)		(14)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Honshu Island—Continued.																			
	Shimo-tsu, Inland Sea (34° 26′ N., 133° 48′ E.).		Tomo, Inland Sea (34° 23′ N., 133° 22′ E.).		Setoda, Inland Sea (34° 18′ N., 133° 5′ E.).		Mitsugi,[1] Inland Sea (34° 23′ N., 133° 6′ E.).		Mitarai, Inland Sea (34° 10′ N., 132° 52′ E.).		Karoto Shima, Inland Sea (34° 04′ N., 132° 33′ E.).		Kure,[1] Inland Sea (34° 14′ N., 132° 32′ E.).		Hitsukino Hana, Inland Sea (34° 12′ N., 132° 31′ E.).		Higashi Nomi Jima, Inland Sea (34° 9′ N., 132° 29′ E.).		Yokohama Inland Sea (34° 20′ N., 132° 30′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg	Feet.	Deg	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1							0.042	276					0.035	288						
K_1	1.072	220	1.174	223	0.91	224	1.040	234	0.96	203	0.89	213	0.973	218	1.04	215	1.11	216	1.02	219
K_2	0.300	217	0.380	6	0.33	343	0.337	348	0.34	323			0.362	305						
L_2							0.172	350					0.128	285						
M_1							0.041	250					0.038	250						
M_2	2.938	327	3.525	327	3.48	307	3.349	316	3.59	289	2.98	276	3.365	279	3.39	283	3.19	274	3.51	276
M_3							0.013	104					0.020	342						
M_4							0.013	66					0.086	44						
M_6							0.011	203					0.118	162						
M_8																				
N_2							0.585	298					0.570	268						
2N																				
O_1	0.851	209	0.810	208	0.80	206	0.756	209	0.80	201	0.88	194	0.688	195	0.83	192	0.70	173	0.79	200
OO																				
P_1	0.357	220	0.392	223	0.30	224	0.260	240	0.32	203			0.282	230						
Q_1							0.149	198					0.116	181						
2Q																				
R_2							0.011	148					0.026	25						
S_1							0.046	111					0.055	68						
S_2	1.102	22	1.392	6	1.21	343	1.281	250	1.26	323	1.29	307	1.392	308	1.18	311	1.25	306	1.35	309
S_4							0.004	199					0.008	8						
S_6							0.002	105					0.006	127						
T_2							0.099	1					0.086	301						
λ_2																				
μ_2							0.175	80												
ν_2							0.220	276					0.232	268						
ρ_1																				
Series	1893		1893																	
Length	1 month.		2 months.								1 month.		2 years.				1 month.		1 month.	
Reference	(15)		(15)		(14)		(65)		(14)		(17)		(17)		(17)		(17)		(17)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Honshu Island—Continued.

Component.	Ujina, Inland Sea (34° 21′ N., 132° 28′ E.).		Etanchi, Inland Sea (34° 15′ N., 132° 28′ E.).		Kanne Bana, Inland Sea (34° 16′ N., 132° 22′ E.).		Hirukezdki Bana, Inland Sea (34° 17′ N., 132° 16′ E.).		Shimminato, Inland Sea (34° 15′ N., 132° 23′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1										
K_1	0.93	224	0.97	211	0.94	210	1.01	220	0.98	218
K_2	0.44	300	0.39	311						
L_2										
M_1										
M_2	3.26	283	3.25	278	3.07	273	3.26	277	3.07	276
M_3										
M_4										
M_6										
M_8										
N_2										
$2N$										
O_1	0.80	201	0.78	192	0.60	192	0.84	199	0.68	198
OO										
P_1	0.31	217	0.32	198						
Q_1										
$2Q$										
R_2										
S_1										
S_2	1.60	300	1.43	311	1.47	316	1.28	310	1.37	307
S_4										
S_6										
T_2										
λ_2										
μ_2										
ν_2										
ρ_1										
Series Length			1 month.		2 months.		2 months.		3 months.	
Reference	(14), (17)		(14), (17)		(17)		(17)		(17)	

Component.	Nasakejima, Inland Sea (33° 57′ N., 132° 28′ E.).		Okikamuro Shima, Inland Sea (33° 51′ N., 132° 22′ E.).		Hikuma, Inland Sea (33° 55′ N., 132° 18′ E.).		Obatake, Inland Sea (33° 58′ N., 132° 10′ E.).		Murotsu, Inland Sea (33° 50′ N., 132° 07′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1										
K_1	1.11	216	0.97	213	0.96	219	0.95	212	0.86	210
K_2			0.30	291			0.36	290	0.32	289
L_2										
M_1										
M_2	3.20	265	2.94	262	3.03	277	2.92	261	2.66	258
M_3										
M_4										
M_6										
M_8										
N_2										
$2N$										
O_1	0.75	187	0.72	193	0.66	193	0.70	199	0.61	191
OO										
P_1			0.33	200			0.31	198	0.29	197
Q_1										
$2Q$										
R_2										
S_1										
S_2	1.22	292	1.10	291	1.27	307	1.32	290	1.18	289
S_4										
S_6										
T_2										
λ_2										
μ_2										
ν_2										
ρ_1										
Series Length	1 month.		4 months.		2 months.		3 months.		6 months.	
Reference	(17)		(14), (17)		(17)		(14), (17)		(14), (17)	

JAPAN—Continued.

Component.	Honshu Island—Continued. Hedomari, Shimonoseki Strait (33° 57′ N., 130° 52′ E.)		Setozaki (34° 24′ N., 131° 12′ E.).		Hagi (34° 25′ N., 131° 24′ E.).		Esaki (34° 39′ N., 131° 39′ E.).		Tonoura[1] (34° 55′ N., 132° 4′ E.).		Sagi-ura (35° 26′ N., 132° 41′ E.).		Saigo, Oki Island (36° 12′ N., 133° 20′ E.).		Yonago (35° 22′ N., 133° 18′ E.).		Okinoura (35° 40′ N., 131° 40′ E.).		Tsuiyama (35° 39′ N., 134° 50′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1									0.010	3										
K_1	0.38	266	0.322	321	0.299	321	0.264	325	0.228	352	0.139	345	0.17	336	0.128	357	0.158	327	0.159	329
K_2	0.16	321	0.091	340	0.076	338	0.046	318	0.034	0	0.026	47	0.01	85	0.014	153	0.020	82	0.019	92
L_2									0.008	329										
M_1									0.011	356										
M_2	1.26	290	0.628	316	0.535	326	0.348	339	0.268	353	0.217	33	0.23	55	0.142	141	0.198	61	0.203	72
M_3									0.012	23										
M_4									0.007	213										
M_6									0.003	188										
M_8																				
N_2									0.063	354										
2N																				
O_1	0.46	267	0.380	301	0.377	303	0.318	309	0.275	324	0.149	337	0.20	310	0.149	352	0.163	315	0.176	311
OO																				
P_1	0.13	266	0.107	321	0.100	321	0.088	325	0.078	35	0.046	315	0.06	336	0.043	357	0.052	327	0.053	329
Q_1									0.064	306										
2Q																				
R_2									0.005	338										
S_1									0.009	323										
S_2	0.58	321	0.336	340	0.276	338	0.169	318	0.131	6	0.094	47	0.05	85	0.053	153	0.073	82	0.068	92
S_4									0.003	269										
S_6									0.002	228										
T_2									0.009	26										
λ_2																				
μ_2									0.020	331										
ν_2									0.014	7										
ρ_1																				
Series			1889		1889		1889		1895–1904		1891				1891		1892		1892	
Length			3 months.		2 months.		2 months.		6 years.		1 month.				1 month.		5 months.		3 months.	
Reference	(14)		(15)		(15)		(15)		(16)		(15)		(14)		(15)		(15)		(15)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Honshu Island—Continued.

Component.	Maizuru (35° 27′ N., 135° 19′ E.).		Wajima[1] (37° 24′ N., 136° 54′ E.).		Nanao (37° 3′ N., 136° 57′ E.).		Ao (Yetchn) (36° 53′ N., 136° 59′ E.).		Naoetzu (37° 11′ N., 138° 11′ E.).		Amaze (37° 32′ N., 138° 41′ E.).		Futami, Sado Is. (37° 57′ N., 138° 14′ E.).		Ebisu, Sado Is. (38° 5′ N., 138° 25′ E.).		Kamo (Uzen) (38° 48′ N., 139° 48′ E.).		Funakawa (39° 54′ N., 139° 51′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.008	338																
K_1	0.23	328	0.170	346	0.19	328	0.189	339	0.146	338	0.146	337	0.18	320	0.18	336	0.18	336	0.256	337
K_2	0.01	94	0.017	104	0.02	115	0.020	109	0.020	106	0.018	104	0.02	100	0.02	117	0.02	128	0.029	140
L_2			0.005	122																
M_1			0.010	301																
M_2	0.24	67	0.195	79	0.21	78	0.216	80	0.182	81	0.188	75	0.20	82	0.18	74	0.17	88	0.177	90
M_3			0.001	319																
M_4			0.005	46																
M_6			0.001	19																
M_8																				
N_2			0.051	62																
2N																				
O_1	0.14	306	0.172	319	0.20	320	0.198	318	0.168	324	0.164	320	0.17	167	0.15	329	0.19	328	0.239	327
OO																				
P_1	0.08	328	0.056	342	0.06	328	0.063	339	0.048	338	0.048	337	0.06	320	0.06	336	0.06	336	0.085	337
Q_1			0.036	300																
2Q																				
R_2			0.004	81																
S_1			0.011	359																
S_2	0.05	94	0.070	107	0.08	115	.074	109	0.075	106	0.075	104	0.08	100	0.07	117	0.08	128	0.105	140
S_4			0.001	139																
S_6			0.001	139																
T_2			0.004	119																
λ_2																				
μ_2			0.010	24																
ν_2			0.010	72																
ρ_1																				
Series			1901-1905				1892		1892		1892								1893	
Length			5 years.				3 months.		4 months.		3 months.								2 months	
Reference	(14)		(16)		(14)		(15)		(15)		(15)		(14)		(14)		(14)		(15)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Honshu Island—Continued.						Awaji Island.								Shikoku Island.					
	Iwasaki[1] (40° 35′ N., 139° 54′ E.).		Fuka-ura (40° 41′ N., 139° 59′ E.).		Kotomari (41° 7′ N., 140° 17′ E.).		Swaya (34° 36′ N., 135° 1′ E.).		Fukura (34° 15′ N., 134° 43′ E.).		Anaga (34° 16′ N., 134° 40′ E.).		Murotsu (34° 32′ N., 134° 53′ E.).		Donoura, Naruto Pass (34° 13′ N., 134° 35′ E.).		Tosadomari, Naruto Pass (34° 11′ N., 134° 38′ E.).		Magosaki, Naruto Pass (34° 14′ N., 134° 39′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.008	10																		
K_1	0.170	355	0.16	338	0.13	352	0.78	205	0.73	194	0.90	236	0.86	221	0.77	198	0.75	215	0.89	263
K_2	0.022	128	(0.02)	(137)	0.02	126	0.10	237	0.21	314	0.07	341	0.07	286	0.15	232	0.17	225	0.05	347
L_2	0.002	93																		
M_1	0.007	16																		
M_2	0.176	101	0.17	98	0.25	89	0.37	220	1.48	192	1.09	338	0.72	335	0.95	219	1.10	205	0.99	330
M_3	0.004	204																		
M_4	0.003	46																		
M_6	0.002	216																		
M_8																				
N_2	0.042	80																		
2N																				
O_1	0.170	328	0.17	329	0.13	326	0.68	196	0.55	177	0.68	211	0.78	206	0.59	194	0.56	187	0.77	198
OO																				
P_1	0.058	347	(0.05)	(338)	0.04	352	0.26	205	0.24	194	0.30	236	0.29	221	0.26	198	0.25	215	0.30	263
Q_1	0.033	311																		
2Q																				
R_2	0.004	64																		
S_1	0.011	357																		
S_2	0.072	136	0.08	137	0.07	126	0.36	237	0.77	214	0.24	341	0.25	286	0.56	232	0.62	225	0.20	347
S_4	0.001	167																		
S_6	0.001	143																		
T_2	0.005	145																		
λ_2																				
μ_2	0.011	47																		
ν_2	0.008	94																		
ρ_1																				
Series	1902–1907																			
Length	6 years.																			
Reference	(16)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)	

[1] For compound and long period components see p. 407.

JAPAN—Continued.

Shikoku Island—Continued.

Component.	Urado (33° 30′ N., 133° 35′ E.).		Susaki (33° 23′ N., 133° 17′ E.).		Aoshima, Inland Sea (33° 44′ N., 132° 29′ E.).		Nada, Inland Sea (33° 41′ N., 132° 38′ E.).		Mitsugahama,[1] Inland Sea (33° 52′ N., 132° 42′ E.).		Gokoshima, Inland Sea (33° 55′ N., 132° 41′ E.).		Oura, Inland Sea (33° 59′ N., 132° 38′ E.).		Uwama, Inland Sea (33° 58′ N., 132° 35′ E.).		Kurushima, Inland Sea (34° 7′ N., 132° 59′ E.).		Hashihama,[1] Inland Sea (34° 6′ N., 132° 58′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1									0.059	232									0.058	271
K_1	0.631	182	0.685	173	1.01	206	0.92	212	1.002	209	0.98	204	1.01	211	1.01	212	1.05	212	1.057	223
K_2	0.166	220	0.193	196	0.336	284			0.374	290	0.32	303					0.36	328	0.392	326
L_2									0.109	300									0.126	319
M_1									0.015	69									0.068	242
M_2	1.561	185	1.650	172	3.029	255	2.95	245	3.264	266	3.15	270	3.17	272	2.78	271	3.54	289	3.560	296
M_3									0.013	34									0.009	60
M_4									0.020	61									0.025	351
M_6									0.026	189									0.013	21
M_8																				
N_2									0.601	253									0.594	280
2N																				
O_1	0.528	117	0.536	171	0.726	183	0.61	180	0.747	188	0.79	193	0.80	192	0.72	196	0.76	201	0.784	201
OO																				
P_1	0.216	182	0.228	173	0.337	193			0.301	207	0.33	204					0.35	212	0.304	224
Q_1									0.152	179									0.158	188
2Q																				
R_2									0.021	46									0.017	163
S_1									0.030	115									0.037	122
S_2	0.610	220	0.706	196	1.235	284	1.22	289	1.344	293	1.19	303	1.23	300	1.26	294	1.35	328	1.375	327
S_4									0.006	29									0.005	70
S_6									0.002	140									0.002	141
T_2									0.095	294									0.089	329
λ_2																				
μ_2																				
ν_2									0.055	215									0.052	283
ρ_1																				
Series	1891		1891		1891															
Length	1 month.		3 months.		1 month.		1 month.		1 year.				3 months.		1 month.				1 year.	
Reference	(15)		(15)		(15), (17)		(17)		(17)		(14)		(17)		(17)		(14)		(17)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Shikoku Island—Continued.										Kiushu Island.									
	Kuroshima (Niigori Syo) Inland Sea (33° 59′ N., 133° 20′ E.).		Awashima,[1] Inland Sea (34° 16′ N., 133° 38′ E.).		Konoura, Inland Sea (34° 26′ N., 134° 14′ E.).		Aiketa, Inland Sea (34° 14′ N., (134° 24′ E.).		Kitadomari, Inland Sea (34° 14′ N., 134° 35′ E.).		Aohama, Inland Sea (33° 57′ N., 131° 2′ E.).		Kakaji, Inland Sea (33° 40′ N., 131° 31′ E.).		Hosojima[1] (32° 25′ N., 131° 40′ E.).		Mimitsu (32° 20′ N., 131° 37′ E.).		Kagoshima (31° 36′ N., 130° 34′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.052	285											0.037	210				
K_1	1.05	232	1.092	240	1.01	221	0.90	221	0.85	224	0.95	197	0.972	202	0.653	193	0.71	185	0.82	184
K_2	0.36	356	0.368	7	0.12	336	0.08	333	0.09	260	0.47	197	0.363	286	0.214	193	0.18	200	0.33	231
L_2			0.204	356											0.060	167				
M_1			0.038	253											0.024	193				
M_2	3.71	291	3.536	333	1.60	318	1.14	348	0.58	270	3.54	254	3.083	258	1.631	182	1.71	179	2.54	206
M_3			0.042	71											0.025	190				
M_4			0.052	181											0.025	306				
M_6			0.064	11											0.007	311				
M_8																				
N_2			0.562	317											0.303	177				
2N																				
O_1	0.71	207	0.772	216	0.67	197	0.69	215	0.64	195	0.71	196	0.684	189	0.501	171	0.57	168	0.61	179
OO																				
P_1	0.35	232	0.331	250	0.34	221	0.30	211	0.28	224	0.31	197	0.324	202	0.208	194	0.24	185	0.27	184
Q_1			0.148	208											0.108	164				
2Q																				
R_2			0.021	17											0.056	183				
S_1			0.048	134											0.032	57				
S_2	1.33	356	1.329	9	0.49	336	0.29	333	0.31	260	1.74	287	1.331	286	0.687	207	0.67	200	1.20	331
S_4			0.010	334											0.005	52				
S_6			0.004	342											0.002	175				
T_2			0.086	358											0.070	220				
λ_2																				
μ_2			0.206	98											0.053	176				
ν_2			0.140	338											0.063	143				
ρ_1																				
Series													1891		1895–1906					
Length													1 month.		4 years.					
Reference	(14)		(65)		(14)		(14)		(14)		(14)		(15)		(16)		(14)		(14)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Kiushu Island—Continued.																			
	Yamakawa (31° 12′ N., 130° 38′ E.).		Ushibuka, Amakusa Is. (32° 12′ N., 130° 1′ E.).		Tomioka, Amakusa Is. (32° 31′ N., 130° 2′ E.).		Ikenoura, Amakusa Is. (32° 23′ N., 130° 21′ E.).		Senzoku shima, Zozoseto (32° 34′ N., 130° 29′ E.).		Misumi (32° 37′ N., 130° 27′ E.).		Wakatsu (33° 7′ N., 130° 20′ E.).		Fake saki shima (32° 57′ N., 130° 14′ E.).		Shimabara (32° 47′ N., 130° 22′ E.).		Kuchi-no-tsu (32° 36′ N., 130° 11′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.84	195	0.93	195	0.84	199	0.88	210	0.98	207	0.87	202	0.82	215	0.92	208	0.90	209	0.82	210
K_2	0.32	233	0.33	252	0.37	255	0.40	283	0.45	292	0.46	290	0.61	301	0.65	296	0.49	299	0.39	287
L_2																				
M_1																				
M_2	2.44	205	2.75	226	2.93	219	3.45	253	3.83	250	3.94	256	5.27	262	5.25	259	4.36	259	3.18	243
M_3																				
M_4																				
M_6																				
M_8																				
N_2																				
2N																				
O_1	0.70	178	0.65	187	0.65	183	0.60	196	0.67	183	0.64	189	0.60	193	0.69	197	0.69	194	0.69	193
OO																				
P_1	0.28	195	0.31	195	0.28	199	0.29	210	0.33	207	0.29	202	0.27	215	0.31	208	0.30	209	0.27	210
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	1.16	233	1.21	252	1.36	255	1.47	283	1.63	292	1.70	290	2.23	301	2.37	296	1.81	299	1.42	287
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series																				
Length																				
Reference	(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)	

JAPAN—Continued.

Kiushu Island—Continued.

Component.	Kaba shima, (32° 34′ N., 129° 47′ E.).		Fukabori,[1] (32° 41′ N., 129° 49′ E.).		Nagasaki, (32° 44′ N., 129° 51′ E.).		Matsu shima, (32° 56′ N., 129° 36′ E.).		Wakametsu, Goto Is., (32° 53′ N., 129° 0′ E.).		Kogozaki, Omura wan, (33° 6′ N., 129° 40′ E.).		Tawaranoura, Omura wan, (33° 7′ N., 129° 40′ E.).		Sasebo, (33° 10′ N., 129° 43′ E.).		Ainoura, (33° 11′ N., 129° 39′ E.).		Kurotojima, Hirado Kaikyo, (33° 23′ N., 129° 33′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.052	222	(0.051)	(216)														
K_1	0.819	190	0.838	207	0.818	206	0.817	196	0.78	204	0.79	201	0.720	203	0.82	214	0.81	200	0.64	220
K_2	0.323	259	0.336	252	0.311	235	0.363	260	0.33	283	0.34	270	0.362	262	0.36	275	0.35	256	0.32	272
L_2			0.079	207	(0.073)	(236)														
M_1			0.031	161	0.032	203														
M_2	2.826	229	2.748	229	2.803	228	2.809	230	2.73	250	2.73	*238	2.730	235	2.84	247	2.90	231	2.69	251
M_3			0.032	267																
M_4			0.036	317	0.048	309														
M_6			0.010	165	0.012	245														
M_8																				
N_2			0.512	223	0.503	221														
2N					(0.067)	(214)														
O_1	0.632	187	0.650	185	0.643	186	0.628	186	0.58	196	0.60	192	0.745	188	0.63	198	0.65	193	0.60	212
OO					(0.028)	(226)														
P_1	0.273	190	0.276	202	(0.271)	(206)	0.273	196	0.28	204	0.26	201	0.240	203	0.27	214	0.27	200	0.21	220
Q_1			0.134	175	(0.125)	(177)														
2Q					(0.017)	(167)														
R_2			0.043	185	(0.010)	(256)														
S_1			0.007	273																
S_2	1.182	259	1.227	257	1.221	256	1.331	260	2.21	283	1.24	270	1.332	262	1.31	275	1.28	256	1.16	272
S_4			0.005	140																
S_6			0.002	196																
T_2			0.082	251	(0.072)	(256)														
λ_2					(0.020)	(241)														
μ_2			(0.114)	(221)	(0.067)	(201)														
ν_2			0.116	187	(0.098)	(222)														
ρ_1					(0.024)	(178)														
Series	1891		1897–1905		1891		1891						1891							
Length	2 months.		5 years.		3 months.		4 months.						3 months.							
Reference	(15)		(16)		(1)		(15)		(14)		(14)		(15)		(14)		(14)		(14)	

[1] For compound and long-period components see p. 407.

JAPAN—Continued.

Component.	Kiushu Island—Continued.																			
	Hoshigaura, Imari wan (33° 23′ N., 129° 40′ E.).		Fukushima, Imari wan (33° 21′ N., 129° 49′ E.).		Kariya, (33° 28′ N., 129° 50′ E.).		Gonoura, Iki Island (33° 44′ N., 129° 41′ E.).		Kazamoto, Iki Island (33° 51′ N., 129° 41′ E.).		Fukuoka (33° 36′ N., 130° 22′ E.).		Fuzasakimura, Fukuoka wan (33° 47′ N., 130° 27′ E.).		Kanekasaki mura (33° 53′ N., 130° 30′ E.).		Moji (33° 57′ N., 130° 39′ E.).		Izukara, Tsu Islands (34° 11′ N., 129° 17′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.58	235	0.605	235	0.588	210	0.51	227	0.51	212	0.48	251	0.69	257	0.45		0.53	211	0.24	211
K_2	0.31	287	0.280	282	0.256	287	0.29	303	0.25	298	0.22	306	0.20	305	0.16	344	0.29	297	0.23	284
L_2																				
M_1																				
M_2	2.18	258	2.348	251	2.098	272	2.17	272	1.96	270	1.88	272	1.58	281	1.51	336	2.44	261	1.72	251
M_3																				
M_4																				
M_6																				
M_8																				
N_2																				
2N																				
O_1	0.52	216	0.518	209	0.528	241	0.42	228	0.44	235	0.46	214	0.43	254	0.44	280	0.45	226	0.18	194
OO																				
P_1	0.19	235	0.202	235	0.196	240	0.17	227	0.17	212	0.16	254	0.23	257	0.15		0.18	221	0.08	214
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	1.14	287	1.027	282	0.941	287	1.05	303	0.91	298	0.80	306	0.75	303	0.59	344	1.08	297	0.86	288
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
μ_2																				
ρ_1																				
Series			1891		1891															
Length			1 month.		2 months.															
Reference	(14)		(15)		(15)		(14)		(14)		(14)		(14)		(14)		(14)		(14)	

JAPAN—Continued.

Component.	Kiushu Island—Continued.								Nansei Islands (Loo Choo).											
	Hirugaura, Tsu Is., (34° 19′ N., 129° 16′ E.)		Shimayama, (34° 19′ N., 129° 18′ E.).		Kamoize, (34° 40′ N., 129° 22′ E.).		Nishidomari, (34° 39′ N., 129° 28′ E.).		Kasari, Amamu Oshima, (28° 27′ N., 129° 30′ E.).		Kuji, Amamu Oshima, (28° 14′ N., 129° 15′ E.).		Unien, Okinawa Is., (26° 40′ N., 128° 0′ E.).		Sesoko, Okinawa Is., (26° 38′ N., 127° 53′ E.).		Naha, Okinawa Is., (26° 23′ N., 127° 40′ E.).		Miyakojima, (24° 48′ N., 125° 18′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.400	198	0.37	201	0.27	216	0.09	217	0.65	191	0.70	201	0.64	195	0.61	202	0.68	195		
K_2	0.282	288	0.26	280	0.20	274	0.16	282	0.23	231	0.23	234	0.21	228	0.18	231	0.23	222	0.549	235
L_2																			0.188	240
M_1																				
M_2	2.174	259	2.16	256	1.54	254	1.12	250	1.82	199	1.71	211	1.72	196	1.85	197	1.86	198	1.655	216
M_3																				
M_4																				
M_6																				
M_8																				
N_2																				
2N																				
O_1	0.308	197	0.31	203	0.16	209	0.11	248	0.47	181	0.54	196	0.51	192	0.52	184	0.50	193	0.506	212
O																				
P_1	0.133	198	0.12	201	0.09	216	0.06	217	0.22	191	0.23	201	0.21	195	0.20	202	0.23	195	0.185	235
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	1.036	288	0.95	280	0.76	274	0.59	282	0.78	231	0.84	234	0.77	228	0.65	231	0.85	222	0.690	240
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1891																		1888	
Length	1 month.																		2 months.	
Reference	(15)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(15)	

JAPAN—Continued.

