FOR THE INCREASE AND DIFFVSION OF KNOWLEDGE AMONG MEN

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SMITHSONIAN INSTITVTION WASHINGTON 1846

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. 69

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

(PUBLICATION 2654)

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The present series, entitled "Smithsonian Miscellaneous Collections," is intended to embrace all the octavo publications of the Institution, except the Annual Report. Its scope is not limited, and the volumes thus far issued relate to nearly every branch of science. Among these various subjects zoology, bibliography, geology, mineralogy, anthropology and astrophysics have predominated.

The Institution also publishes a quarto series entitled "Smithsonian Contributions to Knowledge." It consists of memoirs based on extended original investigations, which have resulted in important additions to knowledge.

CHARLES D. WALCOTT,
Secretary of the Smithsonian Institution.

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 69, NUMBER 1

SMITHSONIAN METEOROLOGICAL TABLES

[BASED ON GUYOT'S METEOROLOGICAL AND PHYSICAL TABLES]

FOURTH REVISED EDITION

(Corrected to January, 1918)

(PUBLICATION 2493)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1918

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ADVERTISEMENT TO FOURTH REVISED EDITION.

THE original edition of the Smithsonian Meteorological Tables was issued in 1893, and revised editions were published in 1896, 1897, and 1907. A fourth revised edition is here presented, which has been prepared under the direction of Professor Charles F. Marvin, Chief of the U.S. Weather Bureau, assisted by Professor Herbert H. Kimball. They have had at their disposal numerous notes left by the late Professor Cleveland Abbe, and have consulted with officials of the U.S. Bureau of Standards and of other Government bureaus relative to the value of certain physical constants that have entered into the calculation of the tables.

All errata thus far detected in the earlier editions have here been corrected. New vapor pressure tables, derived from the latest experimental values by means of a modification of Van der Waals interpolation formula devised by Professor Marvin, have been introduced. The table of relative acceleration of gravity at different latitudes has been recomputed from a new equation based upon the latest investigations of the U.S. Coast and Geodetic Survey. These values have been employed in reducing barometric readings to the standard value of gravity adopted by the International Bureau of Weights and Measures, supplementing a table that has been introduced for directly reducing barometer readings from the value of gravity at the place of observation to its standard value.

The new values of vapor pressure and of gravity acceleration thus obtained, together with a recent and more accurate determination of the density of mercury, have called for an extensive revision of numerous other tables, and especially of those for the reduction of psychrometric observations, and the barometrical tables.

Among the new tables added are those for converting barometric inches and barometric millimeters into millibars, for determining heights from pressures expressed in dynamic units, tables of gradient winds, and tables giving the duration of astronomical and civil twilight, and the transmission percentages of radiation through moist air.

The tables of International Meteorological Symbols, of Cloud Classification, of the Beaufort Scale of Winds, of the Beaufort Weather Notation, and the List of Meteorological Stations, are among those extensively revised.

Tables for reducing barometric readings to sea level, and tables of logarithms of numbers, of natural sines and cosines, of tangents and cotangents, and for dividing by 28, 29, and 31, with a few others, have been omitted from this edition.

This reprint is from the electroplates that were employed in printing the Fourth Revised Edition, after making certain minor corrections.

CHARLES D. WALCOTT,
Secretary.

SMITHSONIAN INSTITUTION,
June, 1924.

ADVERTISEMENT TO THIRD REVISED EDITION

The original edition of Smithsonian Meteorological Tables was issued in 1893, and revised editions were published in 1896 and 1897. A third revised edition is here presented, which has been prepared at the request of the late Professor Langley by the coöperation of Professors Alexander McAdie, Charles F. Marvin, and Cleveland Abbe.

All errata thus far detected have been corrected upon the plates, the Marvin vapor tensions over ice have been introduced, Professor F. H. Bigelow's System of Notation and Formulæ has been added, the List of Meteorological Stations has been revised, and the International Meteorological Symbols, together with the Beaufort Notation, are given at the close of the volume.

R. RATHBUN,
Acting Secretary.

SMITHSONIAN INSTITUTION,
December, 1906.

ADVERTISEMENT TO SECOND REVISED EDITION.

The edition of the Smithsonian Meteorological Tables issued in 1893 having become exhausted, a careful examination of the work has been made, at my request, by Mr. Alexander McAdie, of the United States Weather Bureau, and a revised edition was published in 1896, with corrections upon the plates and a few slight changes. The International Meteorological Symbols and an Index were also added.

The demand for the work has been so great that it becomes necessary to print a new edition of the revised work, which is here presented with corrections to date.

S. P. LANGLEY,
Secretary.

SMITHSONIAN INSTITUTION,
WASHINGTON CITY,
October 30, 1897.

PREFACE TO EDITION OF 1893.

In connection with the system of meteorological observations established by the Smithsonian Institution about 1850, a collection of meteorological tables was compiled by Dr. ARNOLD GUYOT, at the request of Secretary HENRY, and published in 1852 as a volume of the *Miscellaneous Collections.*

Five years later, in 1857, a second edition was published after careful revision by the author, and the various series of tables were so enlarged as to extend the work from 212 to over 600 pages.

In 1859 a third edition was published, with further amendments.

Although designed primarily for the meteorological observers reporting to the Smithsonian Institution, the tables obtained a much wider circulation, and were extensively used by meteorologists and physicists in Europe and in the United States.

After twenty-five years of valuable service, the work was again revised by the author; and the fourth edition, containing over 700 pages, was published in 1884. Before finishing the last few tables, Dr. GUYOT died, and the completion of the work was intrusted to his assistant, Prof. WM. LIBBEY, JR., who executed the duties of final editor.

In a few years the demand for the tables exhausted the edition, and thereupon it appeared desirable to recast entirely the work. After very careful consideration, I decided to publish the new tables in three parts: METEOROLOGICAL TABLES, GEOGRAPHICAL TABLES, and PHYSICAL TABLES, each representative of the latest knowledge in its field, and independent of the others; but the three forming a homogeneous series.

Although thus historically related to Dr. Guyot's Tables, the present work is so substantially changed with respect to material, arrangement, and presentation that it is not a fifth edition of the older tables, but essentially a new publication.

In its preparation the advantage of conformity with the recently issued *International Meteorological Tables* has been kept steadily in view, and so far as consistent with other decisions, the constants and methods there employed have been followed. The most important difference in constants is the relation of the yard to the metre. The value provisionally adopted by the Bureau of Weights and Measures of the United States Coast and Geodetic Survey,

1 metre = 39.3700 inches,

has been used here in the conversion-tables of metric and English linear measures, and in the transformation of all formulæ involving such conversions.

A large number of tables have been newly computed; those taken from the *International Meteorological Tables* and other official sources are credited in the introduction.

To Prof. WM. LIBBEY, JR., especial acknowledgments are due for a large amount of attention given to the present work. Prof. LIBBEY had already completed a revision, involving considerable recomputation, of the meteorological tables contained in the last edition of Guyot's Tables, when it was determined to adopt new values for many of the constants, and to have the present volume set with new type. This involved a large amount of new computation, which was placed under the direction of Mr. GEORGE E. CURTIS, who has also written the text, and has carefully prepared the whole manuscript and carried it through the press. To Mr. Curtis's interest, and to his special experience as a meteorologist, the present volume is therefore largely due.

Prof. LIBBEY has contributed Tables 38, 39, 55, 56, 61, 74, 77, 89, and 90, and has also read the proof-sheets of the entire work.

I desire to express my acknowledgments to Prof. CLEVELAND ABBE, for the manuscript of Tables 32, 81, 82, 83, 84, 85, 86; to Mr. H. A. HAZEN, for Tables 49, 50, 94, 95, 96, which have been taken from his *Hand-book of Meteorological Tables;* and also to the Superintendent of the United States Coast and Geodetic Survey, the Chief Signal Officer of the Army, and the Chief of the Weather Bureau, for much valuable counsel during the progress of the work.

S. P. LANGLEY,

Secretary.

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DESCRIPTION AND USE OF TABLES.

THERMOMETRY.

The present standard for exact thermometry is the normal centigrade scale of the constant-volume hydrogen thermometer as defined by the International Bureau of Weights and Measures. The constant volume is one liter and the pressure at the freezing point is one meter of mercury reduced to freezing and standard gravity. The scale is completely defined by designating the temperature of melting ice, 0°, and of condensing steam, 100°, both under standard atmospheric pressure. All other thermometric scales that depend upon the physical properties of substances may by definition be made to coincide at the ice point and the boiling point with the normal scale as above defined, but they will diverge more or less from it and from each other at all other points. However, by international consent it is customary in most cases to refer other working scales to the hydrogen scale.

The absolute or thermodynamic scale. To obviate the difficulty which arises because thermometers of different type and substance inherently disagree except at the fixed points, Lord Kelvin proposed that temperatures be defined by reference to certain thermodynamic laws. This course furnishes a scale independent of the nature or properties of any particular substance. The resulting scale has been variously named the absolute, the thermodynamic, and, more recently, in honor of its author, the Kelvin scale. The temperature of melting ice by this scale on the centigrade basis is not as yet accurately known, but it is very nearly 273°.13, and that of the boiling point, 373°.13.

Many problems in physics and meteorology call for the use of the absolute scale; but it is not convenient, and in many cases not necessary, to adhere strictly to the true thermodynamic scale. In fact, the general requirements of science will very largely be met by the use of an approximate absolute scale which for the centigrade system is defined by the equation

$$T = (273^\circ. + t^\circ \text{ C.})$$

The observed quantity, t°, may be referred to the normal hydrogen centigrade scale or be determined by any acceptable thermometric method.

This scale differs from the true Kelvin scale, first, because 273° is not the exact value of the ice point on the Kelvin scale, second, because each observed value of t° other than 0° or 100° requires a particular correction to convert it to the corresponding value on the Kelvin scale. These corrections will differ according to the kind of thermometer used in obtaining the value $t°$, and while they are small for temperatures between 0° and 100° they are large at extreme temperatures and are important in all questions involving thermometric precision.

Since, however, the approximate absolute scale is sufficiently exact for nearly all purposes, and especially since it is most convenient in computations and in the publication of results, much confusion and uncertainty of terminology and meaning will be obviated if scientists will agree to give the approximate absolute scale a particular name of its own.

For the purpose of these tables the name *Approximate Absolute* will be employed, and in accordance therewith thermometric scales may be designated as follows:—

Scale.	Ice point.	Boiling point.	Symbol.
Centigrade	0°	100°	*C.*
Fahrenheit	32	212	*F.* or Fahr.
Reaumur	0	80	*R.*
Thermodynamic Absolute Kelvin	273.13 *C.* ± 491.6 *F.* ±	373.13 *C.* ± 671.6 *F.* ±	*A.* or *K.*
	(Names strictly synonymous and strictly one ideal scale.)		
Approximate Absolute	273	373	*A.A.*

Table 1. *Conversion of the Approximate Absolute thermometric scale to the Centigrade, Fahrenheit, and Reaumur scales.*

The equivalent values of the four scales are given for every degree on the Approximate Absolute scale from 375° to 0°.

By the help of the table of proportional parts preceding this table, it is also convenient for converting Fahrenheit to Centigrade and Reaumur, and Centigrade to Fahrenheit and Reaumur.

The formulæ expressing the relations between the different scales are also given, in which

A.A.° = Temperature — Approximate Absolute Scale.
C.° = Temperature — Centigrade Scale.
F.° = Temperature — Fahrenheit Scale.
R.° = Temperature — Reaumur Scale.

Examples:

To convert 285°.5 Approximate Absolute into Centigrade, Fahrenheit, and Reaumur.

From the table,	285° *A.A.* =	12° *C.* =	53°.6 *F.* =	9°.6 *R.*
From the proportional parts,	0.5 =	0.5 =	0.9 =	0.4
	285.5 *A.A.* =	12.5 *C.* =	54.5 *F.* =	10.0 *R.*

To convert 16°.9 Centigrade to Approximate Absolute, Fahrenheit, and Reaumur.

From the table,	16° C.	= 289° A.A.	= 60°.8 F.	= 12°.8 R.
From the proportional parts	0.9	= 0.9	= 1.6	= 0.7
	16.9 C.	= 289.9 A.A.	= 62.4 F.	= 13.5 R.

Or,

$$16^\circ.9 \times 2\left(1 - \frac{1}{10}\right) + 32 = \begin{array}{r} 33.8 \\ -\ 3.4 \\ 32.0 \\ \hline 62.4\ F. \end{array}$$

To convert 147°.7 Fahrenheit to Approximate Absolute, Centigrade, and Reaumur.

From the table,	140° F.	= 333° A.A.	= 60° C.	= 48° R.
From the proportional parts	7.7	= 4.3	= 4.3	= 3.4
	147.7 F.	= 337.3 A.A.	= 64.3 C.	= 51.4 R.

Or,

$$\frac{147.7 - 32.0}{2}\left(1 + \frac{1}{10} + \frac{1}{100} + \frac{1}{1000}\text{ etc.}\right) = \begin{array}{r} 57.85 \\ +\ 5.78 \\ +\ .58 \\ +\ .06 \\ \hline 64.27\ C. \end{array}$$

Fahrenheit may also be reduced to Approximate Absolute by obtaining its equivalent in Centigrade from Table 2 and adding 273 to the result.

To convert 18°.3 Reaumur to Approximate Absolute, Centigrade, and Fahrenheit.

From the table,	16° R.	= 293° A.A.	= 20° C.	= 68° F.
From the proportional parts,	2.3	= 2.9	= 2.9	= 5.2
	18.3 R.	= 295.9 A.A.	= 22.9 C.	= 73.2 F.

Or, $18.3 \times \frac{5}{4} = \frac{91.5}{4} = 22.9$ C., and $(18.3 \times \frac{9}{4}) + 32 = \frac{164.7}{4} + 32 = 73.2$ F.

TABLE 2.

Table 2. *Conversion of readings of the Fahrenheit thermometer to readings Centigrade.*

The conversion of Fahrenheit temperatures to Centigrade temperatures is given for every tenth of a degree from + 130°.9 *F.* to − 120°.9 *F.* The side argument is the whole number of degrees Fahrenheit, and the top argument, tenths of a degree Fahrenheit; interpolation to hundredths of a degree, when desired, is readily effected mentally. The tabular values are given to hundredths of a degree Centigrade.

The formula for conversion is

$$C^\circ = \frac{5}{9}(F^\circ - 32^\circ)$$

where F° is a given temperature Fahrenheit, and C° the corresponding temperature Centigrade.

Example:

To convert 79°.7 Fahrenheit to Centigrade.
The table gives directly 26°.50 *C.*

For conversions of temperatures outside the limits of the table use Table 1.

TABLE 3. *Conversion of readings of the Centigrade thermometer to readings Fahrenheit.*

The conversion of Centigrade temperatures to Fahrenheit temperatures is given for every tenth of a degree Centigrade from + 60°.9 to − 90°.9 *C.* The tabular values are expressed in hundredths of a degree Fahrenheit.

The formula for conversion is

$$F^\circ = \frac{9}{5}C^\circ + 32^\circ$$

where C° is a given temperature Centigrade, and F° the corresponding temperature Fahrenheit.

For conversions of temperatures outside the limits of the table, use Table 1 or 4.

TABLE 4. *Conversion of readings of the Centigrade thermometer near the boiling point to readings Fahrenheit.*

This is an extension of Table 3 from 90°.0 to 100°.9 Centigrade.

Example:

To convert 95°.74 Centigrade to Fahrenheit.

From the table,	95°.70 *C.*	=	204°.26 *F.*
By interpolation,	0.04	=	0.07
	95°.74 *C.*	=	204°.33 *F.*

TABLE 5. *Conversion of differences Fahrenheit to differences Centigrade.*

The table gives for every tenth of a degree from 0° to 20°.9 *F.* the corresponding lengths of the Centigrade scale.

TABLE 6.

Table 6. *Conversion of differences Centigrade to differences Fahrenheit.*

The table gives for every tenth of a degree from 0° to 9°.9 *C.* the corresponding lengths of the Fahrenheit scale.

Example:

To find the equivalent difference in Fahrenheit degrees for a difference of 4°.72 Centigrade.

From the table,	4°.70 *C.*	=	8°.46 *F.*
From the table by moving the decimal point for 0.2,	0.02	=	0.04
	4°.72 *C.*	=	8°.50 *F.*

TABLES 7, 8.

Tables 7, 8. *Correction for the temperature of the emergent mercurial column of thermometers.*

When the temperature of the thermometer stem containing a portion of the mercury column is materially different from that of the bulb, a correction needs to be applied to the observed reading unless the instrument has been previously graduated for the condition of use. This correction frequently becomes necessary in physical experiments where the bulb only, or else the bulb with a portion of the stem, is immersed in a bath whose temperature is to be determined. In meteorological observations the correction may become appreciable in wet-bulb, dew-point, and solar-radiation thermometers, when the temperature of the bulb is considerably above or below the air temperature.

If t' be the average temperature of the emergent mercury column, t the observed reading of the thermometer, n the length of the mercury in the emergent stem in scale degrees, and α the apparent expansion of mercury in glass for 1°, the correction is given by the expression

$$\alpha n\,(t - t'), \text{ or } -\alpha n\,(t' - t)$$

which latter may be the more convenient form when t' is greater than t.

The value of α varies with the composition of the glass of which the thermometer stem is composed. For glass of unknown composition the best average value for centigrade temperatures appears to be 0.000155, while for stems of Jena 16^{III}, or similar glasses, or Jena 59^{III}, the values 0.00016 for the former and 0.000165 for the latter may be preferred. (Letter from U.S. Bureau of Standards dated January 5, 1918.)

The use of the formula given above presupposes that the mean temperature of the emergent column has been determined. This temperature may be approximately obtained in one of three ways. (1) By a "fadenthermometer" (Buckingham, Bulletin, Bureau of Standards, 8, 239, 1911, Scientific Paper 170); (2) by exploring the temperature distribution along the stem and calculating the mean temperature; (3) by suspending along the side of, or attaching to the stem, a single thermometer. If properly placed this thermometer will indicate the temperature of the emergent mercurial column to an accuracy sufficient for many purposes. Under conditions ordinarily met with in practice it is desirable to place the bulb of the auxiliary thermometer at some point below the middle of the emergent column.

It is to be noted that the correction sought is directly proportional to the value of α, and that this may vary for glass stems of different composition from 0.00015 to 0.000165 for Centigrade temperatures. For thermometers ordinarily used in meteorological work, however, 0.000155 appears to be a good average value for Centigrade temperatures (0.000086 for Fahrenheit temperatures), and the correction formulæ, therefore, are,

$$T = t - 0.000086\, n\, (t' - t) \text{ Fahrenheit temperatures.}$$
$$T = t - 0.000155\, n\, (t' - t) \text{ Centigrade temperatures.}$$

In the above, T = Corrected temperature.
t = Observed temperature.
t' = Mean temperature of the glass stem and emergent mercury column.
n = Length of mercury in the emergent stem in scale degrees.

When t' is $\left\{\begin{matrix}\text{higher}\\ \text{lower}\end{matrix}\right\}$ than t the numerical correction is to be $\left\{\begin{matrix}\text{subtracted.}\\ \text{added.}\end{matrix}\right\}$

Table 7 gives corrections computed to $0\overset{\circ}{.}01$ for Fahrenheit thermometers from the equation $C = -0.000086\, n\, (t' - t)$. The side argument, n, is given for 10° intervals from 10° to 130°; the top argument, $t' - t$, for 10° intervals from 10° to 100°.

Table 8 gives corrections computed to $0\overset{\circ}{.}01$ for Centigrade thermometers from the equation $C = -0.000155\, n\, (t' - t)$. The side argument, n, is given for 10° intervals from 10° to 100°; the top argument, $t' - t$, for 10° intervals from 10° to 80°.

Example:

The observed temperature of a black-bulb thermometer is $120\overset{\circ}{.}4$ *F.*, the temperature of the glass stem is $55\overset{\circ}{.}2$ *F.*, and the length of mercury in the emergent stem is 130° *F.* To find the corrected temperature. With $n = 130°$ *F.* and $t' - t = -65°$ *F.*, as arguments, Table 7 gives the correction $0\overset{\circ}{.}7$ *F.*, which by the above rule is to be added to the observed temperature. The corrected temperature is therefore $121\overset{\circ}{.}1$ *F.*

CONVERSIONS INVOLVING LINEAR MEASURES.

The fundamental unit of length is the meter, the length of which is equal to the distance between the defining lines on the international prototype meter at the International Bureau of Weights and Measures (near Paris) when this standard is at the temperature of melting ice (0° *C*). The relation here adopted between the meter and the yard, the English measure of length, is 1 meter = 39.3700 inches, as legalized by Act of U.S. Congress, July 28, 1866. This U.S. Standard of length must be distinguished from the British Imperial yard, comparisons of which with the international prototype meter give the relation 1 meter = 39.370113 inches. (See Smithsonian Physical Tables, 1916, p. 7, Table 3.)

TABLE 9. *Inches into millimeters.* **TABLE 9.**

1 inch = 25.40005 millimeters.

The argument is given for every hundredth of an inch up to 32.00 inches, and the tabular values are given to hundredths of a millimeter. A table of proportional parts for thousandths of an inch is added on each page.

Example:

To convert 24.362 inches to millimeters.
The table gives (p. 20).

(24.36 + .002) inches = (618.75 + 0.05) mm. = 618.80 mm.

TABLE 10. *Millimeters into inches.* **TABLE 10.**

From 0 to 400 mm. the argument is given to every millimeter, with subsidiary interpolation tables for tenths and hundredths of a millimeter. The tabular values are given to four decimals. From 400 to 1000 mm., covering the numerical values which are of frequent use in meteorology for the conversion of barometric readings from the metric to the English barometer, the argument is given for every tenth of a millimeter, and the tabular values to three decimals.

Example:

To convert 143.34 mm. to inches.
The table gives

(143 + .3 + .04) mm. = (5.6299 + 0.0118 + 0.0016) inches = 5.6433 inches.

TABLES 11, 12.

TABLES 11, 12. *Conversion of barometric readings into standard units of pressure.*

The equation for the pressure in millibars,[1] P_{mb}, corresponding to the barometric height, B, is

$$P_{mb} = B \frac{\Delta g}{1000}$$

where Δ is the densitv of mercury and g is the standard value of gravity.

[1] The value of the *bar* as here defined is a pressure of 1,000,000 dynes per square centimeter, and is that employed by meteorological services, and recommended by inter-

In order that pressures thus derived shall be expressed in C.G.S. units it is evident that the recognized standard values of the constants of the equation must be employed. It therefore becomes necessary to abandon the values for the density of mercury and for standard gravity heretofore employed, which had the sanction of the International Meteorological Committee, in favor of the more recently determined values that have been adopted by the International Bureau of Weights and Measures.

The value adopted for Δ is 13.5951 grams per cubic centimeter;[1] and for g, 980.665 dynes.[2]

By the use of these constants in the above equation we obtain

$$P_{mb} = 1.333224\ B \text{ (millimeters), and}$$

$$P_{mb} = \frac{1.333224}{0.03937} B = 33.86395\ B \text{ (inches)}$$

where B is the height of the barometer in the units indicated, after reduction to standard temperature and the standard value of gravity.

Table 11. *Barometric inches to millibars.*

The argument is for 0.01 inch. From 0.00 to 2.49 inches the tabulated values are given to the nearest hundredth of a millibar, so that by removing the decimal one place to the right the value in millibars of every tenth inch from 0.0 to 24.9 inches may be obtained to the nearest tenth of a millibar. From 25.00 to 31.99 inches the tabular values are given to the nearest tenth of a millibar.

The first part of the table may be used as a table of proportional parts for interpolation.

Example:

To convert 23.86 barometric inches into millibars of pressure.

From Table 11,	23.8 inches	=	806.0	millibars
" " "	.06 inch	=	2.0	"
	23.86 inches	=	808.0	millibars

Table 12. *Barometric millimeters to millibars.*

The argument is for each millimeter from 1 to 799, and the tabular values are given to the nearest tenth of a millibar.

This table may also be used to convert millibars into millimeters of mercury.

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national meteorological and aerological conferences. It is 1,000,000 times greater than that given in the Smithsonian Physical Tables, 6th ed., 1914, p. 346. The smaller value is generally employed by physicists and chemists. See Marvin, Charles F. Nomenclature of the Unit of Absolute Pressure. Monthly Weather Review, 1918, 46: 73–75.

[1] Chappuis, Recueil de Constantes Physiques, Soc. Fr. Phys., 1913, p. 139. Leduc, Trav. et Mém., Bur. Int. Poids et Mes., XVI, p. 36, 1917.

[2] Comptes Rendus des Séances, Troisième Conférence Générale, p. 68. Trav. et Mém., Bur. Int. Poids et Mes., XII, 1902.

Example:

To convert 1003.5 millibars into millimeters of mercury. 1003.5 mb. = (1002.6 + 0.9) mb. = (752 + 0.68) mm. = 752.68 mm.

TABLE 13. *Feet into meters.* **TABLE 13.**

From the adopted value of the meter, 39.3700 inches —

1 English foot = 0.3048006 meter.

Table 13 gives the value in meters and thousandths (or millimeters) for every foot from 0 to 99 feet; the value to hundredths of a meter (or centimeters) of every 10 feet from 100 to 4090 feet; and the value to tenths of a meter of every 10 feet from 4000 to 9090 feet. In using the latter part, the first line of the table serves to interpolate for single feet.

Example:

To convert 47 feet 7 inches to meters.	47 feet 7 inches = 47.583 feet.
The table gives	47 feet = 14.326 meters.
By moving the decimal point	0.583 " = 0.178 "
	47.583 feet = 14.504 meters.

TABLE 14. *Meters into feet.* **TABLE 14.**

1 meter = 39.3700 inches = 3.280833 + feet.

From 0 to 509 meters the argument is given for every unit, and the tabular values to two decimals; from 500 to 5090 the argument is given to every 10 meters, and the tabular values to one decimal. The conversion for tenths of a meter is added for convenience of interpolation.

Example:

Convert 4327 meters to feet.

The table gives

(4320 + 7) meters = (14173.2 + 23.0) feet = 14196.2 feet.

TABLE 15. *Miles into kilometers.* **TABLE 15.**

1 mile = 1.609347 kilometers.

The table extends from 0 to 1009 miles with argument to single miles, and from 1000 to 20000 miles for every 1000 miles. The tabular quantities are given to the nearest kilometer.

TABLE 16. *Kilometers into miles.* **TABLE 16.**

1 kilometer = 0.621370 mile.

The table extends to 1009 kilometers with argument to single kilometers, and from 1000 to 20000 kilometers for every 1000 kilometers. Tabular values are given to tenths of a mile.

Example:

Convert 3957 kilometers into miles.

The table gives

(3000 + 957) kilometers = (1864.1 + 594.7) miles = 2458.8 miles.

Table 17. *Interconversion of nautical and statute miles.*

The nautical mile as defined by the U.S. Coast and Geodetic Survey (Tables for a polyconic projection of maps. U.S. Coast and Geodetic Survey, Special Publication No. 5, page 4) is "A minute of arc of a great circle of a sphere whose surface equals that of the Clarke representative spheroid of 1866," and the value given is 1853.25 meters, or 6080.20 feet.

Table 18. *Continental measures of length with their metric and English equivalents.*

This table gives a miscellaneous list of continental measures of length, alphabetically arranged, with the name of the country to which they belong and their metric and English equivalents.

CONVERSION OF MEASURES OF TIME AND ANGLE.

Table 19. *Arc into time.*

$$1^\circ = 4^m;\ 1' = 4^s;\ 1'' = \frac{1}{15}^s = 0^s.067.$$

Example:

Change 124° 15′ 24″.7 into time.

From the table,

124°	=	8^h	16^m	0^s
15′	=		1	0
24″	=			1.600
0″.7	=			.047
		8^h	17^m	$1^s.647$

Table 20. *Time into arc.*

$$1^h = 15^\circ;\ 1^m = 15';\ 1^s = 15''.$$

Example:

Change $8^h\ 17^m\ 1^s.647$ into arc.

From the table,	8^h	=	120°		
	17^m	=	4	15′	
	1^s	=			15″
	0.64	=			9.60
By moving the decimal point,	.007	=			0.10
			124°	15′	24″.7

Table 21. *Days into decimals of a year and angle.*

The table gives for the beginning of each day the corresponding decimal of the year to five places. Thus, at the epoch represented by the beginning of the 15th day, the decimal of the year that has elapsed since January 1.0 is computed from the fraction $\frac{14}{365.25}$. The corresponding value in angle obtained by multiplying this fraction by 360°, is given to the nearest minute.

Two additional columns serve to enter the table with the day of the month either of the common or the bissextile year as the argument, and may be used also for converting the day of the month to the day of the year, and *vice versa.*

Example:

To find the number of days and the decimal of a year between February 12 and August 27 in a bissextile year.

Aug. 27: Day of year	= 240;	decimal of a year	= 0.65435
Feb. 12: " " "	= 43;	" " "	= 0.11499
Interval in days	= 197;	interval in decimal of a year	= 0.53936

The decimal of the year corresponding to the interval 197 days may also be taken from the table by entering with the argument 198.

TABLE 22. *Hours, minutes and seconds into decimals of a day.* TABLE 22.

The tabular values are given to six decimals.

Example:

Convert $5^{h}\ 24^{m}\ 23^{s}.4$ to the decimal of a day:

$$
\begin{aligned}
5^{h} &= 0^{d}.208333 \\
24^{m} &= 016667 \\
23^{s} &= 266 \\
\text{By interpolation, or by moving the decimal for } 4^{s} \quad 0.4 &= 5 \\
\hline
&\quad 0^{d}.225271
\end{aligned}
$$

TABLE 23. *Decimals of a day into hours, minutes and seconds.* TABLE 23.

Example:

Convert $0^{d}.225271$ to hours, minutes and seconds:

$$
\begin{aligned}
0.22 \text{ day} &= 4^{h}\ 48^{m} + 28^{m}\ 48^{s} = 5^{h}\ 16^{m}\ 48^{s} \\
0.0052 \text{ day} &= 7^{m}\ 12^{s} + 17^{s}.28 = 7\ \ 29.28 \\
0.000071 \text{ day} &= 6^{s}.05 + 0.09 = 6.14 \\
\hline
&\qquad 5^{h}\ 24^{m}\ 23^{s}.4
\end{aligned}
$$

TABLE 24. *Minutes and seconds into decimals of an hour.* TABLE 24

The tabular values are given to six decimals.

Example:

Convert $34^{m}\ 28^{s}.7$ to decimals of an hour.

$$
\begin{aligned}
34^{m} &= 0^{h}.566667 \\
28^{s} &= 7778 \\
0^{s}.7 &= 194 \\
\hline
&\quad 0.574639
\end{aligned}
$$

Table 25. *Local mean time at apparent noon.*

This table gives the local mean time[1] that should be shown by a clock when the center of the sun crosses the meridian, on the 1st, 8th, 16th, and 24th days of each month. The table is useful in correcting a clock by means of a sundial or noon mark.

Example:

To find the correct local mean time when the sun crosses the meridian on December 15, 1891.

The table gives for December 16, $11^h\ 56^m$. By interpolating, it is seen that the change to December 15 would be only one-half minute; the correct clock time is therefore 4 minutes before 12 o'clock noon.

Table 26. *Sidereal time into mean solar time.*

Table 27. *Mean solar time into sidereal time.*

According to Newcomb, the length of the tropical year is 365.24220 mean solar days,[2] whence

$$365.24220 \text{ solar days} = 366.24220 \text{ sidereal days.}$$

Any interval of mean time may therefore be changed into sidereal time by increasing it by its $\frac{1}{365.24220}$ part, and any interval of sidereal time may be changed into mean time by diminishing it by its $\frac{1}{366.24220}$ part.

Table 26 gives the quantities to be subtracted from the hours, minutes and seconds of a sidereal interval to obtain the corresponding mean time interval, and Table 27 gives the quantities to be added to the hours, minutes and seconds of a mean time interval to obtain the corresponding sidereal interval. The correction for seconds is sensibly the same for either a sidereal or a mean time interval and is therefore given but once, thus forming a part of each table.

Examples:

Change $14^h\ 25^m\ 36^s.2$ sidereal time into mean solar time.

Given sidereal time			14^h	25^m	$36^s.2$
Correction for 14^h	=	$-\ 2^m\ 17^s.61$			
25^m	=	$-\ 4.10$			
$36^s.2$	=	$-\ .10$			
		$-\ 2\ \ 21.81$		-2	21.8
Corresponding mean time	=		14	23	14.4

[1] Derived from the equation of time for Washington apparent noon for the year 1899. See the American Ephemeris and Nautical Almanac, 1899, pages 377–84.

[2] The length of the tropical year is not absolutely constant. The value here given is for the year 1900. Its decrease in 100 years is about 0.5s. (See the American Ephemeris and Nautical Almanac 1918, page xvi.)

2. Change $13^h\ 37^m\ 22^s.7$ mean solar time into sidereal time.

Given mean time	=		$13^h\ 37^m\ 22^s.7$
Correction for 13^h	= + 2^m	$8^s.13$	
37^m	= +	6.08	
$22^s.7$	= +	0.06	
	+ 2	14.27	+ 2 14.3
Corresponding sidereal time	=		13 39 37.0

CONVERSION OF MEASURES OF WEIGHT.

TABLE 28.

Table 28. *Conversion of avoirdupois pounds and ounces into kilograms.*

The comparisons of July, 1893, made by the International Bureau of Weights and Measures between the Imperial standard pound and the "kilogram prototype" resulted in the relation:

1 pound avoirdupois = 453.592 427 7 grams.

For the conversion of pounds, Table 28 gives the argument for every tenth of a pound up to 9.9, and the tabular conversion values to ten-thousandths of a kilogram.

For the conversion of ounces, the argument is given for every tenth of an ounce up to 15.9, and the tabular values to ten-thousandths of a kilogram.

TABLE 29.

Table 29. *Conversion of kilograms into avoirdupois pounds and ounces.*

From the above relation between the pound and the kilogram,

1 kilogram = 2.204622 avoirdupois pounds.
= 35.274 avoirdupois ounces.

The table gives the value to thousandths of a pound of every tenth of a kilogram up to 9.9; the values of tenths of a kilogram in ounces to four decimals; and the values of hundredths of a kilogram in pounds and ounces to three and two decimals respectively.

TABLES 30, 31.

Table 30. *Conversion of grains into grams.*

Table 31. *Conversion of grams into grains.*

From the above relation between the pound and the kilogram,

1 gram = 15.432356 grains.
1 grain = 0.06479892 gram.

Table 30 gives to ten-thousandths of a gram the value of every grain from 1 to 99, and also the conversion of tenths and hundredths of a grain for convenience in interpolating.

Table 31 gives to hundredths of a grain the value of every tenth of a gram from 0.1 to 9.9, and the value of every gram from 1 to 99. The values of hundredths and thousandths of a gram are added as an aid to interpolation.

WIND TABLES.

CONVERSION OF VELOCITIES.

Table 32. *Synoptic conversion of velocities.*

This table,[1] contained on a single page, converts miles per hour into meters per second, feet per second and kilometers per hour. The argument, miles per hour, is given for every half unit from 0 to 78. Tabular values are given to one decimal. For the rapid interconversion of velocities, when extreme precision is not required, this table has proved of marked convenience and utility.

Table 33. *Conversion of miles per hour into feet per second.*

The argument is given for every unit up to 149 and the tabular values are given to one decimal.

Table 34. *Conversion of feet per second into miles per hour.*

The argument is given for every unit up to 199 and the tabular values are given to one decimal.

Table 35. *Conversion of meters per second into miles per hour.*

The argument is given for every tenth of a meter per second up to 60 meters per second, and the tabular values are given to one decimal.

Table 36. *Conversion of miles per hour into meters per second.*

The argument is given for every unit up to 149, and the tabular values are given to two decimals.

Table 37. *Conversion of meters per second into kilometers per hour.*

The argument is given for every tenth of a meter per second up to 60 meters per second, and the tabular values are given to one decimal.

Table 38. *Conversion of kilometers per hour into meters per second.*

The argument is given for every unit up to 200, and the tabular values are given to two decimals.

Table 39. *Scale of Velocity equivalents of the so-called Beaufort scale of wind.*

The personal observation of the estimated force of the wind on an arbitrary scale is a method that belongs to the simplest meteorological

[1] From *Hand-Book of Meteorological Tables.* By H. A. Hazen. Washington, 1888.

records and is widely practiced. Although anemometers are used at meteorological observatories, the majority of observers are still dependent upon estimates based largely upon their own judgment, and so reliable can such estimates be made that for many purposes they abundantly answer the needs of meteorology as well as of climatology.

A great variety of such arbitrary scales have been adopted by different observers, but the one that has come into the most general use and received the greatest definiteness of application is the duodecimal scale introduced into the British navy by Admiral Beaufort about 1800.

Table 39 is taken from the Observer's Handbook of the Meteorological Office, London, edition of 1917. The velocity equivalents in meters per second and miles per hour are based on extensive observational data collected by Dr. G. C. Simpson and first published by the Meteorological Office in 1906. Several other sets of equivalents have been published in different countries. For a history of this subject see Rept. 10th Meeting International Meteorological Committee, Rome, 1913, Appendix VII. (London, 1914.)

In the *Quarterly Journal of the Royal Meteorological Society*, volume xxx, No. 132, October, 1904, Prof. A. Lawrence Rotch has described an instrument for obtaining the true direction and velocity of the wind at sea aboard a moving vessel. If a line *A B* represents the wind due to the motion of a steamer in an opposite direction, and *A C* the direction of the wind relative to the vessel as shown by the drift of its smoke, then, by measuring the angle *D B A* that the true wind makes with the vessel — which is easily done by watching the wave crests as they approach it — we obtain the third side, *B C*, of the triangle. This represents, in direction and also in length, on the scale used in setting off the speed of the ship, the true direction of the wind relative to the vessel and also its true velocity. The method fails when the wind direction coincides with the ship's course and becomes inaccurate when the angle between them is small.

CALCULATION OF THE MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

Lambert's formula for the eight principal points of the compass is

$$\tan \alpha = \frac{E - W + (NE + SE - NW - SW)\cos 45^\circ}{N - S + (NE + NW - SE - SW)\cos 45^\circ}.$$

α is the angle of the resultant wind direction with the meridian.

E, *NE*, *N*, etc., represent the wind movement from the corresponding directions East, Northeast, North, etc. In practice, instead of taking the total wind movement, it is often considered sufficient to take as proportional thereto the number of times the wind has blown from each direction, which is equivalent to considering the wind to have the same mean velocity for all directions.

If directions are observed to sixteen points, half the number belonging to each extra point should be added to the two octant points between which it lies; for example, $NNE = 6$ should be separated into $N = 3$ and $NE = 3$; $ESE = 4$, into $E = 2$ and $SE = 2$. The result will be approximately identical with that obtained by using the complete formula for sixteen points.

TABLE 40. *Multiples of cos* $45°$; *form for computing the numerator and denominator.*

TABLE 41. *Values of the mean direction* (α) *or its complement* ($90° - \alpha$).

Table 40 gives products of cos $45°$ by numbers up to 209, together with a form for the computation of the numerator and denominator, illustrated by an example. The quadrant in which α lies is determined by the following rule:

When the numerator and denominator are positive, α lies between *N* and *E*.

When the numerator is positive and the denominator negative, α lies between *S* and *E*.

When the numerator and denominator are negative, α lies between *S* and *W*.

When the numerator is negative and the denominator positive, α lies between *N* and *W*.

Table 41[1] combines the use of a division table and a table of natural tangents. It enables the computer, with the numerator and denominator of Lambert's formula (computed from Table 40) as arguments, to take out directly the mean wind direction α or its complement.

The top argument consists of every fifth number from 10 to 200.

The side argument is given for every unit from 1 to 50 and for every two units from 50 to 150. Tabular values are given to the nearest whole degree.

Rule for using the table:

Enter the table with the larger number (either numerator or denominator) as the top argument.

If the denominator be larger than the numerator, the table gives α.

If the denominator be smaller than the numerator, the table gives $90° - \alpha$.

α is measured from the meridian in the quadrant determined by the rule given with Table 40.

---

[1] From *Hand-book of Meteorological Tables*. By H. A. Hazen. Washington, 1888. A corrected copy of the table was kindly furnished by the author.

Example:

$$\tan \alpha = \frac{-43}{-27}.$$

Table 41 gives $\quad 90° - \alpha = 32°$

$$\alpha = S\ 58°\ W.$$

NOTE. — If the numerator and denominator both exceed 150 or if either exceeds 200, the fraction must be divided by some number which will bring them within the limits of the table. The larger the values, provided they are within these limits, the easier and more accurate will be the computation. For example, let $\tan \alpha = \frac{-18}{14}$. The top argument is not given for 18, but if we multiply by 5 or 10 and obtain $\frac{-90}{70}$ or $\frac{-180}{140}$, the table gives, without interpolation, $90° - \alpha = 38°$ and $\alpha = N\ 52°\ W.$

GRADIENT WINDS.

When the motions of the atmosphere attain a state of complete equilibrium of flow under definite systems of pressure gradients, the winds blow across the isobars at small angles of inclination depending upon the retarding effects of friction. At the surface of the earth friction is considerable and the angle across the isobars is often great. In the free air, however, the friction is small, and for some purposes may be disregarded entirely. Under an assumption of complete equilibrium of motion and frictionless flow the winds will blow exactly parallel to the isobars, — that is, perpendicular to the gradient which produces and sustains the motion. Such winds are called gradient winds. The anomalous condition of flow of terrestrial winds perpendicular to the moving force is the result of the modifications of atmospheric motions due to the deflective influence of the earth's rotation, and to that other influence due to the inertia reaction of matter when it is constrained to move in a curved path, and commonly called centrifugal force. The equations for gradient wind motions have long been known to meteorologists from the work of Ferrel and others, and may be written in the following form:

For Cyclones

$$V = r\left[\sqrt{\omega^2 \sin^2 \phi + \frac{\Delta P}{\rho r}} - \omega \sin \phi\right] \qquad (1)$$

For Anticyclones

$$V = r\left[\omega \sin \phi - \sqrt{\omega^2 \sin^2 \phi - \frac{\Delta P}{\rho r}}\right] \qquad (2)$$

In C. G. S. Units, V = velocity of the gradient wind in centimeters per second; r = radius of curvature of isobars in centimeters; ΔP = pressure gradient in dynes per square centimeter per centimeter; ρ = density of air in grams per cubic centimeter; ω = angular velocity of the earth's rotation per second $= \frac{2\pi}{86164}$, and ϕ = latitude. In the Northern Hemisphere the winds gyrate counterclockwise in cyclones and clockwise in anticyclones. These gyrations are in the reversed direction each to each in the Southern Hemisphere.

In equation (2) the values of V are imaginary for values of $\frac{\Delta P}{\rho r}$ greater than $\omega^2 \sin^2 \phi$. The equality $\frac{\Delta P}{\rho r} = \omega^2 \sin^2 \phi$, or $r = \frac{\Delta P}{\rho \omega^2 \sin^2 \phi}$ defines and fixes an isobar with minimum curvature in anticyclones. Winds cannot flow parallel to the isobars within this critical isobar. For this isobar the gradient wind has its maximum value $V_c = \frac{\Delta P}{\rho \omega \sin \phi}$. For the same gradient and for an isobar with the same curvature in a cyclone the gradient velocity is $V_l = V_c (\sqrt{2} - 1) = 0.414\, V_c$.

When the isobars are parallel straight lines, a condition very often closely realized in nature, $r = \infty$ and the gradient winds have the value given by either (1) or (2) after squaring, namely,

$$V_{r=\infty} = V_s = \frac{\Delta P}{2\,\rho\omega \sin \phi} = \frac{1}{2} V_c.$$

For practical units equation (1) becomes

$$V = R \left[\begin{array}{ll} \sqrt{.0053173 \sin^2 \phi + \frac{1}{10\, R\rho d}} - .07292 \sin \phi & \text{(I) (Millibars)} \\ \sqrt{.0053173 \sin^2 \phi + \frac{.13333}{R\rho d}} - .07292 \sin \phi & \text{(II) (Millimeters)} \\ \sqrt{.068914 \sin^2 \phi + \frac{1.6946}{R\rho d}} - .26252 \sin \phi & \text{(III) (Inches)} \end{array} \right] \quad \begin{array}{c}\text{Units of} \\ \text{pressure.}\end{array}$$

V = velocities in meters per second in (I) and (II) and in miles per hour in (III).

R = radius of curvature of isobar (wind path) in kilometers in (I) and (II) and in miles in (III).

The gradient is to be deduced from isobars drawn for pressure intervals of 1 millibar in (I), 1 millimeter in (II) and $\frac{1}{10}$ inch in (III); d, is the perpendicular distance between isobars (as above defined) in kilometers in (I) and (II), and in miles in (III).

ρ = density of air = grams per cubic centimeter in all cases.

Also

Units of pressure.

$$V_c = \begin{cases} \dfrac{1.3713}{\rho d \sin\phi} & \text{(IV)} \\[2ex] \dfrac{1.8284}{\rho d \sin\phi} & \text{(V)} \\[2ex] \dfrac{6.4552}{\rho d \sin\phi} & \text{(VI)} \end{cases} \quad \text{and } R_c = \begin{cases} \dfrac{18.806}{\rho d \sin^2\phi} & \text{(VII) (Millibars)} \\[2ex] \dfrac{25.073}{\rho d \sin^2\phi} & \text{(VIII) (Millimeters)} \\[2ex] \dfrac{24.590}{\rho d \sin^2\phi} & \text{(IX) (Inches)} \end{cases}$$

Radius of critical curvature and velocities of gradient winds for frictionless motion in Highs and Lows.

TABLE 42. *English Measures.* **TABLES 42, 43.**

TABLE 43. *Metric Measures.*

These tables give the radius of curvature of the critical isobar in anticyclones, computed from the equation

$$R_c = \frac{\Delta P}{\rho\omega^2 \sin^2\phi};$$

the velocity of the wind on this isobar, computed from the equation

$$V_c = \frac{\Delta P}{\rho\omega \sin\phi};$$

the velocity of the wind on a straight isobar, computed from the equation

$$V_s = \frac{\Delta P}{2\rho\omega\sin\phi} = \frac{1}{2} V_c; \text{ and}$$

the velocity of the wind in a cyclone having the same gradient as the anticyclone, and on an isobar having a radius of curvature equal to R_c, computed from the equation

$$V_1 = V_c(\sqrt{2} - 1) = 0.414\ V_c$$

Table 42, English measures, gives values of R_c, in miles, and of V_c High, V_s, and V Low, in miles per hour. The side argument is the latitude for 10°, and at 5° intervals from 20° to 90°, inclusive. The top argument, d, is the perpendicular distance in miles between isobars drawn for pressure intervals of $\frac{1}{10}$ inch. For values of d one tenth as great as given in the heading of the table the values of R_c, V_c High, V_s, and V Low are increased tenfold.

Table 43, metric measures, gives values of R_c in kilometers, and of V_c High, V_s, and V Low, in meters per second. The side argument is the same as in Table 42. The top argument, d, is the perpendicular distance in kilometers between isobars drawn for pressure intervals of 1 millimeter. For values of d one tenth as great as given in the heading of the table the values of R_c, V_c High, V_s, and V Low are increased tenfold.

REDUCTION OF TEMPERATURE TO SEA LEVEL.

Table 44. *English Measures.*

Table 45. *Metric Measures.*

These tables give for different altitudes and for different uniform rates of decrease of temperature with altitude, the amount in hundredths of a degree Fahrenheit and Centigrade, which must be added to observed temperatures in order to reduce them to sea level.

The rate of decrease of temperature with altitude varies from one region to another, and in the same region varies according to the season and the meteorological conditions; being in general greater in warm latitudes than in cold ones, greater in summer than in winter, and greater in areas of falling pressure than in areas of rising pressure. For continental plateau regions, the reduction often becomes fictitious or illusory. The use of the tables therefore requires experience and judgment in selecting the rate of decrease of temperature to be used. Much experimental work is now in progress with kites and balloons to determine average vertical gradients. It must be remembered that the tables here given are not tables giving the data as recently determined for various elevations.

The tables are given in order to facilitate the reduction of temperature either upward or downward in special investigations, but the reduction is not ordinarily applied to meteorological observations.

The tables, 44 and 45, are computed for rates of temperature change ranging from 1° Fahrenheit in 200 feet to 1° Fahrenheit in 900 feet, and from 1° Centigrade in 100 meters to 1° Centigrade in 500 meters; and for altitudes up to 5000 feet and 3000 meters respectively.

Example, Table 44.

Observed temperature at an elevation of 2,500 feet,	52°.5 *F.*
Reduction to sea level for an assumed decrease in temperature of 1° *F.* for every 300 feet,	+ 8°.3
Temperature reduced to sea level,	60°.8 *F.*

Example, Table 45.

Observed temperature at an elevation of 500 meters,	12°.5 *C.*
Reduction to sea level for an assumed decrease in temperature of 1° *C.* for every 200 meters,	+ 2°.5
Temperature reduced to sea level,	15°.0 *C.*

BAROMETRICAL TABLES.

REDUCTION TO A STANDARD TEMPERATURE OF OBSERVATIONS MADE WITH MERCURIAL BAROMETERS HAVING BRASS SCALES.

The indicated height of the mercurial column in a barometer varies not only with changes of atmospheric pressure, but also with variations of the temperature of the mercury and of the scale. It is evident therefore that if the height of the barometric column is to be a true relative measure of atmospheric pressure, the observed readings must be reduced to the values they would have if the mercury and scale were maintained at a constant standard temperature. This reduction is known as the reduction for temperature, and combines both the correction for the expansion of the mercury and that for the expansion of the scale, on the assumption that the attached thermometer gives the temperature both of the mercury and of the scale.

The freezing point is universally adopted as the standard temperature of the mercury, to which all readings are to be reduced. The temperature to which the scale is reduced is the normal or standard temperature of the adopted standard of length. For English scales, which depend upon the English yard, this is 62° Fahrenheit. For metric scales, which depend upon the meter, it is 0° Centigrade. As thus reduced, observations made with English and metric barometers become perfectly comparable when converted by the ordinary tables of linear conversion, viz: inches to millimeters and millimeters to inches (see Tables 9, 10), for these conversions refer to the meter at 0° Centigrade and the English yard at 62° Fahrenheit.

Prof. C. F. Marvin in the Monthly Weather Review for July, 1898, has pointed out the necessity of caution in conversion of metric and English barometer readings:

Example:

Attached thermometer, 25°.4 *C.*
Barometer reading, 762.15 mm.

If the temperature is converted to Fahrenheit = 77°.7 and the reading to 30.006 in., the temperature correction according to table 47 would be —0.133 inch and the reduced reading 29.873. *This would be erroneous.* The correct conversion is found by taking the correction corresponding to 25°.4 *C.* and 762 mm., *i.e.*, – 3.15 mm., which gives a corrected reading of 759 mm., and converted into inches gives 29.882 which is the correct result.

Professor Marvin further remarks that circumstances sometimes arise in which a Centigrade thermometer may be used to determine the temperature of an English barometer, or a Fahrenheit attached thermometer may be used with a metric scale. In all such cases the temperature must be brought into the same system of units as the observed scale reading before corrections can be applied, and the observed reading must then be corrected for temperature before any conversion can be made.

With aneroid barometers corrections for temperature and instrumental error must be determined for each instrument.

The general formula for reducing mercurial barometers with brass scales to the standard temperature is

$$C = -B\frac{m(t-T) - l(t-\theta)}{1 + m(t-T)},$$

in which C = Correction for temperature.
B = Observed height of the barometric column.
t = Temperature of the attached thermometer.
T = Standard temperature of the mercury.
m = Coefficient of expansion of mercury.
l = Coefficient of linear expansion of brass.
θ = Standard temperature of the scale.

The accepted determination of the coefficient of expansion of mercury is that given by Broch's reduction of Regnault's experiments, viz:

$$m \text{ (for } 1^\circ C.) = 10^{-9} (181792 + 0.175t + 0.035116t^2).$$

As a sufficiently accurate approximation, the intermediate value

$$m = 0.0001818$$

has been adopted uniformly for all temperatures in conformity with the usage of the *International Meteorological Tables.*

Various specimens of brass scales made of alloys of different composition show differences in their coefficients of expansion amounting to eight and sometimes ten per cent. of the total amount. The *Smithsonian Tables* prepared by Prof. Guyot were computed with the average value l (for 1° $C.$) = 0.0000188; for the sake of uniformity with the *International Meteorological Tables,* the value

$$l = 0.0000184$$

has been used in the present volume. For any individual scale, either value may easily be in error by four per cent.

A small portion of the tables has been independently computed, but the larger part of the values have been copied from the *International Meteorological Tables,* one inaccuracy having been found and corrected.

Table 46. *Reduction of the barometer to standard temperature — English measures.*

For the English barometer the formula for reducing observed readings to a standard temperature becomes

$$C = -B\frac{m\,(t - 32^\circ) - l\,(t - 62^\circ)}{1 + m\,(t - 32^\circ)}$$

in which B = Observed height of the barometer in English inches.
t = Temperature of attached thermometer in degrees Fahrenheit.

$$m = 0.0001818 \times \frac{5}{9} = 0.000101$$

$$l = 0.0000184 \times \frac{5}{9} = 0.0000102$$

The combined reduction of the mercury to the freezing point and of the scale to 62° Fahrenheit brings the point of no correction to approximately 28°.5 Fahrenheit. For temperatures above 28°.5 Fahrenheit, the correction is subtractive, and for temperatures below 28°.5 Fahrenheit, the correction is additive, as indicated by the signs (+) and (−) inserted throughout the table.

The table gives the corrections for every half degree Fahrenheit from 0° to 100°. The limits of pressure are 19 and 31.6 inches, the corrections being computed for every half inch from 19 to 24 inches, and for every two-tenths of an inch from 24 to 31.6 inches.

Example:

Observed height of barometer	=	29.143
Attached thermometer, 54°.5 *F.*		
Reduction for temperature	= −	0.068
Barometric reading corrected for temperature	=	29.075

TABLE 47. *Reduction of the barometer to standard temperature — Metric measures.*

For the metric barometer the formula for reducing observed readings to the standard temperature, 0° *C.*, becomes

$$C = -B\frac{(m-l)t}{1+mt}$$

in which C and B are expressed in millimeters and t in Centigrade degrees.

$$m = 0.0001818; \quad l = 0.0000184.$$

In the table, the limits adopted for the pressure are 440 and 795 millimeters, the intervals being 10 millimeters between 440 and 600 millimeters, and 5 millimeters between 600 and 795 millimeters.

The limits adopted for the temperature are 0° and + 35°.8, the intervals being 0°.5 and 1°.0 from 440 to 560 millimeters, and 0°.2 from 560 to 795 millimeters.

For temperatures above 0° Centigrade the correction is *negative*, and hence is to be subtracted from the observed readings.

For temperatures below 0° Centigrade the correction is *positive*, and from 0° *C.* down to − 20° *C.* the numerical values thereof, for ordinary barometric work, do not materially differ from the values for the corresponding temperatures above 0° *C.* Thus the correction for − 9° *C.* is *numerically* the same as for + 9° *C.* and is taken from the table. In physical work of extreme precision, the numerical values given for positive temperatures may be used for temperatures below 0° *C.* by applying to them the following corrections:

Corrections to be applied to the tabular values of Table 47 in order to use them when the temperature of the attached thermometer is below 0° Centigrade.

Temperature.	PRESSURE IN MILLIMETERS.							
	450	500	550	600	650	700	750	800
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
− 1°	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
− 9	.00	.00	.00	.00	.00	.00	.00	.00
−10	0.00	0.00	0.00	0.00	0.00	+0.01	+0.01	+0.01
11	.00	.00	.00	.00	+0.01	.01	.01	.01
12	.00	.00	.00	+0.01	.01	.01	.01	.01
13	.00	.00	+0.01	.01	.01	.01	.01	.01
−14	.00	+0.01	.01	.01	.01	.01	.01	.01
−15	+0.01	+0.01	+0.01	+0.01	+0.01	+0.01	+0.01	+0.01
16	.01	.01	.01	.01	.01	.01	.01	.01
17	.01	.01	.01	.01	.01	.01	.01	.02
18	.01	.01	.01	.01	.01	.01	.01	.02
−19	.01	.01	.01	.01	.01	.01	.02	.02
−20	+0.01	+0.01	+0.01	+0.01	+0.01	+0.02	+0.02	+0.02
21	.01	.01	.01	.02	.02	.02	.02	.02
22	.01	.01	.02	.02	.02	.02	.02	.02
23	.01	.02	.02	.02	.02	.02	.02	.02
−24	.01	.02	.02	.02	.02	.02	.02	.03

Example:

Observed height of barometer, $763.17^{mm.}$: Temperature of the attached thermometer, − 12° *C.*

Numerical value of the reduction for + 12° *C.*	=	1.50
Correction for temperature below 0° *C.*	= +	0.01
Reduction for − 12° *C.*	= +	1.51
Observed height of barometer	=	763.17
Barometer corrected for temperature	=	764.68

REDUCTION OF THE MERCURIAL BAROMETER TO STANDARD GRAVITY.

Tables 48, 49, 50.

The mercurial barometer does not directly measure the atmospheric pressure. The latter is proportional to the weight of the mercurial column, and also to its height after certain corrections have been applied. Since the height of the barometric column is easily measured, by common consent the pressures are expressed in terms of this corrected height.

The observed height of the barometer changes with the temperature of the mercury as already shown, and also with the variations in the value of gravity, as well as with the pressure. Therefore, to obtain a height that shall be a true relative measure of the atmospheric pressure, the observed height of the mercurial column must not only be reduced to what its height would be if at a standard temperature, but also to what it would be at a standard value of gravity.

As stated on page xviii, the standard value of gravity adopted is 980.665 dynes. At the time of its adoption this value was assumed to apply for "latitude 45° and sea-level" on the basis of the absolute determination of g at the International Bureau by Defforges, 1887–1890 (Procés-Verbaux, Comité Inter. d. Poids et Mesures, 1887, pp. 27–28, 86; 1891, p. 135).

More recent determinations,[1] based upon numerous measurements in all parts of the world, and assuming a certain ideal figure for the earth, give for the mean value of g at latitude 45° and sea level the value 980.621 dynes. This differs from the standard value by 0.044 dyne. Departures of this magnitude from the mean sea-level gravity of a given latitude are frequently encountered, and in some cases surpassed. They are attributed to topography and isostatic compensation, and to gravity anomalies. For example, according to Bowie,[2] at Pikes Peak, Colo., the correction for topography and compensation is + 0.187 dyne, while the gravity anomaly[3] is + 0.021 dyne, giving a total gravity departure of + 0.208 dyne. Also, at Seattle, Wash., from the mean of measurements at two stations, the correction for topography and compensation is − 0.019 dyne[4] and the gravity anomaly is − 0.093 dyne,[5] giving a total gravity departure of − 0.112 dyne. The gravity departure at Pikes Peak is sufficient to cause the barometer to read 0.004 inch or 0.10 mm. low, while the departure at Seattle is sufficient to cause the barometer to read 0.003 inch or 0.09 mm. high, as compared with what the readings would have been with gravity at normal intensity for the latitudes of the respective stations.

From the foregoing it is evident that the value of local gravity, g_l, at the observing station must be determined before the barometer reading can be accurately reduced to standard gravity. In many cases, and especially at sea, it is not practicable to measure g_l. In the United States its value may frequently be determined with sufficient accuracy in the following manner:

(1) Compute g_ϕ, mean gravity at sea level for the latitude of the station, from the equation[6]

$$g_\phi = 978.039\ (1 + 0.005294 \sin^2\phi - 0.000007 \sin^2 2\phi),$$
$$= 980.621\ (1 - 0.002640 \cos 2\phi + 0.000007 \cos^2 2\phi)$$

(2) Correct g_ϕ for altitude by the equation[7]

$$c \text{ (dynes)} = -\ 0.0003086\ h \text{ (meters), or}$$
$$c \text{ (dynes)} = -\ 0.000094\ h \text{ (feet),}$$

[1] Investigations of gravity and isostasy, by William Bowie. U.S. Coast and Geodetic Survey, Special Publication No. 40, 1917, p. 134.
[2] Op. cit. p. 50. [3] Op. cit. p. 59. [4] Op. cit. p. 50. [5] Op. cit. p. 59.
[6] Bowie, op. cit. p. 134. [7] Bowie, op. cit. p. 93.

where h is the altitude of the station above sea level.

(3) Correct g_ϕ for gravity anomaly.[1]

(4) Finally, g_ϕ is to be corrected for topography and isostatic compensation.[2]

Example:

To determine the value of local gravity g_l, at the Weather Bureau Office, Atlanta, Ga., latitude 33° 45′ N., longitude 84° 23′ W., height of barometer above sea level, 1218 feet.

From Table 83, mean sea level gravity for latitude 33° 45′	=	979.631 dynes.
Correction for height of barometer (-0.000094×1218)	= −	0.114 "
Correction for gravity anomaly,	= −	0.023 "
Correction for topography and compensation	= +	0.014 "
Local gravity at Weather Bureau Office, Atlanta, Ga.	=	979.508 dynes.

Having determined g_l, the reduction of barometer readings to standard gravity is easily and accurately accomplished by multiplying by the ratio g_l/g, or by applying a correction to the barometer reading, otherwise corrected, derived from the expression $\frac{(g_l - g)}{g} B$. With $g_l < g$ the correction is to be subtracted; with $g_l > g$ the correction is to be added. In general, sufficient accuracy will be attained by computing the gravity correction for a station once for all from the equation $C = B_n \frac{(g_l - g)}{g}$, in which B_n is the normal station barometer pressure, and C is expressed in the same units as B_n.

Table 48 gives corrections to reduce barometer readings to standard gravity. The top argument is the barometer reading. The side argument is the difference, $g_l - g$, for each tenth of a dyne up to 4.0 dynes. The relation is a linear function of both $g_l - g$ and B, and for barometer readings 10 or 100 times greater than those given in the argument the correction may be obtained by removing the decimal point in the tabulated values one or two places, respectively, to the right. The correction obtained will be expressed in the same units as the barometer reading to be corrected.

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[1] In most cases the gravity anomaly may be obtained from Bowie's paper, op. cit., figure 11.

[2] In some cases this correction may be obtained from Bowie's paper, op. cit., pp. 50–52, but in many cases, and especially in mountainous districts, it must be separately computed for each station.

Example 1.

The barometer reading corrected for temperature is 29.647 inches, and the local value of gravity is 978.08. The difference, $g_l - g$, $= -2.585$. From the table,

the correction for a barometer reading of 20 inches	=	− 0.0527 in.
the correction for a barometer reading of 9 inches	=	− 0.0237 in.
the correction for a barometer reading of 0.65 inches	=	− 0.0017 in.
Correction for a barometer reading of 29.65 inches	=	− 0.078 in.
Corrected barometer reading = 29.647 in. − 0.078 in.	=	29.569 in.

Example 2.

The barometer reading reduced to 0° *C.* is 637.42 mm., and the local value of gravity is 981.51. The difference, $g_l - g = +0.845$. From the table,

the correction for a barometer reading of 600 mm.	=	+ 0.517 mm.
the correction for a barometer reading of 30 mm.	=	+ 0.026 mm.
the correction for a barometer reading of 7 mm.	=	+ 0.006 mm.
Correction for a barometer reading of 637.4 mm.	=	+ 0.55 mm.
Corrected barometer reading = 637.42 + 0.55	=	+ 637.97 mm.

In the case of barometer readings made at sea, and also at some land stations, it is not practicable to determine local gravity with greater accuracy than it can be computed from the equations for variation with latitude and altitude given above. The reduction to standard gravity, accordingly, consists of two parts — a correction for altitude, and a correction from the computed sea-level gravity for the latitude of the station to standard gravity. The first part of the correction, or the correction for altitude, may be computed once for all from the expression $c = -0.0003086\ h\ B_n$ (metric measures), or $c = -0.000094\ h\ B_n$ (English measures), and is usually combined with the reduction of the barometer to sea level or to some other reference plane. The second part has heretofore consisted of a correction for the difference between the mean value of gravity for the latitude of the station and for latitude 45°; and, in accordance with the equation given above, it may be derived from the expression

$$(-0.002640 \cos 2\phi + 0.000007 \cos^2 2\phi)\, B$$

where ϕ is the latitude of the station, and B is the barometer reading. The value of the ratio $\frac{g_{45^\circ} - g}{g} = \frac{980.621 - 980.665}{980.665} = -0.000045$. Therefore, the expression for the gravity correction becomes

$$(-0.00264 \cos 2\phi + 0.000007 \cos^2 2\phi - 0.000045)\, B$$

Table 49 (*English measures*) gives the corrections in thousandths of an inch for every degree of latitude and for each inch of barometric pressure from 19 to 30 inches, to reduce barometer readings to standard gravity, computed from the equation

$$C = (-0.00264 \cos 2\phi + 0.000007 \cos^2 2\phi - 0.000045) B$$

Table 50 (*metric measures*) gives the same corrections in hundredths of a millimeter for each 20 millimeters barometric pressure from 520 to 780 millimeters.

Example:

Barometric reading (corrected for temperature) at latitude 63° 55′,	= 27.434 inches
Correction to standard gravity, Table 49,	= 0.043 inches
Barometer reduced to standard gravity,	= 27.477 inches

The adoption of this new value for standard gravity may require a slight correction to old barometric records in order to make the entire series of readings homogeneous. The amount of this correction will be the difference between the gravity correction computed by these new tables and by the old tables.

Example:

Seattle, Wash., Lat. 47° 38′ N. Long. 122° 20′ W., height of barometer above sea level 125 feet, normal station barometer 29.89 inches.

g_ϕ (Table 83)	=	980.859 dynes.
Correction for height (-0.000094×125)	= −	.012 "
Correction for topography and compensation	= −	.019 "
Correction for gravity anomaly	= −	.093 "
Value of local gravity		980.735 dynes.

Correction to reduce barometer readings to standard gravity, $\frac{980.735 - 980.665}{980.665} B_n = +0.002$ inch. Old correction, +0.007; correction to old records = 0.002 in. − 0.007 in. = − 0.005 in.

For correcting back records of readings at sea, or at any place where the value of local gravity cannot be determined, the correction is equal to the ratio $\frac{980.599 - 980.665}{980.665} B = -0.000067 B$. The corrections are as follows:

Barometer reading.	Correction.
From 7 to 22 inches	− 0.001 in.
From 23 to 32 inches	− 0.002 in.
From 380 to 520 mm.	− 0.03 mm.
From 530 to 670 mm.	− 0.04 mm.
From 680 to 820 mm.	− 0.05 mm.

THE HYPSOMETRIC FORMULA AND ITS CONSTANTS.

The fundamental formula for reducing the barometer to sea level and for determining heights by the barometer is the original formula of Laplace, amplified into the following form —

$$(1)\quad Z = K(1+\alpha\theta)\left(\frac{1}{1-0.378\frac{e}{b}}\right)\left(1+\frac{g-g_l}{g}\right)\left(1+\frac{h+h_0}{R}\right)\log\frac{p_0}{p},$$

or, where g_l, the value of local gravity is unknown,

$$(2)\quad Z = K(1+\alpha\theta)\left(\frac{1}{1-0.378\frac{e}{b}}\right)(1+k\cos 2\phi - k'\cos^2 2\phi + C)\left(1+\frac{h+h_0}{R}\right)\log\frac{p_0}{p}$$

in which
- h = Height of the upper station.
- h_0 = Height of the lower station.
- $Z = h - h_0$.
- p = Atmospheric pressure at the upper station.
- p_0 = Atmospheric pressure at the lower station.
- R = Mean radius of the earth.
- θ = Mean temperature of the air column between the altitudes h and h_0.
- e = Mean pressure of aqueous vapor in the air column.
- b = Mean barometric pressure of the air column.
- ϕ = Latitude of the stations.
- K = Barometric constant.
- α = Coefficient of the expansion of air.
- k and k' = Constants depending on the figure of the earth.
- C = Constant = the ratio $\frac{g_{45^\circ}-g}{g}$.
- g = standard value of gravity = 980.665 dynes.
- g_l = Local value of gravity.

The pressures p_0 and p are computed from the height of the column of mercury at the two stations; the ratio $\frac{B_0}{B}$ of the barometric heights may be substituted for the ratio $\frac{p_0}{p}$, if B_0 and B are reduced to the values that would be measured at the same temperature and under the same relative value of gravity.

The correction of the observed barometric heights for instrumental temperature is always separately made, but the correction for the variation of gravity with altitude is generally introduced into the formula itself.

If B_0, B represent the barometric heights corrected for temperature only, we have the equation

$$\frac{p_0}{p} = \frac{B_0}{B}\left(1+\mu\frac{Z}{R}\right),$$

μ being a constant depending on the variation of gravity with altitude $\left(\frac{\mu}{R} = 0.0000003\right)$, and

$$\log \frac{p_0}{p} = \log \frac{B_0}{B} + \log \left(1 + \mu \frac{Z}{R}\right).$$

Since $\frac{\mu Z}{R}$ is a very small fraction, we may write

$$\text{Nap. log} \left(1 + \frac{\mu Z}{R}\right) = \frac{\mu Z}{R}, \text{ and log} \left(1 + \frac{\mu Z}{R}\right) = \frac{\mu Z}{R} M,$$

M being the modulus of common logarithms.

By substituting for Z its approximate value $Z = K \log \frac{B_0}{B}$, we have

$$\log \left(1 + \frac{\mu Z}{R}\right) = \frac{\mu K}{R} M \log \frac{B_0}{B}.$$

With these substitutions the barometric formula becomes

$$(1) \quad Z = K(1 + \alpha\theta) \left(\frac{1}{1 - 0.378\frac{e}{b}}\right) \left(1 + \frac{g - g_1}{g}\right) \left(1 + \frac{h + h_0}{R}\right) \times \left(1 + \frac{\mu K}{R} M\right) \log \frac{B_0}{B}, \text{ or}$$

$$(2) \quad Z = K(1 + \alpha\theta) \left(\frac{1}{1 - 0.378\frac{e}{b}}\right) (1 + k \cos 2\phi - k' \cos^2 2\phi + C) \left(1 + \frac{h + h_0}{R}\right) \times \left(1 + \frac{\mu K}{R} M\right) \log \frac{B_0}{B}.$$

As a further simplification we shall put

$$\beta = 0.378\frac{e}{b}, \ \gamma = k \cos 2\phi - k' \cos^2 2\phi + C \text{ and } \eta = \frac{\mu K}{R} M,$$

and write for the second form, (2), the formula —

$$Z = K(1 + \alpha\theta) \left(\frac{1}{1 - \beta}\right) (1 + \gamma) \left(1 + \frac{h + h_0}{R}\right) (1 + \eta) \log \frac{B_0}{B}.$$

Values of the constants. — The barometric constant K is a complex quantity defined by the equation

$$K = \frac{\Delta \times B_n}{\delta \times M}.$$

B_n is the normal barometric height of Laplace, 760 *mm.*

Δ is the density of mercury at the temperature of melting ice. The value adopted by the International Meteorological Committee, and which has been employed in previous editions of these tables is $\Delta = 13.5956$. The most probable value, taking into account the recently determined relation between the liter and the cubic decimeter,[1] is as already stated, $\Delta = 13.5951$ and this value is here adopted.

δ is the density of dry air at $0°C$ under the pressure of a column of mercury B_n and under standard gravity. The value adopted by the International Bureau of Weights and Measures for air under the above conditions and free from CO_2 is $\delta = 0.0012928$ grams per cubic centimeter.[2] This is in close agreement with the value ($\delta = 0.00129278$) used in previous editions of these tables. For air containing 4 parts in 10000 of CO_2 it gives a density of 0.00129307, and for air containing 3 parts in 10000 of CO_2, the proportion adopted by Hann,[3] it gives a density of 0.00129301. Therefore, the value adopted for the density of air containing an average amount of CO_2 is

$$\delta = 0.0012930$$

M (Modulus of common logarithms) = 0.4342945. These numbers give for the value of the barometric constant

$$K = 18400 \text{ meters.}$$

For the remaining constants, the following values have been used:

$\alpha = 0.00367$ for 1° Centigrade. (International Bureau of Weights and Measures: *Travaux et Mémoires*, t. I, p. A. 54.)

$\lambda = k \cos 2\phi - k' \cos^2 2\phi + C = 0.002640 \cos 2\phi - 0.000007 \cos^2 2\phi + 0.000045$

$R = 6367324$ meters. (A. R. Clarke: *Geodesy*, 8°, Oxford, 1880.)

$\eta = \dfrac{\mu K M}{R} = 0.002396.$ (Ferrel: *Report Chief Signal Officer*, 1885, pt. 2, pp. 17 and 393.)

TABLES 51, 52, 53, 54, 55.

THE DETERMINATION OF HEIGHTS BY THE BAROMETER.

Tables 51, 52, 53, 54, 55.

English Measures.

Since a barometric determination of the height will rarely be made at a place where g_l is known, the discussion which follows will be confined to the second form of the barometric formula developed in the preceding section (see page xxxix). For convenience in computing heights it is arranged in the following form:

$$Z = K(\log B_0 - \log B)\left[\begin{array}{l}(1+\alpha\theta)\\(1+\beta)\\(1+k\cos 2\phi - k'\cos^2 2\phi + C)(1+\eta)\\\left(1+\dfrac{Z+2h_0}{R}\right)\end{array}\right]$$

[1] Comptes Rendus, Quatrième Conférence Générale Poids et Mesures, 1907, pp. 60–61.
[2] Leduc, l.c.
[3] Lehrbuch der Meteorologie, dritte Auflage, 1915, s. 5.

in which K (log B_0 − log B) is an approximate value of Z and the factors in the brackets are correction factors depending respectively on the air temperature, the humidity, the variation of gravity with latitude, the variation of gravity with altitude in its effect on the weight of mercury in the barometer, and the variation of gravity with altitude in its effect on the weight of the air. With the constants already given, the formula becomes in English measures:

$$Z\text{ (feet)} = 60368^{1} (\log B_0 - \log B) \left[\begin{array}{l} [1 + 0.002039\,(\theta - 32^\circ)] \\ (1+\beta) \\ (1 + 0.002640 \cos 2\phi - 0.000007 \cos^2 2\phi \\ \qquad + 0.000045)\ (1 + 0.00239) \\ \left(1 + \dfrac{Z + 2h_0}{R}\right) \end{array}\right]$$

In order to make the temperature correction as small as possible for average air temperatures, 50° F. will be taken as the temperature at which the correction factor is zero. This is accomplished by the following transformation:

$$1 + 0.002039\,(\theta - 32^\circ) = [1 + 0.002039\,(\theta - 50^\circ)]\,[1 + 0.0010195 \times 36^\circ].$$

The second factor of this expression combines with the constant, and gives 60368 (1 + 0.0010195 × 36°) = 62583.6.

The first approximate value of Z is therefore

$$62583.6\,(\log B_0 - \log B).$$

In order further to increase the utility of the tables, we shall make a further substitution for log B_0 − log B, and write

$$62583.6\,(\log B_0 - \log B) = 62583.6\left(\log\frac{29.9}{B} - \log\frac{29.9}{B_0}\right).$$

Table 51 contains values of the expression

$$62583.6 \log\frac{29.9}{B}$$

for values of B varying by intervals of 0.01 inch from 12.00 inches to 30.90 inches.

The first approximate value of Z is then obtained by subtracting the tabular value corresponding to B_0 from the tabular value corresponding to B (B and B_0 being the barometric readings observed and corrected for temperature at the upper and lower stations respectively).

Table 52 gives the temperature correction

$$Z \times 0.002039\,(\theta - 50^\circ).$$

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[1] In accordance with the relation between the meter and the foot given on p. xix, this constant should be 60367. (See Table 14.)

The side argument is the mean temperature of the air column (θ) given for intervals of 1° from 0° to 100° *F.* The top argument is the approximate difference of altitude Z obtained from Table 51.

For temperatures above 50° *F.*, the correction is to be added, and for temperatures below 50° *F.*, the correction is to be subtracted. It will be observed that the correction is a linear function of Z, and hence, for example, the value for $Z = 1740$ is the sum of the corrections in the columns headed 1000, 700, and 40.

In general, accurate altitudes cannot be obtained unless the temperature used is freed from diurnal variation.

Table 53 gives the correction for gravity, and for the effect of the variation of gravity with altitude on the weight of the mercury. When altitudes are determined with aneroid barometers the second factor does not enter the formula. In this case the effect of the latitude factor can be obtained by taking the difference between the tabular value for the given latitude and the tabular value for latitude 45° 29′. The side argument is the latitude of the station given for intervals of 2°. The top argument is the approximate difference of height Z.

Table 54 gives the correction for the average humidity of the air at different temperatures. In evaluating the humidity factor as a function of the air temperature, the tables given by Prof. Ferrel have been adopted (*Meteorological researches. Part iii. — Barometric hypsometry and reduction of the barometer to sea level.* Report, U.S. Coast Survey, 1881. Appendix 10.) These tables by interpolation, and by extrapolation below 0° *F.*, give the following values for β:

For Fahrenheit temperatures,

θ	β	θ	β	θ	β	θ	β
F.		F.		F.		F.	
−20°	0.00008	10°	0.00104	36°	0.00267	62°	0.00724
−16	.00020	12	.00111	38	.00293	64	.00762
−12	.00032	14	.00118	40	.00322	66	.00801
− 8	.00044	16	.00126	42	.00353	68	.00839
		18	.00134	44	.00386	70	.00877
− 6	0.00050	20	.00143	46	.00421	72	.00914
− 4	.00056	22	.00153	48	.00458		
− 2	.00062	24	.00163	50	.00496	76	0.00990
0	.00068	26	.00174	52	.00534	80	.01065
+ 2	.00075	28	.00187	54	.00572	84	.01141
4	.00082	30	.00203	56	.00610	88	.01217
6	.00089	32	.00222	58	.00648	92	.01293
8	.00096	34	.00243	60	.00686	96	.01369

This correction could have been incorporated with the temperature factor in Table 52, but it is given separately in order that the magnitude of the correction may be apparent, and in order that, when the actual humidity is observed, the correction may be computed if desired, by the expression

$$Z\left(0.378\,\frac{e}{b}\right)$$

where e is the mean pressure of vapor in the air column, and b the mean barometric pressure.

The side argument is the mean temperature of the air column, varying by intervals of 2° from − 20° *F.* to 96° *F.*, except near the extremities of the table where the interval is 4°. The top argument is the approximate difference of altitude Z.

Table 55 gives the correction for the variation of gravity with altitude in its effect on the weight of the air. The side argument is the approximate difference of altitude Z, and the top argument is the elevation of the lower station h_0.

The corrections given by Tables 53, 54, and 55 are all additive.

Example:

Let the barometric pressure observed, and corrected for temperature, at the upper and lower stations be, respectively, $B = 23.61$ and $B_0 = 29.97$. Let the mean temperature of the air column be 35° *F.*, and the latitude 44° 16′. To determine the difference of height.

	Feet.
Table 51, argument 23.61, gives	6420
Table 51, " 29.97, "	− 64
Approximate difference of height (Z)	= 6484
Table 52, with $Z = 6484$ and $\theta = 35°$ *F.*, gives	− 198
Table 53, with $Z = 6300$ and $\phi = 44°$, gives	+ 16
Table 54, with $Z = 6300$ and $\theta = 35°$ *F.*, gives	+ 16
Table 55, with $Z = 6300$ and $h_0 = 0$, gives	+ 2
Final difference of height (Z)	= 6320

If in this example the barometric readings be observed with aneroid barometers, the correction to be obtained from Table 53 will be simply the portion due to the latitude factor, and this will be obtained by subtracting the tabular value for 45° 29′ from that for 44°, the top argument being $Z = 6300$. This gives 16 − 15 = 1.

Tables 56, 57, 58, 59, 60, 61, 62, 63.

Metric and Dynamic Measures.

The barometric formula developed on page xli is, in metric and dynamic units,

$$Z\text{ (meters)} = 18400\,(\log B_0 - \log B)\left[\begin{array}{l}(1+0.00367\ \theta\ C.)\\(1+0.378\frac{e}{b})\\(1+0.002640\cos 2\phi - 0.000007\cos^2 2\phi\\\qquad + 0.000045)\ (1+0.00239)\\\left(1+\dfrac{Z+2\,h_0}{6\,367\,324}\right)\end{array}\right]$$

The approximate value of Z (the difference of height of the upper and lower station) is given by the factor 18400 ($\log B_0 - \log B$). This expression is computed by means of two entries of a table whose argument is the barometric pressure. In order that the two entries may result at once in an approximate value of the elevation of the upper and lower stations, a transformation is made, which gives the following identities:

$$18400\,(\log B_0 - \log B) = 18400\left(\log\frac{760}{B} - \log\frac{760}{B_0}\right)\text{—Metric measures,}$$

and $18400\,(\log B_0 - \log B) = 18400\left(\log\frac{1013.3}{B} - \log\frac{1013.3}{B_0}\right)$—Dynamic measures.

Table 56 gives values of the expression $18400 \log \frac{760}{B}$ for values of B varying by intervals of 1 mm. from 300 mm. to 779 mm. The first approximate value of Z is then obtained by subtracting the tabular value corresponding to B_0 from the tabular value corresponding to B (B and B_0 being the barometric readings observed and reduced to 0° $C.$ at the upper and lower stations respectively). The first entry of Table 56 with the argument B gives an approximate value of the elevation of the upper station above sea level, and the second entry with the argument B_0 gives an approximate value of the elevation of the lower station.

Table 57 gives values of the expression $18400 \log \frac{1013.3}{B}$ for values of B varying by intervals of 1 mb. from 0 mb. to 1049 mb. The approximate value of Z is then obtained by subtracting the tabular value corresponding to B_0 from the tabular value corresponding to B (B and B_0 being the barometric readings observed and reduced to 0° $C.$ at the upper and lower stations respectively). The first entry of Table 57 with the argument B gives an approximate value of the elevation of the upper station above sea level, and the second entry with the argument B_0 gives an approximate value of the elevation of the lower station.

Table 58 gives the temperature correction factor, $a = 0.00367\theta$, for each tenth of a degree centigrade, from 0° $C.$ to 50.9° $C.$ To find the correction corresponding to any mean temperature of the air column, θ, multiply the approximate altitude as determined from Table 56 or 57 by the value of a obtained from this table, and add the result if θ is above 0° $C.$; subtract, if below 0° $C.$

Attention is called to the fact that the formula is linear with respect to θ, and hence that the correction, for example, for 59°.8 $C.$ equals the correction for 50°.8 plus the correction for 9° or .186 + .033 = .219, and is to be added.

Table 59 is an amplification of Table 58 and gives the temperature correction $0.00367\ \theta \times Z$.

The side argument is the approximate difference of elevation Z and the top argument is the mean temperature of the air column. The values of Z vary by intervals of 100 m. from 100 to 4000 meters and the temperature varies by intervals of 1° from 1° $C.$ to 10° $C.$ with additional columns for 20°, 30°, and 40° $C.$ This formula also is linear with respect to θ, and hence the correction, for example, for 27° equals the correction for 20° plus the correction for 7°. When the table is used for temperatures below 0° $C.$ the tabular correction must be subtracted from, instead of added to, the approximate value of Z.

Table 60 (pp. 149 and 150) gives the correction for humidity resulting from the factor $0.378\ \frac{e}{b} \times Z = \beta\ Z$.

Page 149 gives the value of $0.378\ \frac{e}{b}$ multiplied by 10000. The side argument is the mean pressure of aqueous vapor, e, which serves to represent the mean state of humidity of the air between the two stations. $e = \frac{1}{2}(e_1 + e_0)$ (e_1 and e_0 being the vapor pressures observed at the two stations) has been written at the head of the table, but the value to be assigned to e is in reality left to the observer, independently of all hypothesis. The top argument is the mean barometric pressure $\frac{1}{2}\ (B + B_0)$.

The vapor pressure varies by millimeters from 1 to 40, and the mean barometric pressure varies by intervals of 20 mm. from 500 mm. to 760 mm. The tabular values represent the humidity factor β, or $0.378\ \frac{e}{b}$, multiplied by 10000.

Page 150 gives the correction for humidity, with Z and $10000 \times 0.378\ \frac{e}{b}$ (derived from page 149) as arguments.

The approximate difference of altitude is given by intervals of 100 meters from 100 to 4000 meters, with additional lines for 5000, 6000, and 7000 meters. The values of 10000 β vary by intervals of 25 from 25 to 300. The tabular values are given in tenths of meters to facilitate and increase the accuracy of interpolation.

Table 61. Humidity correction: Value of $\frac{1}{2}\left(\frac{0.378\frac{e}{b}}{0.00367}\right)$. It has been found advantageous to express the humidity term, βZ, as a correction to the temperature term, $\alpha\ \theta\ Z$.

Let $\alpha \Delta\ \theta\ Z = \beta\ Z$; then,

$$\Delta\ \theta = \frac{\beta}{\alpha} = \frac{0.378\frac{e}{b}}{0.00367}.$$

For convenience in computing, the tabulated values of $\Delta\,\theta$ are for $\frac{1}{2}\left(\frac{0.378\frac{e}{b}}{0.00367}\right)$. The side and top arguments are air and vapor pressures, respectively, in mm. on p. 151 and in mb. on p. 152. Instead of computing $\Delta\,\theta$ from the mean of the values of B and e at the upper and lower stations it is computed for each station separately, and the sum of the two determinations is added to θ.

Table 62 gives the correction for gravity, and for the effect of the variation of gravity with altitude on the weight of the mercurial column. When altitudes are determined with aneroid barometers the latter factor does not enter the formula. In this case the effect of the latitude factor can be obtained by subtracting the tabular value for latitude 45° 29′ from the tabular value for the latitude in question.

The side argument is the approximate difference of elevation Z varying by intervals of 100 meters from 100 to 4000, and by 500 meters from 4000 to 7000. The top argument is the latitude, varying by intervals of 5° from 0° to 75.°

Table 63 gives the correction for the variation of gravity with altitude in its effect on the weight of the air.

The side argument is the same as in Table 62; the top argument is the height of the lower station, varying by intervals of 200 meters from 0 to 2000, with additional columns for 2500, 3000 and 4000 meters.

The corrections given in Table 62 and Table 63 apply to the approximate heights computed from metric or dynamic measures by the use of Tables 56 to 61, inclusive, and are additive.

Example: (Metric Measures.)

Let the barometric reading (reduced to 0° $C.$) at the upper station be 655.7 mm.; at the lower station, 772.4 mm. Let the mean temperature of the air column be $\theta = 12\overset{\circ}{.}3$ $C.$, the mean vapor pressure $e =$ 9 mm. and the latitude $\phi = 32°$.

Table 56, with argument 655.7, gives	1179 meters.
Table 56, " " 772.4, "	− 129
Approximate value of Z	= 1308
Table 59, with $Z = 1308$ and $\theta = 12\overset{\circ}{.}3$ C, gives	59
Table 60, with $e = 9$ mm. and $Z = 1370$, gives	7
Table 62, with $Z = 1370$ and $\phi = 32°$, gives	5
Table 63, with $Z = 1370$ and $h_0 = 0$, gives	0
Corrected value of Z	= 1379 meters.

Example: (Dynamic Measures.)

Let the barometer reading (reduced to 0° $C.$) at the upper station be 448.6 mb.; at the lower station, 1000.3 mb. Let the vapor pressure at the upper station be 2.4 mb.; at the lower station 7.3 mb. Let the mean temperature of the air column be $\theta = 5^\circ.8$ *C.* and the latitude $\phi = 39^\circ 25'$ *N.*

Table 57, with argument 448.6, gives	6511 meters.
Table 57, with argument 1000.3, gives	104
Approximate value of Z	6407 meters.
Table 61, with arguments 449 and 2.4 gives $\Delta\ \theta = 0.3$	
Table 61, with arguments 1000 and 7.3 gives $\Delta\ \theta = 0.4$	
Table 58, with $\theta = 5^\circ.8 + 0^\circ.7 = 6^\circ.5$, and $Z = 6407$ gives $6407 \times 0.024 =$	154
Table 62 with $Z = 6561$ and $\phi = 39^\circ 25'$, gives	19
Table 63 with $Z = 6561$ and $h_o = 0$, gives	7
Corrected value of Z	= 6587 meters.

TABLE 64. *Difference of height corresponding to a change of* 0.1 *inch in the barometer — English measures.*

If we differentiate the barometric formula, page xlii, we shall obtain, neglecting insensible quantities,

$$dZ = -26281\ \frac{dB}{B}\left(1 + 0.002039\ (\theta - 32^\circ)\right)(1 + \beta),$$

in which B represents the mean pressure of the air column dZ.

Putting $dB = 0.1$ inch,

$$dZ = -\frac{2628.1}{B}\left(1 + 0.002039\ (\theta - 32^\circ)\right)(1 + \beta).$$

The second member, taken positively, expresses the height of a column of air in feet corresponding to a tenth of an inch in the barometer under standard gravity. Since the last factor $(1 + \beta)$, as given on page xliii, is a function of the temperature, the function has only two variables and admits of convenient tabulation.

Table 64, containing values of dZ for short intervals of the arguments B and θ, has been taken from the Report of the U.S. Coast Survey, 1881, Appendix 10, — *Barometric hypsometry and reduction of the barometer to sea level*, by Wm. Ferrel.[1]

The temperature argument is given for every 5° from 30° *F.* to 85° *F.*, and the pressure argument for every 0.2 inch from 22.0 to 30.8 inches.

This table may be used in computing small differences of altitude, and, up to a thousand feet or more, very approximate results may be obtained.

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[1] Due to the use of a slightly different value for the coefficient of expansion, Prof. Ferrel's formula, upon which the table is computed, is

$$dZ = -\frac{2628.4}{B}\left(1 + 0.002034\ (\theta - 32^\circ)\right)(1 + \beta).$$

Example:

Mean pressure at Augusta, October, 1891, 29.94; temperature, $60\overset{\circ}{.}8$ *F.*
Mean pressure at Atlanta, October, 1891, 28.97; temperature, $59\overset{\circ}{.}4$
Mean pressure of air column $B = 29.455$; $\theta = 60\overset{\circ}{.}1$

Entering the table with 29.455 and $60\overset{\circ}{.}1$ as arguments, we take out 94.95 as the difference of elevation corresponding to a tenth of an inch difference of pressure. Multiplying this value by the number of tenths of inches difference in the observed pressures, viz. 97, we obtain the difference of elevation 921 feet.

TABLE 65.

TABLE 65. *Difference of height corresponding to a change of one millimeter in the barometer — Metric measures.*

This table has been computed by converting Table 64 into metric units. The temperature argument is given for every 2° from − 2° *C.* to + 36° *C.*; the pressure argument is given for 10-mm. intervals from 760 to 560 mm.

TABLE 66.

TABLE 66. *Babinet's formula for determining heights by the barometer.*

Babinet's formula for computing differences of altitude [1] represents the formula of Laplace quite accurately for differences of altitude up to 1000 meters, and within one per cent for much greater altitudes. As it has been quite widely disseminated among travelers and engineers, and is of convenient application, the formula is here given in English and metric measures. It might seem desirable to alter the figures given by Babinet so as to conform to the newer values of the barometrical constants now adopted; but this change would increase the resulting altitudes by less than one-half of one per cent without enhancing their reliability to a corresponding degree, on account of the outstanding uncertainty of the assumed mean temperature of the air.

The formula is, in English measures,

$$Z \text{ (feet)} = 52494 \left[1 + \frac{t_0 + t - 64^\circ}{900}\right] \frac{B_0 - B}{B_0 + B};$$

and in metric measures,

$$Z \text{ (meters)} = 16000 \left[1 + \frac{2\,(t_0 + t)}{1000}\right] \frac{B_0 - B}{B_0 + B},$$

in which Z is the difference of elevation between a lower and an upper station at which the barometric pressures corrected for all sources of instrumental error are B_0 and B, and the observed air temperatures are t_0 and t, respectively.

For ready computation the formula is written

$$Z = C \times \frac{B_0 - B}{B_0 + B},$$

[1] *Comptes Rendus*, Paris, 1850, vol. xxx., page 309.

and the factor C, computed both in English and metric measures, has been kindly furnished by the late Prof. Cleveland Abbe. The argument is $\frac{1}{2}(t_0 + t)$ given for every 5° Fahrenheit between 10° and 100° $F.$, and for every 2° Centigrade between − 10° and 36° Centigrade.

In using the table, it should be borne in mind that on account of the uncertainty in the assumed temperature, the last two figures in the value of C are uncertain, and are here given only for the sake of convenience of interpolation. Consequently one should not attach to the resulting altitudes a greater degree of confidence than is warranted by the accuracy of the temperatures and the formula. The table shows that the numerical factor changes by about one per cent of its value for every change of five degrees Fahrenheit in the mean temperature of the stratum of air between the upper and lower stations; therefore the computed difference of altitude will have an uncertainty of one per cent if the assumed temperature of the air is in doubt by 5° $F.$ With these precautions the observer may properly estimate the reliability of his altitudes whether computed by Babinet's formula or by more elaborate tables.

Example:

Let the barometric pressure observed and corrected for temperature at the upper and lower stations be, respectively, $B = 635$ mm. and $B_0 = 730$ mm. Let the temperatures be, respectively, $t = 15°$ $C.$, $t_0 = 20_0$ $C.$ To find the approximate difference of height:

With $\frac{1}{2}(t_0 + t) = \dfrac{20° + 15°}{2} = 17°.5$ $C.$, the table in metric measures gives

$$C = 17120 \text{ meters.} \qquad \frac{B_0 - B}{B_0 + B} = \frac{95}{1365}.$$

The approximate difference of height $= 17120 \times \dfrac{95}{1365} = 1191.5$ meters.

THERMOMETRICAL MEASUREMENT OF HEIGHTS BY OBSERVATION OF THE TEMPERATURE OF THE BOILING POINT OF WATER.

When water is heated in the open air, the elastic force of its vapor gradually increases, until it becomes equal to the incumbent weight of the atmosphere. Then, the pressure of the atmosphere being overcome, the steam escapes rapidly in large bubbles and the water boils. The temperature at which water boils in the open air thus depends upon the weight of the atmospheric column above it, and under a less barometric pressure the water will boil at a lower temperature than under a greater pressure. Now, as the weight of the atmosphere decreases with the elevation, it is obvious that, in ascending a mountain, the *higher* the station where an observation is made, the *lower* will be the temperature of the boiling point.

The difference of elevation between two places therefore can be deduced from the temperature of boiling water observed at each station. It is only necessary to find the barometric pressures which correspond to those temperatures, and from these to compute the difference of height by the tables given herein for computing heights from barometric observations.

From the above, it may be seen that the heights determined by means of the temperature of boiling water are less reliable than those deduced from barometric observations. Both derive the difference of altitude from the difference of atmospheric pressure. But the temperature of boiling water is a less accurate measurement of the atmospheric pressure than is the height of the barometer. In the present state of thermometry it would hardly be safe, indeed, to rely, in the most favorable circumstances, upon quantities so small as hundredths of a degree, even when the thermometer has been constructed with the utmost care; moreover, the quality of the glass of the instrument, the form and substance of the vessel containing the water, the purity of the water itself, the position at which the bulb of the thermometer is placed, whether in the current of the steam or in the water, — all these circumstances cause no inconsiderable variations to take place in the indications of thermometers observed under the same atmospheric pressure. Owing to these various causes, an observation of the boiling point, differing by one-tenth of a degree from the true temperature, ought to be still admitted as a good one. Now, as the tables show, an error of one-tenth of a degree Centigrade in the temperature of boiling water would cause an error of 2 millimeters in the barometric pressure, or of from 70 to 80 feet in the final result, while with a good barometer the error of pressure will hardly ever exceed one-tenth of a millimeter, making a difference of 3 feet in altitude.

Notwithstanding these imperfections, the hypsometric thermometer is of the greatest utility to travellers and explorers in rough countries, on account of its being more conveniently transported and much less liable to accidents than the mercurial barometer. A suitable form for it, designed by Regnault (*Annales de Chimie et de Physique*, Tome xiv, p. 202), consists of an accurate thermometer with long degrees, subdivided into tenths. For observation the bulb is placed about 2 or 3 centimeters above the surface of the water, in the steam arising from distilled water in a cylindrical vessel, the water being made to boil by a spirit-lamp.

TABLES 67, 68.

Barometric pressures at standard gravity corresponding to the temperature of boiling water.

TABLE 67. *English Measures.*

TABLE 68. *Metric Measures.*

Table 67 is copied directly from Table 70. The argument is the temperature of boiling water for every tenth of a degree from 185°.0 to 214°.9 Fahrenheit. The tabular values are given to the nearest 0.001 inch.

Table 68 is copied directly from Table 72. The argument is given for every tenth of a degree from 80°.0 to 100°.9 C. The tabular values are given to the nearest 0.01 mm.

HYGROMETRICAL TABLES.

PRESSURE OF SATURATED AQUEOUS VAPOR.

In former editions of these tables the values of aqueous vapor pressures at temperatures between − 29° and 100° C. were based upon Broch's reduction of the classic observations of Regnault. (*Travaux et Mémoires du Bureau international des Poids et Mesures*, t. I, p. A 19–39). In these computations the same continuous mathematical function was employed to calculate the values of vapor pressure both above and below the point of change of state on freezing. This resulted in a systematic disagreement between observed and computed vapor pressures below the freezing point, and confirmed the inference from the laws of diffusion following from the kinetic theory of gases, namely, that the pressure of the vapor is different according as it is in contact with its liquid or its solid.

Seeking to remove the uncertainty of the values of vapor pressures at temperatures below freezing, Marvin (Annual Report Chief Signal Officer, 1891, Appendix No. 10) made direct experimental determinations thereof, in the course of which the specimens of water were cooled to temperatures of from − 10° to − 12° C. while still retaining the liquid state, thus affording opportunity for measurements of vapor pressure over ice and over water at various temperatures below the freezing point. The results of these investigations, confirmed by similar independent studies by Juhlin, were printed in the third revised edition of these tables.

Since 1907, especially, several extended series [1] of entirely new determinations, together covering the whole range of temperature from − 70° *C.* to + 374° *C.*, have been made at the Physikalische-Technischen Reichsanstalt. Because of the elaborate instrumental means available and the extreme effort to eliminate all possible errors these results may be presumed to represent the most accurate series of experimental values of this important physical datum available to science.

Hitherto no satisfactory mathematical equation has been offered adequate to give computed values of vapor pressures with an order of precision comparable to the systematic self consistency of the observations

[1] Scheel, Karl und Heuse, Wilhelm. Bestimmung des Sättigungsdrucks von Wasserdampf unter 0°. Annalen der Physik, 1909, 29: 723–737.

Bestimmung des Sättigungsdrucks von Wasserdampf zwischen 0° und + 50°. Annalen der Physik, 1910, 31: 715–736.

Holborn, L. und Henning, F. Über das Platinthermometer und den Sättigungsdruck des Wasserdampfes zwischen 50 und 200°. Annalen der Physik, 1908, 26: 833–883.

Holborn, L. und Baumann, A. Über den Sättigungsdruck des Wasserdampfes oberhalb 200°. Annalen der Physik, 1910, 31: 945–970.

themselves. This is particularly the case with the more recent data over the whole range of temperature from 0° to the critical temperature at about 374° Centigrade. Two remedies have been utilized to overcome this difficulty. First, the employment of separate equations of interpolation adjusted to fit the observations accurately over a short range of temperature, 0° to 100° for example, as in the case of Broch's computations. (It has already been mentioned that theory requires the function for vapor pressures over ice to differ from the one for pressures over water, so that the values for ice offer no difficulty.) The second remedy sometimes employed consists in fitting any reasonably accurate equation as closely as possible to the observations. The differences between the observed and computed values are then charted and a smooth curve drawn by hand through the points thus located. This method has been employed notably by Henning[1] and others, using an empirical equation proposed by Thiesen.

For the purpose of these tables Marvin has found it possible from among a multitude of equations to develop a modification of the theoretical equation of Van der Waals which fits the whole range of observations much better than any hitherto offered and with an order of precision quite comparable to the data itself. In fact, the equation serves to disclose inconsistencies in the observations, more particularly between 50° and 80° *C.*, which seem to suggest the need for further experimental determination of values possibly over the range between 0° and 100°.

Although it is not difficult to show, as Cederberg [2] has done, that the simple form of general theoretical equation for all vapors developed by Van der Waals is inadequate to represent experiments on water vapor with sufficient accuracy for practical requirements, nevertheless a somewhat simple elaboration of its single constant suffices to remove this limitation in a very satisfactory manner.

The resulting equation is:

$$\log e = \log \pi - [A - bX + mX^2 - nX^3 + sX^4]\,\frac{\theta - T}{T}, \text{ where } X = \frac{T - 453}{10}. \quad (1)$$

The quantity within the square brackets in this equation replaces a single term of the Van der Waals equation which was regarded by him as a constant.

In Van der Waals's original equation π and θ are respectively the critical pressure and temperature (absolute). In the present state of physical science, and from the very nature of the data, these quantities cannot be evaluated exactly. Moreover it is unnecessary to do so for the mere purpose of accurately fitting a mathematical curve to the observational data,

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[1] Annalen der Physik, 1907, 22: 609–630.

[2] Cederberg, Ivar W. Über eine exakte Dampfdruckberechnungsmethode. Physik. Zeitschr. xv : 697, 1914; Über die Temperaturabhängigkeit einiger physikalischen Eigenschaften des Wassers in seinen vershiedenen Aggregatzuständen. Physik. Zeitschr. xv: 824, 1914.

because the same result is attained by simply passing the curve through a point more accurately known and as near as may be to the critical point. This is equivalent to defining π and θ by an "equation of condition." Another "equation of condition" fixes the pressure at the boiling point which by definition must be 760 mm. From the considerations given on page xi computations are greatly facilitated by taking all temperatures on the approximate absolute scale represented by $T = 273 + t^\circ$.

A careful preliminary analysis of the observational data in the vicinity of the critical temperature resulted in assigning values to θ and π as follows:

$$\theta = 643^\circ, \log. \pi = 5.1959000$$

It is emphasized here again that these data do not represent critical temperature conditions, but simply a convenient point on the pressure curve slightly below the critical temperature, the value of which is fixed with considerable accuracy by the observational data.

The value of the constant A was fixed by the equation of condition, $e = 760$ mm. when $T = 373$ ($X = -8$). The remaining constants (b, m, n, s) are computed by the method of least squares. The results are as follows:

$$\begin{aligned} A &= 3.1473172 \\ b &= .00295944 \\ m &= .0004191398 \\ n &= .0000001829924 \\ s &= .00000008243516 \end{aligned}$$

The number of significant figures in the constants is obviously greater than the accuracy of the data justifies; but is justified to facilitate computation and to secure accuracy in the interpolation of values which should themselves be as accurate as the data.

Thiesen[1] has shown that the observed values of vapor pressure over ice can be reproduced by the equation

$$\text{Log } e = \log e_0 + 9.632\ (1 - 0.00035\, t)\ \frac{t}{T}$$

where $e_0 = 4.5785$, and $T = 273 + t$.

For convenience in computing this equation, for metric units it may be written

$$\text{Log } e = 0.66072 + \left(\frac{9.632 - 0.0033712\, t}{273 + t}\right) t. \qquad (2)$$

For English units the equation becomes

$$\text{Log } e = \bar{1}.255888 + \left(\frac{9.69193 - 0.00187289\, t_1}{459.4 + t_1}\right) (t_1 - 32). \qquad (3)$$

t = degrees Centigrade; t_1 = degrees Fahrenheit.

[1] Thiesen M. Die Dampfspannung über Eis. (Mitteilung aus der Physikalisch-Technischen Reichsanstalt.) Annalen der Physik, 1909; 29: 1057.

The vapor pressures in the tables here given are expressed in standard manometric units.

TABLE 69.

Table 69. *Pressure of aqueous vapor over ice. English measures.*

The pressures, computed by equation (3) above, are given to 0.00001 inch for each degree of temperature from $-60°$ to $-15°$, for each half degree from -15 to $\pm 0°$, and for each tenth of a degree from $\pm 0°.0$ to $+32°.0$.

TABLE 70.

Table 70. *Pressure of aqueous vapor over water. English measures.*

This table has been computed by converting Table 72 into English units. The temperature argument is given for every 0°.1 from 32°.0 to 214°.9 *F.* The vapor pressures are to 0.0001 inch from 32°.0 to 130°.9, *F.*, and to 0.001 inch from 130°.0 to 214°.9 *F.*

TABLE 71.

Table 71. *Pressure of aqueous vapor over ice. Metric measures.*

The pressures, computed by equation (2) above, are given to the nearest 0.0001 mm. for each degree of temperature from $-70°$ to $-50°$, for each half degree from $-50°$ to $-35°$, and each tenth of a degree from $-35°.0$ to $\pm 0°.0$.

TABLE 72.

Table 72. *Pressure of aqueous vapor over water. Metric measures.*

The pressures, computed by equation (1) above, are given for each tenth of a degree to 0.001 mm. from 0°.0 to 50°.9, and to 0°.01 mm. from 50°.0 to 100°.9. They are given for each degree to 0.1 mm. from 100° to 189°, and in millimeters from 190° to 374°.

TABLES 73, 74.

Table 73. *Weight of cubic foot of saturated aqueous vapor — English measures.*

Table 74. *Weight of a cubic meter of saturated aqueous vapor — Metric measures.*

For many years it has been customary to assume that the specific gravity of water vapor relative to dry air is a constant whose theoretical value computed from the accurately known densities of its constituent gases is 0.6221. Direct experimental determinations of the specific volume of dry saturated steam (as yet but few observations are available at moderate temperatures) show conclusively (1) that this theoretical specific gravity is true only for saturated vapor at very low temperatures or when the vapor is in a very attenuated state of partial saturation; (2) that at increasingly higher temperatures the specific gravity is increasingly greater than 0.6221. These assertions are in accord with the values of weight per cubic foot of water vapor tabulated by Marks & Davis [1] from the most recent determinations of the specific volume of water vapor. However, owing to the paucity of data, and its inaccuracy for the range of atmospheric temperatures and conditions, the values derived from densities given by Marks and Davis between 10° and 50° are probably too low and require revision. The basis on which this assertion is made is the generalization that the theoretical value 0.6221 is probably a minimum specific gravity towards which actual values asymptotically tend at low temperature and low relative humidity in the meteorological sense, or high super heats in the steam engineering sense. This generalization affords a very helpful "control" in harmonizing and combining experimental determinations of specific volume. It was thus employed in a recomputation, from the original experimental data on specific volumes, of the accompanying table of specific gravities, δ, of saturated water vapor.

$T.\ (C^\circ)$	δ	$T.\ (C^\circ)$	δ
− 60	0.6226	60	0.6273
50	0.6227	70	0.6283
40	0.6229	80	0.6296
30	0.6230	90	0.6311
20	0.6232	100	0.6329
− 10	0.6235	110	0.6351
± 0	0.6238	120	0.6377
+ 10	0.6241	130	0.6408
20	0.6246	140	0.6446
30	0.6251	150	0.6491
40	0.6257	160	0.6545
50	0.6264	170	0.6609
		180	0.6687

The weight of a *cubic meter* of saturated vapor is given by the expression

$$W = \frac{a\delta}{1 + \alpha t} \cdot \frac{e}{760},$$

a is the weight of a cubic meter of dry air (free from carbonic acid) at temperature 0° $C.$, and pressure of 760 millimeters of mercury of standard density under standard gravity: $a = 1.29278$ kg. (Bureau International des Poids et Mesures: *Travaux et Mémoires*, t. I, p. A 54.)

δ is the density of aqueous vapor relative to dry air: $\delta = 0.6221$.

While, as stated above, there is reason for believing that this value is too low, for atmospheric temperatures the error is less than one per cent. For practical work in meteorology and at moderate temperatures, it seems best to retain the theoretical value until the actual value has been determined

[1] Marks, Lionel S., and Davis, Harvey N. Tables and diagrams of the thermal properties of saturated and superheated steam. New York, 1909.

with greater accuracy. For all important calculations except those at low temperatures the values of δ in the Table on page lvi should be employed.

e is the pressure of saturated aqueous vapor at temperature t, taken from Tables 71 and 72.