Component.	Nansei Islands—Continued.				Taiwan Island (Formosa).										Pescadores Islands.					
	Taketomijima, Gaeyama (24° 9′ N., 124° 5′ E.).		Funauke, Iriomote (24° 20′ N., 123° 44′ E.).		Tamsui (25° 11′ N., 121° 24′ E.).		Kiirun[1] (25° 9′ N., 121° 45′ E.).		So-o (24° 35′ N., 121° 52′ E.).		Toko (22° 28′ N., 120° 27′ E.).		Takaw[1] (22° 37′ N., 120° 16′ E.).		Gyo-o-to (23° 37′ N., 119° 31′ E.).		Santakuto (23° 38′ N., 119° 31′ E.).		Hatto retto (23° 21′ N., 119° 31′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg*
J_1							0.032	249					0.015	310						
K_1					0.72	240	0.608	232	0.64	217	0.58	294	0.512	295	0.79	271	0.89	264	0.81	218
K_2	0.62	209	0.70	208	0.24	5	0.044	271	0.18	209	0.07	233	0.054	257	0.20	20	0.31	6	0.10	28
L_2	0.18	217	0.17	216			0.038	30					0.021	222						
M_1							0.031	230					0.031	262						
M_2	1.47	197	1.49	200	3.36	322	0.628	294	1.80	185	0.59	243	0.505	244	2.94	332	3.99	324	2.43	134
M_3							0.019	180					0.009	256						
M_4							0.029	307					0.003	222						
M_6							0.011	266					0.006	41						
M_8																				
N_2							0.169	268					0.112	238						
2N																				
O_1	0.56	196	0.54	197	0.58	217	0.503	206	0.57	207	0.53	256	0.497	257	0.76	245	0.84	231	0.72	250
OO																				
P_1	0.21	209	0.23	208	0.24	240	0.198	230	0.21	217	0.20	294	0.172	291	0.26	274	0.30	264	0.27	268
Q_1							0.102	192					0.096	245						
2Q																				
R_2							0.016	174					0.005	245						
S_1							0.016	93					0.015	67						
S_2	0.65	217	0.64	216	0.87	5	0.168	285	0.44	209	0.24	233	0.205	248	0.74	20	1.15	6	0.36	276
S_4							0.005	337					0.001	322						
S_6							0.001	117					0.001	128						
T_2							0.016	266					0.017	232						
λ_2																				
μ_2							0.085	157					0.008	261						
ν_2							0.048	298					0.033	266						
ρ_1																				
Series							1905–1908						1904–5							
Length							4 years.						2 years.							
Reference	(14)		(14)		(14)		(16)		(14)		(14)		(16)		(14)		(14)		(14)	

[1] For compound and long-period components see p. 407.

ASIA, EAST COAST.

Component.	Chosen (Korea).																			
	So-saing-pho (35° 28′ N., 129° 25′ E.).		Fu-san (35° 8′ N., 129° 2′ E.).		Tsu Shima, Korea Strait (34° 17′ N., 129° 21′ E.).		Douglas Inlet (35° 2′ N., 128° 48′ E.).		Ma-san-pho Reach (35° 12′ N., 128° 34′ E.).		Centre Harbor, Koji Do (34° 50′ N., 128° 42′ E.).		Cargodo Gulf, Koji Do (34° 50′ N., 128° 35′ E.).		Shadwell Gulf, Koji Do (34° 53′ N., 128° 27′ E.).		Sylvia Basin, Koji Do (34° 55′ N., 128° 30′ E.).		Sylvia Basin, North Shore (35° 4′ N., 128° 33′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.09	35	0.13	130	0.92	185	0.28	150	0.28	170	0.34	170	0.67	191	0.24	166	0.26	179	0.30	143
K_2	0.08	246	0.17	261	0.41	313	0.25	268	0.29	269	0.21	273	0.23	311	0.31	290	0.29	254	0.28	252
L_2																				
M_1																				
M_2	0.54	209	1.34	233	3.07	276	1.85	240	2.10	245	1.96	244	2.68	251	2.29	245	2.04	230	2.12	239
M_3																				
M_4																				
M_6																				
M_8																				
N_2																				
2N																				
O_1	0.07	346	0.06	144	0.54	167	0.15	136	0.12	143	0.17	145	0.35	151	0.13	147	0.11	107	0.11	124
OO																				
P_1	0.03	35	0.05	130	0.31	185	0.09	150	0.09	170	0.11	170	0.22	191	0.08	166	0.09	179	0.10	143
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.28	246	0.64	261	1.51	313	0.93	268	1.00	269	0.77	273	0.85	311	1.15	290	1.06	254	1.04	252
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series																				
Length																				
Reference	(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)	

ASIA, EAST COAST—Continued.

Component.	Chosen (Korea)—Continued.																			
	[illegible] Do ([illegible])		Sinko Do (34° 51′ N., 128° 13′ E.).		Willes Gulf (34° 44′ N., 127° 45′ E.).		North of Herschel Is. (34° 37′ N., 127° 33′ E.).		Herschel Is. (34° 28′ N., 127° 28′ E.).		Madarin Is., Golden I. (34° 21′ N., 126° 53′ E.).		Madarin Is., Kwando (34° 22′ N., 126° 47′ E.)		Chrichton Harbor (34° 8′ N., 126° 38′ E.).		Green Is., Washington Gulf (34° 27′ N., 126° 25′ E.).		Family Group, Washington Gulf (34° 24′ N., 126° 19′ E.).	
		κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.58	176	0.57	166	0.68	165	0.72	184	0.82	174	0.86	182	0.77	182	0.71	189	0.93	201	2.60	60
K_2	0.34	271	0.37	269	0.42	278	0.48	289	0.43	283	0.37	303	0.55	309	0.36	328	0.36	355	0.19	166
L_2																				
M_1																				
M_2	3.21	242	2.73	252	3.34	252	3.65	268	3.43	260	3.00	282	3.51	263	2.79	295	3.22	308	3.01	342
M_3																				
M_4																				
M_6																				
M_8																				
N_2																				
$2N$																				
O_1	0.52	147	0.37	151	1.42	151	0.46	171	0.53	157	0.53	170	0.70	157	0.57	179	0.69	179		
OO																				
P_1	0.19	176	0.19	166	0.23	165	0.24	184	0.27	174	0.29	182	0.26	182	0.24	189	0.31	201	0.87	60
Q_1																				
$2Q$																				
R_2																				
S_1																				
S_2	1.24	271	1.26	277	1.55	278	1.75	289	1.58	283	1.35	303	2.03	309	1.31	328	1.33	355	0.67	166
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series																				
Length																				
Reference	(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)	

ASIA, EAST COAST—Continued.

Component.	Chosen (Korea)—Continued.																			
	Thistle Is., Chin do, (34° 24′ N., 126° 8′ E.).		Montreal Is., (34° 20′ N., 126° 4′ E.).		Amherst Is., (34° 32′ N., 126° 2′ E.).		Yong San Gang R., (34° 45′ N., 126° 22′ E.).		Pigum Do, Naju Group, (34° 44′ N., 125° 56′ E.).		North Twin Is., Naju Group, (34° 51′ N., 126° 2′ E.).		Fire Is., (35° 3′ N., 126° 5′ E.).		Kokuntau, (35° 49′ N., 126° 25′ E.).		Won-san Is., (36° 22′ N., 126° 26′ E.).		Chemulpho,[1] (37° 29′ N. 126° 37′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																			0.056	341
K_1	0.97	225	0.95	211	1.01	217	1.03	246	1.00	235	0.88	240	0.83	253	1.22	256	1.06	266	0.803	307
K_2	0.37	43	0.30	12	0.34	38	0.36	98	0.19	55	0.41	74	0.53	81	0.64	118	0.80	128	1.168	162
L_2																			0.264	150
M_1																				
M_2	3.70	4	3.04	346	3.57	5	3.94	53	3.83	17	4.50	43	4.67	45	7.40	85	7.86	91	9.429	108
M_3																				
M_4																			0.278	67
M_6																			0.079	7
M_8																				
N_2																			1.669	80
2N																			0.222	53
O_1	0.74	209	0.67	203	0.77	209	0.81	227	0.80	213	0.71	238	0.55	216	0.95	241	0.77	249	0.712	239
OO																			0.031	15
P_1	0.32	225	0.30	211	0.34	217	0.34	246	0.33	235	0.29	240	0.28	253	0.41	256	0.35	266	0.503	307
Q_1																			0.138	205
2Q																				
R_2																				
S_1																				
S_2	1.34	43	1.12	12	1.26	38	1.32	98	0.71	55	1.49	74	1.93	81	2.36	118	2.94	128	3.838	187
S_4																				
S_6																				
T_2																			0.226	187
λ_2																				
μ_2																			0.226	29
ν_2																			0.324	84
ρ_2																				
Series																			1887–88	
Length																			192 days.	
Reference	(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(14)		(1)	

[1] For compound and long-period components see p. 407.

ASIA, EAST COAST—Continued.

Component.	Chosen (Korea)—Continued.								China.											
	Gets-nai-tau Is. (38° 3′ N., 124° 49′ E.).		Dauchin Is., Ping Yang Inlet (38° 37′ N., 125° 0′ E.).		Pio sem, Ping Yang Inlet (38° 40′ N., 125° 10′ E.).		Ping Yang Inlet (38° 38′ N., 125° 35′ E.).		Tientsin Entrance,[1] Taku North Fort (38° 59′ N., 117° 42′ E.).		Wei-ha-wei[1] (37° 29′ N., 122° 13′ E.).		Shanghai[1] (31° 21′ N., 121° 30′ E.).		Amoy (24° 23′ N., 118° 10′ E.).		Swatow[1] (23° 23′ N., 116° 39′ E.).		Hongkong[1] (22° 18′ N., 114° 10′ E.).	
	H	κ	H	κ	H	κ	H	ν	H	κ	H	κ	H	κ	H	κ	H	ν	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1									(0.045)	(161)	0.048	11			(0.049)	(285)	0.025	299	0.026	270
K_1	1.28	304	1.60	316	1.31	316	1.22	331	0.804	146	0.706	306	0.656	207	0.868	274	0.941	292	1.190	296
K_2	0.31	212	0.39	270	0.49	280	0.56	308	0.272	165	0.448	0	0.281	77	0.364	61	0.119	73	0.147	208
L_2									0.231	137	0.114	344	0.058	59	0.111	30	0.080	34	0.033	274
M_1									0.034	139	0.021	289			(0.054)	(263)	0.019	48	(0.075)	(271)
M_2	3.48	161	5.04	226	5.48	244	6.68	262	3.069	95	1.998	297	3.109	30	6.125	1	1.347	23	1.438	266
M_3									0.055	164	0.028	191					0.038	341	0.051	328
M_4									0.347	110	0.063	173	0.700	331	0.042	92	0.228	154	0.076	322
M_6									0.017	113	0.019	261					0.053	172	0.014	140
M_8									0.010	52										
N_2									0.414	68	0.033	249	0.401	2	0.776	332	0.237	358	0.280	255
2N									(0.055)	(41)					(0.103)	(303)				
O_1	0.84	274	0.93	292	0.98	294	0.95	305	0.576	114	0.443	262	0.462	149	0.639	252	0.765	254	0.904	246
OO									(0.025)	(177)					(0.027)	(296)			(0.037)	(344)
P_1	0.43	304	0.53	316	0.44	316	0.41	331	0.146	193	0.197	313	0.217	207	0.287	272	0.269	285	0.384	288
Q_1									0.122	82	0.068	252	0.090	120	0.124	241	0.139	242	0.156	230
2Q									(0.015)	(83)					(0.017)	(230)			(0.024)	(198)
R_2									(0.006)	(164)					(0.011)	(57)	0.043	180	(0.005)	(291)
S_1									0.305	151	0.067	259					0.065	106	0.029	120
S_2	1.15	212	1.42	270	1.81	280	2.05	308	0.793	164	0.588	5	1.032	77	1.338	57	0.316	86	0.564	291
S_4									0.021	260	0.002	311					0.025	216	0.007	37
S_6									0.008	88	0.001	302					0.001	56	0.001	222
T_2									0.160	303			0.061	76	0.079	55	0.015	82	0.034	286
λ_2									0.080	144					(0.043)	(27)			(0.010)	(278)
μ_2									0.265	201	0.184	66			0.147	305	0.070	176	0.071	238
ν_2									0.128	38	0.136	267	0.078	6	0.151	336	0.074	327	0.061	212
ρ_1									(0.022)	(101)					(0.024)	(243)			(0.034)	(226)
Series									1912–13		1898–99		1893–94		1892		1897–98		1883–1889	
Length									369 days.		7 months.		369 days.		58 days.		1 year.		2 years.	
Reference	(14)		(14)		(14)		(14)		(1)		(18)		(1)		(1)		(19)		(2), (19)	

[1] For compound and long-period components see p. 408.

ASIA, EAST COAST—Continued.

Component.	China—Continued.							
	Macao,[1] Inner Harbor (22° 20′ N., 113° 30′ E.).		Whampoa [1] (23° 05′ N., 113° 26′ E.).		Nau Chau, Nau Tsheon (21° 00′ N., 110° 38′ E.).		Pak-hoi (21° 29′ N., 109° 06′ E.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.072	330						
K_1	1.175	310	1.068	354	1.345	310	3.379	76
K_2	0.190	326	0.288	64	0.295	345	0.098	209
L_2	0.043	314						
M_1	0.049	282						
M_2	1.562	300	2.184	32	2.592	304	1.246	180
M_3	0.046	216	0.100	190				
M_4	0.098	78	0.160	313				
M_6	0.026	230						
M_8								
N_2	0.033	286	0.380	16				
2N								
O_1	0.951	270	0.815	310	1.214	276	3.707	49
OO								
P_1	0.384	308	0.351	15	0.459	310	1.115	76
Q_1	0.197	251	0.116	326				
2Q								
R_2								
S_1	0.046	116	0.119	118				
S_2	0.610	327	0.666	64	1.050	345	0.394	209
S_4			0.003	16				
S_6								
T_2			0.036	23				
λ_2								
μ_2	0.033	272	(0.052)	(0)				
ν_2	0.062	289	0.047	352				
ρ_1								
Series	1920–1922		1894–95				1901	
Length	3 years.		1 year.					
Reference	(21)		(19)		(21)		(21)	

Component.	French Indo China (Anam).											
	Do-Son (20° 42′ N., 106° 46′ E.).		Haiphong (20° 52′ N., 106° 39′ E.).		Tourane (16° 07′ N., 108° 12′ E.).		Quin Hone (13° 45′ N., 109° 15′ E.).		Nha-trang (12° 16′ N., 109° 12′ E.).		Saint Jacques Can-Giou (10° 20′ N., 107° 05′ E.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	(0.132)	(119)										
K_1	2.362	91	2.664	81	0.591	277	0.984	295	1.083	296	2.297	309
K_2	0.033	140	0.033	121	0.066	326	0.066	344	0.066	330	0.361	95
L_2	(0.004)	(127)										
M_1	(0.168)	(63)										
M_2	0.131	113	0.131	83	0.492	302	0.558	307	0.558	308	2.625	54
M_3												
M_4												
M_6												
M_8												
N_2	(0.025)	(99)										
2N	(0.003)	(85)										
O_1	2.297	35	2.297	32	0.525	243	0.951	262	0.984	257	1.444	274
OO	(0.073)	(147)										
P_1	0.787	91	0.755	81	0.197	277	0.328	295	0.361	296	0.755	309
Q_1	(0.446)	(7)										
2Q	(0.060)	(339)										
R_2												
S_1												
S_2	0.098	140	0.131	121	0.197	326	0.230	344	0.230	330	1.050	95
S_4												
S_6												
T_2	(0.006)	(140)										
λ_2	(0.001)	(126)										
μ_2	(0.003)	(86)										
ν_2	(0.005)	(101)										
ρ_1	(0.087)	(11)										
Series					1902		1878				1868	
Length												
Reference	(21)		(14)		(21)		(21)		(21)		(21)	

[1] For compound and long-period components see p. 408.

ASIA, EAST COAST, AND PHILIPPINE ISLANDS.

Component.	French Indo China (Anam)—Con. Hatien (10° 22′ N., 104° 28′ E.).		Siam, Koh Hlak[1] (11° 48′ N., 99° 49′ E.).		Malay Peninsula. Kuantan Harbor[1] (3° 48′ N., 103° 21′ E.).		Malay Peninsula. Singapore[1] (1° 17′ N., 103° 51′ E.).		Philippine Islands, Luzon Island. Manila[1] (14° 36′ N., 120° 57′ E.).		Philippine Islands, Luzon Island. Corregidor Is., Manila Bay (14° 23′ N., 120° 36′ E.).		Philippine Islands, Luzon Island. Olongapo,[1] Subic Bay (14° 49′ N., 120° 17′ E.).		Philippine Islands, Luzon Island. Santa Cruz (15° 46′ N., 119° 54′ E.).		Philippine Islands, Luzon Island. Bolinao (16° 24′ N., 119° 54′ E.).		Philippine Islands, Luzon Island. Sual (16° 04′ N., 120° 06′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.070	209			0.037	115	(0.055)	(341)			(0.064)	(336)						
K_1	0.853	65	1.672	163	1.676	1	0.949	100	0.974	320	1.050	321	0.899	316	0.814	313	0.852	313	0.892	325
K_2	0.033	322	0.023	159	0.196	290	0.318	345	0.069	325	(0.018)	(355)	0.058	320	(0.015)	(324)	(0.032)	(306)	(0.023)	(311)
L_2			0.011	176			0.197	310	(0.019)	(320)	(0.016)	(339)	(0.015)	(303)	(0.013)	(268)	(0.009)	(293)		
M_1			0.070	159	0.092	314	(0.068)	(76)	0.026	306	(0.069)	(305)	0.038	318						
M_2	0.328	96	0.168	136	1.829	245	2.602	300	0.665	305	0.567	321	0.557	293	0.383	271	0.315	278	0.290	276
M_3			0.003	147																
M_4			0.014	111	0.029	92	0.053	264	0.018	352	0.027	59	0.002	114	0.032	341	0.020	357	0.018	318
M_6			0.007	297			0.035	43	0.006	285	0.051	268	0.009	127	0.013	250	0.028	203	0.019	230
M_8																				
N_2			0.042	105	0.374	223	0.452	272	0.126	291	(0.110)	(303)	0.106	283	0.092	271	(0.061)	(263)	0.097	250
$2N$							(0.060)	(244)	(0.017)	(276)	(0.015)	(285)	(0.014)	(272)	(0.012)	(277)	(0.008)	(248)		
O_1	0.426	45	1.144	120	1.137	326	0.948	53	0.928	279	0.860	288	0.813	276	0.719	267	0.683	275	0.723	274
OO							(0.029)	(147)	(0.030)	(2)			(0.035)	(356)						
P_1	0.295	65	0.509	164	0.487	359	0.291	93	0.304	317	(0.348)	(321)	0.270	309	(0.279)	(313)	(0.282)	(313)	(0.295)	(325)
Q_1			0.220	105	0.218	304	0.190	16	0.181	254	(0.167)	(272)	0.166	256						
$2Q$							(0.025)	(6)	(0.024)	(238)			(0.021)	(236)						
R_2			0.011	347			(0.009)	(348)	(0.002)	(338)			(0.002)	(325)						
S_1			0.029	20	0.025	97	0.053	211	0.029	352										
S_2	0.066	322	0.043	177	0.560	289	1.067	348	0.222	338	0.177	355	0.198	325	0.056	324	0.117	306	0.085	311
S_4			0.003	192	0.006	172														
S_6			0.001	110	0.002	208														
T_2			0.004	53	0.078	204	(0.063)	(348)	(0.013)	(338)	(0.010)	(355)	(0.012)	(325)						
λ_2							(0.018)	(322)	(0.005)	(321)	(0.004)	(337)	(0.004)	(308)						
μ_2			0.011	20			0.051	97	(0.016)	(272)	(0.014)	(287)	(0.013)	(261)	(0.009)	(218)	(0.008)	(250)	(0.007)	(241)
ν_2			0.011	126	0.090	246	0.058	226	(0.025)	(292)	(0.021)	(305)	(0.020)	(284)						
ρ_1							(0.036)	(33)	(0.035)	(261)			(0.031)	(258)						
Series	1902		1910–1915		1904–1909		1882–83		1901–1903		1861		1901–02		1901		1901		1901	
Length			5 years.		2 years.		1 year.		2 years.		15 days.		369 days.		29 days.		14 days.		29 days.	
Reference	(21)		(22)		(23)		(2)		(1)		(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 408.

PHILIPPINE ISLANDS.

Component.	Luzon Is.—Continued. Tabaco (13° 22′ N., 123° 44′ E.).		Samar Island. Calbayog (12° 04′ N., 124° 35′ E.).		Samar Island. Catbalogan (11° 47′ N., 124° 52′ E.).		Santa Rita Is., San Juanico St. (11° 27′ N., 124° 57′ E.).		Samar Is., Santa Elena (11° 21′ N., 124° 59′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1	(0.031)	(210)	....	....	(0.070)	(357)	(0.063)	(350)	....	....
K_1	0.525	203	0.774	337	0.912	335	0.789	332	0.724	316
K_2	(0.209)	(199)	0.200	42	(0.244)	(36)	(0.207)	(50)	(0.093)	(30)
L_2	(0.042)	(199)	(0.031)	(14)	(0.035)	(7)	(0.026)	(339)	....	....
M_1	0.010	356	....	....	(0.065)	(313)	....	....	....	....
M_2	1.751	175	1.105	343	1.499	341	1.183	348	0.490	312
M_3	....	....	....	....	....	....	....	....	....	....
M_4	0.035	222	0.052	335	0.044	78	0.042	39	0.017	317
M_6	0.004	265	0.025	240	0.010	295	0.025	234	0.026	122
M_8	....	....	....	....	....	....	....	....	....	....
N_2	0.290	150	(0.214)	(311)	0.243	315	0.178	357	(0.095)	(271)
$2N$	(0.039)	(126)	(0.029)	(279)	(0.032)	(288)	0.024	6	....	....
O_1	0.386	190	0.731	302	0.881	291	0.792	296	0.660	270
OO	(0.017)	(217)	....	....	(0.038)	(19)	(0.034)	(8)	....	....
P_1	(0.174)	(203)	(0.256)	(337)	(0.302)	(335)	(0.261)	(332)	(0.241)	(316)
Q_1	0.077	180	....	....	0.124	272	0.170	267	....	....
$2Q$	(0.010)	(177)	....	....	(0.023)	(248)	(0.021)	(260)	....	....
R_2	(0.006)	(199)	....	....	(0.007)	(36)	(0.006)	(50)	....	....
S_1	....	....	....	....	....	....	....	....	....	....
S_2	0.768	199	0.737	42	0.895	36	0.760	50	0.342	30
S_4	....	....	....	....	....	....	....	....	....	....
S_6	....	....	....	....	....	....	....	....	....	....
T_2	(0.045)	(199)	....	....	(0.053)	(36)	(0.045)	(50)	....	....
λ_2	(0.012)	(186)	....	....	(0.010)	(6)	(0.008)	(16)	....	....
μ_2	0.030	256	(0.027)	(284)	0.088	109	(0.028)	(286)	(0.012)	(234)
ν_2	(0.056)	(154)	....	....	(0.047)	(318)	(0.034)	(356)	....	....
ρ_1	(0.015)	(184)	....	....	(0.034)	(272)	(0.030)	(280)	....	....
Series	1901		1902		1902		1902		1902	
Length	29 days.		15 days.		58 days.		29 days.		15 days.	
Reference	(1)		(1)		(1)		(1)		(1)	

Component.	Leyte Is., Tacloban (11° 15′ N., 125° 00′ E.).		Cebu Is., Cebu [1] (10° 18′ N., 123° 54′ E.).		Guimaras Is., Point Gimalik (10° 40′ N., 122° 35′ E.).		Jolo Is., Maibun (5° 56′ N., 121° 02′ E.).		Culion Is., Halsey Harbor (11° 48′ N., 119° 57′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1	....	....	(0.073)	(348)	....	....	(0.043)	(310)	(0.077)	(339)
K_1	0.500	301	0.974	330	1.142	326	0.585	295	0.979	318
K_2	(0.035)	(269)	(0.204)	(22)	(0.174)	(18)	(0.207)	(221)	(0.090)	(4)
L_2	(0.020)	)242)	0.087	339	(0.030)	(359)	(0.031)	(191)	(0.032)	(334)
M_1	(0.039)	(288)	0.079	11	(0.078)	(310)	(0.041)	(279)	0.053	1
M_2	0.525	221	1.371	334	1.350	333	1.324	178	0.779	311
M_3	....	....	....	....	....	....	....	....	....	....
M_4	0.066	355	0.014	73	0.109	248	0.038	325	0.028	239
M_6	0.045	230	0.005	315	0.042	186	0.029	81	0.013	152
M_8	....	....	....	....	....	....	....	....	....	....
N_2	0.137	199	0.217	324	0.207	306	0.213	166	0.221	289
$2N$	(0.018)	(178)	(0.029)	(313)	(0.028)	(279)	(0.028)	(153)	(0.029)	(266)
O_1	0.586	276	0.924	294	1.013	294	0.544	263	0.978	276
OO	....	....	(0.040)	(6)	....	....	(0.023)	(326)	(0.042)	(0)
P_1	(0.166)	(301)	0.315	332	(0.378)	(326)	(0.194)	(295)	(0.324)	(318)
Q_1	(0.114)	(264)	0.190	277	(0.197)	(278)	(0.106)	(248)	0.157	285
$2Q$	....	....	(0.024)	(258)	....	....	(0.014)	(232)	(0.025)	(233)
R_2	....	....	(0.006)	(22)	....	....	(0.006)	(221)	(0.003)	(4)
S_1	....	....	....	....	....	....	....	....	....	....
S_2	0.128	269	0.750	22	0.639	18	0.761	221	0.332	4
S_4	....	....	....	....	....	....	....	....	....	....
S_6	....	....	....	....	....	....	....	....	....	....
T_2	(0.008)	(269)	(0.044)	(22)	(0.038)	(18)	(0.045)	(221)	(0.020)	(4)
λ_2	(0.004)	(243)	(0.010)	(356)	(0.009)	(354)	(0.009)	(198)	(0.006)	(335)
μ_2	(0.013)	(172)	(0.033)	(287)	(0.032)	(287)	(0.032)	(135)	(0.019)	(259)
ν_2	(0.027)	(202)	(0.042)	(325)	(0.040)	(310)	(0.041)	(167)	(0.043)	(292)
ρ_1	....	....	(0.035)	(278)	....	....	(0.021)	(250)	(0.037)	(257)
Series	1901		1902		1900		1903		1902	
Length	29 days.		191½ days.		29 days.		29 days.		29 days.	
Reference	(1)		(1)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 408.