α is the coefficient of expansion of air for 1° $C.$: $\alpha = 0.003670$.

t is the temperature in Centigrade degrees.

Whence we have

$$W\text{(grams)} = 1.05821 \times \frac{e}{1 + 0.003670\,t}.$$

Table 74 is computed from this formula and gives the weight of saturated vapor in grams in a cubic meter for dew-points from −29° to +40°.9 *C.*, the intervals from 6° to 40°.9 *C.*, being 0°.1 *C.* The tabular values are given to three decimals.

The weight W_1 of a *cubic foot* of saturated vapor is obtained by converting the foregoing constants into English measures.

The weight of a cubic foot of dry air at temperature 32° *F.* and at a pressure of 760 mm. or 29.921 inches is

$$a_1\text{(grains)} = \frac{1292.78 \times 15.43235}{(3.280833)^3} = 564.94.$$

We have therefore,

$$W_1\text{(grains)} = \frac{a_1\delta}{29.921} \times \frac{e_1}{1 + \alpha_1(t_1 - 32°)} = 11.7459\,\frac{e_1}{1 + 0.002039\,(t_1 - 32°)}$$

The temperature t_1 is expressed in degrees Fahrenheit; the vapor pressure e_1, expressed in inches, is obtained from Tables 69 and 70.

Table 73 gives the weight of saturated aqueous vapor in grains per cubic foot for dew points given to every degree from −30° to +20°, to each half degree from +20° to +70°, and for every 0°.2 from 70°.0 to 119°.8 F, the values being computed to the thousandth of a grain.

REDUCTION OF OBSERVATIONS WITH THE PSYCHROMETER AND DETERMINATION OF RELATIVE HUMIDITY.

The psychrometric formula derived by Maxwell, Stefan, August, Regnault and others is, in its simplest form,

$$e = e' - AB\,(t - t'),$$

in which t = Air temperature.

t' = Temperature of the wet-bulb thermometer.

e = Pressure of aqueous vapor in the air.

e' = Vapor pressure, saturated, at temperature t'.

B = Barometric pressure.

A = A quantity which, for the same instrument and for certain conditions, is a constant, or a function depending in a small measure on t'.

All pressures are expressed in heights of mercurial column under standard gravity.

The important advance made since the time of Regnault consists in recognizing that the value of A differs materially according to whether the wet-bulb is in quiet or moving air. This was experimentally demonstrated by the distinguished Italian physicist, Belli, in 1830, and was well known to Espy, who always used a whirled psychrometer. The latter describes his practice as follows: "When experimenting to ascertain the dew-point by means of the wet-bulb, I always swung both thermometers moderately in the air, having first ascertained that a moderate movement produced the same depression as a rapid one."

The principles and methods of these two pioneers in accurate psychrometry have now come to be adopted in the standard practice of meteorologists, and psychrometric tables are adapted to the use of a whirled or ventilated instrument.

The factor A depends in theory upon the size and shape of the thermometer bulb, largeness of stem and velocity of ventilation, and different formulæ and tables would accordingly be required for different instruments. But by using a ventilating velocity of three meters or more per second, the differences in the results given by different instruments vanish, and the same tables can be adapted to any kind of a thermometer and to all changes of velocity above that which gives sensibly the greatest depression of the wet-bulb temperature; and with this arrangement there is no necessity to measure or estimate the velocity in each case further than to be certain that it does not fall below the assigned limit.

The formula and tables here given for obtaining the vapor pressure and dew-point from observations of the whirled or ventilated psychrometer are those deduced by Prof. Wm. Ferrel (*Annual Report Chief Signal Officer*, 1886, Appendix 24) from a discussion of a large number of observations.

Taking the psychrometric formula in metric units, pressures being expressed in millimeters and temperatures in centigrade degrees, Prof. Ferrel derived for A the value

$$A = 0.000656\ (1 + 0.0019\ t').$$

In this expression for A, the factor depending on t' arises from a similar term in the expression for the latent heat of water, and the theoretical value of the coefficient of t' is 0.00115. Since it would require a very small change in the method of observing to cause the difference between the theoretical value and that obtained from the experiments, Prof. Ferrel adopted the theoretical coefficient 0.00115 and then recomputed the observations, obtaining therefrom the final value

$$A = 0.000660\ (1 + 0.00115\ t').$$

With this value the psychrometric formula in metric measures becomes

$$e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t').$$

Expressed in English measures, the formula is

$$e = e' - 0.000367\,B\,(t - t')\,[1 + 0.00064\,(t' - 32^\circ)]$$

$$= e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

in which e = Vapor pressure in inches.

e' = Pressure of saturated aqueous vapor at temperature t'.

t = Temperature of the air in Fahrenheit degrees.

t' = Temperature of the wet-bulb thermometer in Fahrenheit degrees.

B = Barometric pressure in inches.

TABLE 75. *Reduction of Psychrometric Observations — English measures.*

$$\text{Values of } e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

This table provides for computing the vapor pressure, e, from observations of ventilated wet- and dry-bulb Fahrenheit thermometers. From the vapor pressure thus computed the dew-point and relative humidity of the atmosphere may be obtained.

The tabular values of the vapor pressure, e, are computed for degree intervals of t' from -20° to $+110^\circ$ *F*. Below $+10^\circ$ the interval for $t - t'$ is $0^\circ.2$, and above 10° the interval is 1°. The computation has been made for $B = 30.0$ inches, but at the bottom, and usually, also, at the top of each page of the table is given a correction, $\Delta e \times \Delta B$, computed for $B = 29.0$ inches or $\Delta B = 1$ inch, and for the value of t' indicated. The correction is a linear function of ΔB. For atmospheric pressures less than 30.0 inches, it is to be added to the tabular values of e, while for atmospheric pressures greater than 30.0 inches it is to be subtracted.

The values of e are given to 0.0001 inch for t' less than 10°, and to 0.001 inch for t' greater than 10°.

Examples:

1. Given, $t = 84^\circ.3$; $t' = 66^\circ.7$, and $B = 30.00$ inches. With $t' = 66^\circ.7$ and $t - t' = 17^\circ.6$ as arguments, Table 75 gives for e the value 0.462 inch. On page 174, for $t - t' = 0^\circ.0$ it is seen that a vapor presure of 0.462 inch corresponds to a temperature $t' = t = 57^\circ$, which is the saturation, or dew-point temperature for the data given.
2. Given, $t = 34^\circ.5$; $t' = 29^\circ.4$; $B = 22.3$ inches. With $t' = 29^\circ.4$ and $t - t' = 5^\circ.1$ as arguments, Table 75 gives for e the value 0.104. $\Delta B = 30.0 - 22.3 = 7.7$, and $\Delta e \times \Delta B = 0.0018 \times 7.7 = 0.014$.
   Correct value of e $= 0.118$ inch

For $t - t' = 0^\circ.0$ a vapor pressure of 0.118 inch corresponds to a temperature $t' = t = 23^\circ$ (see page 174), which is the saturation or dew-point temperature for the data given.

Table 76. *Relative humidity — Temperature Fahrenheit.*

The table gives the vapor pressure corresponding to air temperatures from -30° to $+120^\circ$ at degree intervals (side argument) and for percentages of saturation at 10 per cent intervals (top argument). It is computed from the formula

$$e = e_s \times \text{relative humidity},$$

where e_s is the saturation vapor pressure at the given air temperature. Below a temperature of 20° the values of e are given to 0.0001 inch; above 20° they are given to 0.001 inch.

Examples:

1. In dew-point example 1, above, the computed vapor pressure is 0.462 inch. Entering Table 76 with air temperature $84^\circ.3$ as side argument, we obtain vapor pressure

0.356 inch	= relative humidity			30
and				
0.462 inch − 0.356 inch = 0.106 inch =	"	"	$\frac{90}{10}$ =	9
therefore, vapor pressure				—
0.462 inch with $t = 84^\circ.3$ *F.*	= "	"		39

2. In dew-point example 2, above, the computed vapor pressure is 0.118 inch. Entering Table 76 with air temperature $34^\circ.5$ as side argument, we obtain, vapor pressure

0.100 inch	= relative humidity			50
and				
0.118 inch − 0.100 inch = 0.018 inch =	"	"	$\frac{90}{10}$ =	9
therefore, vapor pressure				—
0.118 inch with $t = 34.5$ *F.*	= "	"		59

Reduction of Psychrometric Observations — Metric measures.

Table 77. *Values of* $e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t')$

This table provides for computing the vapor pressure from observations of ventilated wet- and dry-bulb Centigrade thermometers. From the vapor pressure thus computed the dew-point and relative humidity of the atmosphere may be obtained.

The tabular values of the vapor pressure, e, are computed for degree intervals of t' from -30° to $+45^\circ$ *C.* Below $-5^\circ.0$ the interval for $t - t'$

is $0\overset{\circ}{.}1$, and above $-5\overset{\circ}{.}0$ the interval is 1°. The computation has been made for $B = 760$ mm. but on each page of the table is given a correction, $\Delta e \times \Delta B$, computed for $B = 660$, or $\Delta P = 100$ mm., and for the values of t' indicated. The correction is a linear function of ΔB. For atmospheric pressures less than 760 mm. it is to be added to the tabular values of e, while for atmospheric pressures greater than 760 mm. it is to be subtracted. The values of e are given to 0.001 mm. for t' less than $-5\overset{\circ}{.}0$, and to 0.01 mm. for t' greater than $-5\overset{\circ}{.}0$.

Example:

Given, $t = 10\overset{\circ}{.}4$ *C.*; $t' = 8\overset{\circ}{.}3$ *C.*, and $B = 740$ mm. With $t' = 8\overset{\circ}{.}3$ and $t - t' = 2\overset{\circ}{.}1$ as arguments, Table 77 gives for e the value 7.15 mm.

$\Delta B = \frac{760 - 740}{100} = 0.2. \quad \Delta e \times \Delta B = 0.14 \times 0.2 \qquad = 0.03.$

Corrected value of e $\qquad = 7.18$ mm.

For $t - t' = 0$ a vapor pressure of 7.18 mm. corresponds to a temperature $t' = t = 6\overset{\circ}{.}3$ *C.*, which is the saturation, or dew-point temperature for the data given.

TABLE 78.

TABLE 78. *Relative humidity — Temperature Centigrade.*

This table gives the vapor pressure corresponding to air temperatures from -45° *C.* to $+55^\circ$ *C.* at degree intervals (side argument) and for percentage of saturation at 10 per cent intervals (top argument). It is computed from the same formula as Table 76, namely,

$$e = e_s \times \text{relative humidity}.$$

Below a temperature of $+5\overset{\circ}{.}0$ the values of e are given to 0.01 mm.; above $5\overset{\circ}{.}0$ they are given to 0.1 mm.

Example:

In the dew-point example given above, the computed vapor pressure is 7.18 mm. Entering Table 78 with air temperature 10.4 as side argument, we obtain vapor pressure

6.6 mm. = relative humidity 70

and

$7.18 - 6.6 = 0.58$ mm. = " " $\frac{60}{10} = 6$

therefore, vapor pressure

7.18 mm. with $t = 10.4$ *C.* = " " $= 76$

TABLE 79.

TABLE 79. *Rate of decrease of vapor pressure with altitude for mountain stations.*

From hygrometric observations made at various mountain stations on the Himalayas, Mount Ararat, Teneriffe, and the Alps, Dr. J. Hann (*Lehrbuch der Meteorologie Dritte Auflage*, S. 230) has deduced the following empirical formula showing the average relation between the vapor pressure e_0 at a lower station and e the vapor pressure at another station at an altitude h meters above it:

$$\frac{e}{e_0} = 10^{-\frac{h}{6300}}.$$

This is of course an average relation for all times and places from which the actual rate of decrease of vapor pressure in any individual case may widely differ.

Table 79 gives the values of the ratio $\frac{e}{e_0}$ for values of h from 200 to 6000 meters. An additional column gives the equivalent values of h in feet.

REDUCTION OF SNOWFALL MEASUREMENT.

The determination of the water equivalent of snowfall has usually been made by one of two methods: (*a*) by dividing the depth of snow by an arbitrary factor ranging from 8 to 16 for snow of different degrees of compactness; (*b*) by melting the snow and measuring the depth of the resulting water. The first of these methods has always been recognized as incapable of giving reliable results, and the second, although much more accurate, is still open to objection. After extended experience in the trial of both these methods, it has been found that the most accurate and most convenient measurement is that of weighing the collected snow, and then converting the weight into depth in inches. The method is equally applicable whether the snow as it falls is caught in the gage, or a section of the fallen snow is taken by collecting it in an inverted gage.

TABLE 80. *Depth of water corresponding to the weight of a cylindrical snow core, 2.655 inches in diameter.*

This table is prepared for convenience in making surveys of the snow layer on the ground, particularly in the western mountain sections of the country. The weighing method is the only one found to be practicable. Present Weather Bureau practice is to take out a sample by means of a special tube, whose diameter, 2.655 inches, has been selected by reason of convenience in manipulation and simplicity in relation to the pound. Table 80 gives the depth of water in inches and hundredths corresponding to given weights. The argument is given in hundredths of a pound from 0.01 pound to 2.99 pounds.

TABLE 81. *Depth of water corresponding to the weight of snow (or rain) collected in an 8-inch gage.*

The table gives the depth to hundredths of an inch, corresponding to the weight of snow or rain collected in a gage having a circular collecting mouth 8 inches in diameter — this being the standard size of gage used throughout the United States.

The argument is given in hundredths of a pound from 0.01 pound to 0.99 pound. When the weight of the collected snow or rain is one pound or more, the depth corresponding to even pounds may be obtained from the equivalent of one pound given in the heading of the table.

Example:

The weight of the snow collected in a gage having a circular collecting mouth 8 inches in diameter is 3.48 pounds. Find the corresponding depth of water.

A weight of 3 lbs. corresponds to a depth of water of 0.5507 × 3, equals	1.65 in.
A weight of 0.48 lbs. corresponds to a depth of water of	0.26
A " " 3.48 " " " " "	1.91 in.

TABLE 82. *Quantity of rainfall corresponding to given depths.* **TABLE 82.**

This table gives for different depths of rainfall in inches over an acre the total quantity of water expressed in cubic inches, cubic feet, gallons, and tons. (See Henry, A. J. "Quantity of Rainfall corresponding to Given Depths." *Monthly Weather Review*, 1898, **26**: 408–09.)

GEODETICAL TABLES.

TABLE 83. *Value of apparent gravity on the earth at sea level.*[1] **TABLE 83.**

The value of apparent gravity on the earth at sea level is given for every twenty minutes of latitude from 5° to 86°, and for degree intervals near the equator and the poles. It is computed to 0.001 dyne from the equation[2]

$$
\begin{aligned}
g_\phi &= 978.039\,(1 + 0.005294 \sin^2 \phi - 0.000007 \sin^2 2\phi) \\
&= 980.621\,(1 - 0.002640 \cos 2\phi + 0.000007 \cos^2 2\phi)
\end{aligned}
$$

in which g_ϕ is the value of the gravity at latitude ϕ.

The second form of the equation is the more convenient for the computation.

TABLE 84. *Relative acceleration of gravity at sea level at different latitudes.* **TABLE 84.**

The formula adopted for the variation with latitude of apparent gravity at sea level is that of the U.S. Coast and Geodetic Survey, given above.

The table gives the values of the ratio $\frac{g_\phi}{g_{45°}}$ to six decimals for every 10′ of latitude from the equator to the pole.

[1] Gravity is here considered in terms of force (expressed in dynes) that is exerted on a mass of one gram rather than its numerical equivalent, acceleration (expressed in centimeters and seconds), for which there is no convenient expression.

[2] See Bowie, William, *Investigations of Gravity and Isostasy.* U.S. Coast and Geodetic Survey, Special Publication No. 40, 1917, page 134.

LENGTH OF A DEGREE OF THE MERIDIAN AND OF ANY PARALLEL.

The dimensions of the earth used in computing lengths of the meridian and of parallels of latitude are those of Clarke's spheroid of 1866.[1] This spheroid undoubtedly represents very closely the true size and shape of the earth, and is the one to which nearly all geodetic work in the United States is now referred.

The values of the constants are as follows:

a, semi-major axis = 20926062 feet; $\log a = 7.3206875$.
b, semi-minor axis = 20855121 feet; $\log b = 7.3192127$.

$$e^2 = \frac{a^2 - b^2}{a^2} = 0.00676866; \qquad \log e^2 = 7.8305030 - 10.$$

With these values for the figure of the earth, the formula for computing any portion of a quadrant of the meridian is

$$\begin{aligned}\text{Meridional distance in feet} &= [5.5618284]\,\Delta\phi \text{ (in degrees)},\\ &- [5.0269880] \cos 2\phi \sin \Delta\phi,\\ &+ [2.0528] \cos 4\phi \sin 2\Delta\phi,\end{aligned}$$

in which $2\phi = \phi_2 + \phi_1$, $\Delta\phi = \phi_2 - \phi_1$; ϕ_1, ϕ_2 = end latitudes of arc.

For the length of 1 degree, the formula becomes:

$$1 \text{ degree of the meridian, in feet} = 364609.9 - 1857.1 \cos 2\phi + 3.94 \cos 4\phi.$$

The length of the parallel is given by the equation

$$1 \text{ degree of the parallel at latitude } \phi, \text{ in feet} = 365538.48 \cos\phi - 310.17 \cos 3\phi + 0.39 \cos 5\phi.$$

TABLE 85. *Length of one degree of the meridian at different latitudes.*

This gives for every degree of latitude the length of one degree of the meridian in statute miles to three decimals, in meters to one decimal, and in geographic miles to three decimals — the geographic mile being here defined to be one minute of arc on the equator. The values in meters are computed from the relation: 1 meter = 39.3700 inches. The tabular values represent the length of an arc of one degree, the middle of which is situated at the corresponding latitude. For example, the length of an arc of one degree of the meridian, whose end latitudes are 29° 30′ and 30° 30′, is 68.879 statute miles.

TABLE 86. *Length of one degree of the parallel at different latitudes.*

This table is similar to Table 85.

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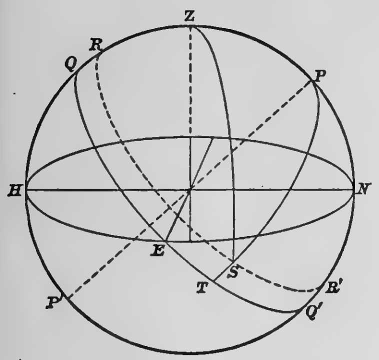
[1] *Comparisons of Standards of Length*, made at the Ordnance Survey Office, Southampton, England, by Capt. A. R. Clarke, R. E., 1866.

TABLE 87. *Duration of sunshine at different latitudes for different values of the sun's declination.*



Let Z be the zenith, and NH the horizon of a place in the northern hemisphere.
P the pole;
QEQ' the celestial equator;
RR' the parallel described by the sun on any given day;
S the position of the sun when its upper limb appears on the horizon;
PN the latitude of the place, ϕ.
ST the sun's declination, δ.
PS the sun's polar distance, $90° - \delta$.
ZS the sun's zenith distance, z.
ZPS the hour angle of the sun from meridian, t.
r the mean horizontal refraction $= 34'$ approximately.
s the mean solar semi-diameter $= 16'$ "

$$z = 90° + r + s = 90° \, 50'$$

In the spherical traingle ZPS, the hour angle ZPS may be computed from the values of the three known sides by the formula

$$\sin \tfrac{1}{2} ZPS = \sqrt{\frac{\sin \frac{1}{2} (ZS + PZ - PS) \sin \frac{1}{2} (ZS + PS - PZ)}{\sin PZ \sin PS}}$$

or

$$\sin \tfrac{1}{2} t = \sqrt{\frac{\sin \frac{1}{2} (z + \delta - \phi) \sin \frac{1}{2} (z - \delta + \phi)}{\cos \phi \cos \delta}}$$

The hour angle t, converted into mean solar time and multiplied by 2 is the duration of sunshine.

Table 87 has been computed for this volume by Prof. Wm. Libbey, Jr. It is a table of double entry with arguments δ and ϕ. For north latitudes northerly declination is considered positive and southerly declination as negative. The table may be used for south latitudes by considering southerly declination as positive and northerly declination as negative.

The top argument is the latitude, given for every 5° from 0° to 40°, for every 2° from 40° to 60°, and for every degree from 60° to 80°.

The side argument is the sun's declination for every 20′ from S 23° 27′ to N 23° 27′.

The duration of sunshine is given in hours and minutes.

To find the duration of sunshine for a given day at a place whose latitude is known, find the declination of the sun at mean noon for that day in the *Nautical Almanac*, and enter the table with the latitude and declination as arguments.

Example:

To find the duration of sunshine, May 18, 1892, in latitude $49° 30'$ North.

From the Nautical Almanac, $\delta = 19° 43' N$.

From the table, with $\delta = 19° 43' N$ and $\phi = 49° 30'$, the duration of sunshine is found to be $15^h 31^m$.

Table 88. *Declination of the sun for the year* 1899.

This table is an auxiliary to Table 87, and gives the declination of the sun for every third day of the year 1899. These declinations may be used as approximate values for the corresponding dates of other years when the exact declination cannot readily be obtained. Thus, in the preceding example, the declination for May 18, 1892, may be taken as approximately the same as that for the same date in 1899, viz. $19° 37'$.

THE DURATION OF TWILIGHT.

A review of the literature [1] indicates that from an early date *astronomical* twilight has been considered to end in the evening and begin in the morning when the true position of the sun's center is 18° below the horizon. At this time stars of the sixth magnitude are visible near the zenith, and generally there is no trace on the horizon of the twilight glow.

It also appears that *civil* twilight ends in the evening and begins in the morning when the true position of the sun's center is 6° below the horizon. At this time stars and planets of the first magnitude are just visible. In the evening the first purple light has just disappeared, and darkness compels the suspension of outdoor work unless artificial lighting is provided. In the morning the first purple light is beginning to be visible, and the illumination is sufficient for the resumption of outdoor occupations.

Some confusion has arisen in the computation of tables of the duration of both astronomical and civil twilight, due to the fact that in some instances the time of sunrise or sunset has been considered to be that instant when the *center* of the sun is on the true horizon; in others, when its center *appears* to be on the true horizon; and in still others when the *upper limb* of the sun appears to coincide with the true horizon. In the United States this latter is regarded as defining the time of sunrise and sunset.

In the tables here presented the duration of astronomical twilight is the interval between sunrise or sunset, according to this latter definition, and the instant the true position of the sun's center is 18° below the horizon. Likewise, the duration of civil twilight is the interval from sunrise or sunset to the instant the true position of the sun's center is 6° below the horizon.

[1] Kimball, Herbert H. "Duration and Intensity of Twilight," *Monthly Weather Review*, 1916, 44: 614–620.

The computations may be made from the equation

$$\cos t = \frac{\sin a - \sin \phi \sin \delta}{\cos \phi \cos \delta}$$

where t is the sun's hour angle from the meridian, a is the sun's altitude, considered minus below the horizon, δ is the solar declination, and ϕ is the latitude of the place of observation.

The solar declinations employed are those given in the *American Ephemeris and Nautical Almanac*, 1899, pp. 377–384, Solar Ephemeris for Washington.

The atmospheric refraction with the sun on the horizon has been assumed to be 34′, and 16′ has been allowed for the sun's semi-diameter, so that at the instant of sunrise or sunset, as defined above, the true position of the sun's center is about 50′ below the horizon. The difference between this value of t and its value with the sun 6° and 18° below the horizon gives, respectively, the duration of civil and astronomical twilight.

The computations have been simplified by the use of Ball's Altitude Tables,[1] from which the value of t has been determined for true altitudes of the sun of − 50′, − 6°, and − 18°.

TABLE 89. *Duration of astronomical twilight.* **TABLE 89.**

The duration of astronomical twilight is given to the nearest minute for the 1st, 11th, and 21st day of each month for north latitudes, 0°, 10°, 20°, 25°, and at 2° intervals from 30° to 50°, inclusive. The absence of data for latitude 50° from June 1 to July 11, inclusive, indicates that between these dates at this latitude astronomical twilight continues throughout the night.

TABLE 90. *Duration of civil twilight.* **TABLE 90.**

The duration of civil twilight is given to the nearest minute for the 1st, 11th and 21st day of each month for north latitudes 0°, 10°, 20°, 25°, and at 2° intervals from 30° to 50°, inclusive.

RELATIVE INTENSITY OF SOLAR RADIATION AT DIFFERENT LATITUDES.

TABLE 91.

TABLE 91. *Mean intensity for 24 hours of solar radiation on a horizontal surface at the top of the atmosphere.*

This table is that of Prof. Wm. Ferrel, published in the *Annual Report of the Chief Signal Officer*, 1885, Part 2, p. 427, and computed from formulæ and constants given in Chapter II of the above publication, pages 75 to 82. It gives the mean intensity, J, for 24 hours of solar radiation received by a horizontal surface at the top of the atmosphere, in terms of the mean solar

[1] Ball, Frederick. *Altitude Tables for lat. 31° to 60°.* London, 1907; [same] for lat. 0° to 30°, London, 1910.

constant A_0, for each tenth parallel of latitude of the northern hemisphere, and for the first and sixteenth day of each month; also the values of the solar constant A in terms of A_0, and the longitude of the sun for the given dates.

TABLE 92. *Relative amounts of solar radiation received on a horizontal surface during the year at different latitudes.*

The second column of this table is obtained from the last line of Table 91 by multiplying by 1440, the number of minutes in 24 hours. It therefore gives the average daily amount of radiation that would be received from the sun on a horizontal surface at the surface of the earth if none were absorbed or scattered by the atmosphere, expressed in terms of the mean solar constant. The following columns give similar data, except that the atmospheric transmission coefficient is assumed to be 0.9, 0.8, 0.7 and 0.6, respectively, and have been computed by utilizing Angot's work (*Recherches théoretiques sur la distribution de la chaleur à la surface du globe*, par M. Alfred Angot, *Annales du Bureau Central Météorologique de France*, Année 1883. v. 1. B 121–B 169), which leads to practically the same values as Ferrel's when expressed in the same units.

The vertical argument of the table is for 10° intervals of latitude from the equator to the north pole, inclusive.

TABLE 93. *Air mass, m, corresponding to different zenith distances of the sun.*

For homogenous rays, the intensity of solar energy after passing through an air mass, *m*, is expressed by the equation $I = I_0 a^m$, where I_0 is the intensity before absorption, *a* is the atmospheric transmission coefficient, or the proportion of the energy transmitted by unit air mass, and *m* is the air mass passed through. If we take for unit air mass the atmospheric mass passed through by the rays when the sun is in the zenith, then for zenith distances of the sun less than 80° the air mass is nearly proportional to the secant of the sun's zenith distance. In general, the secant gives air masses that are too high by an increasing amount as the zenith distance of the sun increases.

The equation by which air masses are sometimes computed is

$$m = \frac{\textit{atmospheric refraction}}{K \sin Z}$$

where Z is the sun's zenith distance and K is a constant. The uncertain factor in this equation is the atmospheric refraction. Table 93 gives values of *m* computed by Bemporad (*Rend. Acc. Lincei.*, Roma, Ser. 5, V. 16, 2 Sem. 1907, pp. 66–71) from the above formula, using for K the value 58″.36. The argument is for each degree of Z from 20° to 89°, with values of *m* added for $Z = 0°$, 10°, and 15°. The values of *m* are given to two decimal places.

Table 94. *Relative illumination intensities.* **Table 94.**

The table gives illumination intensities in foot-candles for zenithal sun, sky at sunset, sky at end of civil twilight, zenithal full moon, quarter moon, and starlight, and the ratio of these intensities to the illumination from the zenithal full moon. For the sources of the data see Kimball, Herbert H., "Duration and Intensity of Twilight," *Monthly Weather Review*, 1916, 44: 614–620.

MISCELLANEOUS TABLES.

WEIGHT IN GRAMS OF A CUBIC CENTIMETER OF AIR.

The following tables (95 to 100) give the factors for computing the weight of a cubic centimeter of air at different temperatures, humidities and pressures.

$$\delta = \frac{0.00129305}{1 + 0.00367\, t}\left(\frac{B - 0.378\, e}{760}\right)$$

in which δ is the weight of a cubic centimeter of air expressed in grams, under the standard value of gravity ($g = 980.665$)

B is the atmospheric pressure in millimeters, under standard gravity;

e is the pressure of aqueous vapor in millimeters, under standard gravity;

t is the temperature in Centigrade degrees.

For dry atmospheric air (containing 0.0004 of its weight of carbonic acid) at a pressure of 760 mm. and temperature 0° *C.*, the absolute density, or the weight of one cubic centimeter, is 0.00129305 gram. (International Bureau of Weights and Measures. *Travaux et Mémoires*, *t.* I, p. A 54.) See also these Tables, p. xli.

The weight of a cubic centimeter may also be written as follows:

$$\delta = \frac{0.00129305}{1 + 0.0020389\,(t - 32^\circ)}\left(\frac{B - 0.378\, e}{29.921}\right)$$

where δ is defined as before, but B and e are expressed in inches and t in Fahrenheit degrees. Thus by the use of tables based on these two formulæ, lines of equal atmospheric density may be drawn for the whole world, no matter whether the original observations are in English or metric measures.

ENGLISH MEASURES. **TABLES 95, 96, 97.**

Table 95. *Temperature Term.*

This table gives the values and logarithms of the expression

$$\delta_{t,\,29.921} = \frac{0.00129305}{1 + 0.0020389\,(t - 32^\circ)}$$

for values of t extending from -45° *F.* to $+140^\circ$ *F.*, the intervals between 0° *F.* and 110° *F.* being 1°.

The tabular values are given to five significant figures.

Table 96. *Term for humidity; auxiliary to Table* 95.

Table 97. *Humidity and pressure term.* $\frac{h}{29.921} = \frac{B - 0.378\,e}{29.921}$.

Table 96 gives values of 0.378 e to three decimal places as an aid to the use of Table 97. The argument is the dew-point given for every degree from $-60°$ *F.* to $+140°$ *F.* The second column gives the corresponding values of the vapor pressure (e) derived from Tables 69 and 70.

Table 97 gives values and logarithms of $\frac{h}{29.921} = \frac{B - 0.378\,e}{29.921}$ for values of h extending from 10.0 to 31.7 inches. The logarithms are given to five significant figures and the corresponding numbers to four decimals.

Example:

The air temperature is 68° *F.*, the pressure is 29.36 inches and the dew-point 51° *F.* Find the logarithm of the density.

Table 95, for $t = 68°$ *F.*, gives	7.08085 − 10
Table 96, for dew-point 51°, gives 0.378 e = 0.142 inch,	
Table 97, for $h = B - 0.378\,e = 29.36 - 0.14 = 29.22$, gives	9.98941 − 10
	30
Logarithm of density =	7.07056 − 10

METRIC MEASURES.

Table 98. *Temperature term.*

This table gives values and logarithms of the expression

$$\delta_{t,\,760} = \frac{0.00129305}{1 + 0.00367\,t}$$

for values of t extending from $-34°$ *C.* to $+69°$ *C.* The tabular values are given to five significant figures.

Table 99. *Term for humidity ; auxiliary to Table* 100.

Table 100. *Humidity and pressure terms.* $\frac{h}{760} = \frac{B - 0.378\,e}{760}$.

Table 99 gives the values of 0.378 e to hundredths of a millimeter for dew-points extending from $-50°$ *C.* to $+60°$ *C.* Above $-25°$ *C.* the interval is one degree. The values of the vapor pressure, e, corresponding to these dew-points, given in the second column, are taken from tables 71 and 72.

Table 100 gives values and logarithms of $\frac{h}{760} = \frac{B - 0.378\,e}{760}$ for values of h extending from 300 to 799 mm. The atmospheric pressure B is the barometer reading corrected for gravity and 0.378 e is the term for humidity obtained from Table 99. The logarithms are given to five significant figures and the corresponding numbers to four decimal places.

TABLE 101. *Atmospheric water-vapor lines in the visible spectrum.* **TABLE 101.**

Table 101, prepared by the Astrophysical Observatory at Washington, gives a summary of lines in Rowland's "Preliminary Table of Solar Spectrum Wave Lengths," recorded as of atmospheric water vapor origin. There are more than 400 such lines in Rowland's table, but an abridgment is here made as follows:

Only lines of intensity "1" or greater are here separately given, but the total number and average intensity of the fainter lines lying between these are inserted. Rowland's scale of intensities is such that a line of intensity "1" is "just clearly visible" on Rowland's map; the *H* and *K* lines are of intensity, 1,000; D_1 (the sodium line of greater wave length), 20; *C*., 40. "Lines more and more difficult to see" are distinguished by 0, 00, 000, and 0000.

TABLE 102. *Atmospheric water-vapor bands in the infra-red spectrum.* **TABLE 102.**

The values of Table 102 relate to the transmission of energy in the minima of various water-vapor bands, when there is 1 cm. of precipitable water in the path through the air. For other amounts of water-vapor, the depths of these minima may be taken as equal to a^δ, where a is the coefficient taken from the third column of Table 102 and δ is the amount of precipitable water in the path. For average conditions in the transmission of radiation through the atmosphere, δ may be determined by the modification of Hann's formula $\delta = 2.0\, e\ sec.\ Z$, where e is the vapor pressure in cms. as determined by wet and dry thermometers and Z is the angle which the path makes with the vertical.

For the use of the transmissions observed in such bands for the inverse process of determining the amount of water-vapor in the atmosphere, see Fowle, *Astrophysical Journal*, 35, p. 149, 1912; 37, p. 359, 1913.

TABLE 103. *Transmission percentages of radiation through moist air.* **TABLE 103.**

The values of Table 103 will be of use when the transmission of energy through the atmosphere containing a known amount of water-vapor is under consideration. An approximate value for the energy transmitted may be had if the amount of energy from the source between the wave-lengths of the first column is known and is multiplied by the corresponding transmission coefficients of the subsequent columns of the table. The table is compiled from Fowle, "Water-vapor Transparency," *Smithsonian Miscellaneous Collections*, 68, No. 8, 1917; see also, Fowle, "The Transparency of Aqueous Vapor," *Astrophysical Journal*, 42, p. 394, 1915.

TABLE 104. *International meteorological symbols.* **TABLE 104.**

The information under this heading has been compiled for the present edition by the librarian of the United States Weather Bureau, and represents current practice in the use of the symbols approved by the International Meteorological Organization. For further information on the subject of meteorological symbols, see *Monthly Weather Review* (Wash., D.C.), May, 1916, pp. 265–274.

Table 105. *International cloud classification.*

The text under this heading is condensed from the International Cloud Atlas, 2d edition, Paris, 1910.

Table 106. *Beaufort weather notation.*

This table has been revised in the library of the United States Weather Bureau, and represents the current practice of American and British observers in the use of the Beaufort letters.

Table 107. *List of meteorological stations.*

This list has been extensively revised in the library of the Weather Bureau, and has been enlarged to include all the stations for which data appear in the "Réseau Mondial" of the British Meteorological Office for 1912 (published 1917). The stations of the Réseau Mondial were selected to represent, so far as available data permitted, the meteorology of all land areas of the globe, on the basis of two, or in some cases three, stations for each ten-degree square of latitude and longitude.

No attempt has been made in this edition of the Smithsonian Tables to indicate the "order" of the several stations, according to the definitions adopted at the Vienna Congress of 1873; as, owing to the present widespread use of self-recording instruments, the old distinction between first and second order stations has lost much of its importance.

Several stations included in the list are no longer in operation. Data concerning the locations and altitudes of these stations are still valuable, in view of the frequent use made of their records in meteorological and climatological studies.

In general, the spellings of names are those most frequently met with in existing compilations of meteorological data, without regard to the practice of English-speaking countries. In a majority of cases the native orthography has been followed.

THERMOMETRICAL TABLES

TABLE 1.

APPROXIMATE ABSOLUTE, CENTIGRADE, FAHRENHEIT, AND REAUMUR SCALES.

Conversion Formulæ for Approximate Absolute (*A.A*), Centigrade (*C*), Fahrenheit (*F*), and Reaumur (*R*) Scales.

$$A.A = 5/9\ (F - 32) + 273 = C + 273 = 5/4\,R + 273$$

$$C = 5/9\ (F - 32) = 5/4\,R = A.A - 273 = \frac{1}{2}\,(F - 32)\left(1 + \frac{1}{10} + \frac{1}{100} + \frac{1}{1000} + \right)$$

$$F = 9/5\,C + 32 = 9/4\,R + 32 = 9/5\,(A.A - 273) + 32 = 2\,C\left(1 - \frac{1}{10}\right) + 32$$

$$R = 4/9\ (F - 32) = 4/5\,C = 4/5\,(A.A - 273)$$

PROPORTIONAL PARTS.

C, A.A	1	2	3	4	5	6	7	8	9
F	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2
R	.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2

F	1	2	3	4	5	6	7	8	9
C, A.A	.55*	1.11*	1.66*	2.22*	2.77*	3.33*	3.88*	4.44*	5.00*
R	.44*	.88*	1.33*	1.77*	2.22*	2.66*	3.11*	3.55*	4.00*

R	1	2	3	4	5	6	7	8	9
C, A.A	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25
F	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25

* These last figures repeated indefinitely.

A.A.	C.	F.	R.	A.A.	C.	F.	R.	A.A.	C.	F.	R.
375°	102°	215°.6	81°.6	350°	77°	170°.6	61°.6	325°	52°	125°.6	41°.6
374	101	213.8	80.8	349	76	168.8	60.8	324	51	123.8	40.8
373	100	212.0	80.0	348	75	167.0	60.0	323	50	122.0	40.0
372	99	210.2	79.2	347	74	165.2	59.2	322	49	120.2	39.2
371	98	208.4	78.4	346	73	163.4	58.4	321	48	118.4	38.4
370	97	206.6	77.6	345	72	161.6	57.6	320	47	116.6	37.6
369	96	204.8	76.8	344	71	159.8	56.8	319	46	114.8	36.8
368	95	203.0	76.0	343	70	158.0	56.0	318	45	113.0	36.0
367	94	201.2	75.2	342	69	156.2	55.2	317	44	111.2	35.2
366	93	199.4	74.4	341	68	154.4	54.4	316	43	109.4	34.4
365	92	197.6	73.6	340	67	152.6	53.6	315	42	107.6	33.6
364	91	195.8	72.8	339	66	150.8	52.8	314	41	105.8	32.8
363	90	194.0	72.0	338	65	149.0	52.0	313	40	104.0	32.0
362	89	192.2	71.2	337	64	147.2	51.2	312	39	102.2	31.2
361	88	190.4	70.4	336	63	145.4	50.4	311	38	100.4	30.4
360	87	188.6	69.6	335	62	143.6	49.6	310	37	98.6	29.6
359	86	186.8	68.8	334	61	141.8	48.8	309	36	96.8	28.8
358	85	185.0	68.0	333	60	140.0	48.0	308	35	95.0	28.0
357	84	183.2	67.2	332	59	138.2	47.2	307	34	93.2	27.2
356	83	181.4	66.4	331	58	136.4	46.4	306	33	91.4	26.4
355	82	179.6	65.6	330	57	134.6	45.6	305	32	89.6	25.6
354	81	177.8	64.8	329	56	132.8	44.8	304	31	87.8	24.8
353	80	176.0	64.0	328	55	131.0	44.0	303	30	86.0	24.0
352	79	174.2	63.2	327	54	129.2	43.2	302	29	84.2	23.2
351	78	172.4	62.4	326	53	127.4	42.4	301	28	82.4	22.4
350	77	170.6	61.6	325	52	125.6	41.6	300	27	80.6	21.6
A.A.	C.	F.	R.	A.A.	C.	F.	R.	A.A.	C.	F.	R.

APPROXIMATE ABSOLUTE, CENTIGRADE, FAHRENHEIT, AND REAUMUR SCALES.

A.A.	C.	F.	R.	A.A.	C.	F.	R.	A.A.	C.	F.	R.
300°	27°	80°.6	21°.6	250°	−23°	− 9°.4	−18°.4	200°	−73°	− 99°.4	−58°.4
299	26	78.8	20.8	249	24	11.2	19.2	199	74	101.2	59.2
298	25	77.0	20.0	248	25	13.0	20.0	198	75	103.0	60.0
297	24	75.2	19.2	247	26	14.8	20.8	197	76	104.8	60.8
296	23	73.4	18.4	246	27	16.6	21.6	196	77	106.6	61.6
295	22	71.6	17.6	245	−28	−18.4	−22.4	195	−78	−108.4	−62.4
294	21	69.8	16.8	244	29	20.2	23.2	194	79	110.2	63.2
293	20	68.0	16.0	243	30	22.0	24.0	193	80	112.0	64.0
292	19	66.2	15.2	242	31	23.8	24.8	192	81	113.8	64.8
291	18	64.4	14.4	241	32	25.6	25.6	191	82	115.6	65.6
290	17	62.6	13.6	240	−33	−27.4	−26.4	190	−83	−117.4	−66.4
289	16	60.8	12.8	239	34	29.2	27.2	189	84	119.2	67.2
288	15	59.0	12.0	238	35	31.0	28.0	188	85	121.0	68.0
287	14	57.2	11.2	237	36	32.8	28.8	187	86	122.8	68.8
286	13	55.4	10.4	236	37	34.6	29.6	186	87	124.6	69.6
285	12	53.6	9.6	235	−38	−36.4	−30.4	185	−88	−126.4	−70.4
284	11	51.8	8.8	234	39	38.2	31.2	184	89	128.2	71.2
283	10	50.0	8.0	233	40	40.0	32.0	183	90	130.0	72.0
282	9	48.2	7.2	232	41	41.8	32.8	182	91	131.8	72.8
281	8	46.4	6.4	231	42	43.6	33.6	181	92	133.6	73.6
280	7	44.6	5.6	230	−43	−45.4	−34.4	180	−93	−135.4	−74.4
279	6	42.8	4.8	229	44	47.2	35.2	179	94	137.2	75.2
278	5	41.0	4.0	228	45	49.0	36.0	178	95	139.0	76.0
277	4	39.2	3.2	227	46	50.8	36.8	177	96	140.8	76.8
276	3	37.4	2.4	226	47	52.6	37.6	176	97	142.6	77.6
275	+ 2	35.6	+ 1.6	225	−48	−54.4	−38.4	175	−98	−144.4	−78.4
274	+ 1	33.8	+ 0.8	224	49	56.2	39.2	174	99	146.2	79.2
273	± 0	32.0	± 0.0	223	50	58.0	40.0	173	100	148.0	80.0
272	− 1	30.2	− 0.8	222	51	59.8	40.8	172	101	149.8	80.8
271	− 2	28.4	− 1.6	221	52	61.6	41.6	171	102	151.6	81.6
270	− 3	26.6	− 2.4	220	−53	−63.4	−42.4	170	−103	−153.4	−82 4
269	4	24.8	3.2	219	54	65.2	43.2	169	104	155.2	83.2
268	5	23.0	4.0	218	55	67.0	44.0	168	105	157.0	84.0
267	6	21.2	4.8	217	56	68.8	44.8	167	106	158.8	84.8
266	7	19.4	5.6	216	57	70.6	45.6	166	107	160.6	85.6
265	− 8	17.6	− 6.4	215	−58	−72.4	−46.4	165	−108	−162.4	−86.4
264	9	15.8	7.2	214	59	74.2	47.2	164	109	164.2	87.2
263	10	14.0	8.0	213	60	76.0	48.0	163	110	166.0	88.0
262	11	12.2	8.8	212	61	77.8	48.8	162	111	167.8	88.8
261	12	10.4	9.6	211	62	79.6	49.6	161	112	169.6	89.6
260	−13	8.6	−10.4	210	−63	−81.4	−50.4	160	−113	−171.4	−90.4
259	14	6.8	11.2	209	64	83.2	51.2	159	114	173.2	91.2
258	15	5.0	12.0	208	65	85.0	52.0	158	115	175.0	92.0
257	16	3.2	12.8	207	66	86.8	52.8	157	116	176.8	92.8
256	17	+ 1.4	13.6	206	67	88.6	53.6	156	117	178.6	93.6
255	−18	−0.4	−14.4	205	−68	−90.4	−54.4	155	−118	−180.4	−94.4
254	19	2.2	15.2	204	69	92.2	55.2	154	119	182.2	95.2
253	20	4.0	16.0	203	70	94.0	56.0	153	120	184.0	96.0
252	21	5.8	16.8	202	71	95.8	56.8	152	121	185.8	96.8
251	22	7.6	17.6	201	72	97.6	57.6	151	122	187.6	97.6
250	−23	−9.4	−18.4	200	−73	−99.4	−58.4	150	−123	−189.4	−98.4
A.A.	C.	F.	R.	A.A.	C.	F.	R.	A.A.	C.	F.	R.

TABLE 1

APPROXIMATE ABSOLUTE, CENTIGRADE, FAHRENHEIT, AND REAUMUR SCALES.

A.A.	C.	F.	R.	A.A.	C.	F.	R.	A.A.	C.	F.	R.
150°	−123°	−189°.4	− 98°.4	100°	−173°	−279°.4	−138°.4	50°	−223°	−369°.4	−178°.4
149	124	191.2	99.2	99	174	281.2	139.2	49	224	371.2	179.2
148	125	193.0	100.0	98	175	283.0	140.0	48	225	373.0	180.0
147	126	194.8	100.8	97	176	284.8	140.8	47	226	374.8	180.8
146	127	196.6	101.6	96	177	286.6	141.6	46	227	376.6	181.6
145	−128	−198.4	−102.4	95	−178	−288.4	−142.4	45	−228	−378.4	−182.4
144	129	200.2	103.2	94	179	290.2	143.2	44	229	380.2	183.2
143	130	202.0	104.0	93	180	292.0	144.0	43	230	382.0	184.0
142	131	203.8	104.8	92	181	293.8	144.8	42	231	383.8	184.8
141	132	205.6	105.6	91	182	295.6	145.6	41	232	385.6	185.6
140	−133	−207.4	−106.4	90	−183	−297.4	−146.4	40	−233	−387.4	−186.4
139	134	209.2	107.2	89	184	299.2	147.2	39	234	389.2	187.2
138	135	211.0	108.0	88	185	301.0	148.0	38	235	391.0	188.0
137	136	212.8	108.8	87	186	302.8	148.8	37	236	392.8	188.8
136	137	214.6	109.6	86	187	304.6	149.6	36	237	394.6	189.6
135	−138	−216.4	−110.4	85	−188	−306.4	−150.4	35	−238	−396.4	−190.4
134	139	218.2	111.2	84	189	308.2	151.2	34	239	398.2	191.2
133	140	220.0	112.0	83	190	310.0	152.0	33	240	400.0	192.0
132	141	221.8	112.8	82	191	311.8	152.8	32	241	401.8	192.8
131	142	223.6	113.6	81	192	313.6	153.6	31	242	403.6	193.6
130	−143	−225.4	−114.4	80	−193	−315.4	−154.4	30	−243	−405.4	−194.4
129	144	227.2	115.2	79	194	317.2	155.2	29	244	407.2	195.2
128	145	229.0	116.0	78	195	319.0	156.0	28	245	409.0	196.0
127	146	230.8	116.8	77	196	320.8	156.8	27	246	410.8	196.8
126	147	232.6	117.6	76	197	322.6	157.6	26	247	412.6	197.6
125	−148	−234.4	−118.4	75	−198	−324.4	−158.4	25	−248	−414.4	−198.4
124	149	236.2	119.2	74	199	326.2	159.2	24	249	416.2	199.2
123	150	238.0	120.0	73	200	328.0	160.0	23	250	418.0	200.0
122	151	239.8	120.8	72	201	329.8	160.8	22	251	419.8	200.8
121	152	241.6	121.6	71	202	331.6	161.6	21	252	421.6	201.6
120	−153	−243.4	−122.4	70	−203	−333.4	−162.4	20	−253	−423.4	−202.4
119	154	245.2	123.2	69	204	335.2	163.2	19	254	425.2	203.2
118	155	247.0	124.0	68	205	337.0	164.0	18	255	427.0	204.0
117	156	248.8	124.8	67	206	338.8	164.8	17	256	428.8	204.8
116	157	250.6	125.6	66	207	340.6	165.6	16	257	430.6	205.6
115	−158	−252.4	−126.4	65	−208	−342.4	−166.4	15	−258	−432.4	−206.4
114	159	254.2	127.2	64	209	344.2	167.2	14	259	434.2	207.2
113	160	256.0	128.0	63	210	346.0	168.0	13	260	436.0	208.0
112	161	257.8	128.8	62	211	347.8	168.8	12	261	437.8	208.8
111	162	259.6	129.6	61	212	349.6	169.6	11	262	439.6	209.6
110	−163	−261.4	−130.4	60	−213	−351.4	−170.4	10	−263	−441.4	−210.4
109	164	263.2	131.2	59	214	353.2	171.2	9	264	443.2	211.2
108	165	265.0	132.0	58	215	355.0	172.0	8	265	445.0	212.0
107	166	266.8	132.8	57	216	356.8	172.8	7	266	446.8	212.8
106	167	268.6	133.6	56	217	358.6	173.6	6	267	448.6	213.6
105	−168	−270.4	−134.4	55	−218	−360.4	−174.4	5	−268	−450.4	−214.4
104	169	272.2	135.2	54	219	362.2	175.2	4	269	452.2	215.2
103	170	274.0	136.0	53	220	364.0	176.0	3	270	454.0	216.0
102	171	275.8	136.8	52	221	365.8	176.8	2	271	455.8	216.8
101	172	277.6	137.6	51	222	367.6	177.6	1	272	457.6	217.6
100	−173	−279.4	−138.4	50	−223	−369.4	−178.4	0	−273	−459.4	−218.4
A.A.	C.	F.	R.	A.A.	C.	F.	R.	A.A.	C.	F.	R.

FAHRENHEIT SCALE TO CENTIGRADE.

Fahrenheit.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
+130°	+54°.44	+54°.50	+54°.56	+54°.61	+54°.67	+54°.72	+54°.78	+54°.83	+54°.89	+54°.94
129	53.89	53.94	54.00	54.06	54.11	54.17	54.22	54.28	54.33	54.39
128	53.33	53.39	53.44	53.50	53.56	53.61	53.67	53.72	53.78	53.83
127	52.78	52.83	52.89	52.94	53.00	53.06	53.11	53.17	53.22	53.28
126	52.22	52.28	52.33	52.39	52.44	52.50	52.56	52.61	52.67	52.72
+125	+51.67	+51.72	+51.78	+51.83	+51.89	+51.94	+52.00	+52.06	+52.11	+52.17
124	51.11	51.17	51.22	51.28	51.33	51.39	51.44	51.50	51.56	51.61
123	50.56	50.61	50.67	50.72	50.78	50.83	50.89	50.94	51.00	51.06
122	50.00	50.06	50.11	50.17	50.22	50.28	50.33	50.39	50.44	50.50
121	49.44	49.50	49.56	49.61	49.67	49.72	49.78	49.83	49.89	49.94
+120	+48.89	+48.94	+49.00	+49.06	+49.11	+49.17	+49.22	+49.28	+49.33	+49.39
119	48.33	48.39	48.44	48.50	48.56	48.61	48.67	48.72	48.78	48.83
118	47.78	47.83	47.89	47.94	48.00	48.06	48.11	48.17	48.22	48.28
117	47.22	47.28	47.33	47.39	47.44	47.50	47.56	47.61	47.67	47.72
116	46.67	46.72	46.78	46.83	46.89	46.94	47.00	47.06	47.11	47.17
+115	+46.11	+46.17	+46.22	+46.28	+46.33	+46.39	+46.44	+46.50	+46.56	+46.61
114	45.56	45.61	45.67	45.72	45.78	45.83	45.89	45.94	46.00	46.06
113	45.00	45.06	45.11	45.17	45.22	45.28	45.33	45.39	45.44	45.50
112	44.44	44.50	44.56	44.61	44.67	44.72	44.78	44.83	44.89	44.94
111	43.89	43.94	44.00	44.06	44.11	44.17	44.22	44.28	44.33	44.39
+110	+43.33	+43.39	+43.44	+43.50	+43.56	+43.61	+43.67	+43.72	+43.78	+43.83
109	42.78	42.83	42.89	42.94	43.00	43.06	43.11	43.17	43.22	43.28
108	42.22	42.28	42.33	42.39	42.44	42.50	42.56	42.61	42.67	42.72
107	41.67	41.72	41.78	41.83	41.89	41.94	42.00	42.06	42.11	42.17
106	41.11	41.17	41.22	41.28	41.33	41.39	41.44	41.50	41.56	41.61
+105	+40.56	+40.61	+40.67	+40.72	+40.78	+40.83	+40.89	+40.94	+41.00	+41.06
104	40.00	40.06	40.11	40.17	40.22	40.28	40.33	40.39	40.44	40.50
103	39.44	39.50	39.56	39.61	39.67	39.72	39.78	39.83	39.89	39.94
102	38.89	38.94	39.00	39.06	39.11	39.17	39.22	39.28	39.33	39.39
101	38.33	38.39	38.44	38.50	38.56	38.61	38.67	38.72	38.78	38.83
+100	+37.78	+37.83	+37.89	+37.94	+38.00	+38.06	+38.11	+38.17	+38.22	+38.28
99	37.22	37.28	37.33	37.39	37.44	37.50	37.56	37.61	37.67	37.72
98	36.67	36.72	36.78	36.83	36.89	36.94	37.00	37.06	37.11	37.17
97	36.11	36.17	36.22	36.28	36.33	36.39	36.44	36.50	36.56	36.61
96	35.56	35.61	35.67	35.72	35.78	35.83	35.89	35.94	36.00	36.06
+95	+35.00	+35.06	+35.11	+35.17	+35.22	+35.28	+35.33	+35.39	+35.44	+35.50
94	34.44	34.50	34.56	34.61	34.67	34.72	34.78	34.83	34.89	34.94
93	33.89	33.94	34.00	34.06	34.11	34.17	34.22	34.28	34.33	34.39
92	33.33	33.39	33.44	33.50	33.56	33.61	33.67	33.72	33.78	33.83
91	32.78	32.83	32.89	32.94	33.00	33.06	33.11	33.17	33.22	33.28
+90	+32.22	+32.28	+32.33	+32.39	+32.44	+32.50	+32.56	+32.61	+32.67	+32.72
89	31.67	31.72	31.78	31.83	31.89	31.94	32.00	32.06	32.11	32.17
88	31.11	31.17	31.22	31.28	31.33	31.39	31.44	31.50	31.56	31.61
87	30.56	30.61	30.67	30.72	30.78	30.83	30.89	30.94	31.00	31.06
86	30.00	30.06	30.11	30.17	30.22	30.28	30.33	30.39	30.44	30.50
+85	+29.44	+29.50	+29.56	+29.61	+29.67	+29.72	+29.78	+29.83	+29.89	+29.94
84	28.89	28.94	29.00	29.06	29.11	29.17	29.22	29.28	29.33	29.39
83	28.33	28.39	28.44	28.50	28.56	28.61	28.67	28.72	28.78	28.83
82	27.78	27.83	27.89	27.94	28.00	28.06	28.11	28.17	28.22	28.28
81	27.22	27.28	27.33	27.39	27.44	27.50	27.56	27.61	27.67	27.72
+80	+26.67	+26.72	+26.78	+26.83	+26.89	+26.94	+27.00	+27.06	+27.11	+27.17
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

TABLE 2.