MALAY ARCHIPELAGO.

Component.	Borneo.																			
	Laboean (5.2° N., 115.2° E.).		Gaya (6.1° N., 116.1° E.).		Koedat (6.9° N., 116.8° E.).		Sandakan (5.9° N., 118.1° E.).		Reede Linkas, Tarakan (3.3° N., 117.6° E.).		Tandjong Seilor, Bulungan R. (2.8° N., 117.4° E.).		Bulungan, Bulungan R. (2.8° N., 117.4° E.).		Biwau (2.1° N., 117.9° E.).		Moeara Bajor, Kutei R. (0.6° S., 117.7° E.).		Moeara Djawa, Kutei R. (0.6° S., 117.3° E.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*
J_1																				
K_1	1.348	315	0.971	309	1.184	321	1.168	323	0.623	64	0.344	339	0.472	330	0.394	217	0.207	278	0.554	318
K_2	0.141	343	0.102	336	0.095	329	0.174	5	0.722	186	0.423	247	0.184	263			0.088	209	0.361	241
L_2																				
M_1																				
M_2	0.899	321	0.699	312	0.794	305	1.211	309	2.789	145	1.053	235	1.024	228	2.493	162	0.476	152	1.611	198
M_3																				
M_4																				
M_6																				
M_8																				
N2	0.194	299	0.151	308	0.131	290	0.190	292			0.200	223					0.059	144	0.138	152
2N																				
O_1	1.092	266	0.978	267	0.971	267	0.896	281	0.525	236	0.345	284	0.328	265	0.426	234	0.134	243	0.443	285
OO																				
P_1	0.469	322	0.394	293	0.564	311	0.348	319	0.197	64	0.256	342					0.062	265	0.377	302
Q_1																				
2Q																				
R_2																				
S_1	0.039	33	0.049	205	0.144	1	0.354	15											0.387	200
S_2	0.387	359	0.348	345	0.351	342	0.502	345	1.870	186	0.633	306	0.564	292	1.378	217	0.394	200	1.053	256
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1896		1896		1896		1896						1898–1900				1899–1904		1899–1900	
Length	1 year.		1 year.		1 year.		1 year.						2 years.				3 years.		1 year.	
Reference	(24)		(24)		(24)		(24)		(25)		(24)		(24)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Borneo—Continued.																			
	Smarinda, Kutei R. (0° 30′ S., 117° 8′ E.).		Balik Pappan (1° 16′ S., 116° 48′ E.).		Aroebank, Kleine Paternoster Is. (2.2° S., 116.6° E.).		Pamoekan Bay (2.6° S., 116.5° E.).		Kotta Baroe (3.2° S., 116.2° E.).		Tabanian, Cape Selatan (3.8° S., 114.6° E.).		Soengai Moesang Ketjil Barito R. (3.5° S., 114.5° E.).		Kampong Pangkok, Kahajan R. (3.5° S., 114.2° E.).		Tandjoeng Pagatan, Mendawai R. (3.3° S., 113.4° E.).		Kampong Koemai Pambuang R. (2.8° S., 112.5° E.)	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*	*Feet.*	*Degs.*
J_1																				
K_1	0.581	300	0.423	276	0.236	291	0.755	260	1.345	339	1.804	336	2.034	330	1.903	9	2.034	321	1.345	318
K_2	0.315	229	0.256	187	0.118	205	0.262	202					0.128	19			0.262	83		
L_2																				
M_1																				
M_2	1.391	209	1.942	150	0.561	147	2.067	152	1.214	160	0.754	159	0.945	142	1.280	202	1.378	171	0.787	180
M_3																				
M_4	0.075	113																		
M_6																				
M_8																				
N_2			0.246	126	0.039	126							0.187	92			0.427	152		
2N																				
O_1	0.709	271	0.433	251	0.210	253	0.492	196	0.459	313	0.853	287	0.896	269	1.181	299	1.115	282	0.689	276
OO																				
P_1	0.115	237	0.325	137	0.118	299	0.394	260	0.426	339			0.482	314			0.492	321	0.459	318
Q_1																				
2Q																				
R_2																				
S_1	0.459	339																		
S_2	0.860	261	1.942	211	0.545	199	1.411	202	1.608	216	0.164	15	0.243	52	0.262	160	0.394	83	0.197	53
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1898		1899–1901		1901–1904								1902–1904							
Length	8 months.		2 years.		2 years.				2 months.				2 years.							
Reference	(24)		(24)		(24)		(25)		(24)		(24)		(24)		(24)		(24), (25)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Borneo—Continued.																			
	Koemai River Entrance (2.9° S., 111.7° E.).		Kotta Waringin River Entrance (2.9° S., 111.4° E.).		Djilai River Entrance (2.9° S., 110.8° E.).		Soekadana (1.2° S., 109.9° E.).		Tebon (0.5° S., 109.2° E.).		Soengei Kakap (0.0°, 108.6° E.).		Little Kapuas River (0.1°, N., 109.1° E.).		Pontinak, Kapuas R. (0.0°, 109.3° E.).		Temadjoc (0.5° N., 108.9° E.).		Tambelan Is. (1.0° N., 107.6° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	1.083	335	1.181	322	0.525	332	1.998	141	0.984	103	0.787	150	1.247	137	1.066	143	0.886	115	0.754	82
K_2							0.262	341			0.180	63			0.082	184				
L_2																				
M_1																				
M_2	0.689	206	0.722	198	0.394	220	0.364	328	0.164	187	0.302	142	0.525	141	0.380	177	0.590	137	0.164	155
M_3																				
M_4																				
M_6																				
M_8																				
N_2							0.036	345			0.072	156			0.095	166				
2N																				
O_1	0.689	263	0.525	243	0.328	235	1.188	98	0.886	40	0.535	76	1.050	66	0.800	67	1.017	50	0.754	35
OO																				
P_1	0.426	335					0.226	137	0.262	93	0.371	135	0.492	146	0.285	144	0.230	105	0.197	72
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.197	127	0.197	129	0.098	154	0.289	350	0.131	132	0.338	151	0.295	155	0.190	181	0.492	168	0.295	114
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series							1893–1895				1896–1901				1892–1900					
Length							2 years.				5 years.				7 years.					
Reference	(24)		(24)		(24)		(24)		(24)		(24)		(26)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Borneo—Continued.						South Natuna Islands.				Natuna Is., Sedanau (3.8° N., 108.0° E.).		N. Natuna Is., Laoet (4.7° N., 107.9° E.).		Celebes.					
	Pemangkat (1.2° N., 109.0° E.).		Paloh River (1.8° N., 109.3° E.).		Point Datoe (2.1° N., 109.6° E.).		Serasan Is. (2.5° N., 109.0° E.).		Soebi Is. (2.9° N., 108.9° E.).						De Bril (6.0° S., 118.9° E.).		Makasser (5.1° S., 119.4° E.).		Madjene (3.5° S., 119.0° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.443	54	0.886	346	1.148	325	0.295	321	1.148	339	1.312	338	1.148	323	0.978	298	0.909	300	0.787	311
K_2																	0.161	233	0.295	252
L_2																				
M_1																				
M_2	0.843	111	1.968	93	2.953	105	2.132	92	1.640	95	0.689	130	0.295	73	0.689	18	0.272	70	0.394	150
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.223	86													0.161	349	0.085	347		
$2N$																				
O_1	0.508	7	0.459	293	0.492	254	0.492	312	0.951	300	0.984	318	0.623	289	0.587	276	0.558	278	0.492	257
OO																				
P_1			0.230	336	0.295	315	0.066	311	0.295	329	0.328	328			0.269	275	0.344	296	0.394	304
Q_1																				
$2Q$																				
R_2																				
S_1																				
S_2	0.148	177	0.820	135	0.558	120	1.115	144	0.525	132	0.197	114	0.131	45	0.167	156	0.364	194	0.787	190
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1892–1894														1891–1898		1894–1899			
Length	2 years.														7 years.		,5 years.			
Reference	(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Celebes—Continued.

Component.	Dongala (0.7° S., 119.7° E.).		Tontoli (1.0° N., 120.9° E.).		Talisai (1.8° N., 125.1° E.).		Kema (1.4° N., 125.1° E.).		Toroena, Sangir Is. (3.7° N., 125.5° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1										
K_1	0.735	277	0.472	285	0.590	252	0.551	260	0.561	265
K_2	0.243	195	0.279	229			0.213	266	0.187	218
L_2										
M_1										
M_2	1.548	159	1.378	161	1.804	204	0.692	161	1.670	167
M_3										
M_4										
M_6										
M_8										
N_2	0.118	108	0.200	131			0.052	186	0.295	148
2N										
O_1	0.354	239	0.459	227	0.361	222	0.374	252	0.466	228
OO										
P_1	0.216	291	0.190	328			0.433	249	0.226	259
Q_1										
2Q										
R_2										
S_1										
S_2	1.299	208	1.161	199	1.148	196	0.886	190	1.109	209
S_4										
S_6										
T_2										
λ_2										
μ_2										
ν_2										
ρ_1										
Series	1895–1899		1895–1899				1894–1899		1894–1900	
Length	4 years.		4 years.		28 days.		5 years.		4 years.	
Reference	(24)		(24)		(24)		(24)		(24)	

Component.	Liroeng, Talauer Is. (3.9° N., 126.7° E.).		Gorontalo, Gulf of Tomini (0.5° N., 123.1° E.).		Menelili, Gulf of Tomini (0.5° N., 120.2° E.).		Posso, Gulf of Tomini (1.4° S., 120.8° E.).		Telok Lamala, Peleng Strait (0.9° S., 123.1° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1										
K_1	0.522	226	0.807	284	0.722	272	0.531	263	0.623	288
K_2	0.148	254	0.164	170	0.197	175	0.180	183	0.164	126
L_2										
M_1										
M_2	1.427	170	0.476	115	0.689	125	0.758	123	0.820	40
M_3										
M_4										
M_6										
M_8										
N_2	0.394	142	0.075	85	0.394	298	0.088	92		
2N										
O_1	0.338	203	0.341	227	0.492	230	0.387	231	0.427	262
OO										
P_1	0.305	260			0.361	272	0.259	294	0.295	288
Q_1										
2Q										
R_2										
S_1										
S_2	1.010	207	0.672	173	0.591	175	0.738	166	0.492	126
S_4										
S_6										
T_2										
λ_2										
μ_2										
ν_2										
ρ_1										
Series	1897–1902		1894–1899				1895–1902			
Length	4 years.		5 years.		26 days.		5 years.		28 days.	
Reference	(24)		(24)		(24), (27)		(24)		(24), (27)	

MALAY ARCHIPELAGO—Continued.

Component.	Celebes—Continued.																			
	Kintong, Peleng Strait, (1.2° S., 122.5° E.).		Banggai, Banggai Archi., (1.6° S., 123.5° E.).		Moemoe, (1.7° S., 121.9° E.).		Tomboekoe, (2.6° S., 122.0° E.).		Poeloe Galla besar, Tioro Strait, (4.9° S., 122.3° E.).		Buton, Buton Is., (5.5° S., 122.6° E.).		Wadjo Bay, Buton Is., (5.5° S., 122.8° E.).		Bola, Buton Is., (5.7° S., 122.6° E.).		Tampona Woh, Muna Is., (5.2° S., 122.3° E.).		Poeloe Baleara, Kabaena Is., (5.2° S., 121.8° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.837	315	0.886	300	1.050	308	0.886	295	1.148	305	0.984	302	1.017	307	0.886	308	1.083	305	1.214	294
K_2	0.118	116	0.164	97					0.164	79	0.164	76							0.164	61
L_2																				
M_1																				
M_2	0.994	37	1.017	28	1.444	31	1.444	12	2.231	24	1.739	20	1.608	23	1.640	21	1.870	21	1.837	10
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.138	351							0.459	40	0.328	5	0.295	349	0.361	340	0.492	359		
2N																				
O_1	0.597	277	0.525	265	0.459	270	0.591	269	0.656	291	0.656	292	0.558	288	0.689	293	0.689	290	0.623	286
OO																				
P_1	0.604	282	0.558	300	0.525	308	0.295	295	0.427	305	0.328	302	0.262	307	0.295	308	0.295	305	0.394	294
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.574	114	0.492	97	0.459	97	0.591	71	0.755	79	0.525	68	0.492	95	0.459	61	0.558	68	0.591	61
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1898–99																			
Length	1 year.		29 days.		28 days.		23 days.		28 days.		112 days.		58 days.		58 days.		57 days.		28 days.	
Reference	(24)		(27)		(27)		(27)		(27)		(24), (27)		(27)		(27)		(27)		(27)	

MALAY ARCHIPELAGO—Continued.

Component.	Celebes—Continued.						Gilolo Island (Halmahera).															
	Saleyer (6.1° S., 120.5° E.).		Kadjang (5.4° S., 120.4° E.).		Bonthain (5.6° S., 119.9° E.).		Batjan (0.6° S., 127.5° E.).		Ternate Is. (0.8° N., 127.4° E.).		Galela (1.8° N., 127.8° E.).		Gamsoengi Patani (0.2° N., 128.8° E.).		Ombi Is., Lawoei (1.7° S., 128.0° E.).		Buru Is., Tifoe Bay (3.7° S., 126.4° E.).		Ambon Is., (3.7° S., 128.2° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	1.056	300	0.633	305	0.879	299	0.679	273	0.456	261	0.371	217	0.459	266	0.548	276	1.106	327	0.958	316
K_2	0.118	351	0.108	7	0.112	301	0.189	204	0.259	203	0.171	206	0.118	209	0.131	180	0.361	101	0.141	79
L_2																				
M_1																				
M_2	1.266	4	1.001	3	0.663	357	0.279	63	0.899	169	1.329	181	0.466	145	0.709	114	1.188	9	1.529	36
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.305	339	0.157	353	0.134	317	0.049	105	0.118	149	0.210	173	0.079	127	0.075	51	0.161	318	0.325	4
2N																				
O_1	0.692	281	0.423	267	0.302	275	0.262	224	0.338	249	0.335	195	0.322	217	0.430	266	0.203	310	0.689	314
OO																				
P_1	0.331	286	0.495	281	0.259	250	0.253	278	0.210	272	0.184	275	0.208	279	0.272	285	0.390	62	0.308	312
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.341	67	0.528	93	0.200	115	0.318	174	0.728	197	0.745	210	0.482	190	0.440	171	0.308	118	0.558	95
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1895–1900		1895–1900		1895–1897		1895–1900		1895–1900		1895–1900		1893–1898		1898–99		1898–99		1894–1897	
Length	5 years.		5 years.		3 years.		5 years.		5 years.		5 years.		5 years.		1 year.		1 year.		3 years.	
Reference	(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Banda Island, (4.5° S., 129.9° E.).		Kei Is., Toeal, (5.6 S., 132.7° E.).		Aru Is., Dobo, (5.8 S., 134.2° E.).		Sumatra. Telok Betong, Lampong Bay, (5.5° S., 105.5° E.).		Sumatra. Sawang Toengko, Pagi Is., (2.8° S., 100.2° E.).		Sumatra. Siberoet, (1.6° S., 99.2° E.).		Sumatra. Padang, Emma-haven, (1.0° S., 100.3° E.).		Sumatra. Poeloe-Tello, Batoe Is., (0.1° S., 98.3° E.).		Sumatra. Ajerbangies, (0.2° N., 99.4° E.).		Sumatra. Natal, (0.6° N., 99.1° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.955	314	0.571	327	1.148	332	0.508	269	0.427	254	0.394	269	0.417	277	0.351	275	0.486	268	0.358	274
K_2	0.190	71			0.164	135	0.174	246					0.131	209	0.079	180	0.128	198	0.105	214
L_2																				
M_1																				
M_2	1.873	36	1.434	36	1.968	51	1.053	222	1.017	176	0.984	173	1.155	177	0.778	164	0.886	161	0.925	174
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.364	8	0.180	11			0.184	192					0.240	157	0.164	151	0.151	137	0.161	152
2N																				
O_1	0.594	298	0.354	323	0.590	320	0.256	265	0.262	250	0.295	246	0.246	265	0.194	250	0.164	240	0.213	254
OO																				
P_1	0.282	289	0.102	283	0.164	332	0.138	231			0.131	269	0.131	277	0.121	215	0.194	217	0.157	259
Q_1																				
2Q																				
R_2																				
S_1							0.089	27					0.043	38						
S_2	0.709	103	0.735	111	0.590	135	0.449	262	0.459	211	0.394	220	0.472	218	0.489	204	0.489	216	0.423	208
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1895–1897		1896–1900				1897–98						1893–1895		1895–1900		1891–1900		1894–1898	
Length	2 years.		3 years.				1 year.						2 years.		5 years.		9 years.		4 years.	
Reference	(24)		(24)		(24)		(24)		(28)		(28)		(24)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Sumatra—Continued.																			
	Goenoeng Sitoli Nias Is. (1.3° N., 97.6° E.).		Telok Dalam, Nias Is. (0.6° N., 97.8° E.).		Simanari Bay, Nias Is. (1.4° N., 97.2° E.).		Siboga (1.7° N., 98.8° E.).		Baros (2.0° N., 98.4° E.).		Sinabang Bay (3.3° N., 96.4° E.).		Singkel (2.3° N., 97.8° E.).		Tapa Toeam (3.2° N., 97.2° E.).		Malaboeh (4.1° N., 96.1° E.).		Poeloe Rajah (4.8° N., 95.4° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.177	282	0.328	257	0.262	239	0.322	262	0.390	281	0.295	280	0.331	283	0.328	295	0.184	312	0.253	309
K_2	0.154	38					0.243	233	0.141	209			0.088	222			0.075	253		
L_2																				
M_1																				
M_2	0.253	152	0.722	161	0.656	163	0.440	167	0.830	167	0.427	163	0.709	181	0.591	185	0.282	193	0.138	203
M_3																				
M_4																				
M_6																				
M_8																				
N_2					0.164	173	0.062	190	0.171	162			0.144	171			0.066	208	0.046	94
$2N$																				
O_1			0.197	260	0.197	256	0.134	299	0.200	246	0.164	260	0.174	254	0.230	293	0.118	252	0.056	281
OO																				
P_1							0.223	300	0.174	269			0.085	264			0.125	309		
Q_1																				
$2Q$																				
R_2																				
S_1																				
S_2	0.581	185	0.295	214	0.427	187	0.426	211	0.512	200	0.262	228	0.380	213	0.262	237	0.279	221	0.164	189
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1897–1900						1893–1900		1893–1897				1896–1900				1895–1898		1895–96	
Length	3 years.						7 years.		5 years.				3 years.				3 years.		2 years.	
References	(24)		(28)		(28)		(24)		(24)		(28)		(24)		(28)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Sumatra—Continued.																			
	Benkoelen (3.8° S., 102.3° E.).		Enggano Bay (5.5° S., 102.4° E.).		Oleh-leh (5.6° N., 95.3° E.).		Sabang Bay, Weh Is. (5.9° N., 95.3° E.).		Segli (5.3° N., 96.0° E.).		Telok, Semaweh (5.2° N., 97.2° E.).		Edi (5.1° N., 97.8° E.).		Belawan Deli, Malacca Strait (3.8° N., 98.7° E.).		Tandjong Tiram, Malacca Strait (3.3° N., 99.5° E.).		Bagan Api Api, Malacca Strait (2.2° N., 100.8° E.).	
	H		H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.361	280	0.492	259	0.174	353	0.253	304	0.282	310	0.456	310	0.446	299	0.505	335	0.630	0	0.476	31
K_2	0.164	237			0.138	333	0.203	267	0.236	328	0.246	318	0.197	317	0.184	48	0.272	121	0.420	178
L_2																				
M_1																				
M_2	1.050	200	0.984	182	0.751	285	1.437	263	1.106	275	1.516	279	1.535	310	1.630	63	2.316	83	5.509	147
M_3																				
M_4																				
M_6																				
M_8																				
N_2					0.069	286	0.236	280	0.295	250	0.272	268	0.246	308	0.302	48	0.446	75	1.027	134
2N																				
O_1	0.328	264	0.295	261	0.075	323	0.148	280	0.125	290	0.187	268	0.194	295	0.108	295			0.249	98
OO																				
P_1			0.164	259	0.174	325					0.174	79	0.148	82			0.226	30	0.272	268
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.459	237	0.361	247	0.436	329	0.866	303	0.771	315	0.882	318	0.810	352	0.860	79	1.066	127	2.986	198
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series					1895–1898		1895–1897		1895–1897		1896–1899		1895–1900		1895–1901		1895–1904		1896	
Length					3 years.		2 years.		2 years.		3 years.		5 years.		3 years.		9 years.		1 year.	
Reference	(28)		(28)		(24)		(24)		(24)		(24)		(24)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Sumatra—Continued.																			
	Bengkalis, Malacca Strait (1.5° N., 102.1° E.).		Tandjong Balei, Karimon Is. (1.0° N., 103.4° E.).		Bojan, Batam Is. (1.0° N., 103.9° E.).		Tandjong Boeton, Linga Archipelago (0.2° S., 104.6° E.).		Kwala Ladjau (0.4° S., 103.6° E.).		Tandjong Kalean, Banka Strait (2.0° S., 105.1° E.).		Palembang Light Ship Banka Strait, (2.2° S., 105.0° E.).		Poeloe Nangka, Banka Strait (2.5° S., 106.0° E.).		Poeloe Besar, Banka Strait (2.9° S., 106.1° E.).		Poeloe Langkoeas, Billiton Is. (2.5° S., 107.6° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.187	118	0.882	143	0.988	134	2.008	152	1.801	182	3.104	159	2.887	154	3.100	158	2.402	154	2.103	141
K_2	0.164	281	0.394	344			0.213	98	0.745	93	0.115	244	0.131	274	0.171	205	0.256	60		
L_2																				
M_1																				
M_2	2.520	208	2.549	304	1.184	316	0.659	35	2.962	98	0.830	186	0.853	192	1.296	192	0.738	167	0.062	237
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.344	213	0.558	286	0.236	292	0.134	2	0.522	65	0.177	166	0.164	163	0.236	151	0.190	112		
2N																				
O_1	0.774	127	0.653	105	0.988	62	1.562	74	1.627	108	1.791	93	1.968	89	1.765	94	1.388	107	1.243	86
OO																				
P_1	0.413	77	0.328	120	0.505	129	0.623	134	0.417	171	0.876	151	0.755	149	0.748	152	0.554	146	0.505	134
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	1.276	282	1.424	350	0.384	8	0.377	136	0.869	145	0.390	216	0.427	232	0.256	197	0.344	51	0.092	16
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1895		1896–1901		1896–1900		1895–1899		1895–96		1890–1894				1897–1900		1890–1899		1890–1899	
Length	1 year.		5 years.		4 years.		4 years.		1 year.		4 years.		4 years.		3 years.		9 years.		9 years.	
Reference	(24)		(24)		(24)		(24)		(24)		(24)		(29)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Summatra—Continued.						Java.													
	Tandjong Panda, Billiton Is. (2.8° S., 107.6° E.).		Ondiepwater Is., Billiton Is. (3.3° S., 107.2° E.).		Kampong Teladas (4.4° S., 105.8° E.).		Tjilatjap (7.7° S., 109.0° E.).		Genteng Bay (7.4° S., 106.4° E.).		Laboean (6.4° S., 105.2° E.).		Java's Fourth Point, Sunda Strait (6.1° S., 105.9° E.).		Duizend Is. (5.6° S., 106.3° E.).		Edam Island (6.0° S., 106.8° E.).		Batavia,[1] Tandjong Priok (6° 06′ S., 106° 53′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																			0.053	189
K_1	2.031	140	1.729	146	1.083	144	0.620	279	0.394	250	0.259	242	0.218	220	0.922	165	0.873	141	0.867	143
K_2			0.148	54			0.233	311	0.164	307	0.131	307	0.059	297	0.066	294	0.052	233	0.073	268
L_2																			0.027	110
M_1																			0.046	188
M_2	0.164	105	0.253	66	0.525	79	1.627	249	1.214	230	0.699	196	0.794	210	0.026	266	0.157	294	0.174	350
M_3																				
M_4																				
M_6																				
M_8																				
N_2			0.088	69			0.322	224	0.230	207	0.102	180	0.135	190	0.016	314	0.049	322	0.069	314
$2N$																				
O_1	1.280	90	0.919	99	0.787	114	0.381	268	0.230	242	0.180	227	0.112	216	0.216	138	0.253	129	0.443	120
OO																				
P_1	0.751	140	0.453	146			0.151	274			0.059	19	0.043	195	0.318	157	0.285	135	0.251	142
Q_1																			0.113	110
$2Q$																				
R_2																				
S_1							0.062	72											0.072	26
S_2	0.164	6	0.243	42	0.656	63	0.817	311	0.623	295	0.282	240	0.410	208	0.180	11	0.213	308	0.181	294
S_4																				
S_6																				
T_2																				
λ_2																			0.021	127
μ_2																			0.032	205
ν_2																			0.016	343
ρ_1																				
Series			1890–1901				1889–1892				1894–95		1890–1902		1885–86		1898–1901		1887–1904	
Length			11 years.				3 years.				1 year.		10 years.		1 year.		3 years.		7 years.	
Reference	(24)		(24)		(24)		(24)		(26)		(24)		(24)		(24)		(24)		(24), (30)	

[1] For compound and long-period components see p. 408.