FAHRENHEIT SCALE TO CENTIGRADE.

Fahrenheit.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
+80°	+26°.67	+26°.72	+26°.78	+26°.83	+26°.89	+26°.94	+27°.00	+27°.06	+27°.11	+27°.17
79	26.11	26.17	26.22	26.28	26.33	26.39	26.44	26.50	26.56	26.61
78	25.56	25.61	25.67	25.72	25.78	25.83	25.89	25.94	26.00	26.06
77	25.00	25.06	25.11	25.17	25.22	25.28	25.33	25.39	25.44	25.50
76	24.44	24.50	24.56	24.61	24.67	24.72	24.78	24.83	24.89	24.94
+75	+23.89	+23.94	+24.00	+24.06	+24.11	+24.17	+24.22	+24.28	+24.33	+24.39
74	23.33	23.39	23.44	23.50	23.56	23.61	23.67	23.72	23.78	23.83
73	22.78	22.83	22.89	22.94	23.00	23.06	23.11	23.17	23.22	23.28
72	22.22	22.28	22.33	22.39	22.44	22.50	22.56	22.61	22.67	22.72
71	21.67	21.72	21.78	21.83	21.89	21.94	22.00	22.06	22.11	22.17
+70	+21.11	+21.17	+21.22	+21.28	+21.33	+21.39	+21.44	+21.50	+21.56	+21.61
69	20.56	20.61	20.67	20.72	20.78	20.83	20.89	20.94	21.00	21.06
68	20.00	20.06	20.11	20.17	20.22	20.28	20.33	20.39	20.44	20.50
67	19.44	19.50	19.56	19.61	19.67	19.72	19.78	19.83	19.89	19.94
66	18.89	18.94	19.00	19.06	19.11	19.17	19.22	19.28	19.33	19.39
+65	+18.33	+18.39	+18.44	+18.50	+18.56	+18.61	+18.67	+18.72	+18.78	+18.83
64	17.78	17.83	17.89	17.94	18.00	18.06	18.11	18.17	18.22	18.28
63	17.22	17.28	17.33	17.39	17.44	17.50	17.56	17.61	17.67	17.72
62	16.67	16.72	16.78	16.83	16.89	16.94	17.00	17.06	17.11	17.17
61	16.11	16.17	16.22	16.28	16.33	16.39	16.44	16.50	16.56	16.61
+60	+15.56	+15.61	+15.67	+15.72	+15.78	+15.83	+15.89	+15.94	+16.00	+16.06
59	15.00	15.06	15.11	15.17	15.22	15.28	15.33	15.39	15.44	15.50
58	14.44	14.50	14.56	14.61	14.67	14.72	14.78	14.83	14.89	14.94
57	13.89	13.94	14.00	14.06	14.11	14.17	14.22	14.28	14.33	14.39
56	13.33	13.39	13.44	13.50	13.56	13.61	13.67	13.72	13.78	13.83
+55	+12.78	+12.83	+12.89	+12.94	+13.00	+13.06	+13.11	+13.17	+13.22	+13.28
54	12.22	12.28	12.33	12.39	12.44	12.50	12.56	12.61	12.67	12.72
53	11.67	11.72	11.78	11.83	11.89	11.94	12.00	12.06	12.11	12.17
52	11.11	11.17	11.22	11.28	11.33	11.39	11.44	11.50	11.56	11.61
51	10.56	10.61	10.67	10.72	10.78	10.83	10.89	10.94	11.00	11.06
+50	+10.00	+10.06	+10.11	+10.17	+10.22	+10.28	+10.33	+10.39	+10.44	+10.50
49	9.44	9.50	9.56	9.61	9.67	9.72	9.78	9.83	9.89	9.94
48	8.89	8.94	9.00	9.06	9.11	9.17	9.22	9.28	9.33	9.39
47	8.33	8.39	8.44	8.50	8.56	8.61	8.67	8.72	8.78	8.83
46	7.78	7.83	7.89	7.94	8.00	8.06	8.11	8.17	8.22	8.28
+45	+ 7.22	+ 7.28	+ 7.33	+ 7.39	+ 7.44	+ 7.50	+ 7.56	+ 7.61	+ 7.67	+ 7.72
44	6.67	6.72	6.78	6.83	6.89	6.94	7.00	7.06	7.11	7.17
43	6.11	6.17	6.22	6.28	6.33	6.39	6.44	6.50	6.56	6.61
42	5.56	5.61	5.67	5.72	5.78	5.83	5.89	5.94	6.00	6.06
41	5.00	5.06	5.11	5.17	5.22	5.28	5.33	5.39	5.44	5.50
+40	+ 4.44	+ 4.50	+ 4.56	+ 4.61	+ 4.67	+ 4.72	+ 4.78	+ 4.83	+ 4.89	+ 4.94
39	3.89	3.94	4.00	4.06	4.11	4.17	4.22	4.28	4.33	4.39
38	3.33	3.39	3.44	3.50	3.56	3.61	3.67	3.72	3.78	3.83
37	2.78	2.83	2.89	2.94	3.00	3.06	3.11	3.17	3.22	3.28
36	2.22	2.28	2.33	2.39	2.44	2.50	2.56	2.61	2.67	2.72
+35	+ 1.67	+ 1.72	+ 1.78	+ 1.83	+ 1.89	+ 1.94	+ 2.00	+ 2.06	+ 2.11	+ 2.17
34	+ 1.11	+ 1.17	+ 1.22	+ 1.28	+ 1.33	+ 1.39	+ 1.44	+ 1.50	+ 1.56	+ 1.61
33	+ 0.56	+ 0.61	+ 0.67	+ 0.72	+ 0.78	+ 0.83	+ 0.89	+ 0.94	+ 1.00	+ 1.06
32	0.00	+ 0.06	+ 0.11	+ 0.17	+ 0.22	+ 0.28	+ 0.33	+ 0.39	+ 0.44	+ 0.50
31	− 0.56	− 0.50	− 0.44	− 0.39	− 0.33	− 0.28	− 0.22	− 0.17	− 0.11	− 0.06
+30	− 1.11	− 1.06	− 1.00	− 0.94	− 0.89	− 0.83	− 0.78	− 0.72	− 0.67	− 0.61
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

FAHRENHEIT SCALE TO CENTIGRADE.

Fahrenheit.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
+30°	− 1°.11	− 1°.06	− 1°.00	− 0°.94	− 0°.89	− 0°.83	− 0°.78	− 0°.72	− 0°.67	− 0°.61
29	1.67	1.61	1.56	1.50	1.44	1.39	1.33	1.28	1.22	1.17
28	2.22	2.17	2.11	2.06	2.00	1.94	1.89	1.83	1.78	1.72
27	2.78	2.72	2.67	2.61	2.56	2.50	2.44	2.39	2.33	2.28
26	3.33	3.28	3.22	3.17	3.11	3.06	3.00	2.94	2.89	2.83
+25	− 3.89	− 3.83	− 3.78	− 3.72	− 3.67	− 3.61	− 3.56	− 3.50	− 3.44	− 3.39
24	4.44	4.39	4.33	4.28	4.22	4.17	4.11	4.06	4.00	3.94
23	5.00	4.94	4.89	4.83	4.78	4.72	4.67	4.61	4.56	4.50
22	5.56	5.50	5.44	5.39	5.33	5.28	5.22	5.17	5.11	5.06
21	6.11	6.06	6.00	5.94	5.89	5.83	5.78	5.72	5.67	5.61
+20	− 6.67	− 6.61	− 6.56	− 6.50	− 6.44	− 6.39	− 6.33	− 6.28	− 6.22	− 6.17
19	7.22	7.17	7.11	7.06	7.00	6.94	6.89	6.83	6.78	6.72
18	7.78	7.72	7.67	7.61	7.56	7.50	7.44	7.39	7.33	7.28
17	8.33	8.28	8.22	8.17	8.11	8.06	8.00	7.94	7.89	7.83
16	8.89	8.83	8.78	8.72	8.67	8.61	8.56	8.50	8.44	8.39
+ 15	− 9.44	− 9.39	− 9.33	− 9.28	− 9.22	− 9.17	− 9.11	− 9.06	− 9.00	− 8.94
14	10.00	9.94	9.89	9.83	9.78	9.72	9.67	9.61	9.56	9.50
13	10.56	10.50	10.44	10.39	10.33	10.28	10.22	10.17	10.11	10.06
12	11.11	11.06	11.00	10.94	10.89	10.83	10.78	10.72	10.67	10.61
11	11.67	11.61	11.56	11.50	11.44	11.39	11.33	11.28	11.22	11.17
+ 10	−12.22	−12.17	−12.11	−12.06	−12.00	−11.94	−11.89	−11.83	−11.78	−11.72
9	12.78	12.72	12.67	12.61	12.56	12.50	12.44	12.39	12.33	12.28
8	13.33	13.28	13.22	13.17	13.11	13.06	13.00	12.94	12.89	12.83
7	13.89	13.83	13.78	13.72	13.67	13.61	13.56	13.50	13.44	13.39
6	14.44	14.39	14.33	14.28	14.22	14.17	14.11	14.06	14.00	13.94
+ 5	−15.00	−14.94	−14.89	−14.83	−14.78	−14.72	−14.67	−14.61	−14.56	−14.50
4	15.56	15.50	15.44	15.39	15.33	15.28	15.22	15.17	15.11	15.06
3	16.11	16.06	16.00	15.94	15.89	15.83	15.78	15.72	15.67	15.61
2	16.67	16.61	16.56	16.50	16.44	16.39	16.33	16.28	16.22	16.17
1	17.22	17.17	17.11	17.06	17.00	16.94	16.89	16.83	16.78	16.72
+ 0	17.78	17.72	17.67	17.61	17.56	17.50	17.44	17.39	17.33	17.28
− 0	−17.78	−17.83	−17.89	−17.94	−18.00	−18.06	−18.11	−18.17	−18.22	−18.28
1	18.33	18.39	18.44	18.50	18.56	18.61	18.67	18.72	18.78	18.83
2	18.89	18.94	19.00	19.06	19.11	19.17	19.22	19.28	19.33	19.39
3	19.44	19.50	19.56	19.61	19.67	19.72	19.78	19.83	19.89	19.94
4	20.00	20.06	20.11	20.17	20.22	20.28	20.33	20.39	20.44	20.50
− 5	−20.56	−20.61	−20.67	−20.72	−20.78	−20.83	−20.89	−20.94	−21.00	−21.06
6	21.11	21.17	21.22	21.28	21.33	21.39	21.44	21.50	21.56	21.61
7	21.67	21.72	21.78	21.83	21.89	21.94	22.00	22.06	22.11	22.17
8	22.22	22.28	22.33	22.39	22.44	22.50	22.56	22.61	22.67	22.72
9	22.78	22.83	22.89	22.94	23.00	23.06	23.11	23.17	23.22	23.28
− 10	−23.33	−23.39	−23.44	−23.50	−23.56	−23.61	−23.67	−23.72	−23.78	−23.83
11	23.89	23.94	24.00	24.06	24.11	24.17	24.22	24.28	24.33	24.39
12	24.44	24.50	24.56	24.61	24.67	24.72	24.78	24.83	24.89	24.94
13	25.00	25.06	25.11	25.17	25.22	25.28	25.33	25.39	25.44	25.50
14	25.56	25.61	25.67	25.72	25.78	25.83	25.89	25.94	26.00	26.06
− 15	−26.11	−26.17	−26.22	−26.28	−26.33	−26.39	−26.44	−26.50	−26.56	−26.61
16	26.67	26.72	26.78	26.83	26.89	26.94	27.00	27.06	27.11	27.17
17	27.22	27.28	27.33	27.39	27.44	27.50	27.56	27.61	27.67	27.72
18	27.78	27.83	27.89	27.94	28.00	28.06	28.11	28.17	28.22	28.28
19	28.33	28.39	28.44	28.50	28.56	28.61	28.67	28.72	28.78	28.83
−20	−28.89	−28.94	−29.00	−29.06	−29.11	−29.17	−29.22	−29.28	−29.33	−29.39
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

TABLE 2.

FAHRENHEIT SCALE TO CENTIGRADE.

Fahrenheit.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
−20°	−28°.89	−28°.94	−29°.00	29°.06	−29°.11	−29°.17	−29°.22	−29°.28	−29°.33	−29°.39
21	29.44	29.50	29.56	29.61	29.67	29.72	29.78	29.83	29.89	29.94
22	30.00	30.06	30.11	30.17	30.22	30.28	30.33	30.39	30.44	30.50
23	30.56	30.61	30.67	30.72	30.78	30.83	30.89	30.94	31.00	31.06
24	31.11	31.17	31.22	31.28	31.33	31.39	31.44	31.50	31.56	31.61
−25	−31.67	−31.72	−31.78	−31.83	31.89	−31.94	−32.00	−32.06	−32.11	−32.17
26	32.22	32.28	32.33	32.39	32.44	32.50	32.56	32.61	32.67	32.72
27	32.78	32.83	32.89	32.94	33.00	33.06	33.11	33.17	33.22	33.28
28	33.33	33.39	33.44	33.50	33.56	33.61	33.67	33.72	33.78	33.83
29	33.89	33.94	34.00	34.06	34.11	34.17	34.22	34.28	34.33	34.39
−30	−34.44	−34.50	−34.56	−34.61	−34.67	−34.72	−34.78	−34.83	−34.89	−34.94
31	35.00	35.06	35.11	35.17	35.22	35.28	35.33	35.39	35.44	35.50
32	35.56	35.61	35.67	35.72	35.78	35.83	35.89	35.94	36.00	36.06
33	36.11	36.17	36.22	36.28	36.33	36.39	36.44	36.50	36.56	36.61
34	36.67	36.72	36.78	36.83	36.89	36.94	37.00	37.06	37.11	37.17
−35	−37.22	−37.28	−37.33	−37.39	−37.44	−37.50	−37.56	−37.61	−37.67	−37.72
36	37.78	37.83	37.89	37.94	38.00	38.06	38.11	38.17	38.22	38.28
37	38.33	38.39	38.44	38.50	38.56	38.61	38.67	38.72	38.78	38.83
38	38.89	38.94	39.00	39.06	39.11	39.17	39.22	39.28	39.33	39.39
39	39.44	39.50	39.56	39.61	39.67	39.72	39.78	39.83	39.89	39.94
−40	−40.00	−40.06	−40.11	−40.17	−40.22	−40.28	−40.33	−40.39	−40.44	−40.50
41	40.56	40.61	40.67	40.72	40.78	40.83	40.89	40.94	41.00	41.06
42	41.11	41.17	41.22	41.28	41.33	41.39	41.44	41.50	41.56	41.61
43	41.67	41.72	41.78	41.83	41.89	41.94	42.00	42.06	42.11	42.17
44	42.22	42.28	42.33	42.39	42.44	42.50	42.56	42.61	42.67	42.72
−45	−42.78	−42.83	−42.89	−42.94	−43.00	−43.06	−43.11	−43.17	−43.22	−43.28
46	43.33	43.39	43.44	43.50	43.56	43.61	43.67	43.72	43.78	43.83
47	43.89	43.94	44.00	44.06	44.11	44.17	44.22	44.28	44.33	44.39
48	44.44	44.50	44.56	44.61	44.67	44.72	44.78	44.83	44.89	44.94
49	45.00	45.06	45.11	45.17	45.22	45.28	45.33	45.39	45.44	45.50
−50	−45.56	−45.61	−45.67	−45.72	−45.78	−45.83	−45.89	−45.94	−46.00	−46.06
51	46.11	46.17	46.22	46.28	46.33	46.39	46.44	46.50	46.56	46.61
52	46.67	46.72	46.78	46.83	46.89	46.94	47.00	47.06	47.11	47.17
53	47.22	47.28	47.33	47.39	47.44	47.50	47.56	47.61	47.67	47.72
54	47.78	47.83	47.89	47.94	48.00	48.06	48.11	48.17	48.22	48.28
−55	−48.33	−48.39	−48.44	−48.50	−48.56	−48.61	−48.67	−48.72	−48.78	−48.83
56	48.89	48.94	49.00	49.06	49.11	49.17	49.22	49.28	49.33	49.39
57	49.44	49.50	49.56	49.61	49.67	49.72	49.78	49.83	49.89	49.94
58	50.00	50.06	50.11	50.17	50.22	50.28	50.33	50.39	50.44	50.50
59	50.56	50.61	50.67	50.72	50.78	50.83	50.89	50.94	51.00	51.06
−60	−51.11	−51.17	−51.22	−51.28	−51.33	−51.39	−51.44	−51.50	−51.56	−51.61
61	51.67	51.72	51.78	51.83	51.89	51.94	52.00	52.06	52.11	52.17
62	52.22	52.28	52.33	52.39	52.44	52.50	52.56	52.61	52.67	52.72
63	52.78	52.83	52.89	52.94	53.00	53.06	53.11	53.17	53.22	53.28
64	53.33	53.39	53.44	53.50	53.56	53.61	53.67	53.72	53.78	53.83
−65	−53.89	−53.94	−54.00	−54.06	−54.11	−54.17	−54.22	−54.28	−54.33	−54.39
66	54.44	54.50	54.56	54.61	54.67	54.72	54.78	54.83	54.89	54.94
67	55.00	55.06	55.11	55.17	55.22	55.28	55.33	55.39	55.44	55.50
68	55.56	55.61	55.67	55.72	55.78	55.83	55.89	55.94	56.00	56.06
69	56.11	56.17	56.22	56.28	56.33	56.39	56.44	56.50	56.56	56.61
−70	−56.67	−56.72	−56.78	−56.83	−56.89	−56.94	−57.00	−57.06	−57.11	−57.17
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

FAHRENHEIT SCALE TO CENTIGRADE.

Fahrenheit.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
−70°	−56°.67	−56°.72	−56°.78	−56°.83	−56°.89	−56°.94	−57°.00	−57°.06	−57°.11	−57°.17
71	57.22	57.28	57.33	57.39	57.44	57.50	57.56	57.61	57.67	57.72
72	57.78	57.83	57.89	57.94	58.00	58.06	58.11	58.17	58.22	58.28
73	58.33	58.39	58.44	58.50	58.56	58.61	58.67	58.72	58.78	58.83
74	58.89	58.94	59.00	59.06	59.11	59.17	59.22	59.28	59.33	59.39
−75	−59.44	−59.50	−59.56	−59.61	−59.67	−59.72	−59.78	−59.83	−59.89	−59.94
76	60.00	60.06	60.11	60.17	60.22	60.28	60.33	60.39	60.44	60.50
77	60.56	60.61	60.67	60.72	60.78	60.83	60.89	60.94	61.00	61.06
78	61.11	61.17	61.22	61.28	61.33	61.39	61.44	61.50	61.56	61.61
79	61.67	61.72	61.78	61.83	61.89	61.94	62.00	62.06	62.11	62.17
−80	−62.22	−62.28	−62.33	−62.39	−62.44	−62.50	−62.56	−62.61	−62.67	−62.72
81	62.78	62.83	62.89	62.94	63.00	63.06	63.11	63.17	63.22	63.28
82	63.33	63.39	63.44	63.50	63.56	63.61	63.67	63.72	63.78	63.83
83	63.89	63.94	64.00	64.06	64.11	64.17	64.22	64.28	64.33	64.39
84	64.44	64.50	64.56	64.61	64.67	64.72	64.78	64.83	64.89	64.94
−85	−65.00	−65.06	−65.11	−65.17	−65.22	−65.28	−65.33	−65.39	−65.44	−65.50
86	65.56	65.61	65.67	65.72	65.78	65.83	65.89	65.94	66.00	66.06
87	66.11	66.17	66.22	66.28	66.33	66.39	66.44	66.50	66.56	66.61
88	66.67	66.72	66.78	66.83	66.89	66.94	67.00	67.06	67.11	67.17
89	67.22	67.28	67.33	67.39	67.44	67.50	67.56	67.61	67.67	67.72
−90	−67.78	−67.83	−67.89	−67.94	−68.00	−68.06	−68.11	−68.17	−68.22	−68.28
91	68.33	68.39	68.44	68.50	68.56	68.61	68.67	68.72	68.78	68.83
92	68.89	68.94	69.00	69.06	69.11	69.17	69.22	69.28	69.33	69.39
93	69.44	69.50	69.56	69.61	69.67	69.72	69.78	69.83	69.89	69.94
94	70.00	70.06	70.11	70.17	70.22	70.28	70.33	70.39	70.44	70.50
−95	−70.56	−70.61	−70.67	−70.72	−70.78	−70.83	−70.89	−70.94	−71.00	−71.06
96	71.11	71.17	71.22	71.28	71.33	71.39	71.44	71.50	71.56	71.61
97	71.67	71.72	71.78	71.83	71.89	71.94	72.00	72.06	72.11	72.17
98	72.22	72.28	72.33	72.39	72.44	72.50	72.56	72.61	72.67	72.72
99	72.78	72.83	72.89	72.94	73.00	73.06	73.11	73.17	73.22	73.28
−100	−73.33	−73.39	−73.44	−73.50	−73.56	−73.61	−73.67	−73.72	−73.78	−73.83
101	73.89	73.94	74.00	74.06	74.11	74.17	74.22	74.28	74.33	74.39
102	74.44	74.50	74.56	74.61	74.67	74.72	74.78	74.83	74.89	74.94
103	75.00	75.06	75.11	75.17	75.22	75.28	75.33	75.39	75.44	75.50
104	75.56	75.61	75.67	75.72	75.78	75.83	75.89	75.94	76.00	76.06
−105	−76.11	−76.17	−76.22	−76.28	−76.33	−76.39	−76.44	−76.50	−76.56	−76.61
106	76.67	76.72	76.78	76.83	76.89	76.94	77.00	77.06	77.11	77.17
107	77.22	77.28	77.33	77.39	77.44	77.50	77.56	77.61	77.67	77.72
108	77.78	77.83	77.89	77.94	78.00	78.06	78.11	78.17	78.22	78.28
109	78.33	78.39	78.44	78.50	78.56	78.61	78.67	78.72	78.78	78.83
−110	−78.89	−78.94	−79.00	−79.06	−79.11	−79.17	−79.22	−79.28	−79.33	−79.39
111	79.44	79.50	79.56	79.61	79.67	79.72	79.78	79.83	79.89	79.94
112	80.00	80.06	80.11	80.17	80.22	80.28	80.33	80.39	80.44	80.50
113	80.56	80.61	80.67	80.72	80.78	80.83	80.89	80.94	81.00	81.06
114	81.11	81.17	81.22	81.28	81.33	81.39	81.44	81.50	81.56	81.61
−115	−81.67	−81.72	−81.78	−81.83	−81.89	−81.94	−82.00	−82.06	−82.11	−82.17
116	82.22	82.28	82.33	82.39	82.44	82.50	82.56	82.61	82.67	82.72
117	82.78	82.83	82.89	82.94	83.00	83.06	83.11	83.17	83.22	83.28
118	83.33	83.39	83.44	83.50	83.56	83.61	83.67	83.72	83.78	83.83
119	83.89	83.94	84.00	84.06	84.11	84.17	84.22	84.28	84.33	84.39
−120	−84.44	−84.50	−84.56	−84.61	−84.67	−84.72	−84.78	−84.83	−84.89	−84.94
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

TABLE 3.

CENTIGRADE SCALE TO FAHRENHEIT.

Centigrade.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
+60°	+140°.00	+140°.18	+140°.36	+140°.54	+140°.72	+140°.90	+141°.08	+141°.26	+141°.44	+141°.62
59	138.20	138.38	138.56	138.74	138.92	139.10	139.28	139.46	139.64	139.82
58	136.40	136.58	136.76	136.94	137.12	137.30	137.48	137.66	137.84	138.02
57	134.60	134.78	134.96	135.14	135.32	135.50	135.68	135.86	136.04	136.22
56	132.80	132.98	133.16	133.34	133.52	133.70	133.88	134.06	134.24	134.42
+55	+131.00	+131.18	+131.36	+131.54	+131.72	+131.90	+132.08	+132.26	+132.44	+132.62
54	129.20	129.38	129.56	129.74	129.92	130.10	130.28	130.46	130.64	130.82
53	127.40	127.58	127.76	127.94	128.12	128.30	128.48	128.66	128.84	129.02
52	125.60	125.78	125.96	126.14	126.32	126.50	126.68	126.86	127.04	127.22
51	123.80	123.98	124.16	124.34	124.52	124.70	124.88	125.06	125.24	125.42
+50	+122.00	+122.18	+122.36	+122.54	+122.72	+122.90	+123.08	+123.26	+123.44	+123.62
49	120.20	120.38	120.56	120.74	120.92	121.10	121.28	121.46	121.64	121.82
48	118.40	118.58	118.76	118.94	119.12	119.30	119.48	119.66	119.84	120.02
47	116.60	116.78	116.96	117.14	117.32	117.50	117.68	117.86	118.04	118.22
46	114.80	114.98	115.16	115.34	115.52	115.70	115.88	116.06	116.24	116.42
+45	+113.00	+113.18	+113.36	+113.54	+113.72	+113.90	+114.08	+114.26	+114.44	+114.62
44	111.20	111.38	111.56	111.74	111.92	112.10	112.28	112.46	112.64	112.82
43	109.40	109.58	109.76	109.94	110.12	110.30	110.48	110.66	110.84	111.02
42	107.60	107.78	107.96	108.14	108.32	108.50	108.68	108.86	109.04	109.22
41	105.80	105.98	106.16	106.34	106.52	106.70	106.88	107.06	107.24	107.42
+40	+104.00	+104.18	+104.36	+104.54	+104.72	+104.90	+105.08	+105.26	+105.44	+105.62
39	102.20	102.38	102.56	102.74	102.92	103.10	103.28	103.46	103.64	103.82
38	100.40	100.58	100.76	100.94	101.12	101.30	101.48	101.66	101.84	102.02
37	98.60	98.78	98.96	99.14	99.32	99.50	99.68	99.86	100.04	100.22
36	96.80	96.98	97.16	97.34	97.52	97.70	97.88	98.06	98.24	98.42
+35	+ 95.00	+ 95.18	+ 95.36	+ 95.54	+ 95.72	+ 95.90	+ 96.08	+ 96.26	+ 96.44	+ 96.62
34	93.20	93.38	93.56	93.74	93.92	94.10	94.28	94.46	94.64	94.82
33	91.40	91.58	91.76	91.94	92.12	92.30	92.48	92.66	92.84	93.02
32	89.60	89.78	89.96	90.14	90.32	90.50	90.68	90.86	91.04	91.22
31	87.80	87.98	88.16	88.34	88.52	88.70	88.88	89.06	89.24	89.42
+30	+ 86.00	+ 86.18	+ 86.36	+ 86.54	+ 86.72	+ 86.90	+ 87.08	+ 87.26	+ 87.44	+ 87.62
29	84.20	84.38	84.56	84.74	84.92	85.10	85.28	85.46	85.64	85.82
28	82.40	82.58	82.76	82.94	83.12	83.30	83.48	83.66	83.84	84.02
27	80.60	80.78	80.96	81.14	81.32	81.50	81.68	81.86	82.04	82.22
26	78.80	78.98	79.16	79.34	79.52	79.70	79.88	80.06	80.24	80.42
+25	+ 77.00	+ 77.18	+ 77.36	+ 77.54	+ 77.72	+ 77.90	+ 78.08	+ 78.26	+ 78.44	+ 78.62
24	75.20	75.38	75.56	75.74	75.92	76.10	76.28	76.46	76.64	76.82
23	73.40	73.58	73.76	73.94	74.12	74.30	74.48	74.66	74.84	75.02
22	71.60	71.78	71.96	72.14	72.32	72.50	72.68	72.86	73.04	73.22
21	69.80	69.98	70.16	70.34	70.52	70.70	70.88	71.06	71.24	71.42
+20	+ 68.00	+ 68.18	+ 68.36	+ 68.54	+ 68.72	+ 68.90	+ 69.08	+ 69.26	+ 69.44	+ 69.62
19	66.20	66.38	66.56	66.74	66.92	67.10	67.28	67.46	67.64	67.82
18	64.40	64.58	64.76	64.94	65.12	65.30	65.48	65.66	65.84	66.02
17	62.60	62.78	62.96	63.14	63.32	63.50	63.68	63.86	64.04	64.22
16	60.80	60.98	61.16	61.34	61.52	61.70	61.88	62.06	62.24	62.42
+15	+ 59.00	+ 59.18	+ 59.36	+ 59.54	+ 59.72	+ 59.90	+ 60.08	+ 60.26	+ 60.44	+ 60.62
14	57.20	57.38	57.56	57.74	57.92	58.10	58.28	58.46	58.64	58.82
13	55.40	55.58	55.76	55.94	56.12	56.30	56.48	56.66	56.84	57.02
12	53.60	53.78	53.96	54.14	54.32	54.50	54.68	54.86	55.04	55.22
11	51.80	51.98	52.16	52.34	52.52	52.70	52.88	53.06	53.24	53.42
+10	+ 50.00	+ 50.18	+ 50.36	+ 50.54	+ 50.72	+ 50.90	+ 51.08	+ 51.26	+ 51.44	+ 51.62
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

CENTIGRADE SCALE TO FAHRENHEIT.

Centigrade.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
+10°	+50°.00	+50°.18	+50°.36	+50°.54	+50°.72	+50°.90	+51°.08	+51°.26	+51°.44	+51°.62
+ 9	+48.20	+48.38	+48.56	+48.74	+48.92	+49.10	+49.28	+49.46	+49.64	+49.82
8	46.40	46.58	46.76	46.94	47.12	47.30	47.48	47.66	47.84	48.02
7	44.60	44.78	44.96	45.14	45.32	45.50	45.68	45.86	46.04	46.22
6	42.80	42.98	43.16	43.34	43.52	43.70	43.88	44.06	44.24	44.42
5	41.00	41.18	41.36	41.54	41.72	41.90	42.08	42.26	42.44	42.62
+ 4	+39.20	+39.38	+39.56	+39.74	+39.92	+40.10	+40.28	+40.46	+40.64	+40.82
3	37.40	37.58	37.76	37.94	38.12	38.30	38.48	38.66	38.84	39.02
2	35.60	35.78	35.96	36.14	36.32	36.50	36.68	36.86	37.04	37.22
1	33.80	33.98	34.16	34.34	34.52	34.70	34.88	35.06	35.24	35.42
+ 0	32.00	32.18	32.36	32.54	32.72	32.90	33.08	33.26	33.44	33.62
− 0	+32.00	+31.82	+31.64	+31.46	+31.28	+31.10	+30.92	+30.74	+30.56	+30.38
1	30.20	30.02	29.84	29.66	29.48	29.30	29.12	28.94	28.76	28.58
2	28.40	28.22	28.04	27.86	27.68	27.50	27.32	27.14	26.96	26.78
3	26.60	26.42	26.24	26.06	25.88	25.70	25.52	25.34	25.16	24.98
4	24.80	24.62	24.44	24.26	24.08	23.90	23.72	23.54	23.36	23.18
− 5	+23.00	+22.82	+22.64	+22.46	+22.28	+22.10	+21.92	+21.74	+21.56	+21.38
6	21.20	21.02	20.84	20.66	20.48	20.30	20.12	19.94	19.76	19.58
7	19.40	19.22	19.04	18.86	18.68	18.50	18.32	18.14	17.96	17.78
8	17.60	17.42	17.24	17.06	16.88	16.70	16.52	16.34	16.16	15.98
9	15.80	15.62	15.44	15.26	15.08	14.90	14.72	14.54	14.36	14.18
−10	+14.00	+13.82	+13.64	+13.46	+13.28	+13.10	+12.92	+12.74	+12.56	+12.38
11	12.20	12.02	11.84	11.66	11.48	11.30	11.12	10.94	10.76	10.58
12	10.40	10.22	10.04	9.86	9.68	9.50	9.32	9.14	8.96	8.78
13	8.60	8.42	8.24	8.06	7.88	7.70	7.52	7.34	7.16	6.98
14	6.80	6.62	6.44	6.26	6.08	5.90	5.72	5.54	5.36	5.18
−15	+ 5.00	+ 4.82	+ 4.64	+ 4.46	+ 4.28	+ 4.10	+ 3.92	+ 3.74	+ 3.56	+ 3.38
16	+ 3.20	+ 3.02	+ 2.84	+ 2.66	+ 2.48	+ 2.30	+ 2.12	+ 1.94	+ 1.76	+ 1.58
17	+ 1.40	+ 1.22	+ 1.04	+ 0.86	+ 0.68	+ 0.50	+ 0.32	+ 0.14	− 0.04	− 0.22
18	− 0.40	− 0.58	− 0.76	− 0.94	− 1.12	− 1.30	− 1.48	− 1.66	− 1.84	− 2.02
19	− 2.20	− 2.38	− 2.56	− 2.74	− 2.92	− 3.10	− 3.28	− 3.46	− 3.64	− 3.82
−20	− 4.00	− 4.18	− 4.36	− 4.54	− 4.72	− 4.90	− 5.08	− 5.26	− 5.44	− 5.62
21	5.80	5.98	6.16	6.34	6.52	6.70	6.88	7.06	7.24	7.42
22	7.60	7.78	7.96	8.14	8.32	8.50	8.68	8.86	9.04	9.22
23	9.40	9.58	9.76	9.94	10.12	10.30	10.48	10.66	10.84	11.02
24	11.20	11.38	11.56	11.74	11.92	12.10	12.28	12.46	12.64	12.82
−25	−13.00	−13.18	−13.36	−13.54	−13.72	−13.90	−14.08	−14.26	−14.44	−14.62
26	14.80	14.98	15.16	15.34	15.52	15.70	15.88	16.06	16.24	16.42
27	16.60	16.78	16.96	17.14	17.32	17.50	17.68	17.86	18.04	18.22
28	18.40	18.58	18.76	18.94	19.12	19.30	19.48	19.66	19.84	20.02
29	20.20	20.38	20.56	20.74	20.92	21.10	21.28	21.46	21.64	21.82
−30	−22.00	−22.18	−22.36	−22.54	−22.72	−22.90	−23.08	−23.26	−23.44	−23.62
31	23.80	23.98	24.16	24.34	24.52	24.70	24.88	25.06	25.24	25.42
32	25.60	25.78	25.96	26.14	26.32	26.50	26.68	26.86	27.04	27.22
33	27.40	27.58	27.76	27.94	28.12	28.30	28.48	28.66	28.84	29.02
34	29.20	29.38	29.56	29.74	29.92	30.10	30.28	30.46	30.64	30.82
−35	−31.00	−31.18	−31.36	−31.54	−31.72	−31.90	−32.08	−32.26	−32.44	−32.62
36	32.80	32.98	33.16	33.34	33.52	33.70	33.88	34.06	34.24	34.42
37	34.60	34.78	34.96	35.14	35.32	35.50	35.68	35.86	36.04	36.22
38	36.40	36.58	36.76	36.94	37.12	37.30	37.48	37.66	37.84	38.02
39	38.20	38.38	38.56	38.74	38.92	39.10	39.28	39.46	39.64	39.82
−40	−40.00	−40.18	−40.36	−40.54	−40.72	−40.90	−41.08	−41.26	−41.44	−41.62
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

CENTIGRADE SCALE TO FAHRENHEIT.

Centigrade.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
– 40°	– 40°.00	– 40°.18	– 40°.36	– 40°.54	– 40°.72	– 40°.90	– 41°.08	– 41°.26	– 41°.44	– 41°.62
41	41.80	41.98	42.16	42.34	42.52	42.70	42.88	43.06	43.24	43.42
42	43.60	43.78	43.96	44.14	44.32	44.50	44.68	44.86	45.04	45.22
43	45.40	45.58	45.76	45.94	46.12	46.30	46.48	46.66	46.84	47.02
44	47.20	47.38	47.56	47.74	47.92	48.10	48.28	48.46	48.64	48.82
– 45	– 49.00	– 49.18	– 49.36	– 49.54	– 49.72	– 49.90	– 50.08	– 50.26	– 50.44	– 50.62
46	50.80	50.98	51.16	51.34	51.52	51.70	51.88	52.06	52.24	52.42
47	52.60	52.78	52.96	53.14	53.32	53.50	53.68	53.86	54.04	54.22
48	54.40	54.58	54.76	54.94	55.12	55.30	55.48	55.66	55.84	56.02
49	56.20	56.38	56.56	56.74	56.92	57.10	57.28	57.46	57.64	57.82
– 50	– 58.00	– 58.18	– 58.36	– 58.54	– 58.72	– 58.90	– 59.08	– 59.26	– 59.44	– 59.62
51	59.80	59.98	60.16	60.34	60.52	60.70	60.88	61.06	61.24	61.42
52	61.60	61.78	61.96	62.14	62.32	62.50	62.68	62.86	63.04	63.22
53	63.40	63.58	63.76	63.94	64.12	64.30	64.48	64.66	64.84	65.02
54	65.20	65.38	65.56	65.74	65.92	66.10	66.28	66.46	66.64	66.82
– 55	– 67.00	– 67.18	– 67.36	– 67.54	– 67.72	– 67.90	– 68.08	– 68.26	– 68.44	– 68.62
56	68.80	68.98	69.16	69.34	69.52	69.70	69.88	70.06	70.24	70.42
57	70.60	70.78	70.96	71.14	71.32	71.50	71.68	71.86	72.04	72.22
58	72.40	72.58	72.76	72.94	73.12	73.30	73.48	73.66	73.84	74.02
59	74.20	74.38	74.56	74.74	74.92	75.10	75.28	75.46	75.64	75.82
– 60	– 76.00	– 76.18	– 76.36	– 76.54	– 76.72	– 76.90	– 77.08	– 77.26	– 77.44	– 77.62
61	77.80	77.98	78.16	78.34	78.52	78.70	78.88	79.06	79.24	79.42
62	79.60	79.78	79.96	80.14	80.32	80.50	80.68	80.86	81.04	81.22
63	81.40	81.58	81.76	81.94	82.12	82.30	82.48	82.66	82.84	83.02
64	83.20	83.38	83.56	83.74	83.92	84.10	84.28	84.46	84.64	84.82
– 65	– 85.00	– 85.18	– 85.36	– 85.54	– 85.72	– 85.90	– 86.08	– 86.26	– 86.44	– 86.62
66	86.80	86.98	87.16	87.34	87.52	87.70	87.88	88.06	88.24	88.42
67	88.60	88.78	88.96	89.14	89.32	89.50	89.68	89.86	90.04	90.22
68	90.40	90.58	90.76	90.94	91.12	91.30	91.48	91.66	91.84	92.02
69	92.20	92.38	92.56	92.74	92.92	93.10	93.28	93.46	93.64	93.82
– 70	– 94.00	– 94.18	– 94.36	– 94.54	– 94.72	– 94.90	– 95.08	– 95.26	– 95.44	– 95.62
71	95.80	95.98	96.16	96.34	96.52	96.70	96.88	97.06	97.24	97.42
72	97.60	97.78	97.96	98.14	98.32	98.50	98.68	98.86	99.04	99.22
73	99.40	99.58	99.76	99.94	100.12	100.30	100.48	100.66	100.84	101.02
74	101.20	101.38	101.56	101.74	101.92	102.10	102.28	102.46	102.64	102.82
– 75	–103.00	–103.18	–103.36	–103.54	–103.72	–103.90	–104.08	–104.26	–104.44	–104.62
76	104.80	104.98	105.16	105.34	105.52	105.70	105.88	106.06	106.24	106.42
77	106.60	106.78	106.96	107.14	107.32	107.50	107.68	107.86	108.04	108.22
78	108.40	108.58	108.76	108.94	109.12	109.30	109.48	109.66	109.84	110.02
79	110.20	110.38	110.56	110.74	110.92	111.10	111.28	111.46	111.64	111.82
– 80	–112.00	–112.18	–112.36	–112.54	–112.72	–112.90	–113.08	–113.26	–113.44	–113.62
81	113.80	113.98	114.16	114.34	114.52	114.70	114.88	115.06	115.24	115.42
82	115.60	115.78	115.96	116.14	116.32	116.50	116.68	116.86	117.04	117.22
83	117.40	117.58	117.76	117.94	118.12	118.30	118.48	118.66	118.84	119.02
84	119.20	119.38	119.56	119.74	119.92	120.10	120.28	120.46	120.64	120.82
– 85	–121.00	–121.18	–121.36	–121.54	–121.72	–121.90	–122.08	–122.26	–122.44	–122.62
86	122.80	122.98	123.16	123.34	123.52	123.70	123.88	124.06	124.24	124.42
87	124.60	124.78	124.96	125.14	125.32	125.50	125.68	125.86	126.04	126.22
88	126.40	126.58	126.76	126.94	127.12	127.30	127.48	127.66	127.84	128.02
89	128.20	128.38	128.56	128.74	128.92	129.10	129.28	129.46	129.64	129.82
– 90	–130.00	–130.18	–130.36	–130.54	–130.72	–130.90	–131.08	–131.26	–131.44	–131.62
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

TABLE 4.

CENTIGRADE SCALE TO FAHRENHEIT—Near the Boiling Point.

Centigrade.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
100°	212°.00	212°.18	212°.36	212°.54	212°.72	212°.90	213°.08	213°.26	213°.44	213°.62
99	210.20	210.38	210.56	210.74	210.92	211.10	211.28	211.46	211.64	211.82
98	208.40	208.58	208.76	208.94	209.12	209.30	209.48	209.66	209.84	210.02
97	206.60	206.78	206.96	207.14	207.32	207.50	207.68	207.86	208.04	208.22
96	204.80	204.98	205.16	205.34	205.52	205.70	205.88	206.06	206.24	206.42
95	203.00	203.18	203.36	203.54	203.72	203.90	204.08	204.26	204.44	204.62
94	201.20	201.38	201.56	201.74	201.92	202.10	202.28	202.46	202.64	202.82
93	199.40	199.58	199.76	199.94	200.12	200.30	200.48	200.66	200.84	201.02
92	197.60	197.78	197.96	198.14	198.32	198.50	198.68	198.86	199.04	199.22
91	195.80	195.98	196.16	196.34	196.52	196.70	196.88	197.06	197.24	197.42
90	194.00	194.18	194.36	194.54	194.72	194.90	195.08	195.26	195.44	195.62

TABLE 5.

DIFFERENCES FAHRENHEIT TO DIFFERENCES CENTIGRADE.

Fahrenheit.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
0°	0°.00	0°.06	0°.11	0°.17	0°.22	0°.28	0°.33	0°.39	0°.44	0°.50
1	0.56	0.61	0.67	0.72	0.78	0.83	0.89	0.94	1.00	1.06
2	1.11	1.17	1.22	1.28	1.33	1.39	1.44	1.50	1.56	1.61
3	1.67	1.72	1.78	1.83	1.89	1.94	2.00	2.06	2.11	2.17
4	2.22	2.28	2.33	2.39	2.44	2.50	2.56	2.61	2.67	2.72
5	2.78	2.83	2.89	2.94	3.00	3.06	3.11	3.17	3.22	3.28
6	3.33	3.39	3.44	3.50	3.56	3.61	3.67	3.72	3.78	3.83
7	3.89	3.94	4.00	4.06	4.11	4.17	4.22	4.28	4.33	4.39
8	4.44	4.50	4.56	4.61	4.67	4.72	4.78	4.83	4.89	4.94
9	5.00	5.06	5.11	5.17	5.22	5.28	5.33	5.39	5.44	5.50
10	5.56	5.61	5.67	5.72	5.78	5.83	5.89	5.94	6.00	6.06
11	6.11	6.17	6.22	6.28	6.33	6.39	6.44	6.50	6.56	6.61
12	6.67	6.72	6.78	6.83	6.89	6.94	7.00	7.06	7.11	7.17
13	7.22	7.28	7.33	7.39	7.44	7.50	7.56	7.61	7.67	7.72
14	7.78	7.83	7.89	7.94	8.00	8.06	8.11	8.17	8.22	8.28
15	8.33	8.39	8.44	8.50	8.56	8.61	8.67	8.72	8.78	8.83
16	8.89	8.94	9.00	9.06	9.11	9.17	9.22	9.28	9.33	9.39
17	9.44	9.50	9.56	9.61	9.67	9.72	9.78	9.83	9.89	9.94
18	10.00	10.06	10.11	10.17	10.22	10.28	10.33	10.39	10.44	10.50
19	10.56	10.61	10.67	10.72	10.78	10.83	10.89	10.94	11.00	11.06
20	11.11	11.17	11.22	11.28	11.33	11.39	11.44	11.50	11.56	11.61

TABLE 6.

DIFFERENCES CENTIGRADE TO DIFFERENCES FAHRENHEIT.

Centigrade.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
0°	0°.00	0°.18	0°.36	0°.54	0°.72	0°.90	1°.08	1°.26	1°.44	1°.62
1	1.80	1.98	2.16	2.34	2.52	2.70	2.88	3.06	3.24	3.42
2	3.60	3.78	3.96	4.14	4.32	4.50	4.68	4.86	5.04	5.22
3	5.40	5.58	5.76	5.94	6.12	6.30	6.48	6.66	6.84	7.02
4	7.20	7.38	7.56	7.74	7.92	8.10	8.28	8.46	8.64	8.82
5	9.00	9.18	9.36	9.54	9.72	9.90	10.08	10.26	10.44	10.62
6	10.80	10.98	11.16	11.34	11.52	11.70	11.88	12.06	12.24	12.42
7	12.60	12.78	12.96	13.14	13.32	13.50	13.68	13.86	14.04	14.22
8	14.40	14.58	14.76	14.94	15.12	15.30	15.48	15.66	15.84	16.02
9	16.20	16.38	16.56	16.74	16.92	17.10	17.28	17.46	17.64	17.82

CORRECTION FOR THE TEMPERATURE OF THE EMERGENT MERCURIAL COLUMN OF THERMOMETERS.

$T = t - 0.000086\, n(t' - t)$ — Fahrenheit temperatures.
$T = t - 0.000155\, n(t' - t)$ — Centigrade temperatures.
T = Corrected temperature.
t = Observed temperature.
t' = Mean temperature of the glass stem and emergent mercury column.
n = Length of mercury in the emergent stem in scale degrees.

When t' is $\left\{\frac{\text{higher}}{\textit{lower}}\right\}$ than t the numerical correction is to be $\left\{\frac{\text{subtracted.}}{\textit{added.}}\right\}$

TABLE 7.

CORRECTION FOR FAHRENHEIT THERMOMETERS.

Values of $0.000086\, n(t' - t)$

n	$t' - t$									
	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
10°	0.°01	0.°02	0.°03	0.°03	0.°04	0.°05	0.°06	0.°07	0.°08	0.°09
20	0.02	0.03	0.05	0.07	0.09	0.10	0.12	0.14	0.15	0.17
30	0.03	0.05	0.08	0.10	0.13	0.15	0.18	0.21	0.23	0.26
40	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28	0.31	0.34
50	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.34	0.39	0.43
60	0.05	0.10	0.15	0.21	0.26	0.31	0.36	0.41	0.46	0.52
70	0.06	0.12	0.18	0.24	0.30	0.36	0.42	0.48	0.54	0.60
80	0.07	0.14	0.21	0.28	0.34	0.41	0.48	0.55	0.62	0.69
90	0.08	0.15	0.23	0.31	0.39	0.46	0.54	0.62	0.70	0.77
100	0.09	0.17	0.26	0.34	0.43	0.52	0.60	0.69	0.77	0.86
110	0.09	0.19	0.28	0.38	0.47	0.57	0.66	0.76	0.85	0.95
120	0.10	0.21	0.31	0.41	0.52	0.62	0.72	0.83	0.93	1.03
130	0.11	0.22	0.34	0.45	0.56	0.67	0.78	0.90	1.01	1.12

TABLE 8.

CORRECTION FOR CENTIGRADE THERMOMETERS.

Values of $0.000155\, n(t' - t)$

n	$t' - t$							
	10°	20°	30°	40°	50°	60°	70°	80°
C.	C.	C.	C.	C.	C.	C.	C.	C.
10°	0.°02	0.°03	0.°05	0.°06	0.°08	0.°09	0.°11	0.°12
20	0.03	0.06	0.09	0.12	0.16	0.19	0.22	0.25
30	0.05	0.09	0.14	0.19	0.23	0.28	0.33	0.37
40	0.06	0.12	0.19	0.25	0.31	0.37	0.43	0.50
50	0.08	0.16	0.23	0.31	0.39	0.46	0.54	0.62
60	0.09	0.19	0.28	0.37	0.46	0.56	0.65	0.74
70	0.11	0.22	0.33	0.43	0.54	0.65	0.76	0.87
80	0.12	0.25	0.37	0.50	0.62	0.74	0.87	0.99
90	0.14	0.28	0.42	0.56	0.70	0.84	0.98	1.12
100	0.16	0.31	0.46	0.62	0.78	0.93	1.08	1.24

CONVERSIONS INVOLVING LINEAR MEASURES.

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0.00	0.00	0.25	0.51	0.76	1.02	1.27	1.52	1.78	2.03	2.29
0.10	2.54	2.79	3.05	3.30	3.56	3.81	4.06	4.32	4.57	4.83
0.20	5.08	5.33	5.59	5.84	6.10	6.35	6.60	6.86	7.11	7.37
0.30	7.62	7.87	8.13	8.38	8.64	8.89	9.14	9.40	9.65	9.91
0.40	10.16	10.41	10.67	10.92	11.18	11.43	11.68	11.94	12.19	12.45
0.50	12.70	12.95	13.21	13.46	13.72	13.97	14.22	14.48	14.73	14.99
0.60	15.24	15.49	15.75	16.00	16.26	16.51	16.76	17.02	17.27	17.53
0.70	17.78	18.03	18.29	18.54	18.80	19.05	19.30	19.56	19.81	20.07
0.80	20.32	20.57	20.83	21.08	21.34	21.59	21.84	22.10	22.35	22.61
0.90	22.86	23.11	23.37	23.62	23.88	24.13	24.38	24.64	24.89	25.15
1.00	25.40	25.65	25.91	26.16	26.42	26.67	26.92	27.18	27.43	27.69
1.10	27.94	28.19	28.45	28.70	28.96	29.21	29.46	29.72	29.97	30.23
1.20	30.48	30.73	30.99	31.24	31.50	31.75	32.00	32.26	32.51	32.77
1.30	33.02	33.27	33.53	33.78	34.04	34.29	34.54	34.80	35.05	35.31
1.40	35.56	35.81	36.07	36.32	36.58	36.83	37.08	37.34	37.59	37.85
1.50	38.10	38.35	38.61	38.86	39.12	39.37	39.62	39.88	40.13	40.39
1.60	40.64	40.89	41.15	41.40	41.66	41.91	42.16	42.42	42.67	42.93
1.70	43.18	43.43	43.69	43.94	44.20	44.45	44.70	44.96	45.21	45.47
1.80	45.72	45.97	46.23	46.48	46.74	46.99	47.24	47.50	47.75	48.01
1.90	48.26	48.51	48.77	49.02	49.28	49.53	49.78	50.04	50.29	50.55
2.00	50.80	51.05	51.31	51.56	51.82	52.07	52.32	52.58	52.83	53.09
2.10	53.34	53.59	53.85	54.10	54.36	54.61	54.86	55.12	55.37	55.63
2.20	55.88	56.13	56.39	56.64	56.90	57.15	57.40	57.66	57.91	58.17
2.30	58.42	58.67	58.93	59.18	59.44	59.69	59.94	60.20	60.45	60.71
2.40	60.96	61.21	61.47	61.72	61.98	62.23	62.48	62.74	62.99	63.25
2.50	63.50	63.75	64.01	64.26	64.52	64.77	65.02	65.28	65.53	65.79
2.60	66.04	66.29	66.55	66.80	67.06	67.31	67.56	67.82	68.07	68.33
2.70	68.58	68.83	69.09	69.34	69.60	69.85	70.10	70.36	70.61	70.87
2.80	71.12	71.37	71.63	71.88	72.14	72.39	72.64	72.90	73.15	73.41
2.90	73.66	73.91	74.17	74.42	74.68	74.93	75.18	75.44	75.69	75.95
3.00	76.20	76.45	76.71	76.96	77.22	77.47	77.72	77.98	78.23	78.49
3.10	78.74	78.99	79.25	79.50	79.76	80.01	80.26	80.52	80.77	81.03
3.20	81.28	81.53	81.79	82.04	82.30	82.55	82.80	83.06	83.31	83.57
3.30	83.82	84.07	84.33	84.59	84.84	85.09	85.34	85.60	85.85	86.11
3.40	86.36	86.61	86.87	87.12	87.38	87.63	87.88	88.14	88.39	88.65
3.50	88.90	89.15	89.41	89.66	89.92	90.17	90.42	90.68	90.93	91.19
3.60	91.44	91.69	91.95	92.20	92.46	92.71	92.96	93.22	93.47	93.73
3.70	93.98	94.23	94.49	94.74	95.00	95.25	95.50	95.76	96.01	96.27
3.80	96.52	96.77	97.03	97.28	97.54	97.79	98.04	98.30	98.55	98.81
3.90	99.06	99.31	99.57	99.82	100.08	100.33	100.58	100.84	101.09	101.35
4.00	101.60	101.85	102.11	102.36	102.62	102.87	103.12	103.38	103.63	103.89
4.10	104.14	104.39	104.65	104.90	105.16	105.41	105.66	105.92	106.17	106.43
4.20	106.68	106.93	107.19	107.44	107.70	107.95	108.20	108.46	108.71	108.97
4.30	109.22	109.47	109.73	109.98	110.24	110.49	110.74	111.00	111.25	111.51
4.40	111.76	112.01	112.27	112.52	112.78	113.03	113.28	113.54	113.79	114.05
4.50	114.30	114.55	114.81	115.06	115.32	115.57	115.82	116.08	116.33	116.59
4.60	116.84	117.09	117.35	117.60	117.86	118.11	118.36	118.62	118.87	119.13
4.70	119.38	119.63	119.89	120.14	120.40	120.65	120.90	121.16	121.41	121.67
4.80	121.92	122.17	122.43	122.68	122.94	123.19	123.44	123.70	123.95	124.21
4.90	124.46	124.71	124.97	125.22	125.48	125.73	125.98	126.24	126.49	126.75
5.00	127.00	127.25	127.51	127.76	128.02	128.27	128.52	128.78	129.03	129.29

Proportional Parts.										
Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
5.00	127.00	127.25	127.51	127.76	128.02	128.27	128.52	128.78	129.03	129.29
5.10	129.54	129.79	130.05	130.30	130.56	130.81	131.06	131.32	131.57	131.83
5.20	132.08	132.33	132.59	132.84	133.10	133.35	133.60	133.86	134.11	134.37
5.30	134.62	134.87	135.13	135.38	135.64	135.89	136.14	136.40	136.65	136.91
5.40	137.16	137.41	137.67	137.92	138.18	138.43	138.68	138.94	139.19	139.45
5.50	139.70	139.95	140.21	140.46	140.72	140.97	141.22	141.48	141.73	141.99
5.60	142.24	142.49	142.75	143.00	143.26	143.51	143.76	144.02	144.27	144.53
5.70	144.78	145.03	145.29	145.54	145.80	146.05	146.30	146.56	146.81	147.07
5.80	147.32	147.57	147.83	148.08	148.34	148.59	148.84	149.10	149.35	149.61
5.90	149.86	150.11	150.37	150.62	150.88	151.13	151.38	151.64	151.89	152.15
6.00	152.40	152.66	152.91	153.16	153.42	153.67	153.92	154.18	154.43	154.69
6.10	154.94	155.19	155.45	155.70	155.96	156.21	156.46	156.72	156.97	157.23
6.20	157.48	157.73	157.99	158.24	158.50	158.75	159.00	159.26	159.51	159.77
6.30	160.02	160.27	160.53	160.78	161.04	161.29	161.54	161.80	162.05	162.31
6.40	162.56	162.81	163.07	163.32	163.58	163.83	164.08	164.34	164.59	164.85
6.50	165.10	165.35	165.61	165.86	166.12	166.37	166.62	166.88	167.13	167.39
6.60	167.64	167.89	168.15	168.40	168.66	168.91	169.16	169.42	169.67	169.93
6.70	170.18	170.43	170.69	170.94	171.20	171.45	171.70	171.96	172.21	172.47
6.80	172.72	172.97	173.23	173.48	173.74	173.99	174.24	174.50	174.75	175.01
6.90	175.26	175.51	175.77	176.02	176.28	176.53	176.78	177.04	177.29	177.55
7.00	177.80	178.05	178.31	178.56	178.82	179.07	179.32	179.58	179.83	180.09
7.10	180.34	180.59	180.85	181.10	181.36	181.61	181.86	182.12	182.37	182.63
7.20	182.88	183.13	183.39	183.64	183.90	184.15	184.40	184.66	184.91	185.17
7.30	185.42	185.67	185.93	186.18	186.44	186.69	186.94	187.20	187.45	187.71
7.40	187.96	188.21	188.47	188.72	188.98	189.23	189.48	189.74	189.99	190.25
7.50	190.50	190.75	191.01	191.26	191.52	191.77	192.02	192.28	192.53	192.79
7.60	193.04	193.29	193.55	193.80	194.06	194.31	194.56	194.82	195.07	195.33
7.70	195.58	195.83	196.09	196.34	196.60	196.85	197.10	197.36	197.61	197.87
7.80	198.12	198.37	198.63	198.88	199.14	199.39	199.64	199.90	200.15	200.41
7.90	200.66	200.91	201.17	201.42	201.68	201.93	202.18	202.44	202.69	202.95
8.00	203.20	203.45	203.71	203.96	204.22	204.47	204.72	204.98	205.23	205.49
8.10	205.74	205.99	206.25	206.50	206.76	207.01	207.26	207.52	207.77	208.03
8.20	208.28	208.53	208.79	209.04	209.30	209.55	209.80	210.06	210.31	210.57
8.30	210.82	211.07	211.33	211.58	211.84	212.09	212.34	212.60	212.85	213.11
8.40	213.36	213.61	213.87	214.12	214.38	214.63	214.88	215.14	215.39	215.65
8.50	215.90	216.15	216.41	216.66	216.92	217.17	217.42	217.68	217.93	218.19
8.60	218.44	218.69	218.95	219.20	219.46	219.71	219.96	220.22	220.47	220.73
8.70	220.98	221.23	221.49	221.74	222.00	222.25	222.50	222.76	223.01	223.27
8.80	223.52	223.77	224.03	224.28	224.54	224.79	225.04	225.30	225.55	225.81
8.90	226.06	226.31	226.57	226.82	227.08	227.33	227.58	227.84	228.09	228.35
9.00	228.60	228.85	229.11	229.36	229.62	229.87	230.12	230.38	230.63	230.89
9.10	231.14	231.39	231.65	231.90	232.16	232.41	232.66	232.92	233.17	233.43
9.20	233.68	233.93	234.19	234.44	234.70	234.95	235.20	235.46	235.71	235.97
9.30	236.22	236.47	236.73	236.98	237.24	237.49	237.74	238.00	238.25	238.51
9.40	238.76	239.01	239.27	239.52	239.78	240.03	240.28	240.54	240.79	241.05
9.50	241.30	241.55	241.81	242.06	242.32	242.57	242.82	243.08	243.33	243.59
9.60	243.84	244.09	244.35	244.60	244.86	245.11	245.36	245.62	245.87	246.13
9.70	246.38	246.63	246.89	247.14	247.40	247.65	247.90	248.16	248.41	248.67
9.80	248.92	249.17	249.43	249.68	249.94	250.19	250.44	250.70	250.95	251.21
9.90	251.46	251.71	251.97	252.22	252.48	252.73	252.98	253.24	253.49	253.75
10.00	254.00	254.25	254.51	254.76	255.02	255.27	255.52	255.78	256.03	256.29

Proportional Parts.										
	Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

TABLE 9.

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
10.00	254.00	254.25	254.51	254.76	255.02	255.27	255.52	255.78	256.03	256.29
10.10	256.54	256.79	257.05	257.30	257.56	257.81	258.06	258.32	258.57	258.83
10.20	259.08	259.33	259.59	259.84	260.10	260.35	260.60	260.86	261.11	261.37
10.30	261.62	261.87	262.13	262.38	262.64	262.89	263.14	263.40	263.65	263.91
10.40	264.16	264.41	264.67	264.92	265.18	265.43	265.68	265.94	266.19	266.45
10.50	266.70	266.95	267.21	267.46	267.72	267.97	268.22	268.48	268.73	268.99
10.60	269.24	269.49	269.75	270.00	270.26	270.51	270.76	271.02	271.27	271.53
10.70	271.78	272.03	272.29	272.54	272.80	273.05	273.30	273.56	273.81	274.07
10.80	274.32	274.57	274.93	275.08	275.34	275.59	275.84	276.10	276.35	276.61
10.90	276.86	277.11	277.37	277.62	277.88	278.13	278.38	278.64	278.89	279.15
11.00	279.40	279.65	279.91	280.16	280.42	280.67	280.92	281.18	281.43	281.69
11.10	281.94	282.19	282.45	282.70	282.96	283.21	283.46	283.72	283.97	284.23
11.20	284.48	284.73	284.99	285.24	285.50	285.75	286.00	286.26	286.51	286.77
11.30	287.02	287.27	287.53	287.78	288.04	288.29	288.54	288.80	289.05	289.31
11.40	289.56	289.81	290.07	290.32	290.58	290.83	291.08	291.34	291.59	291.85
11.50	292.10	292.35	292.61	292.86	293.12	293.37	293.62	293.88	294.13	294.39
11.60	294.64	294.89	295.15	295.40	295.66	295.91	296.16	296.42	296.67	296.93
11.70	297.18	297.43	297.69	297.94	298.20	298.45	298.70	298.96	299.21	299.47
11.80	299.72	299.97	300.23	300.48	300.74	300.99	301.24	301.50	301.75	302.01
11.90	302.26	302.51	302.77	303.02	303.28	303.53	303.78	304.04	304.29	304.55
12.00	304.80	305.05	305.31	305.56	305.82	306.07	306.32	306.58	306.83	307.09
12.10	307.34	307.59	307.85	308.10	308.36	308.61	308.86	309.12	309.37	309.63
12.20	309.88	310.13	310.39	310.64	310.90	311.15	311.40	311.66	311.91	312.17
12.30	312.42	312.67	312.93	313.18	313.44	313.69	313.94	314.20	314.45	314.71
12.40	314.96	315.21	315.47	315.72	315.98	316.23	316.48	316.74	316.99	317.25
12.50	317.50	317.75	318.01	318.26	318.52	318.77	319.02	319.28	319.53	319.79
12.60	320.04	320.29	320.55	320.80	321.06	321.31	321.56	321.82	322.07	322.33
12.70	322.58	322.83	323.09	323.34	323.60	323.85	324.10	324.36	324.61	324.87
12.80	325.12	325.37	325.63	325.88	326.14	326.39	326.64	326.90	327.15	327.41
12.90	327.66	327.91	328.17	328.42	328.68	328.93	329.18	329.44	329.69	329.95
13.00	330.20	330.45	330.71	330.96	331.22	331.47	331.72	331.98	332.23	332.49
13.10	332.74	332.99	333.25	333.50	333.76	334.01	334.26	334.52	334.77	335.03
13.20	335.28	335.53	335.79	336.04	336.30	336.55	336.80	337.06	337.31	337.57
13.30	337.82	338.07	338.33	338.58	338.84	339.09	339.34	339.60	339.85	340.11
13.40	340.36	340.61	340.87	341.12	341.38	341.63	341.88	342.14	342.39	342.65
13.50	342.90	343.15	343.41	343.66	343.92	344.17	344.42	344.68	344.93	345.19
13.60	345.44	345.69	345.95	346.20	346.46	346.71	346.96	347.22	347.47	347.73
13.70	347.98	348.23	348.49	348.74	349.00	349.25	349.50	349.76	350.01	350.27
13.80	350.52	350.77	351.03	351.28	351.54	351.79	352.04	352.30	352.55	352.81
13.90	353.06	353.31	353.57	353.82	354.08	354.33	354.58	354.84	355.09	355.35
14.00	355.60	355.85	356.11	356.36	356.62	356.87	357.12	357.38	357.63	357.89
14.10	358.14	358.39	358.65	358.90	359.16	359.41	359.66	359.92	360.17	360.43
14.20	360.68	360.93	361.19	361.44	361.70	361.95	362.20	362.46	362.71	362.97
14.30	363.22	363.47	363.73	363.98	364.24	364.49	364.74	365.00	365.25	365.51
14.40	365.76	366.01	366.27	366.52	366.78	367.03	367.28	367.54	367.79	368.05
14.50	368.30	368.55	368.81	369.06	369.32	369.57	369.82	370.08	370.33	370.59
14.60	370.84	371.09	371.35	371.60	371.86	372.11	372.36	372.62	372.87	373.13
14.70	373.38	373.63	373.89	374.14	374.40	374.65	374.90	375.16	375.41	375.67
14.80	375.92	376.17	376.43	376.68	376.94	377.19	377.44	377.70	377.95	378.21
14.90	378.46	378.71	378.97	379.22	379.48	379.73	379.98	380.24	380.49	380.75
15.00	381.00	381.25	381.51	381.76	382.02	382.27	382.52	382.78	383.03	383.29

Proportional Parts.										
	Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
15.00	381.00	381.25	381.51	381.76	382.02	382.27	382.52	382.78	383.03	383.29
15.10	383.54	383.79	384.05	384.30	384.56	384.81	385.06	385.32	385.57	385.83
15.20	386.08	386.33	386.59	386.84	387.10	387.35	387.60	387.86	388.11	388.37
15.30	388.62	388.87	389.13	389.38	389.64	389.89	390.14	390.40	390.65	390.91
15.40	391.16	391.41	391.67	391.92	392.18	392.43	392.68	392.94	393.19	393.45
15.50	393.70	393.95	394.21	394.46	394.72	394.97	395.22	395.48	395.73	395.99
15.60	396.24	39.649	396.75	397.00	397.26	397.51	397.76	398.02	398.27	398.53
15.70	398.78	399.03	399.29	399.54	399.80	400.05	400.30	400.56	400.81	401.07
15.80	401.32	401.57	401.83	402.08	402.34	402.59	402.84	403.10	403.35	403.61
15.90	403.86	404.11	404.37	404.62	404.88	405.13	405.38	405.64	405.89	406.15
16.00	406.40	406.65	406.91	407.16	407.52	407.67	407.92	408.18	408.43	408.69
16.10	408.94	409.19	409.45	409.70	409.96	410.21	410.46	410.72	410.97	411.23
16.20	411.48	411.73	411.99	412.24	412.50	412.75	413.00	413.26	413.51	413.77
16.30	414.02	414.27	414.53	414.78	415.04	415.29	415.54	415.80	416.05	416.31
16.40	416.56	416.81	417.07	417.32	417.58	417.83	418.08	418.34	418.59	418.85
16.50	419.10	419.35	419.61	419.86	420.12	420.37	420.62	420.88	421.13	421.39
16.60	421.64	421.89	422.15	422.40	422.66	422.91	423.16	423.42	423.67	423.93
16.70	424.18	424.43	424.69	424.94	425.20	425.45	425.70	425.96	426.21	426.47
16.80	426.72	426.97	427.23	427.48	427.74	427.99	428.24	428.50	428.75	429.01
16.90	429.26	429.51	429.77	430.02	430.28	430.53	430.78	431.04	431.29	431.55
17.00	431.80	432.05	432.31	432.56	432.82	433.07	433.32	433.58	433.83	434.09
17.10	434.34	434.59	434.85	435.10	435.36	435.61	435.86	436.12	436.37	436.63
17.20	436.88	437.13	437.39	437.64	437.90	438.15	438.40	438.66	438.91	439.17
17.30	439.42	439.67	439.93	440.18	440.44	440.69	440.94	441.20	441.45	441.71
17.40	441.96	442.21	442.47	442.72	442.98	443.23	443.48	443.74	443.99	444.25
17.50	444.50	444.75	445.01	445.26	445.52	445.77	446.02	446.28	446.53	446.79
17.60	447.04	447.29	447.55	447.80	448.06	448.31	448.56	448.82	449.07	449.33
17.70	449.58	449.83	450.09	450.34	450.60	450.85	451.10	451.36	451.61	451.87
17.80	452.12	452.37	452.63	452.88	453.14	453.39	453.64	453.90	454.15	454.41
17.90	454.66	454.91	455.17	455.42	455.68	455.93	456.18	456.44	456.69	456.95
18.00	457.20	457.45	457.71	457.96	458.22	458.47	458.72	458.98	459.23	459.49
18.10	459.74	459.99	460.25	460.50	460.76	461.01	461.26	461.52	461.77	462.03
18.20	462.28	462.53	462.79	463.04	463.30	463.55	463.80	464.06	464.31	464.57
18.30	464.82	465.07	465.33	465.58	465.84	466.09	466.34	466.60	466.85	467.11
18.40	467.36	467.61	467.87	468.12	468.38	468.63	468.88	469.14	469.39	469.35
18.50	469.90	470.15	470.41	470.66	470.92	471.17	471.42	471.68	471.93	472.19
18.60	472.44	472.69	472.95	473.20	473.46	473.71	473.96	474.22	474.47	474.73
18.70	474.98	475.23	475.49	475.74	476.00	476.25	476.50	476.76	477.01	477.27
18.80	477.52	477.77	478.03	478.28	478.54	478.79	479.04	479.30	479.55	479.81
18.90	480.06	480.31	480.57	480.82	481.08	481.33	481.58	481.84	482.09	482.35
19.00	482.60	482.85	483.11	483.36	483.62	483.87	484.12	484.38	484.63	484.89
19.10	485.14	485.39	485.65	485.90	486.16	486.41	486.66	486.92	487.17	487.43
19.20	487.68	487.93	488.19	488.44	488.70	488.95	489.20	489.46	489.71	489.97
19.30	490.22	490.47	490.73	490.98	491.24	491.49	491.74	492.00	492.25	492.51
19.40	492.76	493.01	493.27	493.52	493.78	494.03	494.28	494.54	494.79	495.05
19.50	495.30	495.55	495.81	496.06	496.32	496.57	496.82	497.08	497.33	497.59
19.60	497.84	498.09	498.35	498.60	498.86	499.11	499.36	499.62	499.87	500.13
19.70	500.38	500.34	500.89	501.14	501.40	501.65	501.91	502.16	502.41	502.67
19.80	502.92	503.18	503.43	503.68	503.94	504.19	504.45	504.70	504.95	505.21
19.90	505.46	505.72	505.97	506.22	506.48	506.73	506.99	507.24	507.49	507.75
20.00	508.00	508.26	508.51	508.76	509.02	509.27	509.53	509.78	510.03	510.29

Proportional Parts.										
Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

Table 9.

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
20.00	508.00	508.26	508.51	508.76	509.02	509.27	509.53	509.78	510.03	510.29
20.10	510.54	510.80	511.05	511.30	511.56	511.81	512.07	512.32	512.57	512.83
20.20	513.08	513.34	513.59	513.84	514.10	514.35	514.61	514.86	515.11	515.37
20.30	515.62	515.88	516.13	516.38	516.64	516.89	517.15	517.40	517.65	517.91
20.40	518.16	518.42	518.67	518.92	519.18	519.43	519.69	519.94	520.19	520.45
20.50	520.70	520.96	521.21	521.46	521.72	521.97	522.23	522.48	522.73	522.99
20.60	523.24	523.50	523.75	524.00	524.26	524.51	524.77	525.02	525.27	525.53
20.70	525.78	526.04	526.29	526.54	526.80	526.95	527.31	527.56	527.81	528.07
20.80	528.32	528.58	528.83	529.08	529.34	529.59	529.85	530.10	530.35	530.61
20.90	530.86	531.12	531.37	531.62	531.88	532.13	532.39	532.64	532.89	533.15
21.00	533.40	533.66	533.91	534.16	534.42	534.67	534.93	535.18	535.43	535.69
21.10	535.94	536.20	536.45	536.70	536.96	537.21	537.47	537.72	537.98	538.23
21.20	538.48	538.74	538.99	539.24	539.50	539.75	540.01	540.26	540.51	540.77
21.30	541.02	541.28	541.53	541.78	542.04	542.29	542.55	542.80	543.05	543.31
21.40	543.56	543.82	544.07	544.32	544.58	544.83	545.09	545.34	545.59	545.85
21.50	546.10	546.36	546.61	546.86	547.12	547.37	547.63	547.88	548.13	548.39
21.60	548.64	548.90	549.15	549.40	549.66	549.91	550.17	550.42	550.67	550.93
21.70	551.18	551.44	551.69	551.94	552.20	552.45	552.71	552.96	553.21	553.47
21.80	553.72	553.98	554.23	554.48	554.74	554.99	555.25	555.50	555.75	556.01
21.90	556.26	556.52	556.77	557.02	557.28	557.53	557.79	558.04	558.29	558.55
22.00	558.80	559.06	559.31	559.56	559.82	560.07	560.03	560.58	560.83	561.09
22.10	561.34	561.60	561.85	562.10	562.36	562.61	562.87	563.12	563.37	563.63
22.20	563.88	564.14	564.39	564.64	564.90	565.15	565.41	565.66	565.91	566.17
22.30	566.42	566.68	566.93	567.18	567.44	567.69	567.95	568.20	568.45	568.71
22.40	568.96	569.22	569.47	569.72	569.98	570.23	570.49	570.74	570.99	571.25
22.50	571.50	571.76	572.01	572.26	572.52	572.77	573.03	573.28	573.53	573.79
22.60	574.04	574.30	574.55	574.80	575.06	575.31	575.57	575.82	576.07	576.33
22.70	576.58	576.84	577.09	577.34	577.60	577.95	578.11	578.36	578.61	578.87
22.80	579.12	579.38	579.63	579.88	580.14	580.39	580.65	580.90	581.15	581.41
22.90	581.66	581.92	582.17	582.42	582.68	582.93	583.19	583.44	583.69	583.95
23.00	584.20	584.46	584.71	584.96	585.22	585.47	585.73	585.98	586.23	586.49
23.10	586.74	587.00	587.25	587.50	587.76	588.01	588.27	588.52	588.77	589.03
23.20	589.28	589.54	589.79	590.04	590.30	590.55	590.81	591.06	591.31	591.57
23.30	591.82	592.08	592.33	592.58	592.84	593.09	593.35	593.60	593.85	594.11
23.40	594.36	594.62	594.87	595.12	595.38	595.63	595.89	596.14	596.39	596.65
23.50	596.90	597.16	597.41	597.66	597.92	598.17	598.43	598.68	598.93	599.19
23.60	599.44	599.70	599.95	600.20	600.46	600.71	600.97	601.22	601.47	601.73
23.70	601.98	602,24	602.49	602.74	603.00	603.25	603.51	603.76	604.01	604.27
23.80	604.52	604.78	605.03	605.28	605.54	605.79	606.05	606.30	606.55	606.81
23.90	607.06	607.32	607.57	607.82	608.08	608.33	608.59	608.84	609.09	609.35
24.00	609.60	609.86	610.11	610.36	610.62	610.87	611.13	611.38	611.63	611.89
24.10	612.14	612.40	612.65	612.90	613.16	613.41	613.67	613.92	614.17	614.43
24.20	614.68	614.94	615.19	615.44	615.70	615.95	616.21	616.46	616.71	616.97
24.30	617.22	617.48	617.73	617.98	618.24	618.49	618.75	619.00	619.25	619.51
24.40	619.76	620.02	620.27	620.52	620.78	621.03	621.29	621.54	621.79	622.05
24.50	622.30	622.56	622.81	623.06	623.32	623.57	623.83	624.08	624.33	624.59
24.60	624.84	625 10	625.35	625.60	625.86	626.11	626.37	626.62	626.87	627.13
24.70	627.38	627.64	627.89	628.14	628.40	628.65	628.91	629.16	629.41	629.67
24.80	629.92	630.18	630.43	630.68	630.94	631.19	631.45	631.70	631.95	632.21
24.90	632.46	632.72	632.97	633.22	633.48	633.73	633.99	634.24	634.49	634.75
25.00	635.00	635.26	635.51	635.76	636.02	636.27	636.53	636.78	637.03	637.29

Proportional Parts.										
	Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
25.00	635.00	635.26	635.51	635.76	636.02	636.27	636.53	636.78	637.03	637.29
25.10	637.54	637.80	638.05	638.30	638.56	638.81	639.07	639.32	639.57	639.83
25.20	640.08	640.34	640.59	640.84	641.10	641.35	641.61	641.86	642.11	642.37
25.30	642.62	642.88	643.13	643.38	643.64	643.89	644.15	644.40	644.65	644.91
25.40	645.16	645.42	645.67	645.92	646.18	646.43	646.69	646.94	647.19	647.45
25.50	647.70	647.96	648.21	648.46	648.72	648.97	649.23	649.48	649.73	649.99
25.60	650.24	650.50	650.75	651.00	651.26	651.51	651.77	652.02	654.27	652.53
25.70	652.78	653.04	653.29	653.54	653.80	654.05	654.31	654.56	654.81	655.07
25.80	655.32	655.58	655.83	656.08	656.34	656.59	656.85	657.10	657.35	657.61
25.90	657.86	658.12	658.37	658.62	658.88	659.13	659.39	659.64	659.89	660.15
26.00	660.40	660.66	660.91	661.16	661.42	661.67	661.93	662.18	662.43	662.69
26.10	662.94	663.20	663.45	663.70	663.96	664.21	664.47	664.72	664.97	665.23
26.20	665.48	665.74	665.99	666.24	666.50	666.75	667.01	667.26	667.51	667.77
26.30	668.02	668.28	668.53	668.78	669.04	669.29	669.55	669.80	670.05	670.31
26.40	670.56	670.82	671.07	671.32	671.58	671.83	672.09	672.34	672.59	672.85
26.50	673.10	673.36	673.61	673.86	674.12	674.37	674.63	674.88	675.13	675.39
26.60	675.64	675.90	676.15	676.40	676.66	676.91	677.17	677.42	677.67	677.93
26.70	678.18	678.44	678.69	678.94	679.20	679.45	679.71	679.96	680.21	680.47
26.80	680.72	680.98	681.23	681.48	681.74	681.99	682.25	682.50	682.75	683.01
26.90	683.26	683.52	683.77	684.02	684.28	684.53	684.79	685.04	685.29	685.55
27.00	685.80	686.06	686.31	686.56	686.82	687.07	687.33	687.58	687.83	688.09
27.10	688.34	688.60	688.85	689.10	689.36	689.61	689.87	690.12	690.37	690.63
27.20	690.88	691.14	691.39	691.64	691.90	692.15	692.41	692.66	692.91	693.17
27.30	693.42	693.68	693.93	694.18	694.44	694.69	694.95	695.20	695.45	695.71
27.40	695.96	696.22	696.47	696.72	696.98	697.23	697.49	697.74	697.99	698.25
27.50	698.50	698.76	699.01	699.26	699.52	699.77	700.03	700.28	700.53	700.79
27.60	701.04	701.30	701.55	701.80	702.06	702.31	702.57	702.82	703.07	703.33
27.70	703.58	703.84	704.09	704.34	704.60	704.85	705.11	705.36	705.61	705.87
27.80	706.12	706.38	706.63	706.88	707.14	707.39	707.65	707.90	708.15	708.41
27.90	708.66	708.92	709.17	709.42	709.68	709.93	710.19	710.44	710.69	710.95
28.00	711.20	711.46	711.71	711.96	712.22	712.47	712.73	712.98	713.23	713.49
28.10	713.74	714.00	714.25	714.50	714.76	715.01	715.27	715.52	715.77	716.03
28.20	716.28	716.54	716.79	717.04	717.30	717.55	717.81	718.06	718.31	718.57
28.30	718.82	719.08	719.33	719.58	719.84	720.09	720.35	720.60	720.85	721.11
28.40	721.36	721.62	721.87	722.12	722.39	722.63	722.89	723.14	723.39	723.65
28.50	723.90	724.16	724.41	724.66	724.92	725.17	725.43	725.68	725.93	726.19
28.60	726.44	726.70	726.95	727.20	727.46	727.71	727.97	728.22	728.47	728.73
28.70	728.98	729.24	729.49	729.74	730.00	730.25	730.51	730.76	731.01	731.27
28.80	731.52	731.78	732.03	732.28	732.54	732.79	733.05	733.30	733.55	733.81
28.90	734.06	734.32	734.57	734.82	735.08	735.33	735.59	735.84	736.09	736.35
29.00	736.60	736.86	737.11	737.36	737.62	737.87	738.13	738.38	738.63	738.89
29.10	739.14	739.40	739.65	739.90	740.16	740.41	740.67	740.92	741.17	741.43
29.20	741.68	741.94	742.19	742.44	742.70	742.95	743.21	743.46	743.71	743.97
29.30	744.22	744.48	744.73	744.98	745.24	745.49	745.75	746.00	746.25	746.51
29.40	746.76	747.02	747.27	747.52	747.78	748.03	748.29	748.54	748.79	749.05
29.50	749.30	749.56	749.81	750.06	750.32	750.57	750.83	751.08	751.33	751.59
29.60	751.84	752.10	752.35	752.60	752.86	753.11	753.37	753.62	753.87	754.13
29.70	754.38	754.64	754.89	755.14	755.40	755.65	755.91	756.16	756.41	756.67
29.80	756.92	757.18	757.43	757.68	757.94	758.19	758.45	758.70	758.95	759.21
29.90	759.46	759.72	759.97	760.22	760.48	760.73	760.99	761.24	761.49	761.75
30.00	762.00	762.26	762.51	762.76	763.02	763.27	763.53	763.78	764.03	764.29

Proportional Parts.										
Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

INCHES INTO MILLIMETERS.

1 inch = 25.40005 mm.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
30.00	762.00	762.26	762.51	762.76	763.02	763.27	763.53	763.78	764.03	764.29
30.10	764.54	764.80	765.05	765.30	765.56	765.81	766.07	766.32	766.57	766.83
30.20	767.08	767.34	767.59	767.84	768.10	768.35	768.61	768.86	769.11	769.37
30.30	769.62	769.88	770.13	770.38	770.64	770.89	771.15	771.40	771.65	771.91
30.40	772.16	772.42	772.67	772.92	773.18	773.43	773.69	773.94	774.19	774.45
30.50	774.70	774.96	775.21	775.46	775.72	775.97	776.23	776.48	776.73	776.99
30.60	777.24	777.50	777.75	778.00	778.26	778.51	778.77	779.02	779.27	779.53
30.70	779.78	780.04	780.29	780.54	780.80	781.05	781.31	781.56	781.81	782.07
30.80	782.32	782.58	782.83	783.08	783.34	783.59	783.85	784.10	784.35	784.61
30.90	784.86	785.12	785.37	785.62	785.88	786.13	786.39	786.64	786.89	787.15
31.00	787.40	787.66	787.91	788.16	788.42	788.67	788.93	789.18	789.43	789.69
31.10	789.94	790.20	790.45	790.70	790.96	791.21	791.47	791.72	791.97	792.23
31.20	792.48	792.74	792.99	793.24	793.50	793.75	794.01	794.26	794.51	794.77
31.30	795.02	795.28	795.53	795.78	796.04	796.29	796.55	796.80	797.05	797.31
31.40	797.56	797.82	798.07	798.32	798.58	798.83	799.09	799.34	799.59	799.85
31.50	800.10	800.36	800.61	800.86	801.12	801.37	801.63	801.88	802.13	802.39
31.60	802.64	802.90	803.15	803.40	803.66	803.91	804.17	804.42	804.67	804.93
31.70	805.18	805.44	805.69	805.94	806.20	806.45	806.71	806.96	807.21	807.47
31.80	807.72	807.98	808.23	808.48	808.74	808.99	809.25	809.50	809.75	810.01
31.90	810.26	810.52	810.77	811.02	811.28	811.53	811.79	812.04	812.29	812.55
32.00	812.80									

Proportional Parts.										
	Inch.	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	mm.	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	0	1	2	3	4	5	6	7	8	9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
0	0.0000	0.0394	0.0787	0.1181	0.1575	0.1968	0.2362	0.2756	0.3150	0.3543
10	0.3937	0.4331	0.4724	0.5118	0.5512	0.5906	0.6299	0.6693	0.7087	0.7480
20	0.7874	0.8268	0.8661	0.9055	0.9449	0.9842	1.0236	1.0630	1.1024	1.1417
30	1.1811	1.2205	1.2598	1.2992	1.3386	1.3780	1.4173	1.4567	1.4961	1.5354
40	1.5748	1.6142	1.6535	1.6929	1.7323	1.7716	1.8110	1.8504	1.8898	1.9291
50	1.9685	2.0079	2.0472	2.0866	2.1260	2.1654	2.2047	2.2441	2.2835	2.3228
60	2.3622	2.4016	2.4409	2.4803	2.5197	2.5590	2.5984	2.6378	2.6772	2.7165
70	2.7559	2.7953	2.8346	2.8740	2.9134	2.9528	2.9921	3.0315	3.0709	3.1102
80	3.1496	3.1890	3.2283	3.2677	3.3071	3.3464	3.3858	3.4252	3.4646	3.5039
90	3.5433	3.5828	3.6220	3.6614	3.7008	3.7402	3.7795	3.8189	3.8583	3.8976
100	3.9370	3.9764	4.0157	4.0551	4.0945	4.1338	4.1732	4.2126	4.2520	4.2913
110	4.3307	4.3701	4.4094	4.4488	4.4882	4.5276	4.5669	4.6063	4.6457	4.6850
120	4.7244	4.7638	4.8031	4.8425	4.8819	4.9212	4.9606	5.0000	5.0394	5.0787
130	5.1181	5.1575	5.1968	5.2362	5.2756	5.3150	5.3543	5.3937	5.4331	5.4724
140	5.5118	5.5512	5.5905	5.6299	5.6693	5.7086	5.7480	5.7874	5.8268	5.8661
150	5.9055	5.9449	5.9842	6.0236	6.0630	6.1024	6.1417	6.1811	6.2205	6.2598
160	6.2992	6.3386	6.3779	6.4173	6.4567	6.4960	6.5354	6.5748	6.6142	6.6535
170	6.6929	6.7323	6.7716	6.8110	6.8504	6.8898	6.9291	6.9685	7.0079	7.0472
180	7.0866	7.1260	7.1653	7.2047	7.2441	7.2834	7.3228	7.3622	7.4016	7.4409
190	7.4803	7.5197	7.5590	7.5984	7.6378	7.6772	7.7165	7.7559	7.7953	7.8346
200	7.8740	7.9134	7.9527	7.9921	8.0315	8.0708	8.1102	8.1496	8.1890	8.2283
210	8.2677	8.3071	8.3464	8.3858	8.4252	8.4646	8.5039	8.5433	8.5827	8.6220
220	8.6614	8.7008	8.7401	8.7795	8.8189	8.8582	8.8976	8.9370	8.9764	9.0157
230	9.0551	9.0945	9.1338	9.1732	9.2126	9.2520	9.2913	9.3307	9.3701	9.4094
240	9.4488	9.4882	9.5275	9.5669	9.6063	9.6456	9.6850	9.7244	9.7638	9.8031
250	9.8425	9.8819	9.9212	9.9606	10.0000	10.0394	10.0787	10.1181	10.1575	10.1968
260	10.2362	10.2756	10.3149	10.3543	10.3937	10.4330	10.4724	10.5118	10.5512	10.5905
270	10.6299	10.6693	10.7086	10.7480	10.7874	10.8268	10.8661	10.9055	10.9449	10.9842
280	11.0236	11.0630	11.1023	11.1417	11.1811	11.2204	11.2598	11.2992	11.3338	11.3779
290	11.4173	11.4568	11.4960	11.5354	11.5748	11.6142	11.6535	11.6929	11.7323	11.7716
300	11.8110	11.8504	11.8897	11.9291	11.9685	12.0078	12.0472	12.0866	12.1260	12.1653
310	12.2047	12.2441	12.2834	12.3228	12.3622	12.4016	12.4409	12.4803	12.5197	12.5590
320	12.5984	12.6378	12.6771	12.7165	12.7559	12.7952	12.8346	12.8740	12.9134	12.9527
330	12.9921	13.0315	13.0708	13.1102	13.1496	13.1890	13.2283	13.2677	13.3071	13.3464
340	13.3858	13.4252	13.4645	13.5039	13.5433	13.5826	13.6220	13.6614	13.7008	13.7401
350	13.7795	13.8189	13.8582	13.8976	13.9370	13.9764	14.0157	14.0551	14.0945	14.1338
360	14.1732	14.2126	14.2519	14.2913	14.3307	14.3700	14.4094	14.4488	14.4882	14.5275
370	14.5669	14.6063	14.6456	14 6850	14.7244	14.7638	14.8031	14.8425	14.8819	14.9212
380	14.9606	15.0000	15.0393	15.0787	15.1181	15.1574	15.1968	15.2362	15.2756	15.3149
390	15.3543	15.3937	15.4330	15.4724	15.5118	15.5512	15.5905	15.6299	15.6693	15.7086
400	15.7480	15.7874	15.8267	15.8661	15.9055	15.9448	15.9842	16.0236	16.0630	16.1023

Tenths of a millimeter.				Hundredths of a millimeter.			
mm.	Inch.	mm.	Inch.	mm.	Inch.	mm.	Inch.
0.1	0.0039	0.6	0.0236	0.01	0.0004	0.06	0.0024
.2	.0079	.7	.0276	.02	.0008	.07	.0028
.3	.0118	.8	.0315	.03	.0012	.08	.0031
.4	.0157	.9	.0354	.04	.0016	.09	.0035
.5	.0197	1.0	.0394	.05	.0020	.10	.0039

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
400	15.748	15.752	15.756	15.760	15.764	15.768	15.772	15.776	15.779	15.783
401	15.787	15.791	15.795	15.799	15.803	15.807	15.811	15.815	15.819	15.823
402	15.827	15.831	15.835	15.839	15.842	15.846	15.850	15.854	15.858	15.862
403	15.866	15.870	15.874	15.878	15.882	15.886	15.890	15.894	15.898	15.902
404	15.905	15.909	15.913	15.917	15.921	15.925	15.929	15.933	15.937	15.941
405	15.945	15.949	15.953	15.957	15.961	15.965	15.968	15.972	15.976	15.980
406	15.984	15.988	15.992	15.996	16.000	16.004	16.008	16.012	16.016	16.020
407	16.024	16.028	16.031	16.035	16.039	16.043	16.047	16.051	16.055	16.059
408	16.063	16.067	16.071	16.075	16.079	16.083	16.087	16.091	16.094	16.098
409	16.102	16.106	16.110	16.114	16.118	16.122	16.126	16.130	16.134	16.138
410	16.142	16.146	16.150	16.154	16.157	16.161	16.165	16.169	16.173	16.177
411	16.181	16.185	16.189	16.193	16.197	16.201	16.205	16.209	16.213	16.217
412	16.220	16.224	16.228	16.232	16.236	16.240	16.244	16.248	16.252	16.256
413	16.260	16.264	16.268	16.272	16.276	16.279	16.283	16.287	16.291	16.295
414	16.299	16.303	16.307	16.311	16.315	16.319	16.323	16.327	16.331	16.335
415	16.339	16.342	16.346	16.350	16.354	16.358	16.362	16.366	16.370	16.374
416	16.378	16.382	16.386	16.390	16.394	16.398	16.402	16.405	16.409	16.413
417	16.417	16.421	16.425	16.429	16.433	16.437	16.441	16.445	16.449	16.453
418	16.457	16.461	16.465	16.468	16.472	16.476	16.480	16.484	16.488	16.492
419	16.496	16.500	16.504	16.508	16.512	16.516	16.520	16.524	16.528	16.531
420	16.535	16.539	16.543	16.547	16.551	16.555	16.559	16.563	16.567	16.571
421	16.575	16.579	16.583	16.587	16.591	16.594	16.598	16.602	16.606	16.610
422	16.614	16.618	16.622	16.626	16.630	16.634	16.638	16.642	16.646	16.650
423	16.654	16.657	16.661	16.665	16.669	16.673	16.677	16.681	16.685	16.689
424	16.693	16.697	16.701	16.705	16.709	16.713	16.717	16.720	16.724	16.728
425	16.732	16.736	16.740	16.744	16.748	16.752	16.756	16.760	16.764	16.768
426	16.772	16.776	16.779	16.783	16.787	16.791	16.795	16.799	16.803	16.807
427	16.811	16.815	16.819	16.823	16.827	16.831	16.835	16.839	16.842	16.846
428	16.850	16.854	16.858	16.862	16.866	16.870	16.874	16.878	16.882	16.886
429	16.890	16.894	16.898	16.902	16.905	16.909	16.913	16.917	16.921	16.925
430	16.929	16.933	16.937	16.941	16.945	16.949	16.953	16.957	16.961	16.965
431	16.968	16.972	16.976	16.980	16.984	16.988	16.992	16.996	17.000	17.004
432	17.008	17.012	17.016	17.020	17.024	17.028	17.031	17.035	17.039	17.043
433	17.047	17.051	17.055	17.059	17.063	17.067	17.071	17.075	17.079	17.083
434	17.087	17.091	17.094	17.098	17.102	17.106	17.110	17.114	17.118	17.122
435	17.126	17.130	17.134	17.138	17.142	17.146	17.150	17.154	17.157	17.161
436	17.165	17.169	17.173	17.177	17.181	17.185	17.189	17.193	17.197	17.201
437	17.205	17.209	17.213	17.217	17.220	17.224	17.228	17.232	17.236	17.240
438	17.244	17.248	17.252	17.256	17.260	17.264	17.268	17.272	17.276	17.279
439	17.283	17.287	17.291	17.295	17.299	17.303	17.307	17.311	17.315	17.319
440	17.323	17.327	17.331	17.335	17.339	17.342	17.346	17.350	17.354	17.358
441	17.362	17.366	17.370	17.374	17.378	17.382	17.386	17.390	17.394	17.398
442	17.402	17.405	17.409	17.413	17.417	17.421	17.425	17.429	17.433	17.437
443	17.441	17.445	17.449	17.453	17.457	17.461	17.465	17.468	17.472	17.476
444	17.480	17.484	17.488	17.492	17.496	17.500	17.504	17.508	17.512	17.516
445	17.520	17.524	17.528	17.531	17.535	17.539	17.543	17.547	17.551	17.555
446	17.559	17.563	17.567	17.571	17.575	17.579	17.583	17.587	17.591	17.594
447	17.598	17.602	17.606	17.610	17.614	17.618	17.622	17.626	17.630	17.634
448	17.638	17.642	17.646	17.650	17.654	17.657	17.661	17.665	17.669	17.673
449	17.677	17.681	17.685	17.689	17.693	17.697	17.701	17.705	17.709	17.713
450	17.717	17.720	17.724	17.728	17.732	17.736	17.740	17.744	17.748	17.752

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
450	17.717	17.720	17.724	17.728	17.732	17.736	17.740	17.744	17.748	17.752
451	17.756	17.760	17.764	17.768	17.772	17.776	17.779	17.783	17.787	17.791
452	17.795	17.799	17.803	17.807	17.811	17.815	17.819	17.823	17.827	17.831
453	17.835	17.839	17.842	17.846	17.850	17.854	17.858	17.862	17.866	17.870
454	17.874	17.878	17.882	17.886	17.890	17.894	17.898	17.902	17.905	17.909
455	17.913	17.917	17.921	17.925	17.929	17.933	17.937	17.941	17.945	17.949
456	17.953	17.957	17.961	17.965	17.968	17.972	17.976	17.980	17.984	17.988
457	17.992	17.996	18.000	18.004	18.008	18.012	18.016	18.020	18.024	18.028
458	18.031	18.035	18.039	18.043	18.047	18.051	18.055	18.059	18.063	18.067
459	18.071	18.075	18.079	18.083	18.087	18.091	18.094	18.098	18.102	18.106
460	18.110	18.114	18.118	18.122	18.126	18.130	18.134	18.138	18.142	18.146
461	18.150	18.154	18.157	18.161	18.165	18.169	18.173	18.177	18.181	18.185
462	18.189	18.193	18.197	18.201	18.205	18.209	18.213	18.216	18.220	18.224
463	18.228	18.232	18.236	18.240	18.244	18.248	18.252	18.256	18.260	18.264
464	18.268	18.272	18.276	18.279	18.283	18.287	18.291	18.295	18.299	18.303
465	18.307	18.311	18.315	18.319	18.323	18.327	18.331	18.335	18.339	18.342
466	18.346	18.350	18.354	18.358	18.362	18.366	18.370	18.374	18.378	18.382
467	18.386	18.390	18.394	18.398	18.402	18.405	18.409	18.413	18.417	18.421
468	18.425	18.429	18.433	18.437	18.441	18.445	18.449	18.453	18.457	18.461
469	18.465	18.468	18.472	18.476	18.480	18.484	18.488	18.492	18.496	18.500
470	18.504	18.508	18.512	18.516	18.520	18.524	18.528	18.531	18.535	18.539
471	18.543	18.547	18.551	18.555	18.559	18.563	18.567	18.571	18.575	18.579
472	18.583	18.587	18.591	18.594	18.598	18.602	18.606	18.610	18.614	18.618
473	18.622	18.626	18.630	18.634	18.638	18.642	18.646	18.650	18.654	18.657
474	18.661	18.665	18.669	18.673	18.677	18.681	18.685	18.689	18.693	18.697
475	18.701	18.705	18.709	18.713	18.716	18.720	18.724	18.728	18.732	18.736
476	18.740	18.744	18.748	18.752	18.756	18.760	18.764	18.768	18.772	18.776
477	18.779	18.783	18.787	18.791	18.795	18.799	18.803	18.807	18.811	18.815
478	18.819	18.823	18.827	18.831	18.835	18.839	18.842	18.846	18.850	18.854
479	18.858	18.862	18.866	18.870	18.874	18.878	18.882	18.886	18.890	18.894
480	18.898	18.902	18.905	18.909	18.913	18.917	18.921	18.925	18.929	18.933
481	18.937	18.941	18.945	18.949	18.953	18.957	18.961	18.965	18.968	18.972
482	18.976	18.980	18.984	18.988	18.992	18.996	19.000	19.004	19.008	19.012
483	19.016	19.020	19.024	19.028	19.031	19.035	19.039	19.043	19.047	19.051
484	19.055	19.059	19.063	19.067	19.071	19.075	19.079	19.083	19.087	19.091
485	19.094	19.098	19.102	19.106	19.110	19.114	19.118	19.122	19.126	19.130
486	19.134	19.138	19.142	19.146	19.150	19.154	19.157	19.161	19.165	19.169
487	19.173	19.177	19.181	19.185	19.189	19.193	19.197	19.201	19.205	19.209
488	19.213	19.216	19.220	19.224	19.228	19.232	19.236	19.240	19.244	19.248
489	19.252	19.256	19.260	19.264	19.268	19.272	19.276	19.279	19.283	19.287
490	19.291	19.295	19.299	19.303	19.307	19.311	19.315	19.319	19.323	19.327
491	19.331	19.335	19.339	19.342	19.346	19.350	19.354	19.358	19.362	19.366
492	19.370	19.374	19.378	19.382	19.386	19.390	19.394	19.398	19.402	19.405
493	19.409	19.413	19.417	19.421	19.425	19.429	19.433	19.437	19.441	19.445
494	19.449	19.453	19.457	19.461	19.465	19.468	19.472	19.476	19.480	19.484
495	19.488	19.492	19.496	19.500	19.504	19.508	19.512	19.516	19.520	19.524
496	19.528	19.531	19.535	19.539	19.543	19.547	19.551	19.555	19.559	19.563
497	19.567	19.571	19.575	19.579	19.583	19.587	19.591	19.594	19.598	19.602
498	19.606	19.610	19.614	19.618	19.622	19.626	19.630	19.634	19.638	19.642
499	19.646	19.650	19.654	19.657	19.661	19.665	19.669	19.673	19.677	19.681
500	19.685	19.689	19.693	19.697	19.701	19.705	19.709	19.713	19.716	19.720

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Milli-meters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
500	19.685	19.689	19.693	19.697	19.701	19.705	19.709	19.713	19.716	19.720
501	19.724	19.728	19.732	19.736	19.740	19.744	19.748	19.752	19.756	19.760
502	19.764	19.768	19.772	19.776	19.779	19.783	19.787	19.791	19.795	19.799
503	19.803	19.807	19.811	19.815	19.819	19.823	19.827	19.831	19.835	19.839
504	19.842	19.846	19.850	19.854	19.858	19.862	19.866	19.870	19.874	19.878
505	19.882	19.886	19.890	19.894	19.898	19.902	19.905	19.909	19.913	19.917
506	19.921	19.925	19.929	19.933	19.937	19.941	19.945	19.949	19.953	19.957
507	19.961	19.965	19.968	19.972	19.976	19.980	19.984	19.988	19.992	19.996
508	20.000	20.004	20.008	20.012	20.016	20.020	20.024	20.028	20.031	20.035
509	20.039	20.043	20.047	20.051	20.055	20.059	20.063	20.067	20.071	20.075
510	20.079	20.083	20.087	20.091	20.094	20.098	20.102	20.106	20.110	20.114
511	20.118	20.122	20.126	20.130	20.134	20.138	20.142	20.146	20.150	20.154
512	20.157	20.161	20.165	20.169	20.173	20.177	20.181	20.185	20.189	20.193
513	20.197	20.201	20.205	20.209	20.213	20.216	20.220	20.224	20.228	20.232
514	20.236	20.240	20.244	20.248	20.252	20.256	20.260	20.264	20.268	20.272
515	20.276	20.279	20.283	20.287	20.291	20.295	20.299	20.303	20.307	20.311
516	20.315	20.319	20.323	20.327	20.331	20.335	20.339	20.342	20.346	20.350
517	20.354	20.358	20.362	20.366	20.370	20.374	20.378	20.382	20.386	20.390
518	20.394	20.398	20.402	20.405	20.409	20.413	20.417	20.421	20.425	20.429
519	20.433	20.437	20.441	20.445	20.449	20.453	20.457	20.461	20.465	20.468
520	20.472	20.476	20.480	20.484	20.488	20.492	20.496	20.500	20.504	20.508
521	20.512	20.516	20.520	20.524	20.528	20.531	20.535	20.539	20.543	20.547
522	20.551	20.555	20.559	20.563	20.567	20.571	20.575	20.579	20.583	20.587
523	20.591	20.594	20.598	20.602	20.606	20.610	20.614	20.618	20.622	20.626
524	20.630	20.634	20.638	20.642	20.646	20.650	20.654	20.657	20.661	20.665
525	20.669	20.673	20.677	20.681	20.685	20.689	20.693	20.697	20.701	20.705
526	20.709	20.713	20.716	20.720	20.724	20.728	20.732	20.736	20.740	20.744
527	20.748	20.752	20.756	20.760	20.764	20.768	20.772	20.776	20.779	20.783
528	20.787	20.791	20.795	20.799	20.803	20.807	20.811	20.815	20.819	20.823
529	20.827	20.831	20.835	20.839	20.842	20.846	20.850	20.854	20.858	20.862
530	20.866	20.870	20.874	20.878	20.882	20.886	20.890	20.894	20.898	20.902
531	20.905	20.909	20.913	20.917	20.921	20.925	20.929	20.933	20.937	20.941
532	20.945	20.949	20.953	20.957	20.961	20.965	20.968	20.972	20.976	20.980
533	20.984	20.988	20.992	20.996	21.000	21.004	21.008	21.012	21.016	21.020
534	21.024	21.028	21.031	21.035	21.039	21.043	21.047	21.051	21.055	21.059
535	21.063	21.067	21.071	21.075	21.079	21.083	21.087	21.091	21.094	21.098
536	21.102	21.106	21.110	21.114	21.118	21.122	21.126	21.130	21.134	21.138
537	21.142	21.146	21.150	21.154	21.157	21.161	21.165	21.169	21.173	21.177
538	21.181	21.185	21.189	21.193	21.197	21.201	21.205	21.209	21.213	21.216
539	21.220	21.224	21.228	21.232	21.236	21.240	21.244	21.248	21.252	21.256
540	21.260	21.264	21.268	21.272	21.276	21.279	21.283	21.287	21.291	21.295
541	21.299	21.303	21.307	21.311	21.315	21.319	21.323	21.327	21.331	21.335
542	21.339	21.342	21.346	21.350	21.354	21.358	21.362	21.366	21.370	21.374
543	21.378	21.382	21.386	21.390	21.394	21.398	21.402	21.405	21.409	21.413
544	21.417	21.421	21.425	21.429	21.433	21.437	21.441	21.445	21.449	21.453
545	21.457	21.461	21.465	21.468	21.472	21.476	21.480	21.484	21.488	21.492
546	21.496	21.500	21.504	21.508	21.512	21.516	21.520	21.524	21.528	21.531
547	21.535	21.539	21.543	21.547	21.551	21.555	21.559	21.563	21.567	21.571
548	21.575	21.579	21.583	21.587	21.591	21.594	21.598	21.602	21.606	21.610
549	21.614	21.618	21.622	21.626	21.630	21.634	21.638	21.642	21.646	21.650
550	21.654	21.657	21.661	21.665	21.669	21.673	21.677	21.681	21.685	21.689

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
550	21.654	21.657	21.661	21.665	21.669	21.673	21.677	21.681	21.685	21.689
551	21.693	21.697	21.701	21.705	21.709	21.713	21.716	21.720	21.724	21.728
552	21.732	21.736	21.740	21.744	21.748	21.752	21.756	21.760	21.764	21.768
553	21.772	21.776	21.779	21.783	21.787	21.791	21.795	21.799	21.803	21.807
554	21.811	21.815	21.819	21.823	21.827	21.831	21.835	21.839	21.842	21.846
555	21.850	21.854	21.858	21.862	21.866	21.870	21.874	21.878	21.882	21.886
556	21.890	21.894	21.898	21.902	21.905	21.909	21.913	21.917	21.921	21.925
557	21.929	21.933	21.937	21.941	21.945	21.949	21.953	21.957	21.961	21.965
558	21.968	21.972	21.976	21.980	21.984	21.988	21.992	21.996	22.000	22.004
559	22.008	22.012	22.016	22.020	22.024	22.028	22.031	22.035	22.039	22.043
560	22.047	22.051	22.055	22.059	22.063	22.067	22.071	22.075	22.079	22.083
561	22.087	22.091	22.094	22.098	22.102	22.106	22.110	22.114	22.118	22.122
562	22.126	22.130	22.134	22.138	22.142	22.146	22.150	22.153	22.157	22.161
563	22.165	22.169	22.173	22.177	22.181	22.185	22.189	22.193	22.197	22.201
564	22.205	22.209	22.213	22.216	22.220	22.224	22.228	22.232	22.236	22.240
565	22.244	22.248	22.252	22.256	22.260	22.264	22.268	22.272	22.276	22.279
566	22.283	22.287	22.291	22.295	22.299	22.303	22.307	22.311	22.315	22.319
567	22.323	22.327	22.331	22.335	22.339	22.342	22.346	22.350	22.354	22.358
568	22.362	22.366	22.370	22.374	22.378	22.382	22.386	22.390	22.394	22.398
569	22.402	22.405	22.409	22.413	22.417	22.421	22.425	22.429	22.433	22.437
570	22.441	22.445	22.449	22.453	22.457	22.461	22.465	22.468	22.472	22.476
571	22.480	22.484	22.488	22.492	22.496	22.500	22.504	22.508	22.512	22.516
572	22.520	22.524	22.528	22.531	22.535	22.539	22.543	22.547	22.551	22.555
573	22.559	22.563	22.567	22.571	22.575	22.579	22.583	22.587	22.591	22.594
574	22.598	22.602	22.606	22.610	22.614	22.618	22.622	22.626	22.630	22.634
575	22.638	22.642	22.646	22.650	22.653	22.657	22.661	22.665	22.669	22.673
576	22.677	22.681	22.685	22.689	22.693	22.697	22.701	22.705	22.709	22.713
577	22.716	22.720	22.724	22.728	22.732	22.736	22.740	22.744	22.748	22.752
578	22.756	22.760	22.764	22.768	22.772	22.776	22.779	22.783	22.787	22.791
579	22.795	22.799	22.803	22.807	22.811	22.815	22.819	22.823	22.827	22.831
580	22.835	22.839	22.842	22.846	22.850	22.854	22.858	22.862	22.866	22.870
581	22.874	22.878	22.882	22.886	22.890	22.894	22.898	22.902	22.905	22.909
582	22.913	22.917	22.921	22.925	22.929	22.933	22.937	22.941	22.945	22.949
583	22.953	22.957	22.961	22.965	22.968	22.972	22.976	22.980	22.984	22.988
584	22.992	22.996	23.000	23.004	23.008	23.012	23.016	23.020	23.024	23.028
585	23.031	23.035	23.039	23.043	23.047	23.051	23.055	23.059	23.063	23.067
586	23.071	23.075	23.079	23.083	23.087	23.091	23.094	23.098	23.102	23.106
587	23.110	23.114	23.118	23.122	23.126	23.130	23.134	23.138	23.142	23.146
588	23.150	23.153	23.157	23.161	23.165	23.169	23.173	23.177	23.181	23.185
589	23.189	23.193	23.197	23.201	23.205	23.209	23.213	23.216	23.220	23.224
590	23.228	23.232	23.236	23.240	23.244	23.248	23.252	23.256	23.260	23.264
591	23.268	23.272	23.276	23.279	23.283	23.287	23.291	23.295	23.299	23.303
592	23.307	23.311	23.315	23.319	23.323	23.327	23.331	23.335	23.339	23.342
593	23.346	23.350	23.354	23.358	23.362	23.366	23.370	23.374	23.378	23.382
594	23.386	23.390	23.394	23.398	23.402	23.405	23.409	23.413	23.417	23.421
595	23.425	23.429	23.433	23.437	23.441	23.445	23.449	23.453	23.457	23.461
596	23.465	23.468	23.472	23.476	23.480	23.484	23.488	23.492	23.496	23.500
597	23.504	23.508	23.512	23.516	23.520	23.524	23.528	23.531	23.535	23.539
598	23.543	23.547	23.551	23.555	23.559	23.563	23.567	23.571	23.575	23.579
599	23.583	23.587	23.591	23.594	23.598	23.602	23.606	23.610	23.614	23.618
600	23.622	23.626	23.630	23.634	23.638	23.642	23.646	23.650	23.653	23.657

TABLE 10.