MALAY ARCHIPELAGO—Continued.

Component.	Java—Continued.																			
	Boompjes Is. (5.9° S., 108.4° E.).		Karimondjawa Island (5.9° S., 110.4° E.).		Samarang (7.0° S., 110.4° E.).		Rembang (6.7° S., 111.3° E.).		Bawean Is. (5.9° S., 112.7° E.).		Oedjong Pangka, Surabaya Strait (6.9° S., 112.6° E.).		Djamoean-rif, Surabaya Strait (6° 56′ S., 112° 44′ E.).		Arisbaya, Surabaya Strait (6.9° S., 112.8° E.).		Sembilangan, Surabaya Strait (7.1° S., 112.7° E.).		Surabaya, Surabaya Strait (7.2° S., 112.6° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.469	102	0.764	357	0.597	26	1.335	343	1.411	326	1.660	326	1.772	325	1.690	326	1.519	319	1.539	318
K_2	0.171	186	0.052	22	0.059	247	0.030	214	0.092	315	0.056	16	0.066	351	0.082	3	0.138	26	0.262	357
L_2																				
M_1																				
M_2	0.351	324	0.069	246	0.154	283	0.144	358	0.128	72	0.098	133	0.131	38	0.075	104	0.590	356	1.453	351
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.098	285	0.033	42	0.052	256	0.033	325	0.112	116	0.072	109	0.066	70	0.066	93	0.108	348	0.298	337
2N																				
O_1	0.233	118	0.121	262	0.144	254	0.499	256	0.814	300	0.778	279	0.853	274	0.800	262	0.817	277	0.892	284
OO																				
P_1	0.134	97	0.305	327	0.118	10	0.426	329	0.410	297	0.541	343	0.492	326	0.384	335	0.325	322	0.466	321
Q_1																				
2Q																				
R_2																				
S_1			0.046	141	0.184	331			0.249	187	0.207	341			0.151	341			0.066	83
S_2	0.180	218	0.167	344	0.108	160	0.075	320	0.148	16	0.190	12	0.262	11	0.210	9	0.508	4	0.866	355
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1890–1904		1887–88		1890		1896–1898		1888–89		1887				1887		1890–1900		1878–79	
Length	10 years.		11 months.		1 year.		2 years.				1 year.				1 year.		10 years.		1 year.	
Reference	(24)		(24)		(24)		(24)		(24)		(24)		(31)		(24)		(24)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Java—Continued.																			
	Pasoeroean, Madura Strait (7.4° S., 112.7° E.).		Karang Kleta, Madura Strait (7.3° S., 112.8° E.).		Gading, Madura Strait (7.2° S., 112.9° E.).		Zwaantjes Shoal, Madura Strait (7.5° S., 113.1° E.).		Amboenten, Madura Is. (6.9° S., 113.7° E.).		Maringan, Madura Is. (7.1° S., 113.9° E.).		Poeloe Sapoedi, Sapoedi Is. (7.1° S., 114.3° E.).		Telangoe Is. (7.2° S., 114.8° E.).		Meinderts Shoal (7.6° S., 114.4° E.).		Duiven Island Bali Strait (8.0° S., 114.5° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	1.460	304	1.476	304	1.509	308	1.496	298	1.024	314	0.879	307	1.214	306	1.299	302	1.214	306	0.971	301
K_2	0.262	342	0.161	349	0.266	356	0.246	82			0.220	8	0.134	320	0.131	340	0.125	312	0.256	283
L_2																				
M_1																				
M_2	1.955	340	1.946	341	1.942	344	1.394	319	0.148	329	0.761	320	0.853	339	0.833	333	0.820	327	0.590	316
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.371	332	0.515	317	0.404	325	0.269	300	0.039	348	0.138	299	0.164	318	0.167	331	0.164	316	0.197	300
2N																				
O_1	0.856	276	0.892	275	0.850	269	0.709	276	0.367	275	0.502	309	0.787	279	0.722	275	0.755	276	0.492	267
OO																				
P_1	0.486	302	0.466	326	0.456	306	0.298	280	0.413	281	0.220	287	0.361	297	0.341	294	0.394	296	0.423	274
Q_1																				
2Q																				
R_2																				
S_1	0.079	95	0.171	349	0.049	40														
S_2	0.997	343	0.961	346	0.997	346	0.804	342	0.253	342	0.413	342	0.427	342	0.502	329	0.361	336	0.459	332
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1887		1886		1886–87		1892–1896		1897–1901		1897–1901		1890–1899		1897–1901		1890–1894		1897–1901	
Length	1 year.		1 year.		1 year.		4 years.		4 years.		4 years.		10 years.		4 years.		4 years.		3 years.	
Reference	(24)		(24)		(24)		(24)		(24)		(24)		(24), (26)		(24)		(24), (26)		(24)	

MALAY ARCHIPELAGO—Continued.

Component.	Java—Con. Banjoewangi, Bali Strait (8.2° S., 114.4° E.).		Bali Island. Boeleleng (8.0° S., 115.1° E.).		Bali Island. Teloek Padang (8.5° S., 115.5° E.).		Bali Island. Bay of Sanoer (8.7° S., 115.3° E.).		Lombok Island. Ampenan (8.5° S., 116.1° E.).		Lombok Island. Laboean-Tring (8.8° S., 116.1° E.).		Paternoster Islands, Sailoes (7.5° S., 117.4° E.).		Postiljon Islands, Sapoeka besar (7.1° S., 118.2° E.).		Sumbawa Island. Bima (8.4° S., 118.7° E.).		Sumbawa Island. Waworada Bay (8.7° S., 118.8° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.771	289	1.017	311	1.050	301	1.247	324	1.056	326	1.148	287	1.083	292	1.148	299	0.994	302	0.787	293
K_2	0.269	318	0.164	348	0.197	256	0.197	268	0.161	301	0.361	324					0.207	73	0.591	356
L_2																				
M_1																				
M_2	1.604	292	0.951	334	1.115	315	1.870	290	0.515	308	0.886	323	0.984	9	1.115	4	1.132	9	2.657	294
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.348	267			0.230	315	0.328	264	0.148	295	0.098	303					0.128	350		
2N																				
O_1	0.423	265	0.689	267	0.591	271	0.656	267	0.492	234	0.754	276	0.853	280	0.656	289	0.325	263	0.558	275
OO																				
P_1	0.197	284	0.164	311	0.197	281	0.262	312	0.574	336	0.394	287	0.361	292	0.295	299			0.197	293
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.800	349	0.492	348	0.558	339	0.459	339	0.636	315	0.525	324	0.361	62	0.328	340	0.322	52	1.476	356
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series	1895–1900								1898–1900								1895–1899			
Length	5 years.				58 days.				2 years.		75 days.		15 days.				4 years.			
Reference	(24)		(24)		(27)		(27)		(24)		(24), (27)		(27)		(27)		(24)		(27)	

MALAY ARCHIPELAGO—Continued.

Component.	Sumbawa Is.—Continued.		Komodo Is.,		Sumba Island.				Flores Island.								Tiger Islands.			
	Sapeh Bay (8.6° S., 119.0° E.).		Telok Slawie (8.6° S., 119.5° E.).		Sendikeri Bay (10.0° S., 120.0° E.).		Nangamessi (9.6° S., 120.3° E.).		Telok Perapat (8.8° S., 119.8° E.).		Laboean Badjo (8.5° S., 119.9° E.).		Endeh (8.8° S., 121.6° E.).		Maumeri (8.6° S., 122.2° E.).		Bone Rato (7.4° S., 121.2° E.).		Pasi Teloe Tengah (7.1° S., 121.1° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.656	287	0.820	281	0.722	285	0.853	287	0.919	281	0.886	288	1.017	308	0.984	303	1.017	295	0.984	304
K_2	0.230	36	0.558	351	0.459	342	0.394	350			0.328	39	0.492	11	0.623	66				
L_2																				
M_1																				
M_2	1.608	354	2.329	320	2.920	286	2.723	307	2.920	309	1.509	351	2.723	307	1.739	15	1.476	11	1.214	43
M_3																				
M_4																				
M_6																				
M_8																				
N_2			0.459	336	0.328	247							0.459	294						
2N																				
O_1	0.656	277	0.623	292	0.492	273	0.525	284	0.689	288	0.558	293	0.558	295	0.787	286	0.623	291	0.689	283
OO																				
P_1	0.164	287	0.230	281	0.230	285	0.295	287			0.230	288	0.262	308	0.525	303	0.328	295	0.328	304
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.590	36	1.214	354	1.706	342	1.345	350	1.247	316	0.525	39	1.509	11	0.524	66	0.361	59	0.459	77
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series																				
Length			58 days.		56 days.		28 days.		28 days.				79 days.		70 days.		29 days.		15 days.	
Reference	(24)		(21), (27)		(27)		(24), (27)		(24), (27)		(24)		(24), (27)		(24), (27)		(27)		(27)	

MALAY ARCHIPELAGO AND MELANESIA.

Component.	Pontar Island, Kabir (8.2° S., 124.2° E.).		Alor Island, Kalabahi (8.2° S., 125.5° E.).		Timor Island. Atapoepoe (9.0° S., 124.9° E.).		Timor Island. Kupang (10.2° S., 123.6° E.).		Damma Island (7.1° S., 128.7° E.).		New Guinea. Merauke (8.5° S., 140.4° E.).		New Guinea. Etna Bay (4.0° S., 134.6° E.).		New Guinea. Kaimana (3.7° S., 133.7° E.).		New Guinea. Fak-fak (3.0° S., 132.3° E.).		New Guinea. Kokas, McCluer Gulf (2.7° S., 132.4° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.820	302	0.886	302	0.689	303	0.515	314	1.014	315	2.395	153	0.919	333	1.115	329	0.636	348	1.148	328
K_2	0.230	73	0.328	44	0.361	24	0.230	18	0.066	148							0.312	36		
L_2																				
M_1																				
M_2	1.739	11	2.329	0	1.837	336	1.503	317	1.549	29	4.560	45	2.723	78	2.133	40	1.309	36	1.083	125
M_3																				
M_4																				
M_6																				
M_8																				
N_2							0.318	302	0.210	359							0.253	32	0.295	90
$2N$																				
O_1	0.737	277	0.558	294	0.492	275	0.341	328	0.459	288	1.444	106	0.656	325	0.722	301	0.476	290	0.755	309
OO																				
P_1	0.262	302	0.295	302			0.098	35	0.190	300							0.495	315	0.295	322
Q_1																				
$2Q$																				
R_2																				
S_1																				
S_2	0.690	73	0.951	44	1.017	24	0.866	18	0.709	92	1.444	136	0.722	156	0.820	114	0.709	124	0.459	183
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series							1894–1903										1902–1904			
Length					14 days.		8 years.										2 years.			
Reference	(27)		(27)		(27)		(24)		(32)		(24)		(24)		(33)		(24)		(33)	

MELANESIA.

Component.	New Guinea—Continued.																			
	Modan, McCluer Gulf, (2.6° S., 133.9° E.).		Kais, McCluer Gulf, (2.0° S., 132.0° E.).		Kaiboes, (1.6° S., 131.8° E.).		Sailolof, (1.2° S., 130.8° E.).		Peli, Sele Strait, (1.3° S., 130.9° E.).		Sorong, Sele Strait, (0.9° S., 131.2° E.).		P. Saonek, Dampier Strait, (0.5° S., 130.8° E.).		Moetoe besar, Waigeo Island, (0.4° S., 130.3° E.).		Dorei Hoem, (0.7° S., 131.5° E.).		Mangkokwari, (1.2° S., 134.3° E.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	1.444	338	0.951	325	0.886	326	0.787	291	0.772	284	0.755	222	0.623	233	0.558	258	0.689	204	0.633	31
K_2	0.361	285			0.164	154					0.164	202			0.197	208			0.108	75
L_2																				
M_1																				
M_2	6.102	197	1.706	63	2.231	82	0.820	107	0.689	96	1.345	196	1.542	23	0.919	170	1.378	168	1.542	19
M_3																				
M_4																				
M_6																				
M_8																				
N_2	1.247	188									0.230	180	0.886	42					0.308	0
2N																				
O_1	1.115	312	0.623	309	0.689	317	0.492	276	0.459	259	0.427	180	0.328	234	0.328	258	0.556	179	0.505	18
OO																				
P_1	0.492	338	0.328	325	0.295	326	0.262	291	0.230	284	0.262	222			0.164	258	0.230	204	0.161	49
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	1.903	285	0.722	139	0.820	154	0.591	178	0.656	165	0.591	202	0.951	112	0.623	208	0.623	219	0.699	43
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series																			1902–1904	
Length																			2 years.	
Reference	(33)		(33)		(33)		(33)		(33)		(33)		(33)		(33)		(33)		(24)	

MELANESIA, POLYNESIA, AND AUSTRALIA.

Component.	New Guinea—Continued.						New Britain Island, Matupi (4° 16′ S., 152° 11′ E.).		Samoan Islands, Apia (13° 46′ S., 171° 44′ E.).		Hawaiian Islands, Honolulu[1] (21° 18′ N., 157° 52′ W.).		Northern Territory of Australia, Port Darwin[1] (13° 23′ S., 130° 37′ E.).		Queensland.					
	Jende (P. Roon), Geelvink Bay (2.4° S., 134.6° E.).		Hollandia Bay (Humboldt Bay) (2.5° S., 140.7° E.).		Finsch Harbor (6° 35′ S., 147° 50′ E.).										Cooktown,[1] (15° 27′ S., 145° 15′ E.).		Cairns Harbor,[1] (16° 55′ S., 145° 47′ E.).		Brisbane Bar,[1] (27° 31′ S., 153° 00′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1											(0.027)	(76)	0.14	197						
K_1	0.689	201	0.689	210	0.837	205	0.515	205	0.093	254	0.478	70	1.91	336	0.287	171	0.872	190	0.592	176
K_2					0.007	45	0.075	90	0.081	181	0.045	94	1.02	204	0.215	258	0.305	245	0.158	315
L_2									0.076	139	0.014	126	0.41	216					0.180	258
M_1					0.026	102					0.022	67	0.05	315						
M_2	1.870	218	0.820	213	0.223	75	0.046	185	1.255	186	0.522	106	6.56	144	1.873	282	1.958	282	2.201	290
M_3					0.020	169					0.002	37	0.05	26						
M_4					0.026	211					0.009	284	0.13	279						
M_6					0.020	222					0.003	33	0.06	167						
M_8											0.001	338								
N_2	0.230	223			0.039	120	0.056	181	0.308	166	0.094	96	1.04	121	0.447	239	0.658	269	0.458	288
2N											0.013	91								
O_1	0.459	198	0.427	189	0.230	272	0.276	181	0.070	248	0.260	59	1.14	313	0.299	113	0.407	166	0.325	139
OO											(0.015)	(82)								
P_1	0.230	201					0.125	199	0.030	252	0.144	65	0.44	1	0.096	171	0.290	190	0.196	176
Q_1											0.041	50	0.34	324						
2Q											(0.007)	(51)								
R_2											(0.001)	(102)								
S_1					0.253	72	0.240	142			0.013	105	0.16	169						
S_2	0.755	223	0.131	245	0.315	124	0.177	110	0.289	184	0.161	102	3.44	193	0.788	258	1.120	245	0.579	315
S_4					0.010	272					0.001	179	0.05	127						
S_6					0.007	334					0.001	133	0.01	184						
T_2											0.036	62								
λ_2											0.004	144								
μ_2											0.019	61	0.39	110	(0.045)	(306)				
ν_2											0.012	125	0.48	141						
ρ_1											(0.010)	(54)								
Series					1886		1904		1903		1891–1915		1896		1890		1892–93		1865–66	
Length					250 days.		172 days.		1 year.		2 years.		1 year.		1 year.		1 year.		1 year.	
Reference	(33)		(33)		(34)		(35)		(36)		(1)		(37)		(19)		(19)		(19)	

[1] For compound and long-period components see p. 408.

AUSTRALIA AND NEW ZEALAND.

Component.	Queensland—Continued. Brisbane[1] (27° 20′ S., 153° 10′ E.).		New South Wales. Ballina[1] (28° 52′ S., 153° 33′ E.).		New South Wales. Newcastle[1] (32° 57′ S., 151° 44′ E.).		New South Wales. Sydney,[1] Fort Denison (33° 52′ S., 151° 12′ E.).		Victoria, Melbourne (Williamstown) (37° 52′ S., 144° 54′ E.).		South Australia, Port Adelaide[1] (Semaphore) (34° 51′ S., 138° 30′ E.).		Western Australia. Princess Royal Harbor[1] (35° 08′ S., 118° 00′ E.).		Western Australia. Fremantle[1] (32° 03′ S., 115° 45′ E.).		Western Australia. Port Hedland[1] (20° 22′ S., 118° 36′ E.).		North Island, New Zealand, Port Russell (35° 16′ S., 174° 18′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.042	213	0.031	184	0.035	141	0.026	138			0.05	65	0.037	356	0.028	338	0.036	300		
K_1	0.695	174	0.454	155	0.513	120	0.473	123	0.294	132	0.83	52	0.623	330	0.431	306	0.791	294	0.192	205
K_2	0.176	299	0.072	273	0.127	254	0.124	263	0.028	172	0.46	178	0.074	338	0.033	314	0.800	357	0.106	276
L_2	0.117	302	0.047	236	0.069	238	0.058	212	0.013	74	0.12	140	0.039	349	0.009	319	0.462	337	0.067	248
M_1	0.008	139	0.004	220	0.020	76	0.016	105			0.02	16	0.023	340	0.023	311	0.030	249		
M_2	2.224	290	1.083	262	1.598	249	1.616	254	0.806	69	1.70	120	0.159	339	0.115	311	5.509	316	2.543	216
M_3	0.024	339	0.004	195	0.013	346	0.013	346			0.06	99	0.011	6	0.005	265	0.021	66		
M_4	0.049	148	0.058	121	0.027	233	0.035	83	0.021	49	0.02	174	0.005	16	0.008	309	0.121	86	0.197	37
M_6	0.042	187	0.025	133	0.018	74	0.015	84			0.01	259	0.002	227	0.002	244	0.065	208	0.102	62
M_8							0.005	100												
N_2	0.417	281	0.202	254	0.351	235	0.346	243	0.093	65	0.09	246	0.067	17	0.031	8	0.868	289	0.461	198
$2N$	0.090	286					0.046	232			(0.01)	(12)								
O_1	0.390	143	0.310	128	0.289	88	0.300	93	0.216	95	0.52	32	0.417	312	0.320	315	0.499	283	0.038	140
OO							0.015	154			(0.03)	(73)								
P_1	0.208	174	0.139	149	0.153	116	0.133	122	0.097	129	0.22	56	0.172	332	0.130	309	0.195	288	0.064	205
Q_1	0.086	125	0.077	103	0.072	165	0.074	75	0.042	77	0.07	31	0.091	291	0.079	321	0.102	269	0.007	108
$2Q$							0.008	62			(0.01)	(12)								
R_2	0.011	178	0.006	347	0.011	213	0.003	269			0.04	138	0.043	192	0.020	240	0.096	151		
S_1	0.043	101	0.015	86	0.018	25	0.020	129			0.07	115	0.019	186	0.056	262	0.115	256		
S_2	0.618	309	0.276	275	0.391	265	0.404	269	0.103	164	1.68	181	0.262	342	0.109	309	3.352	17	0.391	276
S_4	0.002	183	0.003	246	0.006	289	0.003	78			0.03	186	0.012	201	0.004	14	0.041	183		
S_6	0.002	46	0.001	130	0.000	31	0.003	353			0.01	180	0.003	299	0.002	88	0.024	184		
T_2	0.022	308	0.016	270	0.024	291	0.071	315	0.006	161	0.11	165	0.038	255	0.023	104	0.214	96	0.023	276
λ_2							0.011	261			(0.01)	(148)								
μ_2	0.093	4	0.026	335	0.061	226	0.051	233			0.28	226	0.019	16	0.010	8	0.221	334	0.061	156
ν_2	0.117	304	0.018	169	0.123	245	0.059	238	0.018	66	0.06	76	0.020	33	0.008	84	0.212	291	0.089	200
ρ_1							0.011	80			(0.02)	(23)								
Series	1908		1898		1900		1910–11		1894		1889–1893		1876–77		1908–1911		1913		1841	
Length	1 year.		1 year.		1 year.		369 days.		29 days.		2 years.		1 year.		4 years.		1 year.		58 days.	
Reference	(38)		(19)		(19)		(1)		(1)		(39)		(19)		(40)		(40)		(1)	

[1] For compound and long-period components see pp. 408–409.

NEW ZEALAND AND ASIA.[1]

Component.	North Island, New Zealand. Auckland[2] (36° 51′ S., 174° 46′ E.).		North Island, New Zealand. Wellington[2] (41° 17′ S., 174° 47′ E.).		South Island, New Zealand. Port Lyttelton[2] (43° 36′ S., 172° 51′ E.).		South Island, New Zealand. Port Chalmers[2] (45° 50′ S., 170° 42′ E.).		South Island, New Zealand. Dunedin[2] (45° 53′ S., 170° 33′ E.).		South Island, New Zealand. Bluff[2] (46° 35′ S., 168° 22′ E.).		South Island, New Zealand. Westport[2] (41° 46′ S., 171° 37′ E.).		India. Port Blair[2] Andaman Is., (11° 41′ N., 92° 45′ E.).		India. Mergui[2] (12° 26′ N., 98° 36′ E.).		India. Amherst[2] Moulmein Riv. (16° 05′ N., 97° 34′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.015	204	0.007	145	0.007	146	0.005	163	0.004	102	0.007	189	0.015	214	0.027	320	0.032	329	0.053	41
K_1	0.235	168	0.085	81	0.148	83	0.085	81	0.073	90	0.060	114	0.077	184	0.399	327	0.525	334	0.709	4
K_2	0.142	253	0.049	350	0.054	103	0.067	75	0.095	126	0.127	51	0.268	327	0.261	310	0.841	344	0.986	96
L_2	0.171	203	0.054	127	0.038	148	0.092	98	0.162	109	0.113	34	0.090	270	0.080	279	0.215	290	0.321	97
M_1	0.011	145	0.007	39	0.010	99	0.009	68	0.012	90	0.017	88	0.013	341	0.015	307	0.017	15	0.032	343
M_2	3.805	205	1.597	137	2.879	126	2.374	102	2.497	123	2.857	35	3.759	304	2.000	280	5.494	310	6.320	67
M_3	0.038	199	0.025	178	0.016	113	0.018	142	0.018	238	0.009	265	0.021	202	0.006	26	0.053	136	0.024	259
M_4	0.108	129	0.038	278	0.016	80	0.040	277	0.260	177	0.094	227	0.064	36	0.014	127	0.120	133	0.324	43
M_6	0.024	310	0.014	98	0.022	69	0.050	337	0.076	359	0.036	78	0.026	37	0.004	294	0.072	237	0.131	252
M_8															0.002	66	0.016	60	0.017	238
N_2	0.793	172	0.397	101	0.663	95	0.504	77	0.538	104	0.657	17	0.754	287	0.400	274	1.037	308	1.284	52
$2N$							0.063	41							0.061	261	0.165	292	0.245	34
O_1	0.055	140	0.103	36	0.088	61	0.090	56	0.090	73	0.111	75	0.094	48	0.155	302	0.210	315	0.323	343
OO																				
P_1	0.075	165	0.031	73	0.051	112	0.032	95	0.025	98	0.023	105	0.027	126	0.133	325	0.153	336	0.191	352
Q_1	0.012	65	0.032	22	0.021	43	0.026	58	0.021	356	0.025	40	0.035	30	0.017	246	0.029	282	0.039	342
$2Q$																				
R_2	0.023	215	0.017	120	0.013	150	0.024	63	0.016	172	0.015	152	0.039	260					0.219	305
S_1	0.010	17	0.004	245	0.035	32	0.074	90	0.015	10	0.007	90	0.009	75	0.019	66	0.076	68	0.176	133
S_2	0.595	265	0.098	332	0.179	143	0.253	101	0.243	130	0.510	49	0.979	332	0.959	315	2.928	349	2.708	102
S_4	0.020	331	0.004	197	0.009	203	0.007	335	0.006	309	0.009	228	0.007	46	0.006	212	0.044	233	0.095	114
S_6	0.003	56	0.005	301	0.015	345	0.003	344	0.003	118	0.006	170	0.005	329	0.002	145	0.018	104	0.008	233
T_2	0.067	293	0.037	280	0.030	220	0.016	19	0.020	255	0.023	112	0.042	44	0.072	312	0.266	345	0.422	169
λ_2							0.017	98							0.051	247			0.246	127
μ_2	0.103	173	0.081	89	0.091	59	0.052	83	0.029	44	0.067	8	0.124	278	0.083	297	0.444	348	0.285	298
ν_2	0.190	198	0.113	118	0.148	122	0.133	62	0.068	124	0.137	58	0.181	317	0.096	268	0.240	291	0.339	110
ρ_1																				
Series	1909–1919		1909–1919		1913–1919		1898–1901		1911–1918		1917–1920		1917–1920		1880–1914		1889–1894		1880–1886	
Length	4 years.		3 years.		3 years.		2 years.		4 years.		3 years.		3 years.		30 years.		5 years.		6 years.	
Reference	(41)		(41)		(41)		(1), (18)		(41)		(41)		(41)		(42)		(42)		(42)	

[1] For Penang, Straits Settlements, see p. 402.

[2] For compound and long-period components see p. 409.

ASIA, SOUTH COAST.

India—Continued.

Component.	Moulmein,[1] Moulmein R. (16° 29′ N., 97° 37′ E.).		Elephant Point[1] (16° 30′ N., 96° 18′ E.).		Rangoon[1] (16° 46′ N., 96° 10′ E.).		Bassein[1] (16° 47′ N., 94° 45′ E.).		Akyab[1] (20° 8′ N., 92° 54′ E.).		Chittagong[1] (22° 20′ N., 91° 50′ E.).		Dublat,[1] Saugor, Hooghly R. (21° 38′ N., 88° 6′ E.).		Diamond Harbor,[1] Hooghly R. (22° 11′ N., 88° 12′ E.).		Calcutta,[1] Kidderpore (22° 32′ N., 88° 20′ E.).		False Point[1] (20° 25′ N., 86° 47′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.022	77	0.030	87	0.036	81	0.015	239	0.025	332	0.039	52	0.031	339	0.030	8	0.023	37	0.026	328
K_1	0.448	39	0.746	19	0.681	34	0.374	48	0.446	343	0.593	22	0.494	352	0.502	14	0.404	53	0.408	344
K_2	0.356	153	0.752	137	0.608	168	0.161	97	0.321	306	0.431	67	0.623	325	0.676	25	0.447	93	0.272	299
L_2	0.317	135	0.395	127	0.468	146	0.170	62	0.107	292	0.338	55	0.192	296	0.256	350	0.218	67	0.070	265
M_1	0.019	113	0.028	69	0.030	111	0.021	237	0.014	345	0.029	74	0.017	356	0.029	163	0.027	112	0.010	324
M_2	3.926	112	5.902	103	5.861	131	2.272	48	2.555	278	4.444	35	4.608	291	5.164	344	3.712	57	2.251	269
M_3	0.027	140	0.029	325	0.034	65	0.007	173	0.017	23	0.033	192	0.048	135	0.050	230	0.042	310	0.014	31
M_4	0.921	167	0.281	88	0.459	168	0.236	323	0.007	274	0.406	343	0.088	149	0.752	247	0.754	35	0.035	229
M_6	0.088	193	0.244	336	0.232	86	0.096	236	0.023	123	0.140	190	0.011	221	0.150	108	0.159	320	0.010	78
M_8	0.044	118	0.104	328	0.089	97	0.017	167	0.007	147	0.031	124	0.010	294	0.058	347	0.072	251	0.004	226
N_2	0.687	97	1.111	88	1.055	116	0.350	39	0.518	271	0.841	25	0.894	285	0.955	340	0.682	44	0.454	264
2N	0.125	91	0.178	59	0.207	82	0.126	3	0.076	254	0.154	4	0.155	261	0.148	334	0.112	22	0.068	249
O_1	0.245	47	0.323	6	0.289	26	0.186	39	0.183	336	0.291	12	0.189	338	0.226	346	0.210	21	0.176	335
OO																				
P_1	0.140	58	0.193	30	0.174	54	0.126	51	0.137	345	0.196	31	0.151	347	0.176	10	0.146	44	0.137	345
Q_1	0.042	58	0.026	351	0.026	41	0.010	48	0.010	283	0.023	3	0.011	353	0.026	350	0.025	358	0.010	287
2Q																				
R_2	0.145	73	0.077	104	0.108	79							0.157	298	0.196	13	0.145	78	0.012	125
S_1	0.096	148	0.096	114	0.115	130	0.066	136	0.046	79	0.066	115	0.046	124	0.091	155	0.086	198	0.011	37
S_2	1.414	147	2.381	140	2.055	169	0.746	91	1.132	308	1.572	69	2.107	328	2.231	26	1.538	98	1.007	302
S_4	0.071	222	0.084	176	0.085	260	0.014	80	0.007	196	0.055	61	0.016	223	0.123	327	0.095	109	0.008	320
S_6	0.007	205	0.010	277	0.014	42	0.002	175	0.003	89	0.009	140	0.003	111	0.012	254	0.005	29	0.001	165
T_2	0.196	131	0.230	139	0.231	152	0.059	45	0.070	315	0.113	199	0.156	180	0.198	71	0.142	144	0.029	107
λ_2	0.163	154	0.183	153	0.253	170					0.207	61	0.150	299	0.147	354	0.089	93	0.053	331
μ_2	0.359	273	0.358	292	0.530	289	0.277	176	0.023	283	0.290	201	0.150	10	0.302	85	0.250	184	0.065	266
ν_2	0.256	92	0.269	95	0.352	113	0.120	17	0.122	262	0.299	27	0.242	275	0.280	311	0.234	22	0.114	273
ρ_1																				
Series	1880–1912		1884–1888		1880–1914		1902–03		1889–1892		1886–1891		1881–1886		1881–1886		1881–1914		1881–1885	
Length	10 years.		5 years.		30 years.		2 years.		5 years.		5 years.		5 years.		5 years.		29 years.		4 years.	
Reference	(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)	

[1] For compound and long-period components see pp. 409–410.

Component.	India—Continued.																			
	Vizagapatam [1] (17° 41′ N., 83° 17′ E.).		Cocanada [1] (16° 56′ N., 82° 15′ E.).		Madras [1] (13° 6′ N., 80° 18′ E.).		Negapatam [1] (10° 46′ N., 79° 51′ E.).		Pamban Pass [1] (9° 16′ N., 79° 12′ E.).		Tuticorin [1] (8° 48′ N., 78° 9′ E.).		Trincomalee,[1] Ceylon (8° 33′ N., 81° 13′ E.).		Galle,[1] Ceylon (6° 2′ N., 80° 13′ E.).		Colombo,[1] Ceylon (6° 57′ N., 79° 51′ E.).		Minicoy [1] (8° 17′ N., 73° 3′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.025	345	0.028	335	0.020	318	0.013	353	0.014	48	0.017	50	0.014	305	0.010	36	0.016	37	0.043	72
K_1	0.358	342	0.347	339	0.295	339	0.220	347	0.294	46	0.300	27	0.214	331	0.167	18	0.238	33	0.690	51
K_2	0.192	278	0.169	284	0.118	272	0.084	285	0.112	90	0.129	83	0.062	253	0.110	95	0.108	90	0.095	15
L_2	0.055	259	0.066	252	0.042	277	0.034	263	0.023	58	0.031	52	0.043	255	0.030	48	0.027	51	0.027	13
M_1	0.012	303	0.018	373	0.015	322	0.010	20	0.011	35	0.010	65	0.008	310	0.006	323	0.010	327	0.020	73
M_2	1.469	254	1.513	253	1.068	244	0.708	251	0.585	47	0.662	43	0.579	241	0.527	57	0.579	50	0.862	329
M_3	0.007	12	0.007	14	0.004	31	0.003	89	0.016	170	0.020	162	0.003	175	0.012	161	0.015	170	0.007	178
M_4	0.013	320	0.030	106	0.006	194	0.022	79	0.016	194	0.025	156	0.012	224	0.012	164	0.016	170	0.009	67
M_6	0.005	69	0.016	97	0.005	127	0.011	130	0.010	42	0.015	19	0.005	112	0.003	341	0.004	27	0.002	64
M_8	0.004	215	0.002	345	0.002	136	0.003	268	0.005	314	0.007	274	0.002	155	0.002	253	0.001	142	0.003	181
N_2	0.308	248	0.319	245	0.238	237	0.158	239	0.082	31	0.082	33	0.144	225	0.063	46	0.073	34	0.175	301
2N	0.052	233	0.052	234	0.043	222	0.025	210	0.008	14	0.008	114	0.026	224	0.010	119	0.010	57	0.021	242
O_1	0.139	332	0.137	333	0.095	326	0.089	322	0.114	45	0.119	47	0.064	308	0.047	76	0.094	62	0.335	59
OO																				
P_1	0.101	341	0.095	343	0.095	341	0.079	345	0.110	46	0.074	9	0.072	338	0.047	22	0.072	26	0.218	48
Q_1	0.012	331	0.006	46	0.007	65	0.005	270	0.021	89	0.033	78	0.009	188	0.026	96	0.032	88	0.064	58
2Q																				
R_2	0.026	148			0.028	82	0.031	325	0.016	114					0.018	358	0.059	340		
S_1	0.048	76	0.036	79	0.029	95	0.042	106	0.036	148	0.046	59	0.017	69	0.015	47	0.013	64	0.044	203
S_2	0.648	286	0.639	286	0.449	274	0.268	283	0.372	92	0.468	84	0.204	265	0.362	94	0.391	95	0.350	20
S_4	0.004	50	0.006	134	0.001	189	0.005	135	0.003	261	0.006	234	0.006	217	0.003	235	0.005	236	0.003	87
S_6	0.001	157	0.003	168	0.001	78	0.001	159	0.004	197	0.007	171	0.001	122	0.001	173	0.002	177	0.001	230
T_2	0.046	269	0.054	259	0.037	273	0.044	249	0.025	92	0.022	107	0.038	206	0.030	69	0.034	54	0.025	290
λ_2	0.023	261	0.008	83	0.022	267	0.019	273	0.016	64					0.015	59	0.024	44		
μ_2	0.028	260	0.024	275	0.037	184	0.017	116	0.009	105	0.023	94	0.033	155	0.024	100	0.017	104	0.011	304
ν_2	0.101	241	0.080	249	0.063	263	0.034	239	0.027	30	0.019	24	0.044	285	0.027	60	0.018	41	0.045	311
ρ_1																				
Series	1879–1885		1886–1891		1880–1914		1881–1888		1878–1882		1883–1893		1890–1894		1884–1890		1884–1890		1891–1894	
Length	6 years.		5 years.		25 years.		5 years.		4 years.		5 years.		5 years.		6 years.		6 years.		4 years.	
Reference	(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)	

[1] For compound and long-period components see p. 410.

ASIA, SOUTH COAST—Continued.

India—Continued.

Component.	Cochin[1] (9° 58′ N., 76° 15′ E.).		Beypore[1] (11° 10′ N., 75° 48′ E.).		Kawar[1] (14° 48′ N., 74° 06′ E.).		Marmagao[1] (15° 25′ N., 73° 48 E.).		Bombay,[1] Prince's Dock (18° 57′ N., 72° 50′ E.).		Bombay,[1] Apollo Bandar (18° 55′ N., 72° 50′ E.).		Bhavnagar,[1] Cambay Gulf (21° 48′ N., 72° 09′ E.).		Port Albert Victor,[1] Combay Gulf, (20° 58′ N., 71° 33′ E.).		Porbandar[1] (21° 37′ N., 69° 37′ E.).		Okha Point[1] (22° 28′ N., 69° 05′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.038	64	0.049	58	0.068	57	0.065	55	0.100	65	0.101	64	0.183	150	0.120	93	0.071	35	0.115	84
K_1	0.591	52	0.708	51	1.004	45	1.025	46	1.392	45	1.395	45	2.322	91	1.620	66	1.163	43	1.424	53
K_2	0.080	23	0.084	9	0.174	330	0.187	323	0.398	357	0.400	355	0.865	171	0.277	78	0.208	223	0.326	14
L_2	0.030	355	0.027	350	0.056	317	0.049	320	0.084	297	0.076	305	0.636	142	0.098	185	0.050	306	0.254	24
M_1	0.018	45	0.033	71	0.033	41	0.029	74	0.054	61	0.055	56	0.095	153	0.090	92	0.045	59	0.046	40
M_2	0.727	332	0.943	328	1.742	302	1.810	300	4.072	331	4.018	331	10.896	134	2.888	58	2.134	293	3.749	347
M_3	0.009	211	0.010	198	0.014	273	0.017	295	0.075	27	0.070	26	0.086	293	0.027	146	0.027	316	0.031	15
M_4	0.026	75	0.021	38	0.055	17	0.047	6	0.106	332	0.120	324	0.894	152	0.212	176	0.033	124	0.127	107
M_6	0.009	87	0.008	133	0.011	224	0.011	249	0.008	186	0.012	62	0.239	125	0.119	128	0.029	307	0.008	225
M_8	0.004	326	0.008	148	0.002	109	0.013	23	0.005	70	0.006	340	0.019	183	0.007	160	0.003	283	0.013	87
N_2	0.156	303	0.201	303	0.410	282	0.433	282	0.996	315	0.989	315	2.430	114	0.774	34	0.514	275	0.821	323
2N	0.019	251	0.024	251	0.056	244	0.063	240	0.152	276	0.147	280	0.322	69	0.126	347	0.068	234	0.160	265
O_1	0.308	58	0.344	57	0.497	49	0.521	49	0.658	48	0.659	48	0.985	84	0.730	67	0.566	46	0.697	57
OO	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
P_1	0.166	50	0.198	53	0.277	42	0.300	44	0.406	44	0.408	44	0.680	94	0.451	64	0.342	43	0.400	51
Q_1	0.075	68	0.083	66	0.114	59	0.108	52	0.146	51	0.143	50	0.199	86	0.156	70	0.108	62	0.150	56
2Q	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
R_2	......	......	0.019	130	0.008	145	0.006	138	......	......	0.040	271	......	......	......	......	......	......	......	......
S_1	0.029	188	0.059	174	0.057	159	0.053	175	0.081	191	0.072	189	0.137	192	0.102	189	0.077	183	0.073	177
S_2	0.261	29	0.333	17	0.624	335	0.641	332	1.608	4	1.590	4	3.473	176	1.139	82	0.782	324	1.188	14
S_4	0.006	175	0.005	135	0.010	98	0.009	92	0.020	212	0.013	242	0.121	235	0.025	264	0.004	277	0.012	116
S_6	0.006	227	0.006	247	0.005	52	0.004	114	0.004	193	0.003	171	0.020	297	0.010	27	0.009	192	0.003	144
T_2	0.036	30	0.047	18	0.060	335	0.079	316	0.150	6	0.158	14	0.324	178	0.103	84	0.024	354	......	......
λ_2	0.013	321	0.010	303	0.020	345	0.012	33	......	......	0.028	210	0.278	142	0.043	107	......	......	0.073	23
μ_2	0.011	168	0.018	260	0.044	263	0.055	250	0.210	309	0.201	305	0.316	273	0.309	338	0.064	255	0.175	183
ν_2	0.039	325	0.046	322	0.088	294	0.099	280	0.189	313	0.187	310	0.657	103	0.115	89	0.171	277	0.234	4
ρ_1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Series	1886–1892		1878–1884		1878–1883		1884–1889		1888–1912		1878–1912		1886–1893		1881–1903		1900–1901		1874–1905	
Length	6 years.		6 years.		5 years.		5 years.		20 years.		30 years.		8 years.		5 years.		2 years.		2 years.	
Reference	(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)	

[1] For compound and long-period components see p. 410.

ASIA AND AFRICA.

Component.	India—Continued.						Persia,		Turkey,		Arabia.						Egypt,		French	
	Navanar Point, Cutch Gulf (22° 44′ N., 69° 43′ E.).		Hansthal Point,[1] Cutch Gulf (22° 56′ N., 70° 21′ E.).		Karachi[1] (24° 48′ N., 66° 58′ E.).		Bushire[1] (29° 00′ N., 50° 52′ E.).		Basrah,[1] Shatt-al-Arab,[2] (30° 30′ N., 47° 34′ E.).		Maskat[1] (23° 37′ N., 58° 35′ E.).		Aden[1] (12° 47′ N., 44° 59′ E.).		Perim,[1] Strait of Bab-el Mandeb (12° 38′ N., 43° 24′ E.).		Suez,[1] Red Sea (29° 56′ N., 32° 33′ E.).		Somaliland, Djibouti (11° 35′ N., 43° 08′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.147	97	0.095	128	0.088	64	0.048	275	0.038	303	0.060	31	0.100	45	0.085	45	0.017	220		
K_1	1.528	63	1.495	81	1.303	46	0.976	280	0.735	29	1.272	39	1.305	35	1.147	33	0.145	186	1.345	30
K_2	0.372	63	0.527	81	0.272	319	0.132	263			0.197	300	0.191	239	0.162	230	0.134	5	0.197	239
L_2	0.505	25	0.570	37	0.078	296	0.035	227			0.039	298	0.041	224	0.031	213	0.075	50		
M_1			0.055	78	0.046	49	0.037	215			0.020	184	0.050	43	0.051	42	0.012	245		
M_2	6.044	24	6.854	46	2.555	294	1.059	211	1.227	105	2.069	276	1.564	226	1.199	226	1.840	343	1.749	220
M_3			0.056	92	0.039	332	0.320	78			0.028	306	0.018	211	0.034	238	0.018	41		
M_4	0.109	273	0.727	330	0.026	1	0.025	337			0.006	65	0.006	306	0.031	17	0.028	135		
M_6	0.065	41	0.305	246	0.046	205	0.008	330			0.006	24	0.006	346	0.006	7	0.011	67		
M_8	0.023	339	0.083	150	0.005	254	0.003	56			0.004	312	0.002	97	0.001	84	0.002	157		
N_2	1.263	11	1.193	26	0.610	278	0.227	184			0.508	258	0.434	221	0.344	226	0.593	313		
2N					0.093	244	0.046	124			0.082	218	0.083	189	0.076	194	0.114	245		
O_1	0.684	66	0.754	75	0.658	47	0.654	243	0.397	355	0.662	41	0.658	37	0.589	36	0.040	207	0.656	35
OO																				
P_1	0.281	72	0.384	84	0.390	45	0.291	271	0.187	358	0.390	37	0.404	32	0.361	30	0.051	123	0.427	30
Q_1	0.146	69	0.139	77	0.138	49	0.115	228	0.077	1	0.117	38	0.149	37	0.125	30	0.015	206		
2Q																				
R_2					0.028	281														
S_1			0.129	164	0.085	175	0.056	25	0.186	200	0.110	185	0.094	166	0.084	154	0.094	68		
S_2	1.893	55	1.928	85	0.956	323	0.386	262			0.776	306	0.678	245	0.560	242	0.460	9	0.755	239
S_4	0.013	0	0.021	62	0.011	16	0.007	104			0.004	333	0.005	281	0.005	325	0.004	71		
S_6			0.007	167	0.008	296	0.002	40			0.002	260	0.005	208	0.007	213	0.002	321		
T_2					0.080	333					0.082	1	0.052	244	0.042	243	0.063	23		
λ_2	0.152	70	0.235	39	0.043	260														
μ_2	0.431	185	0.595	178	0.063	267	0.012	295			0.054	217	0.072	190	0.062	194	0.084	228		
ν_2	0.308	4	0.296	47	0.140	277	0.069	194			0.100	271	0.094	226	0.077	204	0.127	330		
ρ_1																				
Series	1874–75		1874–75		1868–1912		1892–1900		1918–19		1893–94		1879–1913		1900–1902		1899–1903		1899	
Length	103 days.		1 year.		40 years.		3 years.		2 years.		2 years.		30 years.		3 years.		5 years.		17 days.	
Reference	(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(42)		(43)	

[1] For compound and long-period components see pp. 410–411.

[2] For Shatt-al-Arab Bar see p 402.

AFRICA.

Component.	Comoro Islands, Mayotte Island, (12° 47′ S., 45° 17′ E.).		Madagascar.														Miscellaneous Islands.			
			Diego Suarez,[1] (12° 15′ S., 49° 30′ E.).		Tamatave, (18° 08′ S., 49° 26′ E.).		Tulear, (23° 21′ S., 43° 39′ E.).		Maintirano, (18° 09′ S., 44° 03′ E.).		Majunga, (15° 50′ S., 46° 21′ E.).		Hellville, (13° 20′ S., 48° 12′ E.).		Courrier Bay, (12° 13′ S., 49° 10′ E.).		Reunion Is., (21° 16′ S., 55° 35′ E.).		Mauritius Is.,[1] (20° 08′ S., 57° 29′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																			0.009	118
K_1	0.558	49	0.394	55	0.066	56	0.197	111	0.164	86	0.459	56	0.459	51	0.525	41	0.164	159	0.244	121
K_2	0.459	163	0.262	155	0.066	67	0.459	187	0.591	168	0.590	167	0.492	168	0.459	156	0.066	77	0.138	23
L_2			0.262	56			0.066	132											0.033	4
M_1																			0.004	100
M_2	3.707	121	2.100	111	0.722	49	2.592	142	3.839	133	4.101	119	3.740	121	2.854	116	0.459	79	0.433	23
M_3																			0.016	167
M_4																			0.004	296
M_6																			0.005	94
M_8																			0.001	168
N_2			0.591	70			0.558	132											0.137	32
$2N$																				
O_1	0.295	61	0.262	63	0.098	73	0.098	33	0.164	64	0.230	56	0.262	57	0.361	50	0.098	103	0.140	98
OO																				
P_1	0.197	49	0.131	55	0.033	56	0.066	111	0.066	86	0.164	56	0.164	51	0.164	41	0.066	159	0.056	132
Q_1																			0.024	78
$2Q$																				
R_2																				
S_1																			0.013	32
S_2	1.739	163	0.951	155	0.295	67	1.411	187	2.133	168	2.133	167	1.772	168	1.280	156	0.230	77	0.331	26
S_4																			0.003	116
S_6																			0.002	235
T_2																				
λ_2																			0.018	298
μ_2							0.164	100											0.019	317
ν_2			0.082	70			0.312	148											0.008	257
ρ_1																				
Series	1900		1900		1901		1907		1903		1891				1904		1900		1838–39	
Length	15 days.		1 month.		1 month.		1 month.		1 month.		1 month.				22 days.		1 month.		1 year.	
Reference	(43)		(43)		(43)		(43)		(43)		(43)		(14)		(43)		(43)		(3)	

[1] For compound and long-period components see p. 411.

AFRICA—Continued.

Component.	Kerguelen Island, Betsy Cove (49° 09′ S., 70° 12′ E.).		South Africa.						Equatorial Africa.								French Guinea, Conakry (9° 40′ N., 13° 40′ W.).		Senegal, Carabane (12° 33′ N., 16° 40′ W.).	
			Durban, Natal (29° 53′ S., 31° 04′ E.).		Port Elizabeth, Algoa Bay (33° 58′ S., 25° 37′ E.).		Cape Town,[1] Table Bay (33° 54′ S., 18° 25′ E.).		Pointe Noire (4° 55′ S., 11° 50′ E.).		Port Gentil, Cape Lopez (0° 48′ S., 8° 42′ E.).		Pointe Owendo (0° 25′ N., 9° 25′ E.).		Dula,[1] Kamerun (4° 03′ N., 9° 40′ E.).					
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.14	289	0.17	180	0.16	146	0.178	127	0.131	21	0.394	1	0.394	9	0.515	40	0.328	345	0.098	10
K_2	0.23	49	0.27	145	0.23	128	0.245	90	0.131	150	0.197	142	0.230	186	0.249	188	0.262	231	0.098	288
L_2							0.072	47							0.220	148				
M_1																				
M_2	1.42	9	1.72	115	1.76	97	1.596	45	1.640	105	1.804	117	2.428	138	2.448	156	4.298	203	1.378	233
M_3																				
M_4	0.03	289					0.039	96							0.236	139				
M_6							0.013	296							0.062	127				
M_8																				
N_2	0.024	330	0.30	102			0.344	22							0.361	152				
$2N$																				
O_1	0.22	292			0.05	280	0.053	243	0.033	195	0.066	297	0.066	352	0.075	323	0.066	235	0.033	263
OO																				
P_1	0.045	287			0.05	146	0.048	114	0.033	21	0.131	1	0.131	9	0.325	2	0.098	345	0.098	10
Q_1							(0.010)	(300)												
$2Q$																				
R_2																				
S_1																				
S_2	0.80	52	0.95	150	0.83	128	0.672	88	0.492	150	0.689	142	0.919	186	0.810	195	1.148	231	0.459	288
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2							(0.067)	(25)												
ρ_1																				
Series	1874–75				1886		1888–89						1911–12		1898–1902				1909	
Length	74 days.				1 month.		369 days.						20 days.		3 years.				16 days.	
Reference	(2)		(44)		(45)		(1)		(8)		(8)		(8)		(46)		(8)		(47)	

[1] For compound and long-period components see p. 411.