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Milli-meters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
600	23.622	23.626	23.630	23.634	23.638	23.642	23.646	23.650	23.653	23.657
601	23.661	23.665	23.669	23.673	23.677	23.681	23.685	23.689	23.693	23.697
602	23.701	23.705	23.709	23.713	23.716	23.720	23.724	23.728	23.732	23.736
603	23.740	23.744	23.748	23.752	23.756	23.760	23.764	23.768	23.772	23.776
604	23.779	23.783	23.787	23.791	23.795	23.799	23.803	23.807	23.811	23.815
605	23.819	23.823	23.827	23.831	23.835	23.839	23.842	23.846	23.850	23.854
606	23.858	23.862	23.866	23.870	23.874	23.878	23.882	23.886	23.890	23.894
607	23.898	23.902	23.905	23.909	23.913	23.917	23.921	23.925	23.929	23.933
608	23.937	23.941	23.945	23.949	23.953	23.957	23.961	23.965	23.968	23.972
609	23.976	23.980	23.984	23.988	23.992	23.996	24.000	24.004	24.008	24.012
610	24.016	24.020	24.024	24.028	24.031	24.035	24.039	24.043	24.047	24.051
611	24.055	24.059	24.063	24.067	24.071	24.075	24.079	24.083	24.087	24.091
612	24.094	24.098	24.102	24.106	24.110	24.114	24.118	24.122	24.126	24.130
613	24.134	24.138	24.142	24.146	24.150	24.153	24.157	24.161	24.165	24.169
614	24.173	24.177	24.181	24.185	24.189	24.193	24.197	24.201	24.205	24.209
615	24.213	24.216	24.220	24.224	24.228	24.232	24.236	24.240	24.244	24.248
616	24.252	24.256	24.260	24.264	24.268	24.272	24.276	24.279	24.283	24.287
617	24.291	24.295	24.299	24.303	24.307	24.311	24.315	24.319	24.323	24.327
618	24.331	24.335	24.339	24.342	24.346	24.350	24.354	24.358	24.362	24.366
619	24.370	24.374	24.378	24.382	24.386	24.390	24.394	24.398	24.402	24.405
620	24.409	24.413	24.417	24.421	24.425	24.429	24.433	24.437	24.441	24.445
621	24.449	24.453	24.457	24.461	24.465	24.468	24.472	24.476	24.480	24.484
622	24.488	24.492	24.496	24.500	24.504	24.508	24.512	24.516	24.520	24.524
623	24.528	24.531	24.535	24.539	24.543	24.547	24.551	24.555	24.559	24.563
624	24.567	24.571	24.575	24.579	24.583	24.587	24.591	24.594	24.598	24.602
625	24.606	24.610	24.614	24.618	24.622	24.626	24.630	24.634	24.638	24.642
626	24.646	24.650	24.653	24.657	24.661	24.665	24.669	24.673	24.677	24.681
627	24.685	24.689	24.693	24.697	24.701	24.705	24.709	24.713	24.716	24.720
628	24.724	24.728	24.732	24.736	24.740	24.744	24.748	24.752	24.756	24.760
629	24.764	24.768	24.772	24.776	24.779	24.783	24.787	24.791	24.795	24.799
630	24.803	24.807	24.811	24.815	24.819	24.823	24.827	24.831	24.835	24.839
631	24.842	24.846	24.850	24.854	24.858	24.862	24.866	24.870	24.874	24.878
632	24.882	24.886	24.890	24.894	24.898	24.902	24.905	24.909	24.913	24.917
633	24.921	24.925	24.929	24.933	24.937	24.941	24.945	24.949	24.953	24.957
634	24.961	24.965	24.968	24.972	24.976	24.980	24.984	24.988	24.992	24.996
635	25.000	25.004	25.008	25.012	25.016	25.020	25.024	25.028	25.031	25.035
636	25.039	25.043	25.047	25.051	25.055	25.059	25.063	25.067	25.071	25.075
637	25.079	25.083	25.087	25.091	25.094	25.098	25.102	25.106	25.110	25.114
638	25.118	25.122	25.126	25.130	25.134	25.138	25.142	25.146	25.150	25.153
639	25.157	25.161	25.165	25.169	25.173	25.177	25.181	25.185	25.189	25.193
640	25.197	25.201	25.205	25.209	25.213	25.216	25.220	25.224	25.228	25.232
641	25.236	25.240	25.244	25.248	25.252	25.256	25.260	25.264	25.268	25.272
642	25.276	25.279	25.283	25.287	25.291	25.295	25.299	25.303	25.307	25.311
643	25.315	25.319	25.323	25.327	25.331	25.335	25.339	25.342	25.346	25.350
644	25.354	25.358	25.362	25.366	25.370	25.374	25.378	25.382	25.386	25.390
645	25.394	25.398	25.402	25.405	25.409	25.413	25.417	25.421	25.425	25.429
646	25.433	25.437	25.441	25.445	25.449	25.453	25.457	25.461	25.465	25.468
647	25.472	25.476	25.480	25.484	25.488	25.492	25.496	25.500	25.504	25.508
648	25.512	25.516	25.520	25.524	25.528	25.531	25.535	25.539	25.543	25.547
649	25.551	25.555	25.559	25.563	25.567	25.571	25.575	25.579	25.583	25.587
650	25.591	25.594	25.598	25.602	25.606	25.610	25.614	25.618	25.622	25.626

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
650	25.591	25.594	25.598	25.602	25.606	25.610	25.614	25.618	25.622	25.626
651	25.630	25.634	25.638	25.642	25.646	25.650	25.653	25.657	25.661	25.665
652	25.669	25.673	25.677	25.681	25.685	25.689	25.693	25.697	25.701	25.705
653	25.709	25.713	25.716	25.720	25.724	25.728	25.732	25.736	25.740	25.744
654	25.748	25.752	25.756	25.760	25.764	25.768	25.772	25.776	25.779	25.783
655	25.787	25.791	25.795	25.799	25.803	25.807	25.811	25.815	25.819	25.823
656	25.827	25.831	25.835	25.839	25.842	25.846	25.850	25.854	25.858	25.862
657	25.866	25.870	25.874	25.878	25.882	25.886	25.890	25.894	25.898	25.902
658	25.905	25.909	25.913	25.917	25.921	25.925	25.929	25.933	25.937	25.941
659	25.945	25.949	25.953	25.957	25.961	25.965	25.968	25.972	25.976	25.980
660	25.984	25.988	25.992	25.996	26.000	26.004	26.008	26.012	26.016	26.020
661	26.024	26.028	26.031	26.035	26.039	26.043	26.047	26.051	26.055	26.059
662	26.063	26.067	26.071	26.075	26.079	26.083	26.087	26.090	26.094	26.098
663	26.102	26.106	26.110	26.114	26.118	26.122	26.126	26.130	26.134	26.138
664	26.142	26.146	26.150	26.153	26.157	26.161	26.165	26.169	26.173	26.177
665	26.181	26.185	26.189	26.193	26.197	26.201	26.205	26.209	26.213	26.216
666	26.220	26.224	26.228	26.232	26.236	26.240	26.244	26.248	26.252	26.256
667	26.260	26.264	26.268	26.272	26.276	26.279	26.283	26.287	26.291	26.295
668	26.299	26.303	26.307	26.311	26.315	26.319	26.323	26.327	26.331	26.335
669	26.339	26.342	26.346	26.350	26.354	26.358	26.362	26.366	26.370	26.374
670	26.378	26.382	26.386	26.390	26.394	26.398	26.402	26.405	26.409	26.413
671	26.417	26.421	26.425	26.429	26.433	26.437	26.441	26.445	26.449	26.453
672	26.457	26.461	26.465	26.468	26.472	26.476	26.480	26.484	26.488	26.492
673	26.496	26.500	26.504	26.508	26.512	26.516	26.520	26.524	26.528	26.531
674	26.535	26.539	26.543	26.547	26.551	26.555	26.559	26.563	26.567	26.571
675	26.575	26.579	26.583	26.587	26.590	26.594	26.598	26.602	26.606	26.610
676	26.614	26.618	26.622	26.626	26.630	26.634	26.638	26.642	26.646	26.650
677	26.653	26.657	26.661	26.665	26.669	26.673	26.677	26.681	26.685	26.689
678	26.693	26.697	26.701	26.705	26.709	26.713	26.716	26.720	26.724	26.728
679	26.732	26.736	26.740	26.744	26.748	26.752	26.756	26.760	26.764	26.768
680	26.772	26.776	26.779	26.783	26.787	26.791	26.795	26.799	26.803	26.807
681	26.811	26.815	26.819	26.823	26.827	26.831	26.835	26.838	26.842	26.846
682	26.850	26.854	26.858	26.862	26.866	26.870	26.874	26.878	26.882	26.886
683	26.890	26.894	26.898	26.902	26.905	26.909	26.913	26.917	26.921	26.925
684	26.929	26.933	26.937	26.941	26.945	26.949	26.953	26.957	26.961	26.965
685	26.968	26.972	26.976	26.980	26.984	26.988	26.992	26.996	27.000	27.004
686	27.008	27.012	27.016	27.020	27.024	27.028	27.031	27.035	27.039	27.043
687	27.047	27.051	27.055	27.059	27.063	27.067	27.071	27.075	27.079	27.083
688	27.087	27.090	27.094	27.098	27.102	27.106	27.110	27.114	27.118	27.122
689	27.126	27.130	27.134	27.138	27.142	27.146	27.150	27.153	27.157	27.161
690	27.165	27.169	27.173	27.177	27.181	27.185	27.189	27.193	27.197	27.201
691	27.205	27.209	27.213	27.216	27.220	27.224	27.228	27.232	27.236	27.240
692	27.244	27.248	27.252	27.256	27.260	27.264	27.268	27.272	27.276	27.279
693	27.283	27.287	27.291	27.295	27.299	27.303	27.307	27.311	27.315	27.319
694	27.323	27.327	27.331	27.335	27.339	27.342	27.346	27.350	27.354	27.358
695	27.362	27.366	27.370	27.374	27.378	27.382	27.386	27.390	27.394	27.398
696	27.402	27.405	27.409	27.413	27.417	27.421	27.425	27.429	27.433	27.437
697	27.441	27.445	27.449	27.453	27.457	27.461	27.465	27.468	27.472	27.476
698	27.480	27.484	27.488	27.492	27.496	27.500	27.504	27.508	27.512	27.516
699	27.520	27.524	27.528	27.531	27.535	27.539	27.543	27.547	27.551	27.555
700	27.559	27.563	27.567	27.571	27.575	27.579	27.583	27.587	27.590	27.594

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Milli-meters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
700	27.559	27.563	27.567	27.571	27.575	27.579	27.583	27.587	27.590	27.594
701	27.598	27.602	27.606	27.610	27.614	27.618	27.622	27.626	27.630	27.634
702	27.638	27.642	27.646	27.650	27.653	27.657	27.661	27.665	27.669	27.673
703	27.677	27.681	27.685	27.689	27.693	27.697	27.701	27.705	27.709	27.713
704	27.716	27.720	27.724	27.728	27.732	27.736	27.740	27.744	27.748	27.752
705	27.756	27.760	27.764	27.768	27.772	27.776	27.779	27.783	27.787	27.791
706	27.795	27.799	27.803	27.807	27.811	27.815	27.819	27.823	27.827	27.831
707	27.835	27.839	27.842	27.846	27.850	27.854	27.858	27.862	27.866	27.870
708	27.874	27.878	27.882	27.886	27.890	27.894	27.898	27.902	27.905	27.909
709	27.913	27.917	27.921	27.925	27.929	27.933	27.937	27.941	27.945	27.949
710	27.953	27.957	27.961	27.965	27.968	27.972	27.976	27.980	27.984	27.988
711	27.992	27.996	28.000	28.004	28.008	28.012	28.016	28.020	28.024	28.028
712	28.031	28.035	28.039	28.043	28.047	28.051	28.055	28.059	28.063	28.067
713	28.071	28.075	28.079	28.083	28.087	28.090	28.094	28.098	28.102	28.106
714	28.110	28.114	28.118	28.122	28.126	28.130	28.134	28.138	28.142	28.146
715	28.150	28.153	28.157	28.161	28.165	28.169	28.173	28.177	28.181	28.185
716	28.189	28.193	28.197	28.201	28.205	28.209	28.213	28.216	28.220	28.224
717	28.228	28.232	28.236	28.240	28.244	28.248	28.252	28.256	28.260	28.264
718	28.268	28.272	28.276	28.279	28.283	28.287	28.291	28.295	28.299	28.303
719	28.307	28.311	28.315	28.319	28.323	28.327	28.331	28.335	28.339	28.342
720	28.346	28.350	28.354	28.358	28.362	28.366	28.370	28.374	28.378	28.382
721	28.386	28.390	28.394	28.398	28.402	28.405	28.409	28.413	28.417	28.421
722	28.425	28.429	28.433	28.437	28.441	28.445	28.449	28.453	28.457	28.461
723	28.465	28.468	28.472	28.476	28.480	28.484	28.488	28.492	28.496	28.500
724	28.504	28.508	28.512	28.516	28.520	28.524	28.528	28.531	28.535	28.539
725	28.543	28.547	28.551	28.555	28.559	28.563	28.567	28.571	28.575	28.579
726	28.583	28.587	28.590	28.594	28.598	28.602	28.606	28.610	28.614	28.618
727	28.622	28.626	28.630	28.634	28.638	28.642	28.646	28.650	28.653	28.657
728	28.661	28.665	28.669	28.673	28.677	28.681	28.685	28.689	28.693	28.697
729	28.701	28.705	28.709	28.713	28.716	28.720	28.724	28.728	28.732	28.736
730	28.740	28.744	28.748	28.752	28.756	28.760	28.764	28.768	28.772	28.776
731	28.779	28.783	28.787	28.791	28.795	28.799	28.803	28.807	28.811	28.815
732	28.819	28.823	28.827	28.831	28.835	28.839	28.842	28.846	28.850	28.854
733	28.858	28.862	28.866	28.870	28.874	28.878	28.882	28.886	28.890	28.894
734	28.898	28.902	28.905	28.909	28.913	28.917	28.921	28.925	28.929	28.933
735	28.937	28.941	28.945	28.949	28.953	28.957	28.961	28.965	28.968	28.972
736	28.976	28.980	28.984	28.988	28.992	28.996	29.000	29.004	29.008	29.012
737	29.016	29.020	29.024	29.028	29.031	29.035	29.039	29.043	29.047	29.051
738	29.055	29.059	29.063	29.067	29.071	29.075	29.079	29.083	29.087	29.090
739	29.094	29.098	29.102	29.106	29.110	29.114	29.118	29.122	29.126	29.130
740	29.134	29.138	29.142	29.146	29.150	29.153	29.157	29.161	29.165	29.169
741	29.173	29.177	29.181	29.185	29.189	29.193	29.197	29.201	29.205	29.209
742	29.213	29.216	29.220	29.224	29.228	29.232	29.236	29.240	29.244	29.248
743	29.252	29.256	29.260	29.264	29.268	29.272	29.276	29.279	29.283	29.287
744	29.291	29.295	29.299	29.303	29.307	29.311	29.315	29.319	29.323	29.327
745	29.331	29.335	29.339	29.342	29.346	29.350	29.354	29.358	29.362	29.366
746	29.370	29.374	29.378	29.382	29.386	29.390	29.394	29.398	29.402	29.405
747	29.409	29.413	29.417	29.421	29.425	29.429	29.433	29.437	29.441	29.445
748	29.449	29.453	29.457	29.461	29.465	29.468	29.472	29.476	29.480	29.484
749	29.488	29.492	29.496	29.500	29.504	29.508	29.512	29.516	29.520	29.524
750	29.528	29.531	29.535	29.539	29.543	29.547	29.551	29.555	29.559	29.563

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Milli-meters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
750	29.528	29.531	29.535	29.539	29.543	29.547	29.551	29.555	29.559	29.563
751	29.567	29.571	29.575	29.579	29.583	29.587	29.590	29.594	29.598	29.602
752	29.606	29.610	29.614	29.618	29.622	29.626	29.630	29.634	29.638	29.642
753	29.646	29.650	29.653	29.657	29.661	29.665	29.669	29.673	29.677	29.681
754	29.685	29.689	29.693	29.697	29.701	29.705	29.709	29.713	29.716	29.720
755	29.724	29.728	29.732	29.736	29.740	29.744	29.748	29.752	29.756	29.760
756	29.764	29.768	29.772	29.776	29.779	29.783	29.787	29.791	29.795	29.799
757	29.803	29.807	29.811	29.815	29.819	29.823	29.827	29.831	29.835	29.839
758	29.842	29.846	29 850	29.854	29.858	29.862	29.866	29.870	29.874	29.878
759	29.882	29.886	29.890	29.894	29.898	29.902	29.905	29.909	29.913	29.917
760	29.921	29.925	29.929	29.933	29.937	29.941	29.945	29.949	29.953	29.957
761	29.961	29.965	29.968	29.972	29.976	29.980	29.984	29.988	29.992	29.996
762	30.000	30.004	30.008	30.012	30.016	30.020	30.024	30.027	30.031	30.035
763	30.039	30.043	30.047	30.051	30.055	30.059	30.063	30.067	30.071	30.075
764	30.079	30.083	30.087	30.090	30.094	30.098	30.102	30.106	30.110	30.114
765	30.118	30.122	30.126	30.130	30.134	30.138	30.142	30.146	30.150	30.153
766	30.157	30.161	30.165	30.169	30.173	30.177	30.181	30.185	30.189	30.193
767	30.197	30.201	30.205	30.209	30.213	30.216	30.220	30.224	30.228	30.232
768	30.236	30.240	30.244	30.248	30.252	30.256	30.260	30.264	30.268	30.272
769	30.276	30.279	30.283	30.287	30.291	30.295	30.299	30.303	30.307	30.311
770	30.315	30.319	30.323	30.327	30.331	30.335	30.339	30.342	30.346	30.350
771	30.354	30.358	30.362	30.366	30.370	30.374	30.378	30.382	30.386	30.390
772	30.394	30.398	30.402	30.405	30.409	30.413	30.417	30.421	30.425	30.429
773	30.433	30.437	30.441	30.445	30.449	30.453	30.457	30.461	30.465	30.468
774	30.472	30.476	30.480	30.484	30.488	30.492	30.496	30.500	30.504	30.508
775	30.512	30.516	30.520	30.524	30.528	30.531	30.535	30.539	30.543	30.547
776	30.551	30.555	30.559	30.563	30.567	30.571	30.575	30.579	30.583	30.587
777	30.590	30.594	30.598	30.602	30.606	30.610	30.614	30.618	30.622	30.626
778	30.630	30.634	30.638	30.642	30.646	30.650	30.653	30.657	30.661	30.665
779	30.669	30.673	30.677	30.681	30.685	30.689	30.693	30.697	30.701	30.705
780	30.709	30.713	30.716	30.720	30.724	30.728	30.732	30.736	30.740	30.744
781	30.748	30.752	30.756	30.760	30.764	30.768	30.772	30.776	30.779	30.783
782	30.787	30.791	30.795	30.799	30.803	30.807	30.811	30.815	30.819	30.823
783	30.827	30.831	30.835	30.839	30.842	30.846	30.850	30.854	30.858	30.862
784	30.866	30.870	30.874	30.878	30.882	30.886	30.890	30.894	30.898	30.902
785	30.905	30.909	30.913	30.917	30.921	30.925	30.929	30.933	30.937	30.941
786	30.945	30.949	30.953	30.957	30.961	30.965	30.968	30.972	30.976	30.980
787	30.984	30.988	30.992	30.996	31.000	31.004	31.008	31.012	31.016	31.020
788	31.024	31.027	31.031	31.035	31.039	31.043	31.047	31.051	31.055	31.059
789	31.063	31.067	31.071	31.075	31.079	31.083	31.087	31.090	31.094	31.098
790	31.102	31.106	31.110	31.114	31.118	31.122	31.126	31.130	31.134	31.138
791	31.142	31.146	31.150	31.153	31.157	31.161	31.165	31.169	31.173	31.177
792	31.181	31.185	31.189	31.193	31.197	31.201	31.205	31.209	31.213	31.216
793	31.220	31.224	31.228	31.232	31.236	31.240	31.244	31.248	31.252	31.256
794	31.260	31.264	31.268	31.272	31.276	31.279	31.283	31.287	31.291	31.295
795	31.299	31.303	31.307	31.311	31.315	31.319	31.323	31.327	31.331	31.335
796	31.339	31.342	31.346	31.350	31.354	31.358	31.362	31.366	31.370	31.374
797	31.378	31.382	31.386	31.390	31.394	31.398	31.402	31.405	31.409	31.413
798	31.417	31.421	31.425	31.429	31.433	31.437	31.441	31.445	31.449	31.453
799	31.457	31.461	31.465	31.468	31.472	31.476	31.480	31.484	31.488	31.492
800	31.496	31.500	31.504	31.508	31.512	31.516	31.520	31.524	31.527	31.531

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Milli-meters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
800	31.496	31.500	31.504	31.508	31.512	31.516	31.520	31.524	31.527	31.531
801	31.535	31.539	31.543	31.547	31.551	31.555	31.559	31.563	31.567	31.571
802	31.575	31.579	31.583	31.587	31.590	31.594	31.598	31.602	31.606	31.610
803	31.614	31.618	31.622	31.626	31.630	31.634	31.638	31.642	31.646	31.650
804	31.653	31.657	31.661	31.665	31.669	31.673	31.677	31.681	31.685	31.689
805	31.693	31.697	31.701	31.705	31.709	31.713	31.716	31.720	31.724	31.728
806	31.732	31.736	31.740	31.744	31.748	31.752	31.756	31.760	31.764	31.768
807	31.772	31.776	31.779	31.783	31.787	31.791	31.795	31.799	31.803	31.807
808	31.811	31.815	31.819	31.823	31.827	31.831	31.835	31.839	31.842	31.846
809	31.850	31.854	31.858	31.862	31.866	31.870	31.874	31.878	31.882	31.886
810	31.890	31.894	31.898	31.902	31.905	31.909	31.913	31.917	31.921	31.925
811	31.929	31.933	31.937	31.941	31.945	31.949	31.953	31.957	31.961	31.965
812	31.968	31.972	31.976	31.980	31.984	31.988	31.992	31.996	32.000	32.004
813	32.008	32.012	32.016	32.020	32.024	32.027	32.031	32.035	32.039	32.043
814	32.047	32.051	32.055	32.059	32.063	32.067	32.071	32.075	32.079	32.083
815	32.087	32.090	32.094	32.098	32.102	32.106	32.110	32.114	32.118	32.122
816	32.126	32.130	32.134	32.138	32.142	32.146	32.150	32.153	32.157	32.161
817	32.165	32.169	32.173	32.177	32.181	32.185	32.189	32.193	32.197	32.201
818	32.205	32.209	32.213	32.216	32.220	32.224	32.228	32.232	32.236	32.240
819	32.244	32.248	32.252	32.256	32.260	32.264	32.268	32.272	32.276	32.279
820	32.283	32.287	32.291	32.295	32.299	32.303	32.307	32.311	32.315	32.319
821	32.323	32.327	32.331	32.335	32.339	32.342	32.346	32.350	32.354	32.358
822	32.362	32.366	32.370	32.374	32.378	32.382	32.386	32.390	32.394	32.398
823	32.402	32.405	32.409	32.413	32.417	32.421	32.425	32.429	32.433	32.437
824	32.441	32.445	32.449	32.453	32.457	32.461	32.465	32.468	32.472	32.476
825	32.480	32.484	32.488	32.492	32.496	32.500	32.504	32.508	32.512	32.516
826	32.520	32.524	32.527	32.531	32.535	32.539	32.543	32.547	32.551	32.555
827	32.559	32.563	32.567	32.571	32.575	32.579	32.583	32.587	32.590	32.594
828	32.598	32.602	32.606	32.610	32.614	32.618	32.622	32.626	32.630	32.634
829	32.638	32.642	32.646	32.650	32.653	32.657	32.661	32.665	32.669	32.673
830	32.677	32.681	32.685	32.689	32.693	32.697	32.701	32.705	32.709	32.713
831	32.716	32.720	32.724	32.728	32.732	32.736	32.740	32.744	32.748	32.752
832	32.756	32.760	32.764	32.768	32.772	32.776	32.779	32.783	32.787	32.791
833	32.795	32.799	32.803	32.807	32.811	32.815	32.819	32.823	32.827	32.831
834	32.835	32.839	32.842	32.846	32.850	32.854	32.858	32.862	32.866	32.870
835	32.874	32.878	32.882	32.886	32.890	32.894	32.898	32.902	32.905	32.909
836	32.913	32.917	32.921	32.925	32.929	32.933	32.937	32.941	32.945	32.949
837	32.953	32.957	32.961	32.965	32.968	32.972	32.976	32.980	32.984	32.988
838	32.992	32.996	33.000	33.004	33.008	33.012	33.016	33.020	33.024	33.027
839	33.031	33.035	33.039	33.043	33.047	33.051	33.055	33.059	33.063	33.067
840	33.071	33.075	33.079	33.083	33.087	33.090	33.094	33.098	33.102	33.106
841	33.110	33.114	33.118	33.122	33.126	33.130	33.134	33.138	33.142	33.146
842	33.150	33.153	33.157	33.161	33.165	33.169	33.173	33.177	33.181	33.185
843	33.189	33.193	33.197	33.201	33.205	33.209	33.213	33.216	33.220	33.224
844	33.228	33.232	33.236	33.240	33.244	33.248	33.252	33.256	33.260	33.264
845	33.268	33.272	33.276	33.279	33.283	33.287	33.291	33.295	33.299	33.303
846	33.307	33.311	33.315	33.319	33.323	33.327	33.331	33.335	33.339	33.342
847	33.346	33.350	33.354	33.358	33.362	33.366	33.370	33.374	33.378	33.382
848	33.386	33.390	33.394	33.398	33.402	33.405	33.409	33.413	33.417	33.421
849	33.425	33.429	33.433	33.437	33.441	33.445	33.449	33.453	33.457	33.461
850	33.464	33.468	33.472	33.476	33.480	33.484	33.488	33.492	33.496	33.500

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
850	33.464	33.468	33.472	33.476	33.480	33.484	33.488	33.492	33.496	33.500
851	33.504	33.508	33.512	33.516	33.520	33.524	33.527	33.531	33.535	33.539
852	33.543	33.547	33.551	33.555	33.559	33.563	33.567	33.571	33.575	33.579
853	33.583	33.587	33.590	33.594	33.598	33.602	33.606	33.610	33.614	33.618
854	33.622	33.626	33.630	33.634	33.638	33.642	33.646	33.650	33.653	33.657
855	33.661	33.665	33.669	33.673	33.677	33.681	33.685	33.689	33.693	33.697
856	33.701	33.705	33.709	33.713	33.716	33.720	33.724	33.728	33.732	33.736
857	33.740	33.744	33.748	33.752	33.756	33.760	33.764	33.768	33.772	33.776
858	33.779	33.783	33.787	33.791	33.795	33.799	33.803	33.807	33.811	33.815
859	33.819	33.823	33.827	33.831	33.835	33.839	33.842	33.846	33.850	33.854
860	33.858	33.862	33.866	33.870	33.874	33.878	33.882	33.886	33.890	33.894
861	33.898	33.902	33.905	33.909	33.913	33.917	33.921	33.925	33.929	33.933
862	33.937	33.941	33.945	33.949	33.953	33.957	33.961	33.964	33.968	33.972
863	33.976	33.980	33.984	33.988	33.992	33.996	34.000	34.004	34.008	34.012
864	34.016	34.020	34.024	34.027	34.031	34.035	34.039	34.043	34.047	34.051
865	34.055	34.059	34.063	34.067	34.071	34.075	34.079	34.083	34.087	34.090
866	34.094	34.098	34.102	34.106	34.110	34.114	34.118	34.122	34.126	34.130
867	34.134	34.138	34.142	34.146	34.150	34.153	34.157	34.161	34.165	34.169
868	34.173	34.177	34.181	34.185	34.189	34.193	34.197	34.201	34.205	34.209
869	34.213	34.216	34.220	34.224	34.228	34.232	34.236	34.240	34.244	34.248
870	34.252	34.256	34.260	34.264	34.268	34.272	34.276	34.279	34.283	34.287
871	34.291	34.295	34.299	34.303	34.307	34.311	34.315	34.319	34.323	34.327
872	34.331	34.335	34.339	34.342	34.346	34.350	34.354	34.358	34.362	34.366
873	34.370	34.374	34.378	34.382	34.386	34.390	34.394	34.398	34.402	34.405
874	34.409	34.413	34.417	34.421	34.425	34.429	34.433	34.437	34.441	34.445
875	34.449	34.453	34.457	34.461	34.464	24.468	34.472	34.476	34.480	34.484
876	34.488	34.492	34.496	34.500	34.504	34.508	34.512	34.516	34.520	34.524
877	34.527	34.531	34.535	34.539	34.543	34.547	34.551	34.555	34.559	34.563
878	34.567	34.571	34.575	34.579	34.583	34.587	34.590	34.594	34.598	34.602
879	34.606	34.610	34.614	34.618	34.622	34.626	34.630	34.634	34.638	34.642
880	34.646	34.650	34.653	34.657	34.661	34.665	34.669	34.673	34.677	34.681
881	34.685	34.689	34.693	34.697	34.701	34.705	34.709	34.713	34.716	34.720
882	34.724	34.728	34.732	34.736	34.740	34.744	34.748	34.752	34.756	34.760
883	34.764	34.768	34.772	34.776	34.779	34.783	34.787	34.791	34.795	34.799
884	34.803	34.807	34.811	34.815	34.819	34.823	34.827	34.831	34.835	34.839
885	34.842	34.846	34.850	34.854	34.858	34.862	34.866	34.870	34.874	34.878
886	34.882	34.886	34.890	34.894	34.898	34.902	34.905	34.909	34.913	34.917
887	34.921	34.925	34.929	34.933	34.937	34.941	34.945	34.949	34.953	34.957
888	34.961	34.964	34.968	34.972	34.976	34.980	34.984	34.988	34.992	34.996
889	35.000	35.004	35.008	35.012	35.016	35.020	35.024	35.027	35.031	35.035
890	35.039	35.043	35.047	35.051	35.055	35.059	35.063	35.067	35.071	35.075
891	35.079	35.083	35.087	35.090	35.094	35.098	35.102	35.106	35.110	35.114
892	35.118	35.122	35.126	35.130	35.134	35.138	35.142	35.146	35.150	35.153
893	35.157	35.161	35.165	35.169	35.173	35.177	35.181	35.185	35.189	35.193
894	35.197	35.201	35.205	35.209	35.213	35.216	35.220	35.224	35.228	35.232
895	35.236	35.240	35.244	35.248	35.252	35.256	35.260	35.264	35.268	35.272
896	35.276	35.279	35.283	35.287	35.291	35.295	35.299	35.303	35.307	35.311
897	35.315	35.319	35.323	35.327	35.331	35.335	35.339	35.342	35.346	35.350
898	35.354	35.358	35.362	35.366	35.370	35.374	35.378	35.382	35.386	35.390
899	35.394	35.398	35.402	35.405	35.409	35.413	35.417	35.421	35.425	35.429
900	35.433	35.437	35.441	35.445	35.449	35.453	35.457	35.461	35.464	35.468

Table 10.

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Millimeters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
900	35.433	35.437	35.441	35.445	35.449	35.453	35.457	35.461	35.464	35.468
901	35.472	35.476	35.480	35.484	35.488	35.492	35.496	35.500	35.504	35.508
902	35.512	35.516	35.520	35.524	35.527	35.531	35.535	35.539	35.543	35.547
903	35.551	35.555	35.559	35.563	35.567	35.571	35.575	35.579	35.583	35.587
904	35.590	35.594	35.598	35.602	35.606	35.610	35.614	35.618	35.622	35.626
905	35.630	35.634	35.638	35.642	35.646	35.650	35.653	35.657	35.661	35.665
906	35.669	35.673	35.677	35.681	35.685	35.689	35.693	35.697	35.701	35.705
907	35.709	35.713	35.716	35.720	35.724	35.728	35.732	35.736	35.740	35.744
908	35.748	35.752	35.756	35.760	35.764	35.768	35.772	35.776	35.779	35.783
909	35.787	35.791	35.795	35.799	35.803	35.807	35.811	35.815	35.819	35.823
910	35.827	35.831	35.835	35.839	35.842	35.846	35.850	35.854	35.858	35.862
911	35.866	35.870	35.874	35.878	35.882	35.886	35.890	35.894	35.898	35.902
912	35.905	35.909	35.913	35.917	35.921	35.925	35.929	35.933	35.937	35.941
913	35.945	35.949	35.953	35.957	35.961	35.964	35.968	35.972	35.976	35.980
914	35.984	35.988	35.992	35.996	36.000	36.004	36.008	36.012	36.016	36.020
915	36.024	36.027	36.031	36.035	36.039	36.043	36.047	36.051	36.055	36.059
916	36.063	36.067	36.071	36.075	36.079	36.083	36.087	36.090	36.094	36.098
917	36.102	36.106	36.110	36.114	36.118	36.122	36.126	36.130	36.134	36.138
918	36.142	36.146	36.150	36.153	36.157	36.161	36.165	36.169	36.173	36.177
919	36.181	36.185	36.189	36.193	36.197	36.201	36.205	36.209	36.213	36.216
920	36.220	36.224	36.228	36.232	36.236	36.240	36.244	36.248	36.252	36.256
921	36.260	36.264	36.268	36.272	36.276	36.279	36.283	36.287	36.291	36.295
922	36.299	36.303	36.307	36.311	36.315	36.319	36.323	36.327	36.331	36.335
923	36.339	36.342	36.346	36.350	36.354	36.358	36.362	36.366	36.370	36.374
924	36.378	36.382	36.386	36.390	36.394	36.398	36.402	36.405	36.409	36.413
925	36.417	36.421	36.425	36.429	36.433	36.437	36.441	36.445	36.449	36.453
926	36.457	36.461	36.464	36.468	36.472	36.476	36.480	36.484	36.488	36.492
927	36.496	36.500	36.504	36.508	36.512	36.516	36.520	36.524	36.527	36.531
928	36.535	36.539	36.543	36.547	36.551	36.555	36.559	36.563	36.567	36.571
929	36.575	36.579	36.583	36.587	36.590	36.594	36.598	36.602	36.606	36.610
930	36.614	36.618	36.622	36.626	36.630	36.634	36.638	36.642	36.646	36.650
931	36.653	36.657	36.661	36.665	36.669	36.673	36.677	36.681	36.685	36.689
932	36.693	36.697	36.701	36.705	36.709	36.713	36.716	36.720	36.724	36.728
933	36.732	36.736	36.740	36.744	36.748	36.752	36.756	36.760	36.764	36.768
934	36.772	36.776	36.779	36.783	36.787	36.791	36.795	36.799	36.803	36.807
935	36.811	36.815	36.819	36.823	36.827	36.831	36.835	36.839	36.842	36.846
936	36.850	36.854	36.858	36.862	36.866	36.870	36.874	36.878	36.882	36.886
937	36.890	36.894	36.898	36.902	36.905	36.909	36.913	36.917	36.921	36.925
938	36.929	36.933	36.937	36.941	36.945	36.949	36.953	36.957	36.961	36.964
939	36.968	36.972	36.976	36.980	36.984	36.988	36.992	36.996	37.000	37.004
940	37.008	37.012	37.016	37.020	37.024	37.027	37.031	37.035	37.039	37.043
941	37.047	37.051	37.055	37.059	37.063	37.067	37.071	37.075	37.079	37.083
942	37.087	37.090	37.094	37.098	37.102	37.106	37.110	37.114	37.118	37.122
943	37.126	37.130	37.134	37.138	37.142	37.146	37.150	37.153	37.157	37.161
944	37.165	37.169	37.173	37.177	37.181	37.185	37.189	37.193	37.197	37.201
945	37.204	37.208	37.212	37.216	37.220	37.224	37.228	37.232	37.236	37.240
946	37.244	37.248	37.252	37.256	37.260	37.264	37.268	37.272	37.276	37.279
947	37.283	37.287	37.291	37.295	37.299	37.303	37.307	37.311	37.315	37.319
948	37.323	37.327	37.331	37.335	37.339	37.342	37.346	37.350	37.354	37.358
949	37.362	37.366	37.370	37.374	37.378	37.382	37.386	37.390	37.394	37.398
950	37.402	37.405	37.409	37.413	37.417	37.421	37.425	37.429	37.433	37.437

MILLIMETERS INTO INCHES.

1 mm. = 0.03937 inch.

Milli-meters.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
950	37.402	37.405	37.409	37.413	37.417	37.421	37.425	37.429	37.433	37.437
951	37.441	37.445	37.449	37.453	37.457	37.461	37.464	37.468	37.472	37.476
952	37.480	37.484	37.488	37.492	37.496	37.500	37.504	37.508	37.512	37.516
953	37.520	37.524	37.527	37.531	37.535	37.539	37.543	37.547	37.551	37.555
954	37.559	37.563	37.567	37.571	37.575	37.579	37.583	37.587	37.590	37.594
955	37.598	37.602	37.606	37.610	37.614	37.618	37.622	37.626	37.630	37.634
956	37.638	37.642	37.646	37.650	37.653	37.657	37.661	37.665	37.669	37.673
957	37.677	37.681	37.685	37.689	37.693	37.697	37.701	37.705	37.709	37.713
958	37.716	37.720	37.724	37.728	37.732	37.736	37.740	37.744	37.748	37.752
959	37.756	37.760	37.764	37.768	37.772	37.776	37.779	37.783	37.787	37.791
960	37.795	37.799	37.803	37.807	37.811	37.815	37.819	37.823	37.827	37.831
961	37.835	37.839	37.842	37.846	37.850	37.854	37.858	37.862	37.866	37.870
962	37.874	37.878	37.882	37.886	37.890	37.894	37.898	37.901	37.905	37.909
963	37.913	37.917	37.921	37.925	37.929	37.933	37.937	37.941	37.945	37.949
964	37.953	37.957	37.961	37.964	37.968	37.972	37.976	37.980	37.984	37.988
965	37.992	37.996	38.000	38.004	38.008	38.012	38.016	38.020	38.024	38.027
966	38.031	38.035	38.039	38.043	38.047	38.051	38.055	38.059	38.063	38.067
967	38.071	38.075	38.079	38.083	38.087	38.090	38.094	38.098	38.102	38.106
968	38.110	38.114	38.118	38.122	38.126	38.130	38.134	38.138	38.142	38.146
969	38.150	38.153	38.157	38.161	38.165	38.169	38.173	38.177	38.181	38.185
970	38.189	38.193	38.197	38.201	38.205	38.209	38.213	38.216	38.220	38.224
971	38.228	38.232	38.236	38.240	38.244	38.248	38.252	38.256	38.260	38.264
972	38.268	38.272	38.276	38.279	38.283	38.287	38.291	38.295	38.299	38.303
973	38.307	38.311	38.315	38.319	38.323	38.327	38.331	38.335	38.339	38.342
974	38.346	38.350	38.354	38.358	38.362	38.366	38.370	38.374	38.378	38.382
975	38.386	38.390	38.394	38.398	38.401	38.405	38.409	38.413	38.417	38.421
976	38.425	38.429	38.433	38.437	38.441	38.445	38.449	38.453	38.457	38.461
977	38.464	38.468	38.472	38.476	38.480	38.484	38.488	38.492	38.496	38.500
978	38.504	38.508	38.512	38.516	38.520	38.524	38.527	38.531	38.535	38.539
979	38.543	38.547	38.551	38.555	38.559	38.563	38.567	38.571	38.575	38.579
980	38.583	38.587	38.590	38.594	38.598	38.602	38.606	38.610	38.614	38.618
981	38.622	38.626	38.630	38.634	38.638	38.642	38.646	38.650	38.653	38.657
982	38.661	38.665	38.669	38.673	38.677	38.681	38.685	38.689	38.693	38.697
983	38.701	38.705	38.709	38.713	38.716	38.720	38.724	38.728	38.732	38.736
984	38.740	38.744	38.748	38.752	38.756	38.760	38.764	38.768	38.772	38.776
985	38.780	38.783	38.787	38.791	38.795	38.799	38.803	38.807	38.811	38.815
986	38.819	38.823	38.827	38.831	38.835	38.839	38.842	38.846	38.850	38.854
987	38.858	38.862	38.866	38.870	38.874	38.878	38.882	38.886	38.890	38.894
988	38.898	38.901	38.905	38.909	38.913	38.917	38.921	38.925	38.929	38.933
989	38.937	38.941	38.945	38.949	38.953	38.957	38.961	38.964	38.968	38.972
990	38.976	38.980	38.984	38.988	38.992	38.996	39.000	39.004	39.008	39.012
991	39.016	39.020	39.024	39.027	39.031	39.035	39.039	39.043	39.047	39.051
992	39.055	39.059	39.063	39.067	39.071	39.075	39.079	39.083	39.087	39.090
993	39.094	39.098	39.102	39.106	39.110	39.114	39.118	39.122	39.126	39.130
994	39.134	39.138	39.142	39.146	39.150	39.153	39.157	39.161	39.165	39.169
995	39.173	39.177	39.181	39.185	39.189	39.193	39.197	39.201	39.205	39.209
996	39.213	39.216	39.220	39.224	39.228	39.232	39.236	39.240	39.244	39.248
997	39.252	39.256	39.260	39.264	39.268	39.272	39.276	39.279	39.283	39.287
998	39.291	39.295	39.299	39.303	39.307	39.311	39.315	39.319	39.323	39.327
999	39.331	39.335	39.339	39.342	39.346	39.350	39.354	39.358	39.362	39.366
1000	39.370	39.374	39.378	39.382	39.386	39.390	39.394	39.398	39.401	39.405

BAROMETRIC INCHES (MERCURY) INTO MILLIBARS.

1 inch = 33.86395 mb.

Inches	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
0.0	0.00	0.34	0.68	1.02	1.35	1.69	2.03	2.37	2.71	3.05
0.1	3.39	3.73	4.06	4.40	4.74	5.08	5.42	5.76	6.10	6.43
0.2	6.77	7.11	7.45	7.79	8.13	8.47	8.80	9.14	9.48	9.82
0.3	10.16	10.50	10.84	11.18	11.51	11.85	12.19	12.53	12.87	13.21
0.4	13.55	13.88	14.22	14.56	14.90	15.24	15.58	15.92	16.25	16.59
0.5	16.93	17.27	17.61	17.95	18.29	18.63	18.96	19.30	19.64	19.98
0.6	20.32	20.66	21.00	21.33	21.67	22.01	22.35	22.69	23.03	23.37
0.7	23.70	24.04	24.38	24.72	25.06	25.40	25.74	26.08	26.41	26.75
0.8	27.09	27.43	27.77	28.11	28.45	28.78	29.12	29.46	29.80	30.14
0.9	30.48	30.82	31.15	31.49	31.83	32.17	32.51	32.85	33.19	33.53
1.0	33.86	34.20	34.54	34.88	35.22	35.56	35.90	36.23	36.57	36.91
1.1	37.25	37.59	37.93	38.27	38.60	38.94	39.28	39.62	39.96	40.30
1.2	40.64	40.98	41.31	41.65	41.99	42.33	42.67	43.01	43.35	43.68
1.3	44.02	44.36	44.70	45.04	45.38	45.72	46.05	46.39	46.73	47.07
1.4	47.41	47.75	48.09	48.43	48.76	49.10	49.44	49.78	50.12	50.46
1.5	50.80	51.13	51.47	51.81	52.15	52.49	52.83	53.17	53.51	53.84
1.6	54.18	54.52	54.86	55.20	55.54	55.88	56.21	56.55	56.89	57.23
1.7	57.57	57.91	58.25	58.58	58.92	59.26	59.60	59.94	60.28	60.62
1.8	60.96	61.29	61.63	61.97	62.31	62.65	62.99	63.33	63.66	64.00
1.9	64.34	64.68	65.02	65.36	65.70	66.03	66.37	66.71	67.05	67.39
2.0	67.73	68.07	68.41	68.74	69.08	69.42	69.76	70.10	70.44	70.78
2.1	71.11	71.45	71.79	72.13	72.47	72.81	73.15	73.48	73.82	74.16
2.2	74.50	74.84	75.18	75.52	75.86	76.19	76.53	76.87	77.21	77.55
2.3	77.89	78.23	78.56	78.90	79.24	79.58	79.92	80.26	80.60	80.93
2.4	81.27	81.61	81.95	82.29	82.63	82.97	83.31	83.64	83.98	84.32
25.0	846.6	846.9	847.3	847.6	848.0	848.3	848.6	849.0	849.3	849.6
25.1	850.0	850.3	850.7	851.0	851.3	851.7	852.0	852.4	852.7	853.0
25.2	853.4	853.7	854.0	854.4	854.7	855.1	855.4	855.7	856.1	856.4
25.3	856.8	857.1	857.4	857.8	858.1	858.5	858.8	859.1	859.5	859.8
25.4	860.1	860.5	860.8	861.2	861.5	861.8	862.2	862.5	862.9	863.2
25.5	863.5	863.9	864.2	864.5	864.9	865.2	865.6	865.9	866.2	866.6
25.6	866.9	867.3	867.6	867.9	868.3	868.6	868.9	869.3	869.6	870.0
25.7	870.3	870.7	871.0	871.3	871.7	872.0	872.3	872.7	873.0	873.4
25.8	873.7	874.0	874.4	874.7	875.0	875.4	875.7	876.1	876.4	876.7
25.9	877.1	877.4	877.8	878.1	878.4	878.8	879.1	879.4	879.8	880.1
26.0	880.5	880.8	881.1	881.5	881.8	882.2	882.5	882.8	883.2	883.5
26.1	883.8	884.2	884.5	884.9	885.2	885.5	885.9	886.2	886.6	886.9
26.2	887.2	887.6	887.9	888.3	888.6	888.9	889.3	889.6	889.9	890.3
26.3	890.6	891.0	891.3	891.6	892.0	892.3	892.7	893.0	893.3	893.7
26.4	894.0	894.3	894.7	895.0	895.4	895.7	896.0	896.4	896.7	897.1
26.5	897.4	897.7	898.1	898.4	898.7	899.1	899.4	899.8	900.1	900.4
26.6	900.8	901.1	901.5	901.8	902.1	902.5	902.8	903.2	903.5	903.8
26.7	904.2	904.5	904.8	905.2	905.5	905.9	906.2	906.5	906.9	907.2
26.8	907.6	907.9	908.2	908.6	908.9	909.2	909.6	909.9	910.3	910.6
26.9	910.9	911.3	911.6	912.0	912.3	912.6	913.0	913.3	913.6	914.0
27.0	914.3	914.7	915.0	915.3	915.7	916.0	916.4	916.7	917.0	917.4
27.1	917.7	918.1	918.4	918.7	919.1	919.4	919.7	920.1	920.4	920.8
27.2	921.1	921.4	921.8	922.1	922.5	922.8	923.1	923.5	923.8	924.1
27.3	924.5	924.8	925.2	925.5	925.8	926.2	926.5	926.9	927.2	927.5
27.4	927.9	928.2	928.5	928.9	929.2	929.6	929.9	930.2	930.6	930.9

BAROMETRIC INCHES (MERCURY) INTO MILLIBARS.

1 inch = 33.86395 mb.

Inches.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
27.5	931.3	931.6	931.9	932.3	932.6	933.0	933.3	933.6	934.0	934.3
27.6	934.6	935.0	935.3	935.7	936.0	936.3	936.7	937.0	937.4	937.7
27.7	938.0	938.4	938.7	939.0	939.4	939.7	940.1	940.4	940.7	941.1
27.8	941.4	941.8	942.1	942.4	942.8	943.1	943.4	943.8	944.1	944.5
27.9	944.8	945.1	945.5	945.8	946.2	946.5	946.8	947.2	947.5	947.9
28.0	948.2	948.5	948.9	949.2	949.5	949.9	950.2	950.6	950.9	951.2
28.1	951.6	951.9	952.3	952.6	952.9	953.3	953.6	953.9	954.3	954.6
28.2	955.0	955.3	955.6	956.0	956.3	956.7	957.0	957.3	957.7	958.0
28.3	958.3	958.7	959.0	959.4	959.7	960.0	960.4	960.7	961.1	961.4
28.4	961.7	962.1	962.4	962.8	963.1	963.4	963.8	964.1	964.4	964.8
28.5	965.1	965.5	965.8	966.1	966.5	966.8	967.2	967.5	967.8	968.2
28.6	968.5	968.8	969.2	969.5	969.9	970.2	970.5	970.9	971.2	971.6
28.7	971.9	972.2	972.6	972.9	973.2	973.6	973.9	974.3	974.6	974.9
28.8	975.3	975.6	976.0	976.3	976.6	977.0	977.3	977.7	978.0	978.3
28.9	978.7	979.0	979.3	979.7	980.0	980.4	980.7	981.0	981.4	981.7
29.0	982.1	982.4	982.7	983.1	983.4	983.7	984.1	984.4	984.8	985.1
29.1	985.4	985.8	986.1	986.5	986.8	987.1	987.5	987.8	988.2	988.5
29.2	988.8	989.2	989.5	989.8	990.2	990.5	990.9	991.2	991.5	991.9
29.3	992.2	992.6	992.9	993.2	993.6	993.9	994.2	994.6	994.9	995.3
29.4	995.6	995.9	996.3	996.6	997.0	997.3	997.6	998.0	998.3	998.6
29.5	999.0	999.3	999.7	1000.0	1000.4	1000.7	1001.0	1001.4	1001.7	1002.0
29.6	1002.4	1002.7	1003.1	1003.4	1003.7	1004.1	1004.4	1004.7	1005.1	1005.4
29.7	1005.8	1006.1	1006.4	1006.8	1007.1	1007.5	1007.8	1008.1	1008.5	1008.8
29.8	1009.1	1009.5	1009.8	1010.2	1010.5	1010.8	1011.2	1011.5	1011.9	1012.2
29.9	1012.5	1012.9	1013.2	1013.5	1013.9	1014.2	1014.6	1014.9	1015.2	1015.6
30.0	1015.9	1016.3	1016.6	1016.9	1017.3	1017.6	1018.0	1018.3	1018.6	1019.0
30.1	1019.3	1019.6	1020.0	1020.3	1020.7	1021.0	1021.3	1021.7	1022.0	1022.4
30.2	1022.7	1023.0	1023.4	1023.7	1024.0	1024.4	1024.7	1025.1	1025.4	1025.7
30.3	1026.1	1026.4	1026.8	1027.1	1027.4	1027.8	1028.1	1028.4	1028.8	1029.1
30.4	1029.5	1029.8	1030.1	1030.5	1030.8	1031.2	1031.5	1031.8	1032.2	1032.5
30.5	1032.9	1033.2	1033.5	1033.9	1034.2	1034.5	1034.9	1035.2	1035.6	1035.9
30.6	1036.2	1036.6	1036.9	1037.3	1037.6	1037.9	1038.3	1038.6	1038.9	1039.3
30.7	1039.6	1040.0	1040.3	1040.6	1041.0	1041.3	1041.7	1042.0	1042.3	1042.7
30.8	1043.0	1043.3	1043.7	1044.0	1044.4	1044.7	1045.0	1045.4	1045.7	1046.1
30.9	1046.4	1046.7	1047.1	1047.4	1047.8	1048.1	1048.4	1048.8	1049.1	1049.5
31.0	1049.8	1050.1	1050.5	1050.8	1051.1	1051.5	1051.8	1052.2	1052.5	1052.8
31.1	1053.2	1053.5	1053.8	1054.2	1054.5	1054.9	1055.2	1055.5	1055.9	1056.2
31.2	1056.6	1056.9	1057.2	1057.6	1057.9	1058.2	1058.6	1058.9	1059.3	1059.6
31.3	1059.9	1060.3	1060.6	1061.0	1061.3	1061.6	1062.0	1062.3	1062.7	1063.0
31.4	1063.3	1063.7	1064.0	1064.3	1064.7	1065.0	1065.4	1065.7	1066.0	1066.4
31.5	1066.7	1067.1	1067.4	1067.7	1068.1	1068.4	1068.7	1069.1	1069.4	1069.8
31.6	1070.1	1070.4	1070.8	1071.1	1071.5	1071.8	1072.1	1072.5	1072.8	1073.1
31.7	1073.5	1073.8	1074.2	1074.5	1074.8	1075.2	1075.5	1075.9	1076.2	1076.5
31.8	1076.9	1077.2	1077.6	1077.9	1078.2	1078.6	1078.9	1079.2	1079.6	1079.9
31.9	1080.3	1080.6	1080.9	1081.3	1081.6	1082.0	1082.3	1082.6	1083.0	1083.3

BAROMETRIC MILLIMETERS (MERCURY) INTO MILLIBARS.

1 mm. = 1.33322387 mb.

Millimeters.	0	1	2	3	4	5	6	7	8	9
	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
0	0	1.3	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0
10	13.3	14.7	16.0	17.3	18.7	20.0	21.3	22.7	24.0	25.3
20	26.7	28.0	29.3	30.7	32.0	33.3	34.7	36.0	37.3	38.7
30	40.0	41.3	42.7	44.0	45.3	46.7	48.0	49.3	50.7	52.0
40	53.3	54.7	56.0	57.3	58.7	60.0	61.3	62.7	64.0	65.3
50	66.7	68.0	69.3	70.7	72.0	73.3	74.7	76.0	77.3	78.7
60	80.0	81.3	82.7	84.0	85.3	86.7	88.0	89.3	90.7	92.0
70	93.3	94.7	96.0	97.3	98.7	100.0	101.3	102.7	104.0	105.3
80	106.7	108.0	109.3	110.7	112.0	113.3	114.7	116.0	117.3	118.7
90	120.0	121.3	122.7	124.0	125.3	126.7	128.0	129.3	130.7	132.0
100	133.3	134.7	136.0	137.3	138.7	140.0	141.3	142.7	144.0	145.3
110	146.7	148.0	149.3	150.7	152.0	153.3	154.7	156.0	157.3	158.7
120	160.0	161.3	162.7	164.0	165.3	166.7	168.0	169.3	170.7	172.0
130	173.3	174.7	176.0	177.3	178.7	180.0	181.3	182.7	184.0	185.3
140	186.7	188.0	189.3	190.7	192.0	193.3	194.7	196.0	197.3	198.7
150	200.0	201.3	202.7	204.0	205.3	206.6	208.0	209.3	210.6	212.0
160	213.3	214.6	216.0	217.3	218.6	220.0	221.3	222.6	224.0	225.3
170	226.6	228.0	229.3	230.6	232.0	233.3	234.6	236.0	237.3	238.6
180	240.0	241.3	242.6	244.0	245.3	246.6	248.0	249.3	250.6	252.0
190	253.3	254.6	256.0	257.3	258.6	260.0	261.3	262.6	264.0	265.3
200	266.6	268.0	269.3	270.6	272.0	273.3	274.6	276.0	277.3	278.6
210	280.0	281.3	282.6	284.0	285.3	286.6	288.0	289.3	290.6	292.0
220	293.3	294.6	296.0	297.3	298.6	300.0	301.3	302.6	304.0	305.3
230	306.6	308.0	309.3	310.6	312.0	313.3	314.6	316.0	317.3	318.6
240	320.0	321.3	322.6	324.0	325.3	326.6	328.0	329.3	330.6	332.0
250	333.3	334.6	336.0	337.3	338.6	340.0	341.3	342.6	344.0	345.3
260	346.6	348.0	349.3	350.6	352.0	353.3	354.6	356.0	357.3	358.6
270	360.0	361.3	362.6	364.0	365.3	366.6	368.0	369.3	370.6	372.0
280	373.3	374.6	376.0	377.3	378.6	380.0	381.3	382.6	384.0	385.3
290	386.6	388.0	389.3	390.6	392.0	393.3	394.6	396.0	397.3	398.6
300	400.0	401.3	402.6	404.0	405.3	406.6	408.0	409.3	410.6	412.0
310	413.3	414.6	416.0	417.3	418.6	420.0	421.3	422.6	424.0	425.3
320	426.6	428.0	429.3	430.6	432.0	433.3	434.6	436.0	437.3	438.6
330	440.0	441.3	442.6	444.0	445.3	446.6	448.0	449.3	450.6	452.0
340	453.3	454.6	456.0	457.3	458.6	460.0	461.3	462.6	464.0	465.3
350	466.6	468.0	469.3	470.6	472.0	473.3	474.6	476.0	477.3	478.6
360	480.0	481.3	482.6	484.0	485.3	486.6	488.0	489.3	490.6	492.0
370	493.3	494.6	496.0	497.3	498.6	500.0	501.3	502.6	504.0	505.3
380	506.6	508.0	509.3	510.6	512.0	513.3	514.6	516.0	517.3	518.6
390	520.0	521.3	522.6	524.0	525.3	526.6	528.0	529.3	530.6	532.0
400	533.3	534.6	536.0	537.3	538.6	540.0	541.3	542.6	544.0	545.3
410	546.6	548.0	549.3	550.6	552.0	553.3	554.6	556.0	557.3	558.6
420	560.0	561.3	562.6	564.0	565.3	566.6	568.0	569.3	570.6	572.0
430	573.3	574.6	576.0	577.3	578.6	580.0	581.3	582.6	584.0	585.3
440	586.6	588.0	589.3	590.6	592.0	593.3	594.6	596.0	597.3	598.6

BAROMETRIC MILLIMETERS (MERCURY) INTO MILLIBARS.

1 mm. = 1.33322387 mb.

Milli-meters.	0	1	2	3	4	5	6	7	8	9
	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
450	600.0	601.3	602.6	604.0	605.3	606.6	608.0	609.3	610.6	611.9
460	613.3	614.6	615.9	617.3	618.6	619.9	621.3	622.6	623.9	625.3
470	626.6	627.9	629.3	630.6	631.9	633.3	634.6	635.9	637.3	638.6
480	639.9	641.3	642.6	643.9	645.3	646.6	647.9	649.3	650.6	651.9
490	653.3	654.6	655.9	657.3	658.6	659.9	661.3	662.6	663.9	665.3
500	666.6	667.9	669.3	670.6	671.9	673.3	674.6	675.9	677.3	678.6
510	679.9	681.3	682.6	683.9	685.3	686.6	687.9	689.3	690.6	691.9
520	693.3	694.6	695.9	697.3	698.6	699.9	701.3	702.6	703.9	705.3
530	706.6	707.9	709.3	710.6	711.9	713.3	714.6	715.9	717.3	718.6
540	719.9	721.3	722.6	723.9	725.3	726.6	727.9	729.3	730.6	731.9
550	733.3	734.6	735.9	737.3	738.6	739.9	741.3	742.6	743.9	745.3
560	746.6	747.9	749.3	750.6	751.9	753.3	754.6	755.9	757.3	758.6
570	759.9	761.3	762.6	763.9	765.3	766.6	767.9	769.3	770.6	771.9
580	773.3	774.6	775.9	777.3	778.6	779.9	781.3	782.6	783.9	785.3
590	786.6	787.9	789.3	790.6	791.9	793.3	794.6	795.9	797.3	798.6
600	799.9	801.3	802.6	803.9	805.3	806.6	807.9	809.3	810.6	811.9
610	813.3	814.6	815.9	817.3	818.6	819.9	821.3	822.6	823.9	825.3
620	826.6	827.9	829.3	830.6	831.9	833.3	834.6	835.9	837.3	838.6
630	839.9	841.3	842.6	843.9	845.3	846.6	847.9	849.3	850.6	851.9
640	853.3	854.6	855.9	857.3	858.6	859.9	861.3	862.6	863.9	865.3
650	866.6	867.9	869.3	870.6	871.9	873.3	874.6	875.9	877.3	878.6
660	879.9	881.3	882.6	883.9	885.3	886.6	887.9	889.3	890.6	891.9
670	893.3	894.6	895.9	897.3	898.6	899.9	901.3	902.6	903.9	905.3
680	906.6	907.9	909.3	910.6	911.9	913.3	914.6	915.9	917.3	918.6
690	919.9	921.3	922.6	923.9	925.3	926.6	927.9	929.3	930.6	931.9
700	933.3	934.6	935.9	937.3	938.6	939.9	941.3	942.6	943.9	945.3
710	946.6	947.9	949.3	950.6	951.9	953.3	954.6	955.9	957.3	958.6
720	959.9	961.3	962.6	963.9	965.3	966.6	967.9	969.3	970.6	971.9
730	973.3	974.6	975.9	977.3	978.6	979.9	981.3	982.6	983.9	985.3
740	986.6	987.9	989.3	990.6	991.9	993.3	994.6	995.9	997.3	998.6
750	999.9	1001.3	1002.6	1003.9	1005.3	1006.6	1007.9	1009.3	1010.6	1011.9
760	1013.3	1014.6	1015.9	1017.2	1018.6	1019.9	1021.2	1022.6	1023.9	1025.2
770	1026.6	1027.9	1029.2	1030.6	1031.9	1033.2	1034.6	1035.9	1037.2	1038.6
780	1039.9	1041.2	1042.6	1043.9	1045.2	1046.6	1047.9	1049.2	1050.6	1051.9
790	1053.2	1054.6	1055.9	1057.2	1058.6	1059.9	1061.2	1062.6	1063.9	1065.2

FEET INTO METERS.

1 foot = 0.3048006 meter.

Feet.	0	1	2	3	4	5	6	7	8	9
	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
0	0.000	0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175

Feet.	0	10	20	30	40	50	60	70	80	90
100	30.48	33.53	36.58	39.62	42.67	45.72	48.77	51.82	54.86	57.91
200	60.96	64.01	67.06	70.10	73.15	76.20	79.25	82.30	85.34	88.39
300	91.44	94.49	97.54	100.58	103.63	106.68	109.73	112.78	115.82	118.87
400	121.92	124.97	128.02	131.06	134.11	137.16	140.21	143.26	146.30	149.35
500	152.40	155.45	158.50	161.54	164.59	167.64	170.69	173.74	176.78	179.83
600	182.88	185.93	188.98	192.02	195.07	198.12	201.17	204.22	207.26	210.31
700	213.36	216.41	219.46	222.50	225.55	228.60	231.65	234.70	237.74	240.79
800	243.84	246.89	249.94	252.98	256.03	259.08	262.13	265.18	268.22	271.27
900	274.32	277.37	280.42	283.46	286.51	289.56	292.61	295.66	298.70	301.75
1000	304.80	307.85	310.90	313.94	316.99	320.04	323.09	326.14	329.18	332.23
1100	335.28	338.33	341.38	344.42	347.47	350.52	353.57	356.62	359.67	362.71
1200	365.76	368.81	371.86	374.90	377.95	381.00	384.05	387.10	390.14	393.19
1300	396.24	399.29	402.34	405.38	408.43	411.48	414.53	417.58	420.62	423.67
1400	426.72	429.77	432.82	435.86	438.91	441.96	445.01	448.06	451.10	454.15
1500	457.20	460.25	463.30	466.34	469.39	472.44	475.49	478.54	481.58	484.63
1600	487.68	490.73	493.78	496.82	499.87	502.92	505.97	509.02	512.07	515.11
1700	518.16	521.21	524.26	527.31	530.35	533.40	536.45	539.50	542.55	545.59
1800	548.64	551.69	554.74	557.79	560.83	563.88	566.93	569.98	573.03	576.07
1900	579.12	582.17	585.22	588.27	591.31	594.36	597.41	600.46	603.51	606.55
2000	609.60	612.65	615.70	618.75	621.79	624.84	627.89	630.94	633.99	637.03
2100	640.08	643.13	646.18	649.23	652.27	655.32	658.37	661.42	664.47	667.51
2200	670.56	673.61	676.66	679.71	682.75	685.80	688.85	691.90	694.95	697.99
2300	701.04	704.09	707.14	710.19	713.23	716.28	719.33	722.38	725.43	728.47
2400	731.52	734.57	737.62	740.67	743.71	746.76	749.81	752.86	755.91	758.95
2500	762.00	765.05	768.10	771.15	774.19	777.24	780.29	783.34	786.39	789.43
2600	792.48	795.53	798.58	801.63	804.67	807.72	810.77	813.82	816.87	819.91
2700	822.96	826.01	829.06	832.11	835.15	838.20	841.25	844.30	847.35	850.39
2800	853.44	856.49	859.54	862.59	865.63	868.68	871.73	874.78	877.83	880.87
2900	883.92	886.97	890.02	893.07	896.11	899.16	902.21	905.26	908.31	911.35
3000	914.40	917.45	920.50	923.55	926.59	929.64	932.69	935.74	938.79	941.83
3100	944.88	947.93	950.98	954.03	957.07	960.12	963.17	966.22	969.27	972.31
3200	975.36	978.41	981.46	984.51	987.55	990.60	993.65	996.70	999.75	1002.79
3300	1005.84	1008.89	1011.94	1014.99	1018.03	1021.08	1024.13	1027.18	1030.23	1033.27
3400	1036.32	1039.37	1042.42	1045.47	1048.51	1051.56	1054.61	1057.66	1060.71	1063.75
3500	1066.80	1069.85	1072.90	1075.95	1078.99	1082.04	1085.09	1088.14	1091.19	1094.23
3600	1097.28	1100.33	1103.38	1106.43	1109.47	1112.52	1115.57	1118.62	1121.67	1124.71
3700	1127.76	1130.81	1133.86	1136.91	1139.95	1143.00	1146.05	1149.10	1152.15	1155.19
3800	1158.24	1161.29	1164.34	1167.39	1170.43	1173.48	1176.53	1179.58	1182.63	1185.67
3900	1188.72	1191.77	1194.82	1197.87	1200.91	1203.96	1207.01	1210.06	1213.11	1216.15
4000	1219.20	1222.25	1225.30	1228.35	1231.39	1234.44	1237.49	1240.54	1243.59	1246.63

FEET INTO METERS.

1 foot = 0.3048006 meter.

Feet.	0	10	20	30	40	50	60	70	80	90
	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
4000	1219.2	1222.3	1225.3	1228.3	1231.4	1234.4	1237.5	1240.5	1243.6	1246.6
4100	1249.7	1252.7	1255.8	1258.8	1261.9	1264.9	1268.0	1271.0	1274.1	1277.1
4200	1280.2	1283.2	1286.3	1289.3	1292.4	1295.4	1298.5	1301.5	1304.5	1307.6
4300	1310.6	1313.7	1316.7	1319.8	1322.8	1325.9	1328.9	1332.0	1335.0	1338.1
4400	1341.1	1344.2	1347.2	1350.3	1353.3	1356.4	1359.4	1362.5	1365.5	1368.6
4500	1371.6	1374.7	1377.7	1380.7	1383.8	1386.8	1389.9	1392.9	1396.0	1399.0
4600	1402.1	1405.1	1408.2	1411.2	1414.3	1417.3	1420.4	1423.4	1426.5	1429.5
4700	1432.6	1435.6	1438.7	1441.7	1444.8	1447.8	1450.9	1453.9	1456.9	1460.0
4800	1463.0	1466.1	1469.1	1472.2	1475.2	1478.3	1481.3	1484.4	1487.4	1490.5
4900	1493.5	1496.6	1499.6	1502.7	1505.7	1508.8	1511.8	1514.9	1517.9	1521.0
5000	1524.0	1527.1	1530.1	1533.1	1536.2	1539.2	1542.3	1545.3	1548.4	1551.4
5100	1554.5	1557.5	1560.6	1563.6	1566.7	1569.7	1572.8	1575.8	1578.9	1581.9
5200	1585.0	1588.0	1591.1	1594.1	1597.2	1600.2	1603.3	1606.3	1609.3	1612.4
5300	1615.4	1618.5	1621.5	1624.6	1627.6	1630.7	1633.7	1636.8	1639.8	1642.9
5400	1645.9	1649.0	1652.0	1655.1	1658.1	1661.2	1664.2	1667.3	1670.3	1673.4
5500	1676.4	1679.5	1682.5	1685.5	1688.6	1691.6	1694.7	1697.7	1700.8	1703.8
5600	1706.9	1709.9	1713.0	1716.0	1719.1	1722.1	1725.2	1728.2	1731.3	1734.3
5700	1737.4	1740.4	1743.5	1746.5	1749.6	1752.6	1755.7	1758.7	1761.7	1764.8
5800	1767.8	1770.9	1773.9	1777.0	1780.0	1783.1	1786.1	1789.2	1792.2	1795.3
5900	1798.3	1801.4	1804.4	1807.5	1810.5	1813.6	1816.6	1819.7	1822.7	1825.8
6000	1828.8	1831.9	1834.9	1837.9	1841.0	1844.0	1847.1	1850.1	1853.2	1856.2
6100	1859.3	1862.3	1865.4	1868.4	1871.5	1874.5	1877.6	1880.6	1883.7	1886.7
6200	1889.8	1892.8	1895.9	1898.9	1902.0	1905.0	1908.1	1911.1	1914.1	1917.2
6300	1920.2	1923.3	1926.3	1929.4	1932.4	1935.5	1938.5	1941.6	1944.6	1947.7
6400	1950.7	1953.8	1956.8	1959.9	1962.9	1966.0	1969.0	1972.1	1975.1	1978.2
6500	1981.2	1984.3	1987.3	1990.3	1993.4	1996.4	1999.5	2002.5	2005.6	2008.6
6600	2011.7	2014.7	2017.8	2020.8	2023.9	2026.9	2030.0	2033.0	2036.1	2039.1
6700	2042.2	2045.2	2048.3	2051.3	2054.4	2057.4	2060.5	2063.5	2066.5	2069.6
6800	2072.6	2075.7	2078.7	2081.8	2084.8	2087.9	2090.9	2094.0	2097.0	2100.1
6900	2103.1	2106.2	2109.2	2112.3	2115.3	2118.4	2121.4	2124.5	2127.5	2130.6
7000	2133.6	2136.7	2139.7	2142.7	2145.8	2148.8	2151.9	2154.9	2158.0	2161.0
7100	2164.1	2167.1	2170.2	2173.2	2176.3	2179.3	2182.4	2185.4	2188.5	2191.5
7200	2194.6	2197.6	2200.7	2203.7	2206.8	2209.8	2212.9	2215.9	2218.9	2222.0
7300	2225.0	2228.1	2231.1	2234.2	2237.2	2240.3	2243.3	2246.4	2249.4	2252.5
7400	2255.5	2258.6	2261.6	2264.7	2267.7	2270.8	2273.8	2276.9	2279.9	2283.0
7500	2286.0	2289.1	2292.1	2295.1	2298.2	2301.2	2304.3	2307.3	2310.4	2313.4
7600	2316.5	2319.5	2322.6	2325.6	2328.7	2331.7	2334.8	2337.8	2340.9	2343.9
7700	2347.0	2350.0	2353.1	2356.1	2359.2	2362.2	2365.3	2368.3	2371.3	2374.4
7800	2377.4	2380.5	2383.5	2386.6	2389.6	2392.7	2395.7	2398.8	2401.8	2404.9
7900	2407.9	2411.0	2414.0	2417.1	2420.1	2423.2	2426.2	2429.3	2432.3	2435.4
8000	2438.4	2441.5	2444.5	2447.5	2450.6	2453.6	2456.7	2459.7	2462.8	2465.8
8100	2468.9	2471.9	2475.0	2478.0	2481.1	2484.1	2487.2	2490.2	2493.3	2496.3
8200	2499.4	2502.4	2505.5	2508.5	2511.6	2514.6	2517.7	2520.7	2523.7	2526.8
8300	2529.8	2532.9	2535.9	2539.0	2542.0	2545.1	2548.1	2551.2	2554.2	2557.3
8400	2560.3	2563.4	2566.4	2569.5	2572.5	2575.6	2578.6	2581.7	2584.7	2587.8
8500	2590.8	2593.9	2596.9	2599.9	2603.0	2606.0	2609.1	2612.1	2615.2	2618.2
8600	2621.3	2624.3	2627.4	2630.4	2633.5	2636.5	2639.6	2642.6	2645.7	2648.7
8700	2651.8	2654.8	2657.9	2660.9	2664.0	2667.0	2670.1	2673.1	2676.1	2679.2
8800	2682.2	2685.3	2688.3	2691.4	2694.4	2697.5	2700.5	2703.6	2706.6	2709.7
8900	2712.7	2715.8	2718.8	2721.9	2724.9	2728.0	2731.0	2734.1	2737.1	2740.2
9000	2743.2	2746.3	2749.3	2752.3	2755.4	2758.4	2761.5	2764.5	2767.6	2770.6

METERS INTO FEET.

1 meter = 39.3700 inches = 3.280833 feet.

Meters.	0	1	2	3	4	5	6	7	8	9
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	0.00	3.28	6.56	9.84	13.12	16.40	19.68	22.97	26.25	29.53
10	32.81	36.09	39.37	42.65	45.93	49.21	52.49	55.77	59.05	62.34
20	65.62	68.90	72.18	75.46	78.74	82.02	85.30	88.58	91.86	95.14
30	98.42	101.71	104.99	108.27	111.55	114.83	118.11	121.39	124.67	127.95
40	131.23	134.51	137.79	141.08	144.36	147.64	150.92	154.20	157.48	160.76
50	164.04	167.32	170.60	173.88	177.16	180.45	183.73	187.01	190.29	193.57
60	196.85	200.13	203.41	206.69	209.97	213.25	216.53	219.82	223.10	226.38
70	229.66	232.94	236.22	239.50	242.78	246.06	249.34	252.62	255.90	259.19
80	262.47	265.75	269.03	272.31	275.59	278.87	282.15	285.43	288.71	291.99
90	295.27	298.56	301.84	305.12	308.40	311.68	314.96	318.24	321.52	324.80
100	328.08	331.36	334.64	337.93	341.21	344.49	347.77	351.05	354.33	357.61
110	360.89	364.17	367.45	370.73	374.01	377.30	380.58	383.86	387.14	390.42
120	393.70	396.98	400.26	403.54	406.82	410.10	413.38	416.67	419.95	423.23
130	426.51	429.79	433.07	436.35	439.63	442.91	446.19	449.47	452.75	456.04
140	459.32	462.60	465.88	469.16	472.44	475.72	479.00	482.28	485.56	488.84
150	492.12	495.41	498.69	501.97	505.25	508.53	511.81	515.09	518.37	521.65
160	524.93	528.21	531.49	534.78	538.06	541.34	544.62	547.90	551.18	554.46
170	557.74	561.02	564.30	567.58	570.86	574.15	577.43	580.71	583.99	587.27
180	590.55	593.83	597.11	600.39	603.67	606.95	610.23	613.52	616.80	620.08
190	623.36	626.64	629.92	633.20	636.48	639.76	643.04	646.32	649.60	652.89
200	656.17	659.45	662.73	666.01	669.29	672.57	675.85	679.13	682.41	685.69
210	688.97	692.26	695.54	698.82	702.10	705.38	708.66	711.94	715.22	718.50
220	721.78	725.06	728.34	731.63	734.91	738.19	741.47	744.75	748.03	751.31
230	754.59	757.87	761.15	764.43	767.71	771.00	774.28	777.56	780.84	784.12
240	787.40	790.68	793.96	797.24	800.52	803.80	807.08	810.37	813.65	816.93
250	820.21	823.49	826.77	830.05	833.33	836.61	839.89	843.17	846.45	849.74
260	853.02	856.30	859.58	862.86	866.14	869.42	872.70	875.98	879.26	882.54
270	885.82	889.11	892.39	895.67	898.95	902.23	905.51	908.79	912.07	915.35
280	918.63	921.91	925.19	928.48	931.76	935.04	938.32	941.60	944.88	948.16
290	951.44	954.72	958.00	961.28	964.56	967.85	971.13	974.41	977.69	980.97
300	984.25	987.53	990.81	994.09	997.37	1000.65	1003.93	1007.22	1010.50	1013.78
310	1017.06	1020.34	1023.62	1026.90	1030.18	1033.46	1036.74	1040.02	1043.30	1046.59
320	1049.87	1053.15	1056.43	1059.71	1062.99	1066.27	1069.55	1072.83	1076.11	1079.39
330	1082.67	1085.96	1089.24	1092.52	1095.80	1099.08	1102.36	1105.64	1109.92	1112.20
340	1115.48	1118.76	1122.04	1125.33	1128.61	1131.89	1135.17	1138.45	1141.73	1145.01
350	1148.29	1151.57	1154.85	1158.13	1161.41	1164.70	1167.98	1171.26	1174.54	1177.82
360	1181.10	1184.38	1187.66	1190.94	1194.22	1197.50	1200.78	1204.07	1207.35	1210.63
370	1213.91	1217.19	1220.47	1223.75	1227.03	1230.31	1233.59	1236.87	1240.15	1243.44
380	1246.72	1250.00	1253.28	1256.56	1259.84	1263.12	1266.40	1269.68	1272.96	1276.24
390	1279.52	1282.81	1286.09	1289.37	1292.65	1295.93	1299.21	1302.49	1305.77	1309.05
400	1312.33	1315.61	1318.89	1322.18	1325.46	1328.74	1332.02	1335.30	1338.58	1341.86
410	1345.14	1348.42	1351.70	1354.98	1358.26	1361.55	1364.83	1368.11	1371.39	1374.67
420	1377.95	1381.23	1384.51	1387.79	1391.07	1394.35	1397.63	1400.92	1404.20	1407.48
430	1410.76	1414.04	1417.32	1420.60	1423.88	1427.16	1430.44	1433.72	1437.00	1440.29
440	1443.57	1446.85	1450.13	1453.41	1456.69	1459.97	1463.25	1466.53	1469.81	1473.09
450	1476.37	1479.66	1482.94	1486.22	1489.50	1492.78	1496.06	1499.34	1502.62	1505.90
460	1509.18	1512.46	1515.74	1519.03	1522.31	1525.59	1528.87	1532.15	1535.43	1538.71
470	1541.99	1545.27	1548.55	1551.83	1555.11	1558.40	1561.68	1564.96	1568.24	1571.52
480	1574.80	1578.08	1581.36	1584.64	1587.92	1591.20	1594.48	1597.77	1601.05	1604.33
490	1607.61	1610.89	1614.17	1617.45	1620.73	1624.01	1627.29	1630.57	1633.85	1637.14
500	1640.42	1643.70	1646.98	1650.26	1653.54	1656.82	1660.10	1663.38	1660.66	1669.94

METERS INTO FEET.

1 meter = 39.3700 inches = 3.280833 feet.

Meters.	0	10	20	30	40	50	60	70	80	90
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
500	1640.4	1673.2	1706.0	1738.8	1771.6	1804.5	1837.3	1870.1	1902.9	1935.7
600	1968.5	2001.3	2034.1	2066.9	2099.7	2132.5	2165.3	2198.2	2231.0	2263.8
700	2296.6	2329.4	2362.2	2395.0	2427.8	2460.6	2493.4	2526.2	2559.0	2591.9
800	2624.7	2657.5	2690.3	2723.1	2755.9	2788.7	2821.5	2854.3	2887.1	2919.9
900	2952.7	2985.6	3018.4	3051.2	3084.0	3116.8	3149.6	3182.4	3215.2	3248.0
1000	3280.8	3313.6	3346.4	3379.3	3412.1	3444.9	3477.7	3510.5	3543.3	3576.1
1100	3608.9	3641.7	3674.5	3707.3	3740.1	3773.0	3805.8	3838.6	3871.4	3904.2
1200	3937.0	3969.8	4002.6	4035.4	4068.2	4101.0	4133.8	4166.7	4199.5	4232.3
1300	4265.1	4297.9	4330.7	4363.5	4396.3	4429.1	4461.9	4494.7	4527.5	4560.4
1400	4593.2	4626.0	4658.8	4691.6	4724.4	4757.2	4790.0	4822.8	4855.6	4888.4
1500	4921.2	4954.1	4986.9	5019.7	5052.5	5085.3	5118.1	5150.9	5183.7	5216.5
1600	5249.3	5282.1	5314.9	5347.8	5380.6	5413.4	5446.2	5479.0	5511.8	5544.6
1700	5577.4	5610.2	5643.0	5675.8	5708.6	5741.5	5774.3	5807.1	5839.9	5872.7
1800	5905.5	5938.3	5971.1	6003.9	6036.7	6069.5	6102.3	6135.2	6168.0	6200.8
1900	6233.6	6266.4	6299.2	6332.0	6364.8	6397.6	6430.4	6463.2	6496.0	6528.9
2000	6561.7	6594.5	6627.3	6660.1	6692.9	6725.7	6758.5	6791.3	6824.1	6856.9
2100	6889.7	6922.6	6955.4	6988.2	7021.0	7053.8	7086.6	7119.4	7152.2	7185.0
2200	7217.8	7250.6	7283.4	7316.3	7349.1	7381.9	7414.7	7447.5	7480.3	7513.1
2300	7545.9	7578.7	7611.5	7644.3	7677.1	7710.0	7742.8	7775.6	7808.4	7841.2
2400	7874.0	7906.8	7939.6	7972.4	8005.2	8038.0	8070.8	8103.7	8136.5	8169.3
2500	8202.1	8234.9	8267.7	8300.5	8333.3	8366.1	8398.9	8431.7	8464.5	8497.4
2600	8530.2	8563.0	8595.8	8628.6	8661.4	8694.2	8727.0	8759.8	8792.6	8825.4
2700	8858.2	8891.1	8923.9	8956.7	8989.5	9022.3	9055.1	9087.9	9120.7	9153.5
2800	9186.3	9219.1	9251.9	9284.8	9317.6	9350.4	9383.2	9416.0	9448.8	9481.6
2900	9514.4	9547.2	9580.0	9612.8	9645.6	9678.5	9711.3	9744.1	9776.9	9809.7
3000	9842.5	9875.3	9908.1	9940.9	9973.7	10006.5	10039.3	10072.2	10105.0	10137.8
3100	10170.6	10203.4	10236.2	10269.0	10301.8	10334.6	10367.4	10400.2	10433.0	10465.9
3200	10498.7	10531.5	10564.3	10597.1	10629.9	10662.7	10695.5	10728.3	10761.1	10793.9
3300	10826.7	10859.6	10892.4	10925.2	10958.0	10990.8	11023.6	11056.4	11089.2	11122.0
3400	11154.8	11187.6	11220.4	11253.3	11286.1	11318.9	11351.7	11384.5	11417.3	11450.1
3500	11482.9	11515.7	11548.5	11581.3	11614.1	11647.0	11679.8	11712.6	11745.4	11778.2
3600	11811.0	11843.8	11876.6	11909.4	11942.2	11975.0	12007.8	12040.7	12073.5	12106.3
3700	12139.1	12171.9	12204.7	12237.5	12270.3	12303.1	12335.9	12368.7	12401.5	12434.4
3800	12467.2	12500.0	12532.8	12565.6	12598.4	12631.2	12664.0	12696.8	12729.6	12762.4
3900	12795.2	12828.1	12860.9	12893.7	12926.5	12959.3	12992.1	13024.9	13057.7	13090.5
4000	13123.3	13156.1	13188.9	13221.8	13254.6	13287.4	13320.2	13353.0	13385.8	13418.6
4100	13451.4	13484.2	13517.0	13549.8	13582.6	13615.5	13648.3	13681.1	13713.9	13746.7
4200	13779.5	13812.3	13845.1	13877.9	13910.7	13943.5	13976.3	14009.2	14042.0	14074.8
4300	14107.6	14140.4	14173.2	14206.0	14238.8	14271.6	14304.4	14337.2	14370.0	14402.9
4400	14435.7	14468.5	14501.3	14534.1	14566.9	14599.7	14632.5	14665.3	14698.1	14730.9
4500	14763.7	14796.6	14829.4	14862.2	14895.0	14927.8	14960.6	14993.4	15026.2	15059.0
4600	15091.8	15124.6	15157.4	15190.3	15223.1	15255.9	15288.7	15321.5	15354.3	15387.1
4700	15419.9	15452.7	15485.5	15518.3	15551.1	15584.0	15616.8	15649.6	15682.4	15715.2
4800	15748.0	15780.8	15813.6	15846.4	15879.2	15912.0	15944.8	15977.7	16010.5	16043.3
4900	16076.1	16108.9	16141.7	16174.5	16207.3	16240.1	16272.9	16305.7	16338.5	16371.4
5000	16404.2	16437.0	16469.8	16502.6	16535.4	16568.2	16601.0	16633.8	16666.6	16699.4

Tenths of a meter.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Feet.	0.328	0.656	0.984	1.312	1.640	1.968	2.297	2.625	2.953

TABLE 15.

MILES INTO KILOMETERS.

1 mile = 1.609347 kilometers.

Miles.	0	1	2	3	4	5	6	7	8	9
	km.	km.	km.	km.	km.	km.	km.	km.	km.	km
0	0	2	3	5	6	8	10	11	13	14
10	16	18	19	21	23	24	26	27	29	31
20	32	34	35	37	39	40	42	43	45	47
30	48	50	51	53	55	56	58	60	61	63
40	64	66	68	69	71	72	74	76	77	79
50	80	82	84	85	87	89	90	92	93	95
60	97	98	100	101	103	105	106	108	109	111
70	113	114	116	117	119	121	122	124	126	127
80	129	130	132	134	135	137	138	140	142	143
90	145	146	148	150	151	153	154	156	158	159
100	161	163	164	166	167	169	171	172	174	175
110	177	179	180	182	183	185	187	188	190	192
120	193	195	196	198	200	201	203	204	206	208
130	209	211	212	214	216	217	219	220	222	224
140	225	227	229	230	232	233	235	237	238	240
150	241	243	245	246	248	249	251	253	254	256
160	257	259	261	262	264	266	267	269	270	272
170	274	275	277	278	280	282	283	285	286	288
180	290	291	293	295	296	298	299	301	303	304
190	306	307	309	311	312	314	315	317	319	320
200	322	323	325	327	328	330	332	333	335	336
210	338	340	341	343	344	346	348	349	351	352
220	354	356	357	359	360	362	364	365	367	369
230	370	372	373	375	377	378	380	381	383	385
240	386	388	389	391	393	394	396	398	399	401
250	402	404	406	407	409	410	412	414	415	417
260	418	420	422	423	425	426	428	430	431	433
270	435	436	438	439	441	443	444	446	447	449
280	451	452	454	455	457	459	460	462	463	465
290	467	468	470	472	473	475	476	478	480	481
300	483	484	486	488	489	491	492	494	496	497
310	499	501	502	504	505	507	509	510	512	513
320	515	517	518	520	521	523	525	526	528	529
330	531	533	534	536	538	539	541	542	544	546
340	547	549	550	552	554	555	557	558	560	562
350	563	565	566	568	570	571	573	575	576	578
360	579	581	583	584	586	587	589	591	592	594
370	595	597	599	600	602	604	605	607	608	610
380	612	613	615	616	618	620	621	623	624	626
390	628	629	631	632	634	636	637	639	641	642
400	644	645	647	649	650	652	653	655	657	658
410	660	661	663	665	666	668	669	671	673	674
420	676	678	679	681	682	684	686	687	689	690
430	692	694	695	697	698	700	702	703	705	706
440	708	710	711	713	715	716	718	719	721	723
450	724	726	727	729	731	732	734	735	737	739
460	740	742	744	745	747	748	750	752	753	755
470	756	758	760	761	763	764	766	768	769	771
480	772	774	776	778	779	781	782	784	785	787
490	789	790	792	793	795	797	798	800	801	803
500	805	806	808	809	811	813	814	816	818	819
510	821	822	824	826	827	829	830	832	834	835
520	837	838	840	842	843	845	847	848	850	851
530	853	855	856	858	859	861	863	864	866	867
540	869	871	872	874	875	877	879	880	882	884
550	885	887	888	890	892	893	895	896	898	900

MILES INTO KILOMETERS.

Miles.	0	1	2	3	4	5	6	7	8	9
	km.	km.	km.	km.	km.	km.	km.	km.	km.	km.
550	885	887	888	890	892	893	895	896	898	900
560	901	903	904	906	908	909	911	912	914	916
570	917	919	921	922	924	925	927	929	930	932
580	933	935	937	938	940	941	943	945	946	948
590	950	951	953	954	956	958	959	961	962	964
600	966	967	969	970	972	974	975	977	978	980
610	982	983	985	987	988	990	991	993	995	996
620	998	999	1001	1003	1004	1006	1007	1009	1011	1012
630	1014	1015	1017	1019	1020	1022	1024	1025	1027	1028
640	1030	1032	1033	1035	1036	1038	1040	1041	1043	1044
650	1046	1048	1049	1051	1053	1054	1056	1057	1059	1061
660	1062	1064	1065	1067	1069	1070	1072	1073	1075	1077
670	1078	1080	1081	1083	1085	1086	1088	1090	1091	1093
680	1094	1096	1098	1099	1101	1102	1104	1106	1107	1109
690	1110	1112	1114	1115	1117	1118	1120	1122	1123	1125
700	1127	1128	1130	1131	1133	1135	1136	1138	1139	1141
710	1143	1144	1146	1147	1149	1151	1152	1154	1156	1157
720	1159	1160	1162	1164	1165	1167	1168	1170	1172	1173
730	1175	1176	1178	1180	1181	1183	1184	1186	1188	1189
740	1191	1193	1194	1196	1197	1199	1201	1202	1204	1205
750	1207	1209	1210	1212	1213	1215	1217	1218	1220	1221
760	1223	1225	1226	1228	1230	1231	1233	1234	1236	1238
770	1239	1241	1242	1244	1246	1247	1249	1250	1252	1254
780	1255	1257	1259	1260	1262	1263	1265	1267	1268	1270
790	1271	1273	1275	1276	1278	1279	1281	1283	1284	1286
800	1287	1289	1291	1292	1294	1296	1297	1299	1300	1302
810	1304	1305	1307	1308	1310	1312	1313	1315	1316	1318
820	1320	1321	1323	1324	1326	1328	1329	1331	1333	1334
830	1336	1337	1339	1341	1342	1344	1345	1347	1349	1350
840	1352	1353	1355	1357	1358	1360	1362	1363	1365	1366
850	1368	1370	1371	1373	1374	1376	1378	1379	1381	1382
860	1384	1386	1387	1389	1390	1392	1394	1395	1397	1399
870	1400	1402	1403	1405	1407	1408	1410	1411	1413	1415
880	1416	1418	1419	1421	1423	1424	1426	1427	1429	1431
890	1432	1434	1436	1437	1439	1440	1442	1444	1445	1447
900	1448	1450	1452	1453	1455	1456	1458	1460	1461	1463
910	1464	1466	1468	1469	1471	1473	1474	1476	1477	1479
920	1481	1482	1484	1485	1487	1489	1490	1492	1493	1495
930	1497	1498	1500	1502	1503	1505	1506	1508	1510	1511
940	1513	1514	1516	1518	1519	1521	1522	1524	1526	1527
950	1529	1530	1532	1534	1535	1537	1539	1540	1542	1543
960	1545	1547	1548	1550	1551	1553	1555	1556	1558	1559
970	1561	1563	1564	1566	1567	1569	1571	1572	1574	1576
980	1577	1579	1580	1582	1584	1585	1587	1588	1590	1592
990	1593	1595	1596	1598	1600	1601	1603	1605	1606	1608
1000	1609	1611	1613	1614	1616	1617	1619	1621	1622	1624

Miles.	km.	Miles.	km.	Miles.	km.	Miles.	km.
1000	1609	**6000**	9656	**11000**	17703	**16000**	25750
2000	3219	**7000**	11265	**12000**	19312	**17000**	27359
3000	4828	**8000**	12875	**13000**	20922	**18000**	28968
4000	6437	**9000**	14484	**14000**	22531	**19000**	30578
5000	8047	**10000**	16093	**15000**	24140	**20000**	32187

KILOMETERS INTO MILES.

1 kilometer = 0.621370 mile.

Kilometers.	0	1	2	3	4	5	6	7	8	9
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
0	0.0	0.6	1.2	1.9	2.5	3.1	3.7	4.3	5.0	5.6
10	6.2	6.8	7.5	8.1	8.7	9.3	9.9	10.6	11.2	11.8
20	12.4	13.0	13.7	14.3	14.9	15.5	16.2	16.8	17.4	18.0
30	18.6	19.3	19.9	20.5	21.1	21.7	22.4	23.0	23.6	24.2
40	24.9	25.5	26.1	26.7	27.3	28.0	28.6	29.2	29.8	30.4
50	31.1	31.7	32.3	32.9	33.6	34.2	34.8	35.4	36.0	36.7
60	37.3	37.9	38.5	39.1	39.8	40.4	41.0	41.6	42.3	42.9
70	43.5	44.1	44.7	45.4	46.0	46.6	47.2	47.8	48.5	49.1
80	49.7	50.3	51.0	51.6	52.2	52.8	53.4	54.1	54.7	55.3
90	55.9	56.5	57.2	57.8	58.4	59.0	59.7	60.3	60.9	61.5
100	62.1	62.8	63.4	64.0	64.6	65.2	65.9	66.5	67.1	67.7
110	68.4	69.0	69.6	70.2	70.8	71.5	72.1	72.7	73.3	73.9
120	74.6	75.2	75.8	76.4	77.0	77.7	78.3	78.9	79.5	80.2
130	80.8	81.4	82.0	82.6	83.3	83.9	84.5	85.1	85.7	86.4
140	87.0	87.6	88.2	88.9	89.5	90.1	90.7	91.3	92.0	92.6
150	93.2	93.8	94.4	95.1	95.7	96.3	96.9	97.6	98.2	98.8
160	99.4	100.0	100.7	101.3	101.9	102.5	103.1	103.8	104.4	105.0
170	105.6	106.3	106.9	107.5	108.1	108.7	109.4	110.0	110.6	111.2
180	111.8	112.5	113.1	113.7	114.3	115.0	115.6	116.2	116.8	117.4
190	118.1	118.7	119.3	119.9	120.5	121.2	121.8	122.4	123.0	123.7
200	124.3	124.9	125.5	126.1	126.8	127.4	128.0	128.6	129.2	129.9
210	130.5	131.1	131.7	132.4	133.0	133.6	134.2	134.8	135.5	136.1
220	136.7	137.3	137.9	138.6	139.2	139.8	140.4	141.1	141.7	142.3
230	142.9	143.5	144.2	144.8	145.4	146.0	146.6	147.3	147.9	148.5
240	149.1	149.8	150.4	151.0	151.6	152.2	152.9	153.5	154.1	154.7
250	155.3	156.0	156.6	157.2	157.8	158.4	159.1	159.7	160.3	160.9
260	161.6	162.2	162.8	163.4	164.0	164.7	165.3	165.9	166.5	167.1
270	167.8	168.4	169.0	169.6	170.3	170.9	171.5	172.1	172.7	173.4
280	174.0	174.6	175.2	175.8	176.5	177.1	177.7	178.3	179.0	179.6
290	180.2	180.8	181.4	182.1	182.7	183.3	183.9	184.5	185.2	185.8
300	186.4	187.0	187.7	188.3	188.9	189.5	190.1	190.8	191.4	192.0
310	192.6	193.2	193.9	194.5	195.1	195.7	196.4	197.0	197.6	198.2
320	198.8	199.5	200.1	200.7	201.3	201.9	202.6	203.2	203.8	204.4
330	205.1	205.7	206.3	206.9	207.5	208.2	208.8	209.4	210.0	210.6
340	211.3	211.9	212.5	213.1	213.8	214.4	215.0	215.6	216.2	216.9
350	217.5	218.1	218.7	219.3	220.0	220.6	221.2	221.8	222.5	223.1
360	223.7	224.3	224.9	225.6	226.2	226.8	227.4	228.0	228.7	229.3
370	229.9	230.5	231.1	231.8	232.4	233.0	233.6	234.3	234.9	235.5
380	236.1	236.7	237.4	238.0	238.6	239.2	239.8	240.5	241.1	241.7
390	242.3	243.0	243.6	244.2	244.8	245.4	246.1	246.7	247.3	247.9
400	248.5	249.2	249.8	250.4	251.0	251.7	252.3	252.9	253.5	254.1
410	254.8	255.4	256.0	256.6	257.2	257.9	258.5	259.1	259.7	260.4
420	261.0	261.6	262.2	262.8	263.5	264.1	264.7	265.3	265.9	266.6
430	267.2	267.8	268.4	269.1	269.7	270.3	270.9	271.5	272.2	272.8
440	273.4	274.0	274.6	275.3	275.9	276.5	277.1	277.8	278.4	279.0
450	279.6	280.2	280.9	281.5	282.1	282.7	283.3	284.0	284.6	285.2
460	285.8	286.5	287.1	287.7	288.3	288.9	289.6	290.2	290.8	291.4
470	292.0	292.7	293.3	293.9	294.5	295.2	295.8	296.4	297.0	297.6
480	298.3	298.9	299.5	300.1	300.7	301.4	302.0	302.6	303.2	303.8
490	304.5	305.1	305.7	306.3	307.0	307.6	308.2	308.8	309.4	310.1
500	310.7	311.3	311.9	312.5	313.2	313.8	314.4	315.0	315.7	316.3
510	316.9	317.5	318.1	318.8	319.4	320.0	320.6	321.2	321.9	322.5
520	323.1	323.7	324.4	325.0	325.6	326.2	326.8	327.5	328.1	328.7
530	329.3	329.9	330.6	331.2	331.8	332.4	333.1	333.7	334.3	334.9
540	335.5	336.2	336.8	337.4	338.0	338.6	339.3	339.9	340.5	341.1

KILOMETERS INTO MILES.

Kilo-meters.	0	1	2	3	4	5	6	7	8	9
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
550	341.8	342.4	343.0	343.6	344.2	344.9	345.5	346.1	346.7	347.3
560	348.0	348.6	349.2	349.8	350.5	351.1	351.7	352.3	352.9	353.6
570	354.2	354.8	355.4	356.0	356.7	357.3	357.9	358.5	359.2	359.8
580	360.4	361.0	361.6	362.3	362.9	363.5	364.1	364.7	365.4	366.0
590	366.6	367.2	367.9	368.5	369.1	369.7	370.3	371.0	371.6	372.2
600	372.8	373.4	374.1	374.7	375.3	375.9	376.6	377.2	377.8	378.4
610	379.0	379.7	380.3	380.9	381.5	382.1	382.8	383.4	384.0	384.6
620	385.2	385.9	386.5	387.1	387.7	388.4	389.0	389.6	390.2	390.8
630	391.5	392.1	392.7	393.3	393.9	394.6	395.2	395.8	396.4	397.1
640	397.7	398.3	398.9	399.5	400.2	400.8	401.4	402.0	402.6	403.3
650	403.9	404.5	405.1	405.8	406.4	407.0	407.6	408.2	408.9	409.5
660	410.1	410.7	411.3	412.0	412.6	413.2	413.8	414.5	415.1	415.7
670	416.3	416.9	417.6	418.2	418.8	419.4	420.0	420.7	421.3	421.9
680	422.5	423.2	423.8	424.4	425.0	425.6	426.3	426.9	427.5	428.1
690	428.7	429.4	430.0	430.6	431.2	431.9	432.5	433.1	433.7	434.3
700	435.0	435.6	436.2	436.8	437.4	438.1	438.7	439.3	439.9	440.6
710	441.2	441.8	442.4	443.0	443.7	444.3	444.9	445.5	446.1	446.8
720	447.4	448.0	448.6	449.3	449.9	450.5	451.1	451.7	452.4	453.0
730	453.6	454.2	454.8	455.5	456.1	456.7	457.3	457.9	458.6	459.2
740	459.8	460.4	461.1	461.7	462.3	462.9	463.5	464.2	464.8	465.4
750	466.0	466.6	467.3	467.9	468.5	469.1	469.8	470.4	471.0	471.6
760	472.2	472.9	473.5	474.1	474.7	475.3	476.0	476.6	477.2	477.8
770	478.5	479.1	479.7	480.3	480.9	481.6	482.2	482.8	483.4	484.0
780	484.7	485.3	485.9	486.5	487.2	487.8	488.4	489.0	489.6	490.3
790	490.9	491.5	492.1	492.7	493.4	494.0	494.6	495.2	495.9	496.5
800	497.1	497.7	498.3	499.0	499.6	500.2	500.8	501.4	502.1	502.7
810	503.3	503.9	504.6	505.2	505.8	506.4	507.0	507.7	508.3	508.9
820	509.5	510.1	510.8	511.4	512.0	512.6	513.3	513.9	514.5	515.1
830	515.7	516.4	517.0	517.6	518.2	518.8	519.5	520.1	520.7	521.3
840	522.0	522.6	523.2	523.8	524.4	525.1	525.7	526.3	526.9	527.5
850	528.2	528.8	529.4	530.0	530.6	531.3	531.9	532.5	533.1	533.8
860	534.4	535.0	535.6	536.2	536.9	537.5	538.1	538.7	539.3	540.0
870	540.6	541.2	541.8	542.5	543.1	543.7	544.3	544.9	545.6	546.2
880	546.8	547.4	548.0	548.7	549.3	549.9	550.5	551.2	551.8	552.4
890	553.0	553.6	554.3	554.9	555.5	556.1	556.7	557.4	558.0	558.6
900	559.2	559.9	560.5	561.1	561.7	562.3	563.0	563.6	564.2	564.8
910	565.4	566.1	566.7	567.3	567.9	568.6	569.2	569.8	570.4	571.0
920	571.7	572.3	572.9	573.5	574.1	574.8	575.4	576.0	576.6	577.3
930	577.9	578.5	579.1	579.7	580.4	581.0	581.6	582.2	582.8	583.5
940	584.1	584.7	585.3	586.0	586.6	587.2	587.8	588.4	589.1	589.7
950	590.3	590.9	591.5	592.2	592.8	593.4	594.0	594.7	595.3	595.9
960	596.5	597.1	597.8	598.4	599.0	599.6	600.2	600.9	601.5	602.1
970	602.7	603.4	604.0	604.6	605.2	605.8	606.5	607.1	607.7	608.3
980	608.9	609.6	610.2	610.8	611.4	612.0	612.7	613.3	613.9	614.5
990	615.2	615.8	616.4	617.0	617.6	618.3	618.9	619.5	620.1	620.7
1000	621.4	622.0	622.6	623.2	623.9	624.5	625.1	625.7	626.3	627.0

km.	Miles.	km.	Miles.	km.	Miles.	km.	Miles.
1000	621.4	**6000**	3728.2	**11000**	6835.1	**16000**	9941.9
2000	1242.7	**7000**	4349.6	**12000**	7456.4	**17000**	10563.3
3000	1864.1	**8000**	4971.0	**13000**	8077.8	**18000**	11184.7
4000	2485.5	**9000**	5592.3	**14000**	8699.2	**19000**	11806.0
5000	3106.8	**10000**	6213.7	**15000**	9320.5	**20000**	12427.4

TABLE 17.

INTERCONVERSION OF NAUTICAL AND STATUTE MILES.

1 nautical mile* = 6080.20 feet.

Nautical Miles.	Statute Miles.	Statute Miles.	Nautical Miles.
1	1.1516	1	0.8684
2	2.3031	2	1.7368
3	3.4547	3	2.6052
4	4.6062	4	3.4736
5	5.7578	5	4.3420
6	6.9093	6	5.2104
7	8.0609	7	6.0787
8	9.2124	8	6.9471
9	10.3640	9	7.8155

* As defined by the United States Coast Survey.

TABLE 18.

CONTINENTAL MEASURES OF LENGTH WITH THEIR METRIC AND ENGLISH EQUIVALENTS.

The asterisk (*) indicates that the measure is obsolete or seldom used.

Measure.	Metric Equivalent.	English Equivalent.
El (Netherlands)	1 meter.	3.2808 feet.
Fathom, Swedish = 6 feet	1.7814 "	5.8445 "
Foot, Austrian*	0.31608 "	1.0370 "
old French*	0.32484 "	1.0657 "
Russian	0.30480 "	1 "
Rheinlandisch or Rhenish (Prussia*, Denmark, Norway*).	0.31385 "	1.0297 "
Swedish*	0.2969 "	0.9741 "
Spanish* = ⅓ vara	0.2786 "	0.9140 "
*Klafter, Wiener (Vienna)	1.89648 "	6.2221 "
*Line, old French = $\frac{1}{144}$ foot	0.22558 cm.	0.0888 inch.
Mile, Austrian post* = 24000 feet	7.58594 km.	4.714 statute miles.
German sea	1.852 "	1.1508 " "
Swedish = 36000 feet	10.69 "	6.642 " "
Norwegian = 36000 feet	11.2986 "	7.02 " "
Netherlands (mijl)	1 "	0.6214 " "
Prussian (law of 1868)	7.500 "	4.660 " "
Danish	7.5324 "	4.6804 " "
Palm, Netherlands	0.1 meter.	0.3281 feet.
*Rode, Danish	3.7662 "	12.356 "
*Ruthe, Prussian, Norwegian	3.7662 "	12.356 "
Sagene (Russian)	2.1336 "	7 "
*Toise, old French = 6 feet	1.9490 "	6.3943 "
*Vara, Spanish	0.8359 "	2.7424 "
Mexican	0.8380 "	2.7493 "
Werst, or versta (Russian) = 500 sashjene	1.0668 km.	3.500 "

CONVERSION OF MEASURES OF TIME AND ANGLE.