AFRICA AND EUROPE.

Component.	West Africa.				Morocco.						Tunis.				Egypt, Alexandria (31.2° N., 29.9° E.).		Yugoslavia.			
	Dakar, Cape Verde (14° 40′ N., 17° 25′ W.).		Port Etienne, Bay of Repose (20° 55′ N., 17° 02′ W.).		Casablanca (33° 36′ N., 7° 37′ W.).		Rabat (34° 04′ N., 6° 46′ W.).		Mehedia (34° 20′ N., 6° 30′ W.).		La Goulette (36.8° N., 10.3° E.).		Sfax (34.7° N., 10.7° E.).				Meljine (42° 27′ N., 18° 34′ E.).		Ragusa (42° 38′ N., 18° 7′ E.).	
	H	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ	*H*	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.197	328	0.197	357	0.262	36	0.197	51	0.164	51	0.110	206	0.026	60	0.055	303	0.163	56	0.167	62
K_2	0.131	264	0.197	354	0.328	77	0.295	69	0.262	76	0.031	336	0.170	109	0.043	315	0.070	114	0.054	110
L_2																				
M_1																				
M_2	1.542	224	1.804	306	3.346	47	2.887	45	2.592	51	0.255	270	0.680	95	0.236	305	0.299	107	0.305	110
M_3																				
M_4																				
M_6																				
M_8																				
N_2											0.063	242			0.039	308			0.049	98
2N																				
O_1	0.131	226	0.066	306	0.197	293	0.131	297	0.197	316	0.038	126			0.041	271			0.070	48
OO																				
P_1	0.066	328	0.066	357	0.098	36	0.066	51	0.066	51	0.028	253			0.22	303			0.057	58
Q_1																				
2Q																				
R_2																				
S_1																				
S_2	0.558	264	0.787	354	1.247	77	1.148	69	1.017	76	0.100	295	0.352	115	0.133	319	0.194	110	0.190	114
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series			1909								1921–22		1910		1916–17					
Length	1 month.		16 days.								6 months.		6 months.		1 year.		1 year.		1 year.	
Reference	(43)		(47)		(8)		(8)		(8)		(48)		(48)		(48)		(49), (50)		(49), (50)	

Component.	Yugoslavia—Continued.																Italy.			
	Palagosa (42° 24′ N., 16° 15′ E.).		Comisa (43° 3′ N., 16° 5′ E.).		Rogoznica (43° 32′ N., 15° 58′ E.).		Sebenico (43° 43′ N., 15° 51′ E.).		Zara (44° 7′ N., 15° 14′ E.).		Hafen Pantera (44° 9′ N., 14° 50′ E.).		Hafen Cigale (44° 32′ N., 14° 27′ E.).		Zengg (45° 00′ N., 14° 54′ E.).		Fiume (45° 20′ N., 14° 26′ E.).		Pola (44° 52′ N., 13° 51′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1																				
K_1	0.201	72	0.257	58	0.295	68	0.303	58	0.433	68	0.398	60	0.509	66	0.446	65	0.459	65	0.513	68
K_2	0.055	105	0.047	118			0.046	129	0.031	229	0.035	197	0.080	244	0.065	229	0.057	242	0.080	269
L_2																				
M_1																				
M_2	0.281	107	0.243	111	0.216	143	0.206	138	0.212	233	0.150	195	0.279	246	0.326	243	0.340	249	0.494	264
M_3																				
M_4																				
M_6																				
M_8																				
N_2	0.053	10[illegible]	0.043	113													0.063	241	0.077	272
$2N$																				
O_1	0.071	60	0.082	42							0.123	68					0.130	55	0.163	62
OO																				
P_1	0.076	49	0.079	52							0.111	51					0.141	64	0.162	69
Q_1																				
$2Q$																				
R_2																				
S_1																				
S_2	0.315	118	0.169	122	0.153	139	0.145	134	0.107	235	0.113	204	0.143	247	0.169	238	0.186	249	0.285	271
S_4																				
S_6																				
T_2																				
λ_2																				
μ_2																				
ν_2																				
ρ_1																				
Series																				
Length			1 year.		6 months.		1 year.		1 year.								1 year.		1 year.	
Reference	(50)		(49), (50)		(49), (50)		(49), (50)		(49), (50)		(50)		(50)		(50)		(49), (50)		(49), (50)	

EUROPE, MEDITERRANEAN SEA—Continued.

Italy—Continued.

Component.	Triest, (45° 39′ N., 13° 46′ E.).		Venice,[1] Porto Malamocco, (45° 20′ N., 12° 15′ E.).		Brindisi, (40° 38′ N., 17° 57′ E.).		Tareno, (40.4° N., 17.2° E.).		Messina, Sicily, (38.2° N., 15.6° E.).		Catania, Sicily, (37.5° N., 15.1° E.).		Mazzara del Vallo, Sicily, (37.6° N., 12.6° E.).		Palermo, Sicily, (38.1° N., 13.4° E.).		Malta, Valetta Harbor, (35° 55′ N., 14° 30′ E.).		Naples, (40.9° N., 14.3° E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.041	343													0.001	59		
K_1	0.568	69	0.600	79	0.137	63	0.061	59	0.019	281	0.053	60	0.117	98	0.101	213	0.035	43	0.086	216
K_2	0.171	278	0.131	294	0.054	112	0.040	113	0.031	22	0.038	98	0.016	148	0.047	274	0.033	110	0.036	297
L_2			0.014	306													0.016	110		
M_1			0.015	83													0.005	69		
M_2	0.863	276	0.772	292	0.298	106	0.213	105	0.158	29	0.217	95	0.142	153	0.359	264	0.197	93	0.361	268
M_3			0.020	229													0.002	204		
M_4			0.012	331													0.003	350		
M_6			0.002	72													0.001	26		
M_8																	0.003	127		
N_2	0.141	285	0.133	292			0.019	118	0.020	32	0.031	111	0.037	154	0.043	259	0.031	114	0.065	246
2N																				
O_1	0.165	57	0.174	63	0.035	93	0.026	51	0.028	73	0.038	66	0.054	74	0.035	135	0.024	83	0.025	128
OO																				
P_1	0.156	73	0.190	67	0.046	63	0.022	50			0.021	25	0.031	107	0.038	197	0.011	58	0.039	224
Q_1			0.031	88													0.006	69		
2Q																				
R_2			0.023	13																
S_1			0.038	91													0.009	162		
S_2	0.519	283	0.459	300	0.197	110	0.123	107	0.081	49	0.125	95	0.060	128	0.148	285	0.120	100	0.133	287
S_4			0.004	14													0.001	37		
S_6																				
T_2			0.039	347																
λ_2																	0.007	72		
μ_2			0.015	325													0.003	73		
ν_2			0.023	341													0.003	198		
ρ_1																				
Series					1898		1914–15		1917		1914–15		1910–1912		1914–15		1871		1914–15	
Length	1 year.				30 days.		6 months.		6 months.		6 months.		12 months.		6 months.		1 year.		6 months.	
Reference	(49), (50)		(51)		(52)		(48)		(48)		(48)		(48)		(48)		(3)		(48)	

[1] For compound and long-period components see p. 411.

EUROPE, MEDITERRANEAN SEA AND WEST COAST.[1]

Component.	Italy—Continued.				France.				Spain.				Portugal,		France.					
	Civitavecchia (42.1° N., 11.8° E.).		Porto Maurizio (43.9° N., 8.0° E.).		Toulon [2] (43° 07′ N., 5° 56′ E.).		Marseilles [2] (43° 18′ N., 5° 23′ E.).		Alicante (38.3° N., 0.5° W.).		Cadiz (36.5° N., 6.2° W.).		Lisbon [2] Arsenal [3] (38° 41′ N., 9° 06′ W.).		St. Jean de Luz,[2] Fort Socoa (43° 24′ N., 1° 40′ W.).		Mouth of the Gironde [2] (45° 34′ N., 1° 04′ W.).		Fort Boyard [2] (46° 00′ N., 1° 13′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1					0.005	176	0.008	198							0.015	95	0.007	159	0.010	68
K_1	0.095	208	0.117	195	0.105	186	0.104	181	0.122	163	0.201	28	0.193	39	0.198	66	0.190	76	0.210	67
K_2	0.045	253	0.040	257	0.019	254	0.016	254	0.009	96	0.296	82	(0.408)	(83)	0.432	118	0.390	123	0.595	122
L_2					0.009	255	0.006	280					(0.142)	(77)	0.135	111	0.240	107	0.131	109
M_1					0.005	168	0.003	124							0.022	112	0.013	1	0.018	5
M_2	0.366	257	0.273	238	0.195	246	0.220	228	0.061	59	3.045	41	3.829	59	4.373	89	5.049	109	5.823	92
M_3					0.004	174	0.005	185							0.047	345	0.056	350	0.107	329
M_4					0.014	352	0.019	0					0.233	196	0.097	323	0.295	356	0.915	356
M_6					0.001	145							0.032	284	0.017	112	0.033	347	0.080	309
M_8					0.002	60														
N_2	0.077	237	0.042	236	0.049	226	0.043	221	0.012	29	0.540	34	0.980	41	0.926	68	0.991	94	1.223	72
2N															0.106	40			0.177	57
O_1	0.048	110	0.053	116	0.060	120	0.069	106	0.073	110	0.201	294	0.201	309	0.236	317	0.230	268	0.234	321
OO																				
P_1	0.025	179	0.058	183	0.041	178	0.040	182	0.020	142	0.075	41	(0.064)	(39)	0.057	50	0.039	69	0.088	58
Q_1					0.010	44	0.012	28					(0.039)	(265)	0.063	273	0.043	281	0.070	271
2Q																				
R_2															0.023	105	0.010	82	0.025	77
S_1					0.011	20	0.019	48							0.012	23	0.062	21	0.034	41
S_2	0.141	284	0.111	253	0.091	250	0.078	247	0.031	81	1.060	69	1.498	83	1,560	121	1.686	144	2.109	126
S_4					0.002	288	0.003	277							0.004	92	0.020	279	0.029	247
S_6																	0.007	333	0.011	32
T_2													(0.088)	(83)	0.082	119	0.092	131	0.112	131
λ_2					0.010	308	0.004	190												
μ_2					0.009	193	0.004	187					(0.092)	(35)	0.118	43	0.082	117	0.159	71
ν_2					0.011	158	0.003	308					(0.190)	(44)	0.086	134	0.282	59	0.403	69
ρ_1																				
Series	1900		1914–15		1847–1853		1850		1899		1898		1897		1894		1912–13		1896	
Length	6 months.		6 months.		3 years.		1 year.		175 days.		6 months.		29 days.		....		1 year.		1 year.	
Reference	(48)		(48)		(3)		(3)		(48)		(48)		(1)		(53)		(54)		(55)	

[1] For Gibraltar see p. 402. [2] For compound and long-period components see p. 411. [3] For Lisbon (Cacais) see p. 402.

EUROPE, WEST COAST.

Component.	France—Continued.											
	Rochelle,[1] (46° 09′ N., 1° 09′ W.).		St. Nazaire,[1] mouth of Loire, (47° 16′ N., 2° 12′ W.).		Brest,[1] (48° 23′ N., 4° 29′ W.).		St. Servan,[1] St. Malo. (48° 39′ N., 2° 02′ W.).		Cherbourg,[1] (49° 39′ N., 1° 37′ W.).		Havre,[1] (49° 29′ N., 0° 06′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.006	154	0.012	112	0.012	139	0.028	166	0.030	131	0.010	164
K_1	0.205	72	0.193	78	0.207	69	0.297	95	0.299	104	0.297	119
K_2	0.589	126	0.588	133	0.712	137	1.383	223	0.626	268	0.846	331
L_2	0.126	111	0.188	111	0.244	96	0.527	171	0.216	218	0.601	302
M_1	0.023	109	0.007	56	0.007	166	0.200	15	0.014	233	0.011	107
M_2	5.719	93	5.672	101	6.763	99	12.450	174	6.158	225	8.745	286
M_3	0.092	321	0.114	359	0.074	241	0.137	168	0.054	207	0.039	251
M_4	0.804	2	0.518	43	0.182	85	0.855	271	0.450	345	0.786	85
M_6	0.088	316	0.079	50	0.116	325	0.069	3	0.081	91	0.574	301
M_8												
N_2	1.163	70	1.112	80	1.388	80	2.386	155	1.293	206	1.703	262
2N	0.158	56	0.187	67	0.187	62			0.142	202	0.271	272
O_1	0.234	324	0.241	328	0.222	324	0.285	343	0.210	351	0.161	7
OO											(0.009)	(230)
P_1	0.078	66	0.072	73	0.072	60	0.106	96	0.108	95	0.089	103
Q_1	0.076	275	0.064	289	0.086	278	0.079	337	0.075	324	0.029	344
2Q											0.004	257
R_2	0.039	181	0.014	351	0.027	121	0.079	245	0.007	328	0.059	8
S_1	0.041	37	0.046	12	0.019	17	0.041	50	0.022	92	0.049	37
S_2	2.029	126	1.977	136	2.471	139	4.801	225	2.262	269	2.888	333
S_4	0.043	259	0.027	268	0.005	301	0.006	90	1.838	75	0.006	227
S_6	0.004	326	0.005	100					1.773	92		
T_2	0.119	128	0.072	120	0.129	128	0.248	212	0.125	262	0.184	323
λ_2											(0.061)	(302)
μ_2	0.164	92	0.141	126	0.246	89	1.037	191	0.277	209	0.348	320
ν_2	0.148	81	0.062	89	0.361	57	0.148	86	0.406	184	0.462	288
ρ_1											(0.006)	(320)
Series					1873–1875		1876		1883		1895	
Length					3 years.		1 year.		1 year.		1 year.	
Reference	(55)		(55)		(53)		(53)		(53)		(53)	

Component.	Belgium, Ostend,[1] (51° 14′ N., 2° 55′ E.).		Holland.					
			Vlissingen,[1] (51° 26′ N., 3° 34′ E.).		Neuzen,[1] (51° 20′ N., 3° 50′ E.).		Hansweert,[1] (51° 26′ N., 4° 00′ E.).	
	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1			0.011	229	0.029	152	0.033	166
K_1	0.176	351	0.222	6	0.238	15	0.239	24
K_2			0.431	99	0.484	112	0.464	126
L_2	0.507	54	0.399	46	0.478	79	0.620	79
M_1			0.044	62	0.052	71	0.029	64
M_2	5.917	12	5.508	42	5.812	58	6.125	68
M_3	0.020	77	0.038	125	0.056	170	0.053	127
M_4	0.361	345	0.373	77	0.282	108	0.168	132
M_6	0.232	315	0.301	52	0.217	103	0.208	168
M_8	0.106	242	0.105	27	0.097	72	0.124	139
N_2	0.998	1	0.911	24	0.955	42	1.009	43
2N								
O_1	0.323	173	0.348	191	0.351	202	0.383	199
OO								
P_1	0.079	332	0.089	340	0.084	351	0.106	10
Q_1	0.113	133	0.170	132	0.149	138	0.160	147
2Q								
R_2			0.024	285	0.011	238	0.033	270
S_1	0.067	296	0.026	308	0.052	305	0.041	331
S_2	1.796	64	1.503	97	1.541	113	1.571	128
S_4								
S_6								
T_2			0.110	79	0.113	91	0.098	103
λ_2			0.151	72	0.149	90	0.231	82
μ_2			0.364	154	0.451	167	0.575	169
ν_2	0.348	343	0.297	350	0.323	354	0.453	36
ρ_1								
Series	1883–1885		1906		1906		1900–1906	
Length	3 years.		1 year.		1 year.		2 years.	
Reference	(2)		(56)		(56)		(56)	

[1] For compound and long-period components see. pp. 411–412.

EUROPE, WEST COAST—Continued.

Component.	Holland—Continued.																			
	Wemeldinge [1] (51° 31′ N., 3° 59′ E.).		Zierikzee [1] (51° 38′ N., 3° 54′ E.).		Browvershaven [1] (51° 44′ N., 3° 56′ E.).		Willemstad [1] (51° 42′ N., 4° 26′ E.).		Hellevoetsluis [1] (51° 49′ N., 4° 08′ E.).		Rotterdam [1] (51° 55′ N., 4° 29′ E.).		Hoek van Holland [1] (51° 59′ N., 4° 09′ E.).		Ijmuiden [1] (52° 28′ N., 4° 34′ E.).		Helder [1] (52° 58′ N., 4° 46′ E.).		Vlieland [1] (53° 18′ N., 4° 04′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.015	195	0.009	128	0.022	117	0.015	317	0.029	341	0.012	6	0.010	128	0.015	167			0.015	192
K_1	0.244	22	0.236	14	0.236	7	0.206	22	0.221	12	0.184	22	0.253	356	0.253	355	0.180	356	0.169	12
K_2	0.369	136	0.303	128	0.251	125	0.186	181	0.205	146	0.141	199	0.180	132	0.147	183	0.157	239	0.156	294
L_2	0.425	79	0.372	72	0.370	84	0.292	125	0.270	99	0.320	146	0.235	82	0.254	113	0.141	181	0.171	225
M_1	0.047	83	0.039	79	0.038	55	0.033	90	0.033	75	0.035	97	0.044	68	0.045	65			0.030	102
M_2	4.818	75	4.384	65	3.625	68	3.077	117	2.803	90	2.112	135	2.467	72	2.136	116	1.736	171	2.121	232
M_3	0.033	186	0.024	175	0.018	85	0.025	230	0.025	200	0.013	220	0.016	231	0.016	271			0.014	354
M_4	0.235	199	0.193	142	0.413	130	0.433	186	0.481	148	0.336	206	0.557	131	0.596	154	0.367	191	0.078	308
M_6	0.115	197	0.099	103	0.182	112	0.147	238	0.096	110	0.105	207	0.117	71	0.143	254	0.190	293	0.142	32
M_8	0.050	102	0.087	96	0.026	172	0.047	31	0.040	164	0.014	190	0.046	172	0.087	265	0.066	342	0.046	296
N_2	0.786	58	0.710	47	0.583	44	0.460	98	0.436	71	0.310	118	0.356	53	0.300	102	0.262	151	0.337	219
2N																				
O_1	0.316	203	0.345	197	0.325	193	0.300	213	0.336	199	0.275	212	0.367	187	0.375	187	0.249	196	0.208	211
OO																				
P_1	0.096	4	0.085	353	0.109	353	0.094	23	0.091	4	0.082	30	0.098	335	0.109	340	0.085	0	0.078	357
Q_1	0.168	148	0.165	143	0.158	141	0.149	163	0.159	147	0.131	161	0.162	133	0.160	134	0.105	133	0.100	156
2Q																				
R_2	0.018	14	0.002	46	0.024	244	0.014	78	0.020	14	0.011	102	0.027	338	0.023	36			0.029	102
S_1	0.032	328	0.035	326	0.033	310	0.019	37	0.032	351	0.013	44	0.036	298	0.033	301	0.036	300	0.029	322
S_2	1.198	133	1.098	121	0.900	124	0.690	176	0.666	145	0.468	194	0.606	129	0.534	181	0.499	238	0.545	292
S_4																	0.013	353		
S_6																				
T_2	0.104	114	0.108	100	0.062	101	0.053	156	0.073	113	0.055	175	0.056	110	0.048	147	0.043	209	0.062	246
λ_2	0.166	112	0.128	104	0.121	95	0.102	163	0.090	131	0.048	142	0.085	118	0.074	149			0.067	257
μ_2	0.411	184	0.353	180	0.310	189	0.295	228	0.273	208	0.255	254	0.252	201	0.264	220	0.203	266	0.238	344
ν_2	0.311	17	0.251	8	0.240	31	0.206	63	0.172	39	0.142	82	0.146	22	0.143	65	0.102	128	0.124	173
ρ_1																				
Series	1906		1906		1900–1906		1906		1906		1903		1906		1906				1906	
Length	1 year.		1 year.		2 years.		1 year.		1 year.		1 year.		1 year.		1 year.		4 years.		1 year.	
Reference	(56)		(56)		(56)		(56)		(56)		(56)		(56)		(56)		(14)		(56)	

[1] For compound and long-period components see p. 412.

EUROPE, WEST COAST—Continued.

Component.	Holland—Continued.				Germany.										Denmark, Copenhagen (55° 42′ N., 12° 35′ E.).		Finland Hango (59° 49′ N., 22° 58′ E.).		Sweden, Ratan, Gulf of Bothnia (64° 00′ N., 20° 55′ E.).	
	Harlingen[1] (53° 11′ N., 5° 25′ E.).		Delfzijl[1] (53° 20′ N., 6° 56′ E.).		Wilhelmshaven[1] (53° 31′ N., 8° 09′ E.).		Bremerhaven[1] (53° 34′ N., 8° 34′ E.).		Rothen Sande Light House[1] (53° 51′ N., 8° 05′ E.).		Helgoland Is.[1] (54° 11′ N., 7° 53′ E.).		Hamburg (53° 33′ N., 9° 59′ E.).							
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.011	190	0.017	301	0.016	276	0.019	195					(0.019)	(240)						
K_1	0.160	31	0.223	37	0.230	42	0.220	56	0.216	26	0.195	32	0.334	160	0.376	23	0.223	6	0.453	7
K_2	0.151	325	0.289	26	0.361	68	0.377	88	0.335	38	0.228	34	(0.171)	(222)	0.016	245	0.177	193	0.046	112
L_2	0.180	254	0.370	330	0.525	4	0.430	19	0.375	354	0.293	346	(0.078)	(148)	0.022	48	0.026	316		
M_1	0.031	169	0.022	111									(0.021)	(79)			0.052	111		
M_2	1.830	262	3.997	321	5.036	358	4.774	14	4.000	338	3.182	335	2.787	145	0.196	277	0.430	217	0.082	13
M_3	0.007	54	0.012	185													0.007	62		
M_4	0.119	50	0.456	123	0.328	182	0.315	233	0.199	191	0.218	189	(0.492)	(212)			0.023	128		
M_6	0.086	171	0.194	315	0.230	24	0.157	105	0.120	15	0.063	334	(0.089)	(154)						
M_8	0.101	316	0.029	146																
N_2	0.314	254	0.643	298	0.837	334	0.735	348	0.675	308	0.513	304	0.430	143	0.056	248	0.066	191		
2N							0.125	87					(0.057)	(140)						
O_1	0.220	227	0.307	239	0.312	250	0.276	258	0.271	233	0.264	246	0.242	359	0.069	9	0.410	39	0.364	320
OO							0.141	82					(0.011)	(321)						
P_1	0.072	19	0.084	28	0.082	53	0.098	66	0.083	27	0.088	33	(0.110)	(160)			0.144	122	0.154	346
Q_1	0.089	171	0.113	181	0.213	246	0.112	221	0.008	19	0.075	185	(0.047)	(279)						
2Q													(0.006)	(199)						
R_2	0.018	178	0.016	351			0.033	212			0.331	308	(0.005)	(222)			0.062	286		
S_1	0.038	331	0.053	51			0.030	237									0.141	229	0.039	103
S_2	0.471	328	0.976	29	1.312	72	1.184	88	1.090	53	0.832	40	0.626	222	0.089	249	0.154	244	0.052	2
S_4					0.033	26	0.030	85	0.017	97										
S_6							0.007	112												
T_2	0.042	293	0.013	355	0.082	56	0.016	80			0.019	48	(0.037)	(222)			0.056	33		
λ_2	0.066	246	0.171	333	0.098	30	0.239	27					(0.019)	(181)						
μ_2	0.206	358	0.413	50	0.558	78	0.705	94	0.411	66	0.351	56	0.467	226						
ν_2	0.129	204	0.273	280	0.262	332	0.312	0	0.256	296	0.212	307	0.140	205						
ρ_1													(0.010)	(290)						
Series	1906		1900–1906		1918–19		1918		1888–89		1882–1895		1901		1882		1903		1904–05	
Length	1 year.		2 years.		800 days.		400 days.		1 year.		4 years.		29 days.		....		1 year.		2 years.	
Reference	(56)		(56)		(57)		(57)		(35)		(57)		(1)		(2)		(58)		(58)	

[1] For compound and long-period components see p. 412.

EUROPE, WEST COAST AND BRITISH ISLES.[2]

Component.	Sweden.				Norway.[2]										England.					
	Draghallan, Gulf of Bothnia, (62° 20′ N., 17° 23′ E.).		Bjorn, Gulf of Bothnia, (60° 38′ N., 17° 58′ E.).		Kristiania,[1] (59° 55′ N., 10° 44′ E.).		Oscarsborg,[1] (59° 41′ N., 10° 37′ E.).		Arendal,[1] (58° 27′ N., 8° 46′ E.).		Stavanger,[1] (58° 59′ N., 5° 44′ E.).		Bergen,[1] (60° 24′ N., 5° 18′ E.).		West Hartlepool,[1] (54° 41′ N., 1° 12′ W.).		Hull, Humber Riv., (53° 44′ N., 0° 20′ W.).		Sheerness,[1] Thames Riv. ent., (51° 27′ N., 0° 45′ E.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1															0.028	223				
K_1	0.180	123	0.197	139	0.010	218					0.049	180	0.107	170	0.380	246	0.560	282	0.377	14
K_2	0.013	4	0.075	99	0.039	98	0.026	92	0.023	71	0.062	320	0.131	336	0.488	133	(0.636)	(228)	0.470	47
L_2					0.036	209	0.049	238	0.043	198	0.033	232	0.410	334	0.200	111	0.390	198	0.347	6
M_1															0.026	102	(0.036)	(200)		
M_2	0.233	38	0.226	74	0.367	128	0.466	130	0.276	100	0.476	282	1.440	298	5.163	96	7.561	176	6.297	1
M_3															0.036	114				
M_4					0.062	6	0.072	3			0.033	252			0.095	104	0.345	253	0.296	44
M_6					0.023	75	0.026	75			0.049	93			0.074	43	0.164	211	0.199	60
M_8																				
N_2					0.105	92	0.120	89	0.085	64	0.105	264	0.277	270	0.988	71	1.254	164	1.046	337
$2N$																				
O_1	0.108	169	0.180	53	0.069	284	0.072	298	0.056	281	0.052	15	0.098	18	0.434	84	0.433	119	0.451	193
OO																				
P_1	0.105	158	0.194	231	0.020	112							0.036	152	0.112	231	(0.185)	(282)	0.135	350
Q_1					0.026	220							0.022	318	0.148	31	(0.084)	(38)	(0.087)	(283)
$2Q$																				
R_2					0.033	254	0.030	250					0.213	144	0.008	156				
S_1	0.112	76	0.082	329	0.039	90	0.039	94					0.180	88	0.033	152				
S_2	0.112	118	0.141	145	0.118	88	0.164	90	0.092	68	0.217	332	0.517	334	1.738	137	2.338	228	1.750	56
S_4															0.022	174				
S_6																				
T_2					0.010	296							0.279	271	0.140	198	(0.138)	(228)		
λ_2															0.095	114	(0.053)	(200)		
μ_2					0.075	308	0.095	307	0.062	273	0.049	282	0.541	293	0.035	4	0.338	273		
ν_2					0.020	88	0.039	68	0.036	125	0.036	241	0.056	289	0.270	86	0.408	61	(0.203)	(340)
ρ_1																				
Series	1904–5		1904–5		1888–1893		1877–1884		1888–89		1899–1901		1884–1894		1858–1861		1864		1813–1844	
Length	2 years.		2 years.		2 years.		2 years.		1 year.		2 years.		2 years.		3 years.		29 days.		369 days.	
Reference	(58)		(58)		(5)		(5)		(5)		(5)		(5)		(3)		(1)		(1)	

[1] For compound and long-period components see p. 412.

[2] See also p. 321.

EUROPE, BRITISH ISLES.[1]

Component.	England—Continued.														Scotland.				Ireland, Dublin (North Wall) (53° 21′ N., 6° 15′ W.).	
	London Bridge[2] (51° 30′ N., 0° 07′ W.).		Ramsgate[2] (51° 20′ N., 1° 25′ E.).		Dover[2] (51° 07′ N., 1° 19′ E.).		Portland Breakwater[2] (50° 34′ N., 2° 25′ W.).		Newlyn[2] (50° 06′ N., 5° 33 W.).		Helbre Island[2] (53° 22′ N., 3° 18′ W.).		Liverpool[2] (53° 24′ N., 3° 0′ W.).		Greenock,[2] Firth of Clyde (55° 57′ N., 4° 45′ W.).		Edinburgh,[2] (Leith) (55° 59′ N., 3° 10′ W.).			
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.	Feet.	Deg.
J_1											0.026	119					(0.049)	(271)		
K_1	0.406	44	0.223	19	0.139	39	0.294	112	0.200	102	0.391	185	0.355	191	0.193	224	0.316	204	0.283	164
K_2	0.649	102	0.520	27	0.664	20	0.300	233	0.503	167	0.890	351	0.936	1	0.284	27	(0.545)	(88)	0.330	356
L_2	0.635	45	0.447	19	0.493	328	0.170	107	0.386	135	0.428	325	0.529	329	0.259	316	(0.167)	(70)		
M_1	0.041	28					0.014	290			0.033	7	0.031	300			(0.034)	(137)		
M_2	7.574	40	6.144	344	7.361	330	2.048	189	5.621	124	9.758	313	9.975	321	4.357	337	5.938	48	4.38	314
M_3	0.065	20	0.043	60	0.032	9	0.036	173			0.104	283	0.109	315						
M_4	0.581	28	0.548	248	0.794	219	0.468	23			0.479	200	0.691	211	0.346	44	0.231	178		
M_6	0.272	171	0.164	135	0.183	93	0.206	55			0.070	15	0.196	331			0.243	284		
M_8	0.094	162	0.054	65	0.076	358	0.012	30			0.010	326	0.068	255						
N_2	1.215	22	1.084	315	1.401	310	0.477	180	1.091	100	1.857	289	1.903	300	0.707	309	(1.152)	(27)		
2N	0.318	296			0.187	276			0.130	102							(0.153)	(6)		
O_1	0.449	213	0.342	181	0.231	175	0.163	351	0.180	334	0.370	38	0.371	38	0.241	54	0.623	70	0.365	4
OO																	(0.027)	(338)		
P_1	0.136	12	0.073	354	0.056	36	0.108	106	0.071	103	0.146	171	0.128	182	0.063	137	(0.104)	(204)	0.094	164
Q_1									0.060	281	0.112	342			0.040	327	(0.121)	(4)		
2Q																	(0.016)	(297)		
R_2									0.020	169	0.050	352	0.092	40			(0.016)	(88)		
S_1	0.019	334	0.037	314	0.020	285	0.036	87	0.010	330			0.050	71						
S_2	2.022	108	1.877	36	2.326	21	1.074	239	1.868	167	3.128	356	3.161	6	1.036	42	2.004	88	1.21	356
S_4	0.098	169	0.032	9	0.058	353	0.012	176			0.030	298	0.057	302						
S_6			0.027	35																
T_2	0.121	107							0.110	165	0.254	321	0.235	327			(0.118)	(88)		
λ_2			0.174	354			0.082	112	0.047	71	0.194	327	0.228	330			(0.042)	(67)		
μ_2	0.929	130	0.251	90	0.300	44	0.374	191	0.182	155	0.083	27	0.255	33	0.105	272	(0.143)	(9)		
ν_2			0.344	333	0.396	302	0.115	135	0.189	98	0.438	271	0.529	286	0.137	312	(0.224)	(30)		
ρ_1																	(0.024)	(13)		
Series	1911–12		1864				1851–1870		1918		1858–1867		1857–1869		1897–98		1891		1887	
Length	2 years.		1 year.		3 years.		4 years.		6 months.		10 years.		7 years.		369 days.		15 days.		30 days.	
Reference	(59)		(3)		(66)		(3)		(60)		(3)		(3)		(1)		(1)		(61)	

[1] See also p. 402.

[2] For compound and long-period components see pp. 412–413.

EUROPE, ANTARCTIC REGIONS, AND LAKE SUPERIOR.

Component.	Ireland—Continued.				Antarctic region.												Lake Superior.			
	Kingstown,[1] (53° 18′ N., 6° 08′ W.).		Queenstown,[1] (51° 51′ N., 8° 16′ W.).		Scotia Bay, Laurie Is. South Orkney Is. (60° 44′ S., 44° 39′ W.).		Port Foster, Deception Is. (62° 58′ S., 60° 34′ W.).		Port Charcot, Wandell Is. (65° 04′ S., 64° 02′ W.).		Port Circoncision,[1] Petermann Is. (65° 10′ S., 64° 14′ W.).		Ross Island (78° 49′ S., 116° 20′ E.).		Gauss Station (66° 02′ S., 89° 38′ E.).		Marquette, Mich. (46° 32′ N., 87° 23′ W.).		Duluth, Minn. (46° 47′ N., 92° 05′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.007	78																		
K_1	0.149	190			0.482	15	0.797	1	1.024	16	1.027	21	0.770	14	0.637	7	0.007	264	0.032	92
K_2	0.389	353	0.350	181	0.249	198	0.157	222	0.167	257	0.151	261	0.026	272	0.115	88	0.003	336	0.009	78
L_2	0.249	321	0.120	137											0.015	96				
M_1	0.016	210									0.022	67					0.002	209	0.005	169
M_2	4.471	313	4.215	135	1.522	172	1.604	173	0.738	164	0.666	161	0.164	10	0.755	19	0.013	299	0.064	72
M_3	0.061	302																		
M_4	0.264	314	0.110	180											0.012	138	0.004	180		
M_6	0.054	335													0.008	179	0.001	10	0.003	164
M_8	0.018	286																		
N_2	0.826	291	0.857	118	0.298	154			0.033	61	0.115	25			0.195	337			0.010	78
$2N$	0.112	271																		
O_1	0.180	49			0.558	359	0.856	6	1.007	6	0.955	16	0.772	0	0.683	0	0.004	233	0.023	91
OO	0.004	335																		
P_1	0.045	131			0.161	15	0.266	1	0.338	16	0.325	21	0.257	14	0.209	348	0.002	264	0.016	72
Q_1	0.031	225							0.197	349	0 230	4			0.190	353			0.005	78
$2Q$	0.003	241																		
R_2	0.019	2																		
S_1	0.042	28															0.009	12	0.012	89
S_2	1.324	357	1.280	175	0.912	198	0.653	222	0.611	257	0.551	266	0.095	272	0.393	101	0.009	349	0.033	88
S_4	0.016	221																		
S_6	0.010	218																		
T_2	0.070	344																		
λ_2	0.052	331																		
μ_2	0.097	26	0.191	126											0.024	303				
ν_2	0.196	283	0.183	80											0.008	357				
ρ_1	0.018	335																		
Series					1903		1909		1904		1909		1902–1903		1902		1904–5		1901–2	
Length					4 months.		16 days.		47 days.		230 days.		1 year.		162¼ days.		369 days.		2 years.	
Reference	(62)		(62)		(63)		(64)		(64)		(64)		(63)		(1)		(1)		(1)	

[1] For compound and long-period components see p. 413.

TIDAL HARMONIC CONSTANTS.—SUPPLEMENTAL LIST.

[Received too late for insertion in regular order.]

Component.	South America, Georgetown,[1] Br. Guiana (6° 49′ N., 58° 10′ W.).		Asia. Penang,[1] Straits Settlements (5° 24′ N., 100° 21′ E.).		Asia. Shatt-al-Arab[1] Bar (29° 48′ N., 48° 43′ E.).		Gibraltar (36° 07′ N., 5° 22′ W.).		Portugal, Lisbon,[1] Cacais (38° 42′ N., 9° 23′ W.).		Russia, Kem,[1] White Sea (64° 59′ N., 34° 50′ E.).		England. Immingham, Humber River (53° 58′ N., 0° 11′ W.).		England. Avonmouth,[1] Severn River (51° 30′ N., 2° 43′ W.).		Scotland. Oban[1] (56° 25′ N., 5° 28′ W.).		Scotland. Stromness,[1] Orkney Islands (58° 57′ N., 3° 18′ W.).	
	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ	H	κ
	Feet.	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*	*Feet.*	*Deg.*
J_1	0.016	184	0.055	40	0.067	282											0.009	357	0.018	169
K_1	0.374	197	0.572	345	1.632	295	0.984	127	0.200	50	0.220	98	0.479	280	0.201	145	0.225	182	0.374	156
K_2	0.285	142	0.312	32	0.326	350	1.116	78	0.320	80	0.130	175	0.657	204	1.400	258	0.456	198	0.333	299
L_2	0.088	132	0.055	353	0.161	317			0.105	80	0.200	174			1.164	162	0.085	164	0.044	314
M_1	0.023	97											0.038	324	0.043	231				
M_2	2.884	128	1.972	4	2.760	311	12.576	47	3.335	50	1.930	128	7.018	157	14.044	203	3.508	165	2.954	271
M_3	0.185	287			0.042	214							0.035	146	0.179	215	0.145	294	0.049	193
M_4	0.099	79	0.063	280	0.089	211	0.804	159	0.060	155	0.160	190	0.066	142	0.622	3	0.199	153	0.127	269
M_6	0.046	62	0.011	152							0.070	95	0.050	22	0.392	275	0.059	0	0.202	34
M_8	0.004	28											0.042	138	0.080	31	0.015	218		
N_2	0.571	110	0.434	0	0.545	279	2.424	34	0.750	32	0.390	87	1.321	138	2.677	188	0.667	146	0.604	247
$2N$	0.096	42	0.034	353	0.054	324			0.060	348					0.063	345	0.038	237	0.118	277
O_1	0.301	183	0.139	279	0.979	250	0.372	159	0.190	306			0.590	114	0.288	1	0.225	35	0.336	6
OO																				
P_1	0.089	201	0.173	336	0.447	288	0.283	118	0.060	40			0.135	262	0.106	132	0.058	178	0.115	141
Q_1	0.058	158	0.048	256	0.153	238			0.038	250							0.068	326	0.104	321
$2Q$																				
R_2																				
S_1	0.089	144	0.071	47	0.089	44	0.096	359	0.020	111			0.035	241	0.037	82	0.018	60	0.028	45
S_2	0.935	152	1.139	40	0.937	9	4.620	76	1.150	80	0.470	172	2.349	206	5.024	262	1.504	201	1.157	304
S_4	0.016	147											0.030	297	0.216	99	0.028	92	0.015	137
S_6																				
T_2															0.303	259	0.082	280		
λ_2																				
μ_2	0.027	212	0.151	6	0.084	45			0.080	21	0.140	308	0.208	205	1.698	257	0.186	136	0.174	205
ν_2	0.221	118	0.134	352	0.074	329			0.150	35	0.120	104			0.922	177	0.050	38	0.173	221
ρ_1																				
Series	1915		1906–7		1918–9												1911		1911	
Length	1 year.		1 year.		1 year.				2 years.						1 year.		1 year.			
Reference	(66)		(66)		(66)		(66)		(66)		(66)		(66)		(66)		(66)		(66)	

[1] For compound and long-period components see pp. 403 to 413.

Compound and long-period components.

[Upper line for each station gives the amplitudes (H) in feet: lower line gives the epochs (κ) in degrees. For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Arctic regions.										
Fort Conger, Grant Land	....	....	....	....	....	....	....	....	0.199 203	0.143 335
Ekaterinskaya, Russia	....	....	....	....	....	....	....	....	0.180 201	....
Kem, Russia	....	....	....	0.080 196	....	....	....	....	0.180 143	0.220 120
Vardo, Norway	....	....	....	0.094 173	0.074 0	0.092 227	0.048 162	0.061 193	0.482 249	0.200 188
Fineide, Norway	....	....	....	0.061 62	0.034 64	0.010 206	0.089 260	0.079 8	0.348 213	0.226 202
Kabelvaag, Norway	....	....	....	0.154 28	0.077 144	0.125 78	0.049 277	0.094 171	0.374 264	0.187 218
Bodo, Norway	....	....	....	0.139 346	0.062 168	0.121 189	0.131 289	....	0.359 245	0.147 189
British America, East Coast.										
Forteau Bay, Belle Isle Strait	0.034 230	0.044 185	0.033 11	0.022 290	0.013 48	0.088 301	0.053 134	0.070 231	0.217 231	0.092 203
St. Johns, Newfoundland	....	....	....	....	....	....	....	....	0.200 268	0.071 217
South West Point, Anticosti Island.	0.007 130	0.010 60	0.015 223	0.069 22	0.037 118	0.045 208	0.021 120	0.038 84	0.108 128	0.067 194
Father Point, St. Lawrence River.	0.036 154	0.031 105	0.020 9	0.065 77	0.061 124	0.037 195	0.056 348	0.064 196	0.159 151	0.189 156
Quebec, St. Lawrence River	0.171 354	0.168 317	0.316 249	0.400 323	0.078 69	0.164 73	0.529 54	0.270 33	0.502 74	0.424 116
Charlottetown, Prince Edward Island.	0.030 202	0.054 136	0.021 338	0.050 211	0.032 155	0.041 234	0.042 172	0.047 297	0.165 232	0.102 168
St. Paul Island, Cabot Strait	0.015 82	0.011 353	0.011 124	0.016 334	0.010 290	0.041 177	0.037 206	0.056 299	0.142 228	0.083 154
Halifax, Nova Scotia	0.031 86	0.010 30	0.056 318	0.058 152	0.010 279	0.045 140	0.036 211	0.046 206	0.129 249	0.079 184
St. John, New Brunswick	0.069 135	0.034 116	0.054 112	0.187 242	0.096 194	0.049 161	0.083 114	0.045 129	0.130 125	0.150 120
United States, East Coast.										
Eastport, Me	....	....	....	....	....	....	....	....	0.105 338	0.044 309
Pulpit Harbor, Me	....	....	....	0.017 21	0.028 52	....	....	....	0.163 173	0.086 87
Portland, Me	....	....	....	....	....	....	....	....	0.142 143	0.060 130
Boston (Commonwealth Pier), Mass.	....	....	....	0.022 108	....	....	....	....	0.150 143	0.049 87
Newport (Fort Adams), R. I.	....	....	....	....	....	....	....	....	0.144 153	0.067 145
Bristol, R. I.	....	....	....	....	....	....	....	....	0.194 151	0.059 87
Providence, R. I.	....	....	....	....	....	....	....	....	0.244 107	0.044 18
New London (Fort Trumbull), Conn.	....	....	....	....	....	....	....	....	0.242 153	0.124 100
New London (naval station), Conn.	....	....	....	....	....	....	....	....	0.238 152	0.100 43

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
United States, East Coast—Con.										
Willets Point (U. S. E. Wharf), N. Y.									0.153 110	0.113 111
Fort Hamilton, N. Y.				0.046 293					0.297 121	0.091 50
New York (Governors Island), N. Y.									0.245 127	0.173 47
New York (The Battery), N. Y.									0.169 109	0.136 92
Albany, Hudson River, N. Y.				0.040 284					1.955 25	0.750 48
Sandy Hook, N. J.									0.254 143	0.101 58
Atlantic City (Million Dollar Pier), N. J.				0.002 052					0.160 153	0.036 251
Philadelphia (Chestnut St.), Pa.									0.417 146	0.342 325
Breakwater Harbor, Del.				0.024 248					0.286 151	0.140 53
Old Point Comfort, Va.									0.320 126	0.106 161
Richmond, James River, Va.									0.482 49	0.273 35
Washington (navy yard), D. C.				0.024 207					0.166 121	0.047 195
Washington (7th St. Wharf), D. C.									0.272 128	0.194 163
Baltimore (Fells Point), Md.									0.260 123	0.060 35
Baltimore (Fort McHenry), Md.									0.501 129	0.080 56
Wilmington, Cape Fear River, N. C.				0.052 166					0.411 147	0.186 320
Charleston (custom house wharf), S. C.									0.244 141	0.308 70
Tybee Light, Savannah River, Ga.									0.217 124	0.103 25
Savannah (Fort Jackson), Ga.				0.095 34					0.108 232	0.064 329
Savannah (water works), Ga.				0.093 58					0.089 288	0.010 95
Fernandina (Fort Clinch), Fla.									0.237 105	0.168 37
Fernandina (Desoto Street), Fla.									0.406 186	0.308 207
Key West (Fort Taylor), Fla.									0.377 216	0.075 86
Key West (Curry's Wharf), Fla.				0.016 311					0.273 166	0.085 98
Pensacola (Warrington Navy Yard), Fla.									0.244 92	0.212 359
Cat Island, Miss.						0.069 134	0.095 336	0.094 304	0.274 145	0.128 35

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
United States, East Coast—Con.										
Port Eads, La.	......	......	......	......	......	......	......	......	0.361 173	0.180 87
Galveston (Fort Point), Tex.	......	......	......	......	......	......	......	......	0.393 112	0.392 354
Galveston (Doswell's Wharf), Tex.	......	......	......	......	......	......	......	......	0.528 170	0.332 44
Galveston (20th St.), Tex.	......	......	......	0.004 288	......	......	......	......	0.446 135	0.212 74
West Indies.										
Nassau, Bahamas	......	......	......	......	......	......	......	......	0.312 144	0.101 33
St. Thomas Harbor, Virgin Islands.	......	......	......	......	......	......	......	......	0.022 288	0.055 152
South America.										
Georgetown, British Guiana	0.033 290	0.013 348	0.041 9	0.155 120	0.064 2	0.049 359	0.088 46	0.067 44	0.293 243	0.142 129
Itaqui, Maranhao, Brazil	......	......	......	0.341 205	......	......	......	......	......	......
Pernambuco (Recife Arsenal), Brazil.	......	......	......	0.072 96	0.062 11	......	......	......	0.026 75	0.026 100
Rio del Janeiro (arsenal), Brazil.	......	......	......	0.078 174	0.016 356	0.078 324	0.114 130	0.040 354	0.089 23	0.059 172
Rio Grande do Sul, Brazil	......	......	......	0.079 237	......	......	......	......	......	......
Buenos Aires, Argentina	......	......	......	......	......	......	......	......	0.389 321	0.166 336
Mar del Plata, Argentina	......	......	......	0.032 17	0.023 314	.061 329	0.065 75	0.145 179	0.380 16	0.175 180
Puerto Quequen, Argentina	......	......	......	0.135 95	0.026 341	0.059 158	0.171 26	0.102 114	0.177 313	0.112 172
Puerto Belgrano, Bahia Blanca, Argentina.	......	......	......	0.127 272	0.060 281	0.133 209	0.128 266	0.081 238	0.318 211	0.112 173
San Antonio, Argentina	......	......	......	0.036 285	0.157 229	0.042 141	0.098 334	0.102 107	0.351 331	0.115 244
Comodoro Rivadavia, Argentina.	......	......	......	0.061 163	0.177 356	0.067 198	0.049 351	0.117 155	0.181 353	0.086 181
Puerto Deseado, Argentina	......	......	0.036 30	0.352 357	0.062 167	0.102 177	0.200 328	......	0.124 355	0.023 15
Cape Horn, Orange Bay, Chile.	......	......	......	......	......	......	......	......	0.156 92	0.013 37
Valparaiso, Chile	......	......	......	......	......	......	......	......	0.151 351	0.091 228
Panama Canal Zone, West Coast.										
Naos Island, Canal Zone	......	......	......	......	......	......	......	......	0.685 170	0.478 114
Balboa, Canal Zone	......	......	......	0.122 53	......	......	......	......	0.493 167	0.209 145

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Mexico, West Coast.										
Mazatlan, Mexico									0.126 153	0.133 248
United States, West Coast.										
San Diego, Calif.				0.014 190					0.233 183	0.101 269
San Francisco (Fort Point), Calif.									0.398 156	0.184 221
San Francisco (Presidio), Calif.				0.024 24					0.110 94	0.154 304
Sausalito, Calif.									0.150 244	0.043 233
Humboldt Bay (South Jetty Landing), Calif.				0.016 179					0.312 249	0.085 109
Astoria, Oreg.				0.054 340					0.244 284	0.267 151
Port Townsend, Wash.				0.067 313					0.270 288	0.131 225
Seattle (Madison St.), Wash.				0.033 110					0.287 298	0.089 224
British America, West Coast.										
Victoria, Vancouver Island	0.077 9	0.075 344	0.026 252	0.054 3	0.029 66	0.046 142	0.052 255	0.079 138	0.324 284	0.117 240
Sand Heads, Fraser River, British Columbia.	0.033 171	0.015 224	0.013 109	0.047 184	0.035 14	0.077 149	0.059 286	0.077 103	0.207 253	0.181 217
Vancouver, Burrand Inlet, British Columbia.	0.081 273	0.124 273	0.027 186	0.076 182	0.048 356	0.101 130	0.067 335	0.078 316	0.246 274	0.176 217
Clayoquot, Vancouver Island, British Columbia.	0.023 38	0.023 9	0.019 282	0.087 347	0.051 189	0.088 165	0.86 257	0.091 114	0.468 280	0.150 204
Wadhams, Rivers Inlet, British Columbia.	0.008 285	0.018 350	0.013 262	0.120 320	0.079 131	0.088 187	0.070 184	0.076 141	0.411 280	0.096 191
Prince Rupert, Chatham Sound, British Columbia.	0.031 338	0.026 4	0.015 174	0.164 290	0.092 145	0.085 174	0.060 234	0.093 168	0.372 268	0.156 102
Port Simpson, Chatham Sound, British Columbia.	0.040 359	0.026 357	0.015 160	0.097 259	0.060 44	0.092 180	0.069 78	0.087 183	0.420 270	0.200 129
Alaska.										
Craig				0.005 261					0.380 252	0.187 90
Ketchikan				0.033 159					0.486 227	0.188 133
Sitka									0.261 284	0.055 336
Juneau, Gastineau Channel, Stephens Passage.				0.072 205					0.252 247	0.104 199
Skagway, Lynn Canal				0.074 251					0.358 181	0.233 312
Anchorage				0.478 244						

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Alaska.										
Kodiak	......	......	......	......	......	......	......	......	0.335	0.176
	......	......	......	......	......	......	......	......	196	112
Japan, Hokushu Island.										
Hanasaki	......	......	......	0.026	0.017	0.063	0.039	0.047	0.135	0.094
	......	......	......	131	72	172	69	74	233	224
Otaru	......	......	......	0.005	0.005	0.109	0.034	0.049	0.281	0.220
	......	......	......	105	3	200	116	356	165	176
Japan, Honshu Island.										
Ayukawa	......	......	......	0.030	0.023	0.032	0.023	0.027	0.379	0.095
	......	......	......	121	56	151	197	186	176	214
Yokohama, Tokyo Bay	......	......	......	0.101	0.032	0.050	0.019	0.060	0.344	0.074
	......	......	......	133	9	161	91	286	168	185
Aburatsubo, Kawatsu Bay	......	......	......	0.041	0.024	0.041	0.045	0.133	0.303	0.068
	......	......	......	144	19	93	99	180	175	208
Kushimoto, Kii Channel	......	......	......	0.046	0.027	0.040	0.037	0.051	0.479	0.125
	......	......	......	158	345	202	52	183	166	342
Kobe, Inland Sea	......	......	......	0.037	0.043	0.064	0.028	0.040	0.558	0.109
	......	......	......	143	179	149	124	349	149	306
Mitsugi, Inland Sea	......	......	......	0.103	0.128	0.043	0.066	0.034	0.478	0.123
	......	......	......	293	193	156	32	186	158	340
Kure, Inland Sea	......	......	......	0.064	0.106	0.030	0.059	0.104	0.558	0.104
	......	......	......	264	191	14	47	79	152	343
Tonoura	......	......	......	0.014	0.006	0.046	0.038	0.038	0.606	0.071
	......	......	......	284	144	159	179	5	153	202
Wajima	......	......	......	0.012	0.004	0.079	0.038	0.049	0.546	0.126
	......	......	......	71	72	190	188	341	165	217
Iwasaki	......	......	......	0.009	0.003	0.091	0.038	0.055	0.420	0.118
	......	......	......	109	63	209	82	63	168	207
Japan, Shikoku Island.										
Mitsugahama, Inland Sea	......	......	......	0.100	0.067	0.046	0.026	0.053	0.482	0.080
	......	......	......	250	210	134	230	206	155	7
Hashihama, Inland Sea	......	......	......	0.114	0.127	0.052	0.020	0.037	0.568	0.107
	......	......	......	288	189	153	252	212	152	314
Awashima, Inland Sea	......	......	......	0.150	0.140	0.047	0.044	0.054	0.602	0.116
	......	......	......	296	193	87	133	356	148	325
Japan, Kiushu Island.										
Hosojima	......	......	......	0.027	0.033	0.031	0.043	0.064	0.448	0.156
	......	......	......	159	321	159	77	281	148	42
Fukabori	......	......	......	0.056	0.048	0.044	0.042	0.032	0.556	0.090
	......	......	......	196	259	190	28	95	149	349
Japan, Taiwan Island (Formosa).										
Kiirun	......	......	......	0.046	0.021	0.044	0.026	0.038	0.414	0.105
	......	......	......	305	258	53	12	26	135	302
Takaw	......	......	......	0.019	0.009	0.024	0.026	0.040	0.393	0.074
	......	......	......	227	254	348	60	348	147	352
Chosen (Korea).										
Chemulpho	......	......	......	0.226	......	......	......	......	......	......
	......	......	......	146	......	......	......	......	......	......

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
China.										
Tientsin Entrance (Taku North Fort).				0.197 180					0.670 117	0.267 277
Wei-ha-wei				0.110 271	0.029 226				0.420 149	
Shanghai				0.465 18					1.518 128	0.478 73
Swatow				0.103 200	0.025 91	0.069 120	.074 0	0.050 298	0.467 270	0.258 96
Hongkong				0.067 301	0.026 235	0.038 310	0.112 40	0.073 101	0.450 234	0.190 94
Macao (inner harbor), South China.				0.075 106		0.112 360	0.052 69	0.082 99	0.305 194	0.151 54
Whampoa				0.144 359			0.270 59		0.484 171	0.135 92
Siam										
Koh Hlak				0.017 147	0.006 96	0.048 34	0.057 252	0.101 42	0.727 284	0.183 100
Malay Peninsula.										
Kuantan Harbor								0.040 8	0.584 284	0.129 226
Singapore									0.308 209	0.312 234
Philippine Islands.										
Manila, Luzon Island									0.386 152	0.065 42
Olongapo, Subic Bay, Luzon Island.									0.480 162	0.136 31
Cebu, Cebu Island									0.436 159	0.043 60
Java.										
Batavia (Tandjong Priok)					0.014 88					
Hawiian Islands.										
Honolulu				0.003 159					0.225 176	0.113 346
Australia.										
Port Darwin, Northern Territory.				0.16 30	0.17 13	0.13 333	0.47 29	0.04 284	0.97 76	0.54 58
Cooktown, Queensland									0.346 320	0.051 36
Cairn's Harbor, Queensland									0.202 9	0.050 157
Brisbane Bar, Queensland									0.109 8	0.005 156
Brisbane, Queensland	0.021 7	0.033 233	0.024 133	0.068 256	0.022 190	0.042 256	0.008 158	0.061 187	0.331 12	0.028 327
Ballina, New South Wales				0.043 199	0.037 213	0.097 314	0.230 45	0.102 2	0.413 7	0.063 257
Newcastle, New South Wales				0.062 252	0.026 236	0.051 105	0.030 330	0.082 198	0.232 70	0.074 201
Sydney (Fort Denison), New South Wales.				0.013 102					0.121 91	0.172 169

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Australia—Continued.										
Port Adelaide (Semaphore), South Australia.	......	......	......	0.09	0.10	0.06	0.12	0.07	0.30	0.22
	......	......	......	99	67	181	255	200	126	88
Princess Royal Harbor, Western Australia.	......	......	......	0.015	0.027	0.064	0.024	0.065	0.328	0.235
	......	......	......	268	71	175	240	135	111	97
Fremantle, West Australia	......	......	......	0.008	0.006	0.044	0.083	0.102	0.345	0.118
	......	......	......	332	193	151	340	338	244	170
Port Hedland, West Australia	......	......	......	0.073	0.101	0.022	0.048	0.091	0.372	0.148
	......	......	......	272	333	307	187	87	172	75
New Zealand.										
Auckland, North Island	......	......	......	0.180	0.064	0.044	0.054	0.083	0.223	0.065
	......	......	......	195	304	252	182	185	46	113
Wellington, North Island	......	......	......	0.035	0.031	0.052	0.073	0.087	0.073	0.103
	......	......	......	135	352	169	60	308	278	145
Port Lyttelton, South Island	......	......	......	0.102	0.066	0.063	0.129	0.048	0.097	0.085
	......	......	......	124	26	183	156	137	247	140
Port Chalmers, South Island	......	......	......	0.075	0.060	0.142	0.081	0.100	0.102	0.110
	......	......	......	92	69	228	31	32	352	142
Dunedin, South Island	......	......	......	0.107	0.046	0.077	0.051	0.060	0.126	0.081
	......	......	......	140	7	172	90	148	258	89
Bluff, South Island	......	......	......	0.080	0.046	0.065	0.071	0.051	0.085	0.125
	......	......	......	0	122	216	240	242	55	64
Westport, South Island	......	......	......	0.103	0.072	0.046	0.065	0.030	0.093	0.131
	......	......	......	300	204	331	133	99	96	162
Asia, South Coast.										
Penang, Straits Settlements	......	......	......	0.091	0.086	0.092	0.088	0.056	0.269	0.164
	......	......	......	321	179	353	231	118	165	168
Port Blair, Andaman Islands	0.020	0.006	0.035	0.015	0.026	0.045	0.008	0.023	0.205	0.111
	190	215	126	217	156	14	14	10	146	181
Mergui, India	0.058	0.012	0.140	0.157	0.181	0.040	0.046	0.061	0.589	0.158
	172	184	190	176	130	25	27	18	146	113
Amherst, Moulmein River, India.	0.091	0.050	0.214	0.318	0.164	0.062	0.032	0.061	0.758	0.149
	335	315	210	75	3	3	68	19	136	145
Moulmein, Moulmein River, India.	0.167	0.113	0.219	0.739	0.138	0.310	0.127	0.375	2.353	0.605
	87	58	70	208	37	38	44	12	149	290
Elephant Point, India	0.092	0.064	0.191	0.291	0.136	0.098	0.208	0.095	0.842	0.129
	27	353	66	127	38	20	42	355	140	150
Rangoon, India	0.141	0.118	0.175	0.429	0.175	0.170	0.477	0.193	1.295	0.164
	76	51	101	210	50	34	46	15	147	335
Bassein, India	0.096	0.072	0.080	0.184	0.079	0.124	0.251	0.133	1.941	0.390
	301	258	309	8	302	23	52	35	157	342
Akyab, India	0.027	0.014	0.080	0.014	0.034	0.046	0.039	0.035	0.944	0.194
	135	51	115	274	204	331	57	347	145	160
Chittagong, India	0.100	0.059	0.124	0.346	0.131	0.132	0.428	0.188	1.567	0.153
	314	269	244	23	300	16	40	358	134	195
Dublat (Suger Island), Hooghly River, India.	0.062	0.035	0.120	0.074	0.060	0.058	0.013	0.027	0.876	0.195
	225	129	355	170	202	53	74	75	151	141
Diamond Harbor, Hooghly River, India.	0.117	0.061	0.118	0.706	0.070	0.151	0.450	0.115	1.058	0.097
	281	217	52	287	275	43	35	14	142	129
Calcutta (Kidderpore), India	0.118	0.037	0.187	0.689	0.081	0.258	0.916	0.291	2.712	0.914
	31	313	87	76	10	34	42	7	154	332

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Asia, South Coast—Continued.										
False Point, India	0.026 348	0.010 340	0.050 21	0.040 269	0.020 194	0.074 29	0.007 137	0.041 68	0.829 166	0.279 151
Vizagapatam, India	0.018 358	0.012 329	0.037 37	0.011 356	0.011 239	0.050 19	0.027 24	0.030 47	0.694 184	0.340 119
Cocanada, India	0.018 261	0.010 321	0.043 106	0.022 136	0.016 182	0.036 8	0.029 6	0.034 328	0.720 202	0.392 105
Madras, India	0.013 347	0.004 353	0.019 185	0.005 234	0.017 217	0.041 17	0.005 314	0.014 9	0.376 213	0.297 127
Nagapatam, India	0.014 149	0.007 337	0.028 123	0.019 99	0.006 203	0.063 3	0.051 19	0.047 333	0.444 234	0.344 128
Pamban Pass, India	0.004 279	0.006 310	0.018 206	0.018 292	0.010 333	0.042 356	0.012 169	0.042 26	0.149 302	0.157 108
Tuticorin, India	0.005 128	0.006 285	0.018 70	0.012 258	0.007 312	0.040 358	0.008 290	0.020 41	0.299 310	0.140 84
Trincomalee, Ceylon, India	0.008 261	0.004 62	0.020 200	0.011 242	0.017 233	0.054 14	0.012 282	0.019 18	0.251 263	0.203 134
Galle, Ceylon, India	0.004 43	0.004 52	0.018 212	0.007 255	0.009 347	0.034 12	0.009 235	0.036 24	0.350 309	0.127 116
Colombo, Ceylon, India	0.006 116	0.004 34	0.022 273	0.009 253	0.008 335	0.036 359	0.010 293	0.022 34	0.313 308	0.133 111
Minicoy, India	0.007 143	0.003 214	0.026 270	0.007 49	0.004 315	0.051 7	0.009 20	0.022 61	0.357 354	0.138 244
Cochin, India	0.030 131	0.019 107	0.020 103	0.020 140	0.004 293	0.046 358	0.022 294	0.004 196	0.337 302	0.118 150
Beypore, India	0.014 51	0.010 71	0.033 350	0.010 74	0.005 306	0.050 33	0.034 210	0.063 32	0.308 311	0.166 205
Kawar, India	0.021 29	0.008 81	0.054 188	0.026 67	0.007 27	0.040 1	0.007 246	0.055 26	0.352 310	0.068 228
Marmagao, India	0.026 57	0.007 50	0.046 353	0.024 48	0.006 136	0.045 5	0.019 302	0.016 62	0.269 313	0.116 138
Bombay (Prince's Dock), India	0.068 164	0.067 74	0.054 339	0.124 40	0.042 108	0.045 11	0.009 74	0.035 311	0.106 354	0.145 183
Bombay (Apollo Bandar), India.	0.063 157	0.061 71	0.073 286	0.123 29	0.037 108	0.037 10	0.013 187	0.022 336	0.111 1	0.138 196
Bhavnagar, Cambay Gulf, India	0.227 119	0.138 348	0.287 92	0.661 196	0.075 355	0.046 358	0.139 40	0.097 10	0.246 108	0.153 149
Port Albert Victor, Combay Gulf, India.	0.051 156	0.040 154	0.065 115	0.160 213	0.028 79	0.044 347	0.052 214	0.010 226	0.133 237	0.175 133
Porbandar, India	0.022 139	0.006 321	0.078 153	0.028 204	0.008 148	0.009 186	0.021 302	0.027 149	0.078 290	0.144 145
Okha Point, India	0.062 59	0.032 233	0.067 90	0.051 118	0.034 268	0.034 54	0.109 244	0.068 287	0.142 84	0.164 144
Hansthal Point, Cutch Gulf, India.	....	....	....	0.351 12	0.135 299	0.101 37	0.169 13	0.121 14	0.024 195	0.090 156
Karachi, India	0.045 57	0.021 12	0.051 85	0.032 318	0.019 114	0.022 8	0.004 267	0.016 24	0.142 72	0.154 152
Bushire, Persia	0.082 69	0.074 40	0.032 266	0.027 34	0.012 132	0.024 168	0.061 38	0.056 89	0.283 149	0.122 224
Shatt-al-Arab Bar	0.137 170	0.075 129	0.030 145	0.155 287	0.075 220	0.012 196	0.057 28	0.139 248	0.370 132	0.057 210
Basrah, Shatt-al-Arab River, Turkey.	0.221 42	0.189 9	....	....	....	....	....	....	....	....

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Asia, South Coast—Continued.										
Maskat, Arabia	0.018	0.004	0.066	0.014	0.008	0.036	0.012	0.043	0.138	0.140
	188	345	284	305	205	5	253	19	97	187
Aden, Arabia	0.025	0.007	......	0.015	0.021	0.042	0.002	0.021	0.372	0.126
	0	5	......	159	103	17	248	8	356	131
Perim, Strait of Babel Mandeb, Arabia.	0.023	0.020	0.022	0.014	0.021	0.058	0.015	0.012	0.338	0.169
	262	256	268	91	97	24	198	230	345	108
Africa.										
Suez, Red Sea, Egypt	0.031	0.011	0.034	0.016	0.011	0.048	0.035	0.043	0.497	0.190
	66	62	41	169	231	123	163	65	313	105
Diego Suarez, Madagascar	......	......	......	......	......	......	......	......	0.112	......
	......	......	......	......	......	......	......	......	280	......
Mauritius Island	......	......	......	......	......	0.036	0.015	0.047	0.211	0.118
	......	......	......	......	......	350	91	297	346	118
Cape Town (Table Bay)	......	......	......	......	......	......	......	......	0.124	0.111
	......	......	......	......	......	......	......	......	256	76
Duala, Kamerun	......	......	......	......	......	......	......	......	0.361	0.154
	......	......	......	......	......	......	......	......	206	58
Europe, Mediterranean Sea.										
Venice (Porto Malamocco), Italy.	......	......	......	0.032	0.010	0.015	0.014	0.054	0.072	0.075
	......	......	......	294	231	333	262	82	188	286
Toulon, France	......	......	......	......	......	0.061	0.029	0.057	0.123	0.108
	......	......	......	......	......	159	323	196	254	114
Marseilles, France	......	......	......	......	......	0.019	0.008	0.010	0.151	0.170
	......	......	......	......	......	229	41	293	185	118
Europe, West Coast.										
Lisbon (Cacais), Portugal	......	......	......	......	......	0.032	0.012	0.030	0.185	0.170
	......	......	......	......	......	280	37	20	172	90
St. Jean de Luz (Fort Socoa), France.	......	......	......	0.175	0.108	0.015	0.041	0.056	0.180	0.167
	......	......	......	67	61	166	200	327	217	80
Mouth of the Gironde, France	......	......	......	0.200	0.115	0.039	......	0.125	0.217	0.098
	......	......	......	87	2	200	......	253	203	182
Fort Boyard, France	0.030	0.025	0.464	0.555	0.106	0.028	0.042	0.049	0.240	0.063
	321	228	306	82	49	148	343	203	192	129
Rochelle, France	......	......	......	0.513	0.103	0.033	0.104	0.110	0.401	0.080
	......	......	......	88	36	26	30	239	257	123
St. Nazaire (Mouth of Loire), France.	......	......	......	0.384	0.103	0.061	0.176	0.099	0.423	0.190
	......	......	......	122	16	268	33	37	256	65
Brest, France	......	......	......	0.264	0.130	0.043	0.052	0.085	0.203	0.086
	......	......	......	107	22	173	76	315	229	154
St. Servan (St. Malo), France	......	......	......	0.257	0.472	0.085	0.066	0.064	0.320	0.128
	......	......	......	321	652	230	238	154	222	93
Cherbourg, France	0.009	0.031	......	0.078	0.023	0.010	0.080	0.032	0.169	0.061
	17	233	......	60	271	102	159	100	200	158
Le Havre, France	......	......	0.304	0.407	0.314	0.011	0.058	0.101	0.311	0.148
	......	......	64	170	198	359	2	273	218	151
Ostend, Belgium	......	......	......	0.234	0.147	0.174	......	......	0.161	......
	......	......	......	53	316	106	......	......	222	......
Vlissingen, Holland	......	......	......	0.226	0.129	0.171	0.118	0.156	0.246	0.132
	......	......	......	142	359	51	53	260	251	200
Neuzen, Holland	......	......	......	0.172	0.174	0.161	0.148	0.153	0.237	0.133
	......	......	......	174	359	55	31	272	265	201

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Europe, West Coast—Continued.										
Hansweert, Holland	0.036 13	0.079 235	0.077 85	0.083 200	0.192 12	0.059 70	0.138 46	0.129 237	0.224 242	0.120 215
Wemeldinge, Holland	------ ------	------ ------	------ ------	0.142 239	0.149 10	0.162 48	0.115 43	0.150 269	0.245 245	0.121 196
Zierikzee, Holland	------ ------	------ ------	------ ------	0.122 196	0.141 9	0.162 50	0.109 34	0.181 267	0.256 247	0.127 201
Browvershaven, Holland	------ ------	------ ------	------ ------	0.260 185	0.144 24	0.094 107	0.064 92	0.133 236	0.256 232	0.116 184
Willemstad, Holland	------ ------	------ ------	------ ------	0.255 244	0.072 47	0.186 47	0.148 43	0.181 276	0.277 290	0.202 224
Hellevoetsluis, Holland	------ ------	------ ------	------ ------	0.295 201	0.093 38	0.174 65	0.094 23	0.179 268	0.255 262	0.173 211
Rotterdam, Holland	------ ------	------ ------	------ ------	0.225 261	0.050 73	0.155 46	0.146 40	0.213 278	0.292 314	0.265 232
Hoek van Holland	------ ------	------ ------	------ ------	0.335 183	0.081 28	0.136 47	0.096 40	0.186 262	0.279 254	0.167 211
Ijumuiden, Holland	------ ------	------ ------	------ ------	0.331 211	0.052 43	0.124 53	0.099 40	0.203 257	0.352 254	0.203 223
Helder, Holland	------ ------	------ ------	------ ------	0.203 236	0.059 42	------ ------	0.056 308	------ ------	0.341 213	0.135 205
Vlieland, Holland	------ ------	------ ------	------ ------	0.060 44	0.073 213	0.136 50	0.092 54	0.204 264	0.421 250	0.168 215
Harlingen, Holland	------ ------	------ ------	------ ------	0.096 123	0.018 219	0.189 60	0.171 55	0.236 271	0.388 261	0.196 230
Delfzijl, Holland	------ ------	------ ------	------ ------	0.251 200	0.108 251	0.125 104	0.063 121	0.176 247	0.369 223	0.132 174
Wilhelmshaven, Germany	------ ------	------ ------	0.213 163	0.246 267	0.131 279	------ ------	------ ------	------ ------	------ ------	------ ------
Bremerhaven, Germany	0.036 338	0.026 148	0.052 184	0.233 316	0.171 309	------ ------	------ ------	------ ------	------ ------	------ ------
Rothen Sande Lighthouse, Germany.	------ ------	------ ------	------ ------	0.115 244	0.125 258	------ ------	------ ------	------ ------	------ ------	------ ------
Helgoland Island, Germany	------ ------	------ ------	------ ------	0.124 239	0.518 274	------ ------	------ ------	------ ------	------ ------	------ ------
Kristiania, Norway	------ ------	------ ------	------ ------	0.039 101	0.007 163	0.144 166	0.069 232	0.154 235	0.449 185	0.177 218
Oscarsborg, Norway	------ ------	------ ------	------ ------	0.033 109	------ ------	0.197 228	0.164 160	0.177 182	0.449 179	0.115 223
Arendal, Norway	------ ------	------ ------	------ ------	------ ------	------ ------	0.092 223	0.039 100	0.098 229	0.322 195	0.121 180
Stavanger, Norway	------ ------	------ ------	------ ------	0.030 317	------ ------	0.075 205	0.056 117	0.121 229	0.246 221	0.089 198
Bergen, Norway	------ ------	------ ------	------ ------	0.377 318	------ ------	------ ------	0.738 164	0.135 156	0.302 217	0.102 143
Europe, British Isles.										
West Hartlepool, England	------ ------	------ ------	------ ------	0.044 122	0.026 308	0.046 205	0.137 60	0.127 93	0.265 219	0.097 223
Sheerness (Thames River Entrance), England.	------ ------	------ ------	------ ------	------ ------	------ ------	------ ------	------ ------	------ ------	0.209 196	0.046 155
London Bridge, England	------ ------	------ ------	------ ------	------ ------	0.054 285	------ ------	------ ------	------ ------	0.280 220	------ ------

Compound and long-period components—Continued.

[For other components and references see pp. 319 to 402.]

Stations.	Compound components.					Long-period components.				
	MK	2MK	MN	MS	2SM	Mf	MSf	Mm	Sa	Ssa
Europe, British Isles—Contd.										
Ramsgate, England	......	......	......	0.324	0.141	0.044	0.094	0.029	0.127	0.075
	......	......	......	132	265	288	206	45	181	288
Dover, England	0.095	0.017	0.276	0.593	0.119	0.142	0.087	0.135	0.613	0.272
	336	88	185	277	216	186	279	254	271	227
Portland Breakwater, England	......	......	......	0.267	0.058	......	......	......	......	......
	......	......	......	81	350	......	......	......	......	......
Newlyn, England	......	......	......	......	0.100	......	......	......	......	......
	......	......	......	......	28	......	......	......	......	......
Avonmouth, England	......	......	0.296	0.594	0.476	......	......	......	0.153	......
	......	......	350	26	86	......	......	......	231	......
Helbre Island, England	......	......	......	0.280	0.119	......	......	......	......	......
	......	......	......	254	215	......	......	......	......	......
Liverpool, England	......	......	......	0.406	0.137	0.041	0.056	0.126	0.362	0.142
	......	......	......	258	216	282	21	279	239	189
Greenock (Firth of Clyde), Scotland.	......	......	......	......	......	......	......	......	0.485	0.058
	......	......	......	......	......	......	......	......	240	183
Oban, Scotland	......	......	0.061	0.062	0.063	0.038	0.061	0.128	0.256	0.124
	......	......	88	170	325	8	104	145	263	151
Edinburgh (Leith), Scotland	......	......	......	......	......	......	......	......	0.177	0.082
	......	......	......	......	......	......	......	......	220	113
Stromness, Orkney Islands	......	......	0.030	0.099	0.068	0.066	0.032	0.025	0.444	0.099
	......	......	220	287	255	323	263	135	238	202
Kingstown, Ireland	......	......	......	0.155	......	......	......	......	0.346	0.061
	......	......	......	252	......	......	......	......	232	170
Queenstown, Ireland	......	......	......	......	......	......	......	......	0.265	......
	......	......	......	......	......	......	......	......	234	......
Antarctic Regions.										
Port Circoncision, Petermann Island.	......	......	......	......	......	0.184	......	......	......	......
	......	......	......	......	......	238	......	......	......	......

INDEX, TIDAL HARMONIC CONSTANTS.

This index includes the names of the political divisions and many islands and bodies of waters in which stations are located, but does not contain the names of the individual stations represented.]