ARC INTO TIME.

°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	′	m. s.	″	s.
0	0 0	**60**	4 0	**120**	8 0	**180**	12 0	**240**	16 0	**300**	20 0	**0**	0 0	**0**	0.000
1	0 4	61	4 4	121	8 4	181	12 4	241	16 4	301	20 4	1	0 4	1	0.067
2	0 8	62	4 8	122	8 8	182	12 8	242	16 8	302	20 8	2	0 8	2	0.133
3	0 12	63	4 12	123	8 12	183	12 12	243	16 12	303	20 12	3	0 12	3	0.200
4	0 16	64	4 16	124	8 16	184	12 16	244	16 16	304	20 16	4	0 16	4	0.267
5	0 20	**65**	4 20	**125**	8 20	**185**	12 20	**245**	16 20	**305**	20 20	**5**	0 20	**5**	0.333
6	0 24	66	4 24	126	8 24	186	12 24	246	16 24	306	20 24	6	0 24	6	0.400
7	0 28	67	4 28	127	8 28	187	12 28	247	16 28	307	20 28	7	0 28	7	0.467
8	0 32	68	4 32	128	8 32	188	12 32	248	16 32	308	20 32	8	0 32	8	0.533
9	0 36	69	4 36	129	8 36	189	12 36	249	16 36	309	20 36	9	0 36	9	0.600
10	0 40	**70**	4 40	**130**	8 40	**190**	12 40	**250**	16 40	**310**	20 40	**10**	0 40	**10**	0.667
11	0 44	71	4 44	131	8 44	191	12 44	251	16 44	311	20 44	11	0 44	11	0.733
12	0 48	72	4 48	132	8 48	192	12 48	252	16 48	312	20 48	12	0 48	12	0.800
13	0 52	73	4 52	133	8 52	193	12 52	253	16 52	313	20 52	13	0 52	13	0.867
14	0 56	74	4 56	134	8 56	194	12 56	254	16 56	314	20 56	14	0 56	14	0.933
15	1 0	**75**	5 0	**135**	9 0	**195**	13 0	**255**	17 0	**315**	21 0	**15**	1 0	**15**	1.000
16	1 4	76	5 4	136	9 4	196	13 4	256	17 4	316	21 4	16	1 4	16	1.067
17	1 8	77	5 8	137	9 8	197	13 8	257	17 8	317	21 8	17	1 8	17	1.133
18	1 12	78	5 12	138	9 12	198	13 12	258	17 12	318	21 12	18	1 12	18	1.200
19	1 16	79	5 16	139	9 16	199	13 16	259	17 16	319	21 16	19	1 16	19	1.267
20	1 20	**80**	5 20	**140**	9 20	**200**	13 20	**260**	17 20	**320**	21 20	**20**	1 20	**20**	1.333
21	1 24	81	5 24	141	9 24	201	13 24	261	17 24	321	21 24	21	1 24	21	1.400
22	1 28	82	5 28	142	9 28	202	13 28	262	17 28	322	21 28	22	1 28	22	1.467
23	1 32	83	5 32	143	9 32	203	13 32	263	17 32	323	21 32	23	1 32	23	1.533
24	1 36	84	5 36	144	9 36	204	13 36	264	17 36	324	21 36	24	1 36	24	1.600
25	1 40	**85**	5 40	**145**	9 40	**205**	13 40	**265**	17 40	**325**	21 40	**25**	1 40	**25**	1.667
26	1 44	86	5 44	146	9 44	206	13 44	266	17 44	326	21 44	26	1 44	26	1.733
27	1 48	87	5 48	147	9 48	207	13 48	267	17 48	327	21 48	27	1 48	27	1.800
28	1 52	88	5 52	148	9 52	208	13 52	268	17 52	328	21 52	28	1 52	28	1.867
29	1 56	89	5 56	149	9 56	209	13 56	269	17 56	329	21 56	29	1 56	29	1.933
30	2 0	**90**	6 0	**150**	10 0	**210**	14 0	**270**	18 0	**330**	22 0	**30**	2 0	**30**	2.000
31	2 4	91	6 4	151	10 4	211	14 4	271	18 4	331	22 4	31	2 4	31	2.067
32	2 8	92	6 8	152	10 8	212	14 8	272	18 8	332	22 8	32	2 8	32	2.133
33	2 12	93	6 12	153	10 12	213	14 12	273	18 12	333	22 12	33	2 12	33	2.200
34	2 16	94	6 16	154	10 16	214	14 16	274	18 16	334	22 16	34	2 16	34	2.267
35	2 20	**95**	6 20	**155**	10 20	**215**	14 20	**275**	18 20	**335**	22 20	**35**	2 20	**35**	2.333
36	2 24	96	6 24	156	10 24	216	14 24	276	18 24	336	22 24	36	2 24	36	2.400
37	2 28	97	6 28	157	10 28	217	14 28	277	18 28	337	22 28	37	2 28	37	2.467
38	2 32	98	6 32	158	10 32	218	14 32	278	18 32	338	22 32	38	2 32	38	2.533
39	2 36	99	6 36	159	10 36	219	14 36	279	18 36	339	22 36	39	2 36	39	2.600
40	2 40	**100**	6 40	**160**	10 40	**220**	14 40	**280**	18 40	**340**	22 40	**40**	2 40	**40**	2.667
41	2 44	101	6 44	161	10 44	221	14 44	281	18 44	341	22 44	41	2 44	41	2.733
42	2 48	102	6 48	162	10 48	222	14 48	282	18 48	342	22 48	42	2 48	42	2.800
43	2 52	103	6 52	163	10 52	223	14 52	283	18 52	343	22 52	43	2 52	43	2.867
44	2 56	104	6 56	164	10 56	224	14 56	284	18 56	344	22 56	44	2 56	44	2.933
45	3 0	**105**	7 0	**165**	11 0	**225**	15 0	**285**	19 0	**345**	23 0	**45**	3 0	**45**	3.000
46	3 4	106	7 4	166	11 4	226	15 4	286	19 4	346	23 4	46	3 4	46	3.067
47	3 8	107	7 8	167	11 8	227	15 8	287	19 8	347	23 8	47	3 8	47	3.133
48	3 12	108	7 12	168	11 12	228	15 12	288	19 12	348	23 12	48	3 12	48	3.200
49	3 16	109	7 16	169	11 16	229	15 16	289	19 16	349	23 16	49	3 16	49	3.267
50	3 20	**110**	7 20	**170**	11 20	**230**	15 20	**290**	19 20	**350**	23 20	**50**	3 20	**50**	3.333
51	3 24	111	7 24	171	11 24	231	15 24	291	19 24	351	23 24	51	3 24	51	3.400
52	3 28	112	7 28	172	11 28	232	15 28	292	19 28	352	23 28	52	3 28	52	3.467
53	3 32	113	7 32	173	11 32	233	15 32	293	19 32	353	23 32	53	3 32	53	3.533
54	3 36	114	7 36	174	11 36	234	15 36	294	19 36	354	23 36	54	3 36	54	3.600
55	3 40	**115**	7 40	**175**	11 40	**235**	15 40	**295**	19 40	**355**	23 40	**55**	3 40	**55**	3.667
56	3 44	116	7 44	176	11 44	236	15 44	296	19 44	356	23 44	56	3 44	56	3.733
57	3 48	117	7 48	177	11 48	237	15 48	297	19 48	357	23 48	57	3 48	57	3.800
58	3 52	118	7 52	178	11 52	238	15 52	298	19 52	358	23 52	58	3 52	58	3.867
59	3 56	119	7 56	179	11 56	239	15 56	299	19 56	359	23 56	59	3 56	59	3.933
60	4 0	**120**	8 0	**180**	12 0	**240**	16 0	**300**	20 0	**360**	24 0	**60**	4 0	**60**	4.000

TIME INTO ARC.

Hours into Arc.

Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.
hrs.	°	hrs.	°	hrs.	°	hrs.	°	hrs.	°	hrs.	°
1	15	5	75	9	135	13	195	17	255	21	315
2	30	6	90	10	150	14	210	18	270	22	330
3	45	7	105	11	165	15	225	19	285	23	345
4	60	8	120	12	180	16	240	20	300	24	360

Minutes of Time into Arc.

m.	° ′	m.	° ′	m.	° ′
1	0 15	21	5 15	41	10 15
2	0 30	22	5 30	42	10 30
3	0 45	23	5 45	43	10 45
4	1 0	24	6 0	44	11 0
5	1 15	25	6 15	45	11 15
6	1 30	26	6 30	46	11 30
7	1 45	27	6 45	47	11 45
8	2 0	28	7 0	48	12 0
9	2 15	29	7 15	49	12 15
10	2 30	30	7 30	50	12 30
11	2 45	31	7 45	51	12 45
12	3 0	32	8 0	52	13 0
13	3 15	33	8 15	53	13 15
14	3 30	34	8 30	54	13 30
15	3 45	35	8 45	55	13 45
16	4 0	36	9 0	56	14 0
17	4 15	37	9 15	57	14 15
18	4 30	38	9 30	58	14 30
19	4 45	39	9 45	59	14 45
20	5 0	40	10 0	60	15 0

Seconds of Time into Arc.

s.	′ ″	s.	′ ″	s.	′ ″
1	0 15	21	5 15	41	10 15
2	0 30	22	5 30	42	10 30
3	0 45	23	5 45	43	10 45
4	1 0	24	6 0	44	11 0
5	1 15	25	6 15	45	11 15
6	1 30	26	6 30	46	11 30
7	1 45	27	6 45	47	11 45
8	2 0	28	7 0	48	12 0
9	2 15	29	7 15	49	12 15
10	2 30	30	7 30	50	12 30
11	2 45	31	7 45	51	12 45
12	3 0	32	8 0	52	13 0
13	3 15	33	8 15	53	13 15
14	3 30	34	8 30	54	13 30
15	3 45	35	8 45	55	13 45
16	4 0	36	9 0	56	14 0
17	4 15	37	9 15	57	14 15
18	4 30	38	9 30	58	14 30
19	4 45	39	9 45	59	14 45
20	5 0	40	10 0	60	15 0

Hundredths of a Second of Time into Arc.

Hundredths of a Second of Time.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
s.	″	″	″	″	″	″	″	″	″	″
0.00	0.00	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35
.10	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85
.20	3.00	3.15	3.30	3.45	3.60	3.75	3.90	4.05	4.20	4.35
.30	4.50	4.65	4.80	4.95	5.10	5.25	5.40	5.55	5.70	5.85
.40	6.00	6.15	6.30	6.45	6.60	6.75	6.90	7.05	7.20	7.35
0.50	7.50	7.65	7.80	7.95	8.10	8.25	8.40	8.55	8.70	8.85
.60	9.00	9.15	9.30	9.45	9.60	9.75	9.90	10.05	10.20	10.35
.70	10.50	10.65	10.80	10.95	11.10	11.25	11.40	11.55	11.70	11.85
.80	12.00	12.15	12.30	12.45	12.60	12.75	12.90	13.05	13.20	13.35
.90	13.50	13.65	13.80	13.95	14.10	14.25	14.40	14.55	14.70	14.85

DAYS INTO DECIMALS OF A YEAR AND ANGLE.

Day of Year.	Decimal of a Year.	Angle.	Day of Month.		Day of Year.	Decimal of a Year.	Angle.	Day of Month.	
			Common Year.	Bissextile Year.				Common Year.	Bissextile Year.
1	0.00000	0° 0′	*Jan.* 1	*Jan.* 1	**51**	0.13689	49° 17′	*Feb.* 20	*Feb.* 20
2	.00274	0 59	2	2	52	.13963	50 16	21	21
3	.00548	1 58	3	3	53	.14237	51 15	22	22
4	.00821	2 57	4	4	54	.14511	52 14	23	23
5	0.01095	3 57	5	5	**55**	0.14784	53 13	24	24
6	.01369	4 56	6	6	56	.15058	54 13	25	25
7	.01643	5 55	7	7	57	.15332	55 12	26	26
8	.01916	6 54	8	8	58	.15606	56 11	27	27
9	.02190	7 53	9	9	59	.15880	57 10	28	28
10	0.02464	8 52	10	10	**60**	0.16153	58 9	*Mar.* 1	29
11	.02738	9 51	11	11	61	.16427	59 8	2	*Mar.* 1
12	.03011	10 51	12	12	62	.16701	60 7	3	2
13	.03285	11 50	13	13	63	.16975	61 7	4	3
14	.03559	12 49	14	14	64	.17248	62 6	5	4
15	0.03833	13 48	15	15	**65**	0.17522	63 5	6	5
16	.04107	14 47	16	16	66	.17796	64 4	7	6
17	.04381	15 46	17	17	67	.18070	65 3	8	7
18	.04654	16 45	18	18	68	.18344	66 2	9	8
19	.04928	17 44	19	19	69	.18617	67 1	10	9
20	0.05202	18 44	20	20	**70**	0.18891	68 0	11	10
21	.05476	19 43	21	21	71	.19165	69 0	12	11
22	.05749	20 42	22	22	72	.19439	69 59	13	12
23	.06023	21 41	23	23	73	.19713	70 58	14	13
24	.06297	22 40	24	24	74	.19986	71 57	15	14
25	0.06571	23 39	25	25	**75**	0.20260	72 56	16	15
26	.06845	24 38	26	26	76	.20534	73 55	17	16
27	.07118	25 38	27	27	77	.20808	74 54	18	17
28	.07392	26 37	28	28	78	.21081	75 54	19	18
29	.07666	27 36	29	29	79	.21355	76 53	20	19
30	0.07940	28 35	30	30	**80**	0.21629	77 52	21	20
31	.08214	29 34	31	31	81	.21903	78 51	22	21
32	.08487	30 33	*Feb.* 1	*Feb.* 1	82	.22177	79 50	23	22
33	.08761	31 32	2	2	83	.22450	80 49	24	23
34	.09035	32 32	3	3	84	.22724	81 48	25	24
35	0.09309	33 31	4	4	**85**	0.22998	82 48	26	25
36	.09582	34 30	5	5	86	.23272	83 47	27	26
37	.09856	35 29	6	6	87	.23546	84 46	28	27
38	.10130	36 28	7	7	88	.23819	85 45	29	28
39	.10404	37 27	8	8	89	.24093	86 44	30	29
40	0.10678	38 26	9	9	**90**	0.24367	87 43	31	30
41	.10951	39 26	10	10	91	.24641	88 42	*Apr.* 1	31
42	.11225	40 25	11	11	92	.24914	89 42	2	*Apr.* 1
43	.11499	41 24	12	12	93	.25188	90 41	3	2
44	.11773	42 23	13	13	94	.25462	91 40	4	3
45	0.12047	43 22	14	14	**95**	0.25736	92 39	5	4
46	.12320	44 21	15	15	96	.26010	93 38	6	5
47	.12594	45 20	16	16	97	.26283	94 37	7	6
48	.12868	46 19	17	17	98	.26557	95 36	8	7
49	.13142	47 19	18	18	99	.26831	96 35	9	8
50	0.13415	48 18	19	19	**100**	0.27105	97 35	10	9

DAYS INTO DECIMALS OF A YEAR AND ANGLE.

Day of Year.	Decimal of a Year.	Angle.	Day of Month.		Day of Year.	Decimal of a Year.	Angle.	Day of Month.	
			Common Year.	Bissextile Year.				Common Year.	Bissextile Year.
101	0.27379	98° 34′	*Apr.* 11	*Apr.* 10	**151**	0.41068	147° 51′	*May* 31	*May* 30
102	.27652	99 33	12	11	152	.41342	148 50	*June* 1	31
103	.27926	100 32	13	12	153	.41615	149 49	2	*June* 1
104	.28200	101 31	14	13	154	.41889	150 48	3	2
105	0.28474	102 30	15	14	**155**	0.42163	151 47	4	3
106	.28747	103 29	16	15	156	.42437	152 46	5	4
107	.29021	104 29	17	16	157	.42710	153 45	6	5
108	.29295	105 28	18	17	158	.42984	154 45	7	6
109	.29569	106 27	19	18	159	.43258	155 44	8	7
110	0.29843	107 26	20	19	**160**	0.43532	156 43	9	8
111	.30116	108 25	21	20	161	.43806	157 42	10	9
112	.30390	109 24	22	21	162	.44079	158 41	11	10
113	.30664	110 23	23	22	163	.44353	159 40	12	11
114	.30938	111 23	24	23	164	.44627	160 39	13	12
115	0.31211	112 22	25	24	**165**	0.44901	161 39	14	13
116	.31485	113 21	26	25	166	.45175	162 38	15	14
117	.31759	114 20	27	26	167	.45448	163 37	16	15
118	.32033	115 19	28	27	168	.45722	164 36	17	16
119	.32307	116 18	29	28	169	.45996	165 35	18	17
120	0.32580	117 17	30	29	**170**	0.46270	166 34	19	18
121	.32854	118 17	*May* 1	30	171	.46543	167 33	20	19
122	.33128	119 16	2	*May* 1	172	.46817	168 33	21	20
123	.33402	120 15	3	2	173	.47091	169 32	22	21
124	.33676	121 14	4	3	174	.47365	170 31	23	22
125	0.33949	122 13	5	4	**175**	0.47639	171 30	24	23
126	.34223	123 12	6	5	176	.47912	172 29	25	24
127	.34497	124 11	7	6	177	.48186	173 28	26	25
128	.34771	125 10	8	7	178	.48460	174 27	27	26
129	.35044	126 10	9	8	179	.48734	175 26	28	27
130	0.35318	127 9	10	9	**180**	0.49008	176 26	29	28
131	.35592	128 8	11	10	181	.49281	177 25	30	29
132	.35866	129 7	12	11	182	.49555	178 24	*July* 1	30
133	.36140	130 6	13	12	183	.49829	179 23	2	*July* 1
134	.36413	131 5	14	13	184	.50103	180 22	3	2
135	0.36687	132 4	15	14	**185**	0.50376	181 21	4	3
136	.36961	133 4	16	15	186	.50650	182 20	5	4
137	.37235	134 3	17	16	187	.50924	183 20	6	5
138	.37509	135 2	18	17	188	.51198	184 19	7	6
139	.37782	136 1	19	18	189	.51472	185 18	8	7
140	0.38056	137 0	20	19	**190**	0.51745	186 17	9	8
141	.38330	137 59	21	20	191	.52019	187 16	10	9
142	.38604	138 58	22	21	192	.52293	188 15	11	10
143	.38877	139 58	23	22	193	.52567	189 14	12	11
144	.39151	140 57	24	23	194	.52841	190 14	13	12
145	0.39425	141 56	25	24	**195**	0.53114	191 13	14	13
146	.39699	142 55	26	25	196	.53388	192 12	15	14
147	.39973	143 54	27	26	197	.53662	193 11	16	15
148	.40246	144 53	28	27	198	.53936	194 10	17	16
149	.40520	145 52	29	28	199	.54209	195 9	18	17
150	0.40794	146 51	30	29	**200**	0.54483	196 8	19	18

DAYS INTO DECIMALS OF A YEAR AND ANGLE.

Day of Year.	Decimal of a Year.	Angle.	Day of Month. Common Year.	Day of Month. Bissextile Year.	Day of Year.	Decimal of a Year.	Angle.	Day of Month. Common Year.	Day of Month. Bissextile Year.
201	0.54757	197° 8′	*July* 20	*July* 19	**251**	0.68446	246° 24′	*Sept.* 8	*Sept.* 7
202	.55031	198 7	21	20	252	.68720	247 24	9	8
203	.55305	199 6	22	21	253	.68994	248 23	10	9
204	.55578	200 5	23	22	254	.69268	249 22	11	10
205	0.55852	201 4	24	23	**255**	0.69541	250 21	12	11
206	.56126	202 3	25	24	256	.69815	251 20	13	12
207	.56400	203 2	26	25	257	.70089	252 19	14	13
208	.56674	204 1	27	26	258	.70363	253 18	15	14
209	.56947	205 1	28	27	259	.70637	254 17	16	15
210	0.57221	206 0	29	28	**260**	0.70910	255 17	17	16
211	.57495	206 59	30	29	261	.71184	256 16	18	17
212	.57769	207 58	31	30	262	.71458	257 15	19	18
213	.58042	208 57	*Aug.* 1	31	263	.71732	258 14	20	19
214	.58316	209 56	2	*Aug.* 1	264	.72005	259 13	21	20
215	0.58590	210 55	3	2	**265**	0.72279	260 12	22	21
216	.58864	211 55	4	3	266	.72553	261 11	23	22
217	.59138	212 54	5	4	267	.72827	262 11	24	23
218	.59411	213 53	6	5	268	.73101	263 10	25	24
219	.59685	214 52	7	6	269	.73374	264 9	26	25
220	0.59959	215 51	8	7	**270**	0.73648	265 8	27	26
221	.60233	216 50	9	8	271	.73922	266 7	28	27
222	.60507	217 49	10	9	272	.74196	267 6	29	28
223	.60780	218 49	11	10	273	.74470	268 5	30	29
224	.61054	219 48	12	11	274	.74743	269 5	*Oct.* 1	30
225	0.61328	220 47	13	12	**275**	0.75017	270 4	2	*Oct.* 1
226	.61602	221 46	14	13	276	.75291	271 3	3	2
227	.61875	222 45	15	14	277	.75565	272 2	4	3
228	.62149	223 44	16	15	278	.75838	273 1	5	4
229	.62423	224 43	17	16	279	.76112	274 0	6	5
230	0.62697	225 43	18	17	**280**	0.76386	274 59	7	6
231	.62971	226 42	19	18	281	.76660	275 59	8	7
232	.63244	227 41	20	19	282	.76934	276 58	9	8
233	.63518	228 40	21	20	283	.77207	277 57	10	9
234	.63792	229 39	22	21	284	.77481	278 56	11	10
235	0.64066	230 38	23	22	**285**	0.77755	279 55	12	11
236	.64339	231 37	24	23	286	.78029	280 54	13	12
237	.64613	232 36	25	24	287	.78303	281 53	14	13
238	.64887	233 36	26	25	288	.78576	282 52	15	14
239	.65161	234 35	27	26	289	.78850	283 52	16	15
240	0.65435	235 34	28	27	**290**	0.79124	284 51	17	16
241	.65708	236 33	29	28	291	.79398	285 50	18	17
242	.65982	237 32	30	29	292	.79671	286 49	19	18
243	.66256	238 31	31	30	293	.79945	287 48	20	19
244	.66530	239 30	*Sept.* 1	31	294	.80219	288 47	21	20
245	0.66804	240 30	2	*Sept.* 1	**295**	0.80493	289 46	22	21
246	.67077	241 29	3	2	296	.80767	290 46	23	22
247	.67351	242 28	4	3	297	.81040	291 45	24	23
248	.67625	243 27	5	4	298	.81314	292 44	25	24
249	.67899	244 26	6	5	299	.81588	293 43	26	25
250	0.68172	245 25	7	6	**300**	0.81862	294 42	27	26

DAYS INTO DECIMALS OF A YEAR AND ANGLE.

Day of Year.	Decimal of a Year.	Angle.	Day of Month. Common Year	Day of Month. Bissextile Year.
301	0.82136	295° 41′	*Oct.* 28	*Oct.* 27
302	.82409	296 40	29	28
303	.82683	297 40	30	29
304	.82957	298 39	31	30
305	0.83231	299 38	*Nov.* 1	31
306	.83504	300 37	2	*Nov.* 1
307	.83778	301 36	3	2
308	.84052	302 35	4	3
309	.84326	303 34	5	4
310	0.84600	304 34	6	5
311	.84873	305 33	7	6
312	.85147	306 32	8	7
313	.85421	307 31	9	8
314	.85695	308 30	10	9
315	0.85969	309 29	11	10
316	.86242	310 28	12	11
317	.86516	311 27	13	12
318	.86790	312 27	14	13
319	.87064	313 26	15	14
320	0.87337	314 25	16	15
321	.87611	315 24	17	16
322	.87885	316 23	18	17
323	.88159	317 22	19	18
324	.88433	318 21	20	19
325	0.88706	319 21	21	20
326	.88980	320 20	22	21
327	.89254	321 19	23	22
328	.89528	322 18	24	23
329	.89802	323 17	25	24
330	0.90075	324 16	26	25
331	.90349	325 15	27	26
332	.90623	326 15	28	27
333	.90897	327 14	29	28
334	.91170	328 13	30	29
335	0.91444	329 12	*Dec.* 1	30
336	.91718	330 11	2	*Dec.* 1
337	.91992	331 10	3	2
338	.92266	332 9	4	3
339	.92539	333 9	5	4
340	0.92813	334 8	6	5
341	.93087	335 7	7	6
342	.93361	336 6	8	7
343	.93634	337 5	9	8
344	.93908	338 4	10	9
345	0.94182	339 3	11	10
346	.94456	340 2	12	11
347	.94730	341 2	13	12
348	.95003	342 1	14	13
349	.95277	343 0	15	14
350	0.95551	343 59	16	15
351	0.95825	344° 58′	*Dec.* 17	*Dec.* 16
352	.96099	345 57	18	17
353	.96372	346 56	19	18
354	.96646	347 56	20	19
355	0.96920	348 55	21	20
356	.97194	349 54	22	21
357	.97467	350 53	23	22
358	.97741	351 52	24	23
359	.98015	352 51	25	24
360	0.98289	353 50	26	25
361	.98563	354 50	27	26
362	.98836	355 49	28	27
363	.99110	356 48	29	28
364	.99384	357 47	30	29
365	0.99658	358 46	31	30
366	.99932	359 45		31

Conversion for Hours.

Hrs	Dec. of Year.	Angle.
1	0.00011	2.5′
2	23	4.9
3	34	7.4
4	46	9.9
5	0.00057	12.3
6	68	14.8
7	80	17.2
8	91	19.7
9	103	22.2
10	0.00114	24.6
11	126	27.1
12	137	29.6
13	148	32.0
14	160	34.5
15	0.00171	37.0
16	183	39.4
17	194	41.9
18	205	44.4
19	217	46.8
20	0.00228	49.3
21	240	51.7
22	251	54.2
23	262	56.7
24	274	59.1

Conversion for Minutes.

Min.	Dec. of Year.	Angle.
1	0.00000	0.04′
2	0	.08
3	1	.12
4	1	.16
5	0.00001	0.21
6	1	.25
7	1	.29
8	2	.33
9	2	.37
10	0.00002	0.41
20	4	.82
30	6	1.23
40	8	1.64
50	10	2.05
60	0.00011	2.46

TABLE 22.

HOURS, MINUTES AND SECONDS INTO DECIMALS OF A DAY.

Hours.	Day.	Min.	Day.	Min.	Day.	Sec.	Day.	Sec.	Day.
1	0.041 667	**1**	0.000 694	**31**	0.021 528	**1**	0.000 012	**31**	0.000 359
2	.083 333	2	.001 389	32	.022 222	2	.000 023	32	.000 370
3	.125 000	3	.002 083	33	.022 917	3	.000 035	33	.000 382
4	.166 667	4	.002 778	34	.023 611	4	.000 046	34	.000 394
5	0.208 333	**5**	0.003 472	**35**	0.024 305	**5**	0.000 058	**35**	0.000 405
6	.250 000	6	.004 167	36	.025 000	6	.000 069	36	.000 417
7	.291 667	7	.004 861	37	.025 694	7	.000 081	37	.000 428
8	.333 333	8	.005 556	38	.026 389	8	.000 093	38	.000 440
9	.375 000	9	.006 250	39	.027 083	9	.000 104	39	.000 451
10	0.416 667	**10**	0.006 944	**40**	0.027 778	**10**	0.000 116	**40**	0.000 463
11	.458 333	11	.007 639	41	.028 472	11	.000 127	41	.000 475
12	.500 000	12	.008 333	42	.029 167	12	.000 139	42	.000 486
13	.541 667	13	.009 028	43	.029 861	13	.000 150	43	.000 498
14	.583 333	14	.009 722	44	.030 556	14	.000 162	44	.000 509
15	0.625 000	**15**	0.010 417	**45**	0.031 250	**15**	0.000 174	**45**	0.000 521
16	.666 667	16	.011 111	46	.031 944	16	.000 185	46	.000 532
17	.708 333	17	.011 806	47	.032 639	17	.000 197	47	.000 544
18	.750 000	18	.012 500	48	.033 333	18	.000 208	48	.000 556
19	.791 667	19	.013 194	49	.034 028	19	.000 220	49	.000 567
20	0.833 333	**20**	0.013 889	**50**	0.034 722	**20**	0.000 231	**50**	0.000 579
21	.875 000	21	.014 583	51	.035 417	21	.000 243	51	.000 590
22	.916 667	22	.015 278	52	.036 111	22	.000 255	52	.000 602
23	.958 333	23	.015 972	53	.036 806	23	.000 266	53	.000 613
24	1.000 000	24	.016 667	54	.037 500	24	.000 278	54	.000 625
		25	0.017 361	**55**	0.038 194	**25**	0.000 289	**55**	0.000 637
		26	.018 056	56	.038 889	26	.000 301	56	.000 648
		27	.018 750	57	.039 583	27	.000 313	57	.000 660
		28	.019 444	58	.040 278	28	.000 324	58	.000 671
		29	.020 139	59	.040 972	29	.000 336	59	.000 683
		30	0.020 833	**60**	0.041 667	**30**	0.000 347	**60**	.000 694

TABLE 23.

DECIMALS OF A DAY INTO HOURS, MINUTES AND SECONDS.

Hundredths of a Day.				Ten Thousandths of a Day.			Millionths of a Day.	
d.	h.	m.	s.	d.	min.	sec.	d.	sec.
0.01		14	24	**0.0001**		8.64	**0.000001**	0.09
.02		28	48	2		17.28	2	0.17
.03		43	12	3		25.92	3	0.26
.04		57	36	4		34.56	4	0.35
0.05	1	12	0	**0.0005**		43.20	**0.000005**	0.43
.06	1	26	24	6		51.84	6	0.52
.07	1	40	48	7	1	0.48	7	0.60
.08	1	55	12	8	1	9.12	8	0.69
.09	2	9	36	9	1	17.76	9	0.78
0.10	2	24	0	**0.0010**	1	26.40	**0.000010**	0.86
.20	4	48	0	20	2	52.80	20	1.73
.30	7	12	0	30	4	19.20	30	2.59
.40	9	36	0	40	5	45.60	40	3.46
0.50	12	0	0	**0.0050**	7	12.00	**0.000050**	4.32
.60	14	24	0	60	8	38.40	60	5.18
.70	16	48	0	70	10	4.80	70	6.05
.80	19	12	0	80	11	31.20	80	6.91
.90	21	36	0	90	12	57.60	90	7.78

MINUTES AND SECONDS INTO DECIMALS OF AN HOUR.

Min.	Decimals of an hour.	Min.	Decimals of an hour.	Sec.	Decimals of an hour.	Sec.	Decimals of an hour.
1	0.016 667	31	0.516 667	1	0.000 278	31	0.008 611
2	.033 333	32	.533 333	2	.000 556	32	.008 889
3	.050 000	33	.550 000	3	.000 833	33	.009 167
4	.066 667	34	.566 667	4	.001 111	34	.009 444
5	0.083 333	35	0.583 333	5	0.001 389	35	0.009 722
6	.100 000	36	.600 000	6	.001 667	36	.010 000
7	.116 667	37	.616 667	7	.001 944	37	.010 278
8	.133 333	38	.633 333	8	.002 222	38	.010 556
9	.150 000	39	.650 000	9	.002 500	39	.010 833
10	0.166 667	40	0.666 667	10	0.002 778	40	0.011 111
11	.183 333	41	.683 333	11	.003 056	41	.011 389
12	.200 000	42	.700 000	12	.003 333	42	.011 667
13	.216 667	43	.716 667	13	.003 611	43	.011 944
14	.233 333	44	.733 333	14	.003 889	44	.012 222
15	0.250 000	45	0.750 000	15	0.004 167	45	0.012 500
16	.266 667	46	.766 667	16	.004 444	46	.012 778
17	.283 333	47	.783 333	17	.004 722	47	.013 056
18	.300 000	48	.800 000	18	.005 000	48	.013 333
19	.316 667	49	.816 667	19	.005 278	49	.013 611
20	0.333 333	50	0.833 333	20	0.005 556	50	0.013 889
21	.350 000	51	.850 000	21	.005 833	51	.014 167
22	.366 667	52	.866 667	22	.006 111	52	.014 444
23	.383 333	53	.883 333	23	.006 389	53	.014 722
24	.400 000	54	.900 000	24	.006 667	54	.015 000
25	0.416 667	55	0.916 667	25	0.006 944	55	0.015 278
26	.433 333	56	.933 333	26	.007 222	56	.015 556
27	.450 000	57	.950 000	27	.007 500	57	.015 833
28	.466 667	58	.966 667	28	.007 778	58	.016 111
29	.483 333	59	.983 333	29	.008 056	59	.016 389
30	0.500 000	60	1.000 000	30	0.008 333	60	0.016 667

TABLE 25.

LOCAL MEAN TIME AT APPARENT NOON.

Day of Month.	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1	12 4	12 14	12 12	12 4	11 57	11 58
8	12 7	12 14	12 11	12 2	11 56	11 59
16	12 10	12 14	12 9	12 0	11 56	12 0
24	12 12	12 13	12 6	11 58	11 57	12 2
	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1	12 4	12 6	12 0	11 50	11 44	11 49
8	12 5	12 5	11 58	11 48	11 44	11 52
16	12 6	12 4	11 55	11 46	11 45	11 56
24	12 6	12 2	11 52	11 44	11 47	12 0

TABLE 26.

SIDEREAL TIME INTO MEAN SOLAR TIME.

The tabular values are to be *subtracted* from a sidereal time interval.

Hrs.	Reduction to Mean Time.	Min.	Reduction to Mean Time.	Min.	Reduction to Mean Time.
h.	m. s.	m.	s.	m.	s.
1	0 9.83	1	0.16	31	5.08
2	0 19.66	2	0.33	32	5.24
3	0 29.49	3	0.49	33	5.41
4	0 39.32	4	0.66	34	5.57
5	0 49.15	5	0.82	35	5.73
6	0 58.98	6	0.98	36	5.90
7	1 8.81	7	1.15	37	6.06
8	1 18.64	8	1.31	38	6.23
9	1 28.47	9	1.47	39	6.39
10	1 38.30	10	1.64	40	6.55
11	1 48.13	11	1.80	41	6.72
12	1 57.95	12	1.97	42	6.88
13	2 7.78	13	2.13	43	7.04
14	2 17.61	14	2.29	44	7.21
15	2 27.44	15	2.46	45	7.37
16	2 37.27	16	2.62	46	7.54
17	2 47.10	17	2.79	47	7.70
18	2 56.93	18	2.95	48	7.86
19	3 6.76	19	3.11	49	8.03
20	3 16.59	20	3.28	50	8.19
21	3 26.42	21	3.44	51	8.36
22	3 36.25	22	3.60	52	8.52
23	3 46.08	23	3.77	53	8.68
24	3 55.91	24	3.93	54	8.85
		25	4.10	55	9.01
		26	4.26	56	9.17
		27	4.42	57	9.34
		28	4.59	58	9.50
		29	4.75	59	9.67
		30	4.91	60	9.83

TABLE 27.

MEAN SOLAR TIME INTO SIDEREAL TIME.

The tabular values are to be *added* to a mean solar time interval.

Hrs.	Reduction to Sidereal Time.	Min.	Reduction to Sidereal Time.	Min.	Reduction to Sidereal Time.
h.	m. s.	m.	s.	m.	s.
1	0 9.86	1	0.16	31	5.09
2	0 19.71	2	0.33	32	5.26
3	0 29.57	3	0.49	33	5.42
4	0 39.43	4	0.66	34	5.59
5	0 49.28	5	0.82	35	5.75
6	0 59.14	6	0.99	36	5.91
7	1 9.00	7	1.15	37	6.08
8	1 18.85	8	1.31	38	6.24
9	1 28.71	9	1.48	39	6.41
10	1 38.56	10	1.64	40	6.57
11	1 48.42	11	1.81	41	6.74
12	1 58.28	12	1.97	42	6.90
13	2 8.13	13	2.14	43	7.06
14	2 17.99	14	2.30	44	7.23
15	2 27.85	15	2.46	45	7.39
16	2 37.70	16	2.63	46	7.56
17	2 47.56	17	2.79	47	7.72
18	2 57.42	18	2.96	48	7.89
19	3 7.27	19	3.12	49	8.05
20	3 17.13	20	3.29	50	8.21
21	3 26.99	21	3.45	51	8.38
22	3 36.84	22	3.61	52	8.54
23	3 46.70	23	3.78	53	8.71
24	3 56.56	24	3.94	54	8.87
		25	4.11	55	9.04
		26	4.27	56	9.20
		27	4.44	57	9.36
		28	4.60	58	9.53
		29	4.76	59	9.69
		30	4.93	60	9.86

Reduction for Seconds—sidereal or mean solar.

The tabular values are to be { *subtracted* from a sidereal / *added* to a mean solar } time interval.

Sidereal or Mean Time.	0	1	2	3	4	5	6	7	8	9
s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
0	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
10	.03	.03	.03	.04	.04	.04	.04	.05	.05	.05
20	.05	.06	.06	.06	.07	.07	.07	.07	.08	.08
30	.08	.08	.09	.09	.09	.10	.10	.10	.10	.11
40	.11	.11	.11	.12	.12	.12	.13	.13	.13	.13
50	0.14	0.14	0.14	0.15*	0.15	0.15	0.15	0.16	0.16	0.16

* Subtract 0.14 from a sidereal time interval.

CONVERSION OF MEASURES OF WEIGHT.

AVOIRDUPOIS POUNDS AND OUNCES INTO KILOGRAMS.

1 avoirdupois pound = 0.4535924 kilogram.
1 avoirdupois ounce = 0.0283495 kilogram.

Pounds.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.
0	0.0000	0.0454	0.0907	0.1361	0.1814	0.2268	0.2722	0.3175	0.3629	0.4082
1	0.4536	0.4990	0.5443	0.5897	0.6350	0.6804	0.7257	0.7711	0.8165	0.8618
2	0.9072	0.9525	0.9979	1.0433	1.0886	1.1340	1.1793	1.2247	1.2701	1.3154
3	1.3608	1.4061	1.4515	1.4969	1.5422	1.5876	1.6329	1.6783	1.7237	1.7690
4	1.8144	1.8597	1.9051	1.9504	1.9958	2.0412	2.0865	2.1319	2.1772	2.2226
5	2.2680	2.3133	2.3587	2.4040	2.4494	2.4948	2.5401	2.5855	2.6308	2.6762
6	2.7216	2.7669	2.8123	2.8576	2.9030	2.9484	2.9937	3.0391	3.0844	3.1298
7	3.1751	3.2205	3.2659	3.3112	3.3566	3.4019	3.4473	3.4927	3.5380	3.5834
8	3.6287	3.6741	3.7195	3.7648	3.8102	3.8555	3.9009	3.9463	3.9916	4.0370
9	4.0823	4.1277	4.1731	4.2184	4.2638	4.3091	4.3545	4.3998	4.4452	4.4906

Ounces.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.
0	0.0000	0.0028	0.0057	0.0085	0.0113	0.0142	0.0170	0.0198	0.0227	0.0255
1	.0283	.0312	.0340	.0369	.0397	.0425	.0454	.0482	.0510	.0539
2	.0567	.0595	.0624	.0652	.0680	.0709	.0737	.0765	.0794	.0822
3	.0850	.0879	.0907	.0936	.0964	.0992	.1021	.1049	.1077	.1106
4	.1134	.1162	.1191	.1219	.1247	.1276	.1304	.1332	.1361	.1389
5	0.1417	0.1446	0.1474	0.1503	0.1531	0.1559	0.1588	0.1616	0.1644	0.1673
6	.1701	.1729	.1758	.1786	.1814	.1843	.1871	.1899	.1928	.1956
7	.1984	.2013	.2041	.2070	.2098	.2126	.2155	.2183	.2211	.2240
8	.2268	.2296	.2325	.2353	.2381	.2410	.2438	.2466	.2495	.2523
9	.2551	.2580	.2608	.2637	.2665	.2693	.2722	.2750	.2778	.2807
10	0.2835	0.2863	0.2892	0.2920	0.2948	0.2977	0.3005	0.3033	0.3062	0.3090
11	.3118	.3147	.3175	.3203	.3232	.3260	.3289	.3317	.3345	.3374
12	.3402	.3430	.3459	.3487	.3515	.3544	.3572	.3600	.3629	.3657
13	.3685	.3714	.3742	.3770	.3799	.3827	.3856	.3884	.3912	.3941
14	.3969	.3997	.4026	.4054	.4082	.4111	.4139	.4167	.4196	.4224
15	.4252	.4281	.4309	.4337	.4366	.4394	.4423	.4451	.4479	.4508

KILOGRAMS INTO AVOIRDUPOIS POUNDS AND OUNCES.

1 kilogram = 2.204622 avoirdupois pounds.

Kilograms.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.	Av. lbs.
0	0.000	0.220	0.441	0.661	0.882	1.102	1.323	1.543	1.764	1.984
1	2.205	2.425	2.646	2.866	3.086	3.307	3.527	3.748	3.968	4.189
2	4.409	4.630	4.850	5.071	5.291	5.512	5.732	5.952	6.173	6.393
3	6.614	6.834	7.055	7.275	7.496	7.716	7.937	8.157	8.378	8.598
4	8.818	9.039	9.259	9.480	9.700	9.921	10.141	10.362	10.582	10.803
5	11.023	11.244	11.464	11.684	11.905	12.125	12.346	12.566	12.787	13.007
6	13.228	13.448	13.669	13.889	14.110	14.330	14.551	14.771	14.991	15.212
7	15.432	15.653	15.873	16.094	16.314	16.535	16.755	16.976	17.196	17.417
8	17.637	17.857	18.078	18.298	18.519	18.739	18.960	19.180	19.401	19.621
9	19.842	20.062	20.283	20.503	20.723	20.944	21.164	21.385	21.605	21.826

Tenths of a Kilogram into Ounces.				Hundredths of a Kilogram into Decimals of a Pound and Ounces.			
kg.	Oz.	kg.	Oz.	kg.	Av. lbs. Oz.	kg.	Av. lbs. Oz.
0.1	3.5274	0.6	21.1644	0.01	0.022 = 0.35	0.06	0.132 = 2.12
.2	7.0548	.7	24.6918	.02	.044 = 0.71	.07	.154 = 2.47
.3	10.5822	.8	28.2192	.03	.066 = 1.06	.08	.176 = 2.82
.4	14.1096	.9	31.7466	.04	.088 = 1.41	.09	.198 = 3.17
.5	17.6370	1.0	35.2740	.05	.110 = 1.76	.10	.220 = 3.53

GRAINS INTO GRAMS.

1 grain = 0.06479892 gram.

Grains.	0	1	2	3	4	5	6	7	8	9
	grams.	grams.	grams.	grams.	grams.	grams.	grams.	grams.	grams.	grams.
0	0.0000	0.0648	0.1296	0.1944	0.2592	0.3240	0.3888	0.4536	0.5184	0.5832
10	0.6480	0.7128	0.7776	0.8424	0.9072	0.9720	1.0368	1.1016	1.1664	1.2312
20	1.2960	1.3608	1.4256	1.4904	1.5552	1.6200	1.6848	1.7496	1.8144	1.8792
30	1.9440	2.0088	2.0736	2.1384	2.2032	2.2680	2.3328	2.3976	2.4624	2.5272
40	2.5920	2.6568	2.7216	2.7864	2.8512	2.9160	2.9808	3.0455	3.1103	3.1751
50	3.2399	3.3047	3.3695	3.4343	3.4991	3.5639	3.6287	3.6935	3.7583	3.8231
60	3.8879	3.9527	4.0175	4.0823	4.1471	4.2119	4.2767	4.3415	4.4063	4.4711
70	4.5359	4.6007	4.6655	4.7303	4.7951	4.8599	4.9247	4.9895	5.0543	5.1191
80	5.1839	5.2487	5.3135	5.3783	5.4431	5.5079	5.5727	5.6375	5.7023	5.7671
90	5.8319	5.8967	5.9615	6.0263	6.0911	6.1559	6.2207	6.2855	6.3503	6.4151

Tenths of a Grain.				Hundredths of a Grain.			
Grain.	gram.	Grain.	gram.	Grain.	gram.	Grain.	gram.
0.1	0.0065	0.6	0.0389	0.01	0.0006	0.06	0.0039
.2	.0130	.7	.0454	.02	.0013	.07	.0045
.3	.0194	.8	.0518	.03	.0019	.08	.0052
.4	.0259	.9	.0583	.04	.0026	.09	.0058
.5	.0324	1.0	.0648	.05	.0032	.10	.0065

GRAMS INTO GRAINS.

1 gram = 15.432356 grains.

Grams.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
0	0.00	1.54	3.09	4.63	6.17	7.72	9.26	10.80	12.35	13.89
1	15.43	16.98	18.52	20.06	21.61	23.15	24.69	26.24	27.78	29.32
2	30.86	32.41	33.95	35.49	37.04	38.58	40.12	41.67	43.21	44.75
3	46.30	47.84	49.38	50.93	52.47	54.01	55.56	57.10	58.64	60.19
4	61.73	63.27	64.82	66.36	67.90	69.45	70.99	72.53	74.08	75.62
5	77.16	78.71	80.25	81.79	83.33	84.88	86.42	87.96	89.51	91.05
6	92.59	94.14	95.68	97.22	98.77	100.31	101.85	103.40	104.94	106.48
7	108.03	109.57	111.11	112.66	114.20	115.74	117.29	118.83	120.37	121.92
8	123.46	125.00	126.55	128.09	129.63	131.18	132.72	134.26	135.80	137.35
9	138.89	140.43	141.98	143.52	145.06	146.61	148.15	149.69	151.24	152.78
	0	1	2	3	4	5	6	7	8	9
	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
0	0.00	15.43	30.86	46.30	61.73	77.16	92.59	108.03	123.46	138.89
10	154.32	169.76	185.19	200.62	216.05	231.49	246.92	262.35	277.78	293.21
20	308.65	324.08	339.51	354.94	370.38	385.81	401.24	416.67	432.11	447.54
30	462.97	478.40	493.84	509.27	524.70	540.13	555.56	571.00	586.43	601.86
40	617.29	632.73	648.16	663.59	679.02	694.46	709.89	725.32	740.75	756.19
50	771.62	787.05	802.48	817.91	833.35	848.78	864.21	879.64	895.08	910.51
60	925.94	941.37	956.81	972.24	987.67	1003.10	1018.54	1033.97	1049.40	1064.83
70	1080.26	1095.70	1111.13	1126.56	1141.99	1157.43	1172.86	1188.29	1203.72	1219.16
80	1234.59	1250.02	1265.45	1280.89	1296.32	1311.75	1327.18	1342.61	1358.05	1373.48
90	1388.91	1404.34	1419.78	1435.21	1450.64	1466.07	1481.51	1496.94	1512.37	1527.80

gram.	Grain.	gram.	Grain.	gram.	Grain.	gram.	Grain.
0.01	0.154	0.06	0.926	0.001	0.015	0.006	0.093
.02	.309	.07	1.080	.002	.031	.007	.108
.03	.463	.08	1.235	.003	.046	.008	.123
.04	.617	.09	1.389	.004	.062	.009	.139
.05	.772	.10	1.543	.005	.077	.010	.154

WIND TABLES.

TABLE 32.

SYNOPTIC CONVERSION OF VELOCITIES.

Miles per hour into meters per second, feet per second and kilometers per hour.

Miles per hour.	Meters per second.	Feet per second.	Kilometers per hour.	Miles per hour.	Meters per second.	Feet per second.	Kilometers per hour.	Miles per hour.	Meters per second.	Feet per second.	Kilometers per hour.
0.0	0.0	0.0	0.0	**26.0**	11.6	38.1	41.8	**52.0**	23.2	76.3	83.7
0.5	0.2	0.7	0.8	26.5	11.8	38.9	42.6	52.5	23.5	77.0	84.5
1.0	0.4	1.5	1.6	27.0	12.1	39.6	43.5	53.0	23.7	77.7	85.3
1.5	0.7	2.2	2.4	27.5	12.3	40.3	44.3	53.5	23.9	78.5	86.1
2.0	0.9	2.9	3.2	28.0	12.5	41.1	45.1	54.0	24.1	79.2	86.9
2.5	1.1	3.7	4.0	28.5	12.7	41.8	45.9	54.5	24.4	79.9	87.7
3.0	1.3	4.4	4.8	**29.0**	13.0	42.5	46.7	**55.0**	24.6	80.7	88.5
3.5	1.6	5.1	5.6	29.5	13.2	43.3	47.5	55.5	24.8	81.4	89.3
4.0	1.8	5.9	6.4	30.0	13.4	44.0	48.3	56.0	25.0	82.1	90.1
4.5	2.0	6.6	7.2	30.5	13.6	44.7	49.1	56.5	25.3	82.9	90.9
5.0	2.2	7.3	8.0	31.0	13.9	45.5	49.9	57.0	25.5	83.6	91.7
5.5	2.5	8.1	8.9	31.5	14.1	46.2	50.7	57.5	25.7	84.3	92.5
6.0	2.7	8.8	9.7	**32.0**	14.3	46.9	51.5	**58.0**	25.9	85.1	93.3
6.5	2.9	9.5	10.5	32.5	14.5	47.7	52.3	58.5	26.2	85.8	94.1
7.0	3.1	10.3	11.3	33.0	14.8	48.4	53.1	59.0	26.4	86.5	95.0
7.5	3.4	11.0	12.1	33.5	15.0	49.1	53.9	59.5	26.6	87.3	95.8
8.0	3.6	11.7	12.9	34.0	15.2	49.9	54.7	60.0	26.8	88.0	96.6
8.5	3.8	12.5	13.7	34.5	15.4	50.6	55.5	60.5	27.0	88.7	97.4
9.0	4.0	13.2	14.5	**35.0**	15.6	51.3	56.3	**61.0**	27.3	89.5	98.2
9.5	4.2	13.9	15.3	35.5	15.9	52.1	57.1	61:5	27.5	90.2	99.0
10.0	4.5	14.7	16.1	36.0	16.1	52.8	57.9	62.0	27.7	90.9	99.8
10.5	4.7	15.4	16.9	36.5	16.3	53.5	58.7	62.5	27.9	91.7	100.6
11.0	4.9	16.1	17.7	37.0	16.5	54.3	59.5	63.0	28.2	92.4	101.4
11.5	5.1	16.9	18.5	37.5	16.8	55.0	60.4	63.5	28.4	93.1	102.2
12.0	5.4	17.6	19.3	**38.0**	17.0	55.7	61.2	**64.0**	28.6	93.9	103.0
12.5	5.6	18.3	20.1	38.5	17.2	56.5	62.0	64.5	28.8	94.6	103.8
13.0	5.8	19.1	20.9	39.0	17.4	57.2	62.8	65.0	29.1	95.3	104.6
13.5	6.0	19.8	21.7	39.5	17.7	57.9	63.6	65.5	29.3	96.1	105.4
14.0	6.3	20.5	22.5	40.0	17.9	58.7	64.4	66.0	29.5	96.8	106.2
14.5	6.5	21.3	23.3	40.5	18.1	59.4	65.2	66.5	29.7	97.5	107.0
15.0	6.7	22.0	24.1	**41.0**	18.3	60.1	66.0	**67.0**	30.0	98.3	107.8
15.5	6.9	22.7	24.9	41.5	18.6	60.9	66.8	67.5	30.2	99.0	108.6
16.0	7.2	23.5	25.7	42.0	18.8	61.6	67.6	68.0	30.4	99.7	109.4
16.5	7.4	24.2	26.6	42.5	19.0	62.3	68.4	68.5	30.6	100.5	110.2
17.0	7.6	24.9	27.4	43.0	19.2	63.1	69.2	69.0	30.8	101.2	111.0
17.5	7.8	25.7	28.2	43.5	19.4	63.8	70.0	69.5	31.1	101.9	111.8
18.0	8.0	26.4	29.0	**44.0**	19.7	64.5	70.8	**70.0**	31.3	102.7	112.7
18.5	8.3	27.1	29.8	44.5	19.9	65.3	71.6	70.5	31.5	103.4	113.5
19.0	8.5	27.9	30.6	45.0	20.1	66.0	72.4	71.0	31.7	104.1	114.3
19.5	8.7	28.6	31.4	45.5	20.3	66.7	73.2	71.5	32.0	104.9	115.1
20.0	8.9	29.3	32.2	46.0	20.6	67.5	74.0	72.0	32.2	105.6	115.9
20.5	9.2	30.1	33.0	46.5	20.8	68.2	74.8	72.5	32.4	106.3	116.7
21.0	9.4	30.8	33.8	**47.0**	21.0	68.9	75.6	**73.0**	32.6	107.1	117.5
21.5	9.6	31.5	34.6	47.5	21.2	69.7	76.4	73.5	32.9	107.8	118.3
22.0	9.8	32.3	35.4	48.0	21.5	70.4	77.2	74.0	33.1	108.5	119.1
22.5	10.1	33.0	36.2	48.5	21.7	71.1	78.1	74.5	33.3	109.3	119.9
23.0	10.3	33.7	37.0	49.0	21.9	71.9	78.9	75.0	33.5	110.0	120.7
23.5	10.5	34.5	37.8	49.5	22.1	72.6	79.7	75.5	33.8	110.7	121.5
24.0	10.7	35.2	38.6	**50.0**	22.4	73.3	80.5	**76.0**	34.0	111.5	122.3
24.5	11.0	35.9	39.4	50.5	22.6	74.1	81.3	76.5	34.2	112.2	123.1
25.0	11.2	36.7	40.2	51.0	22.8	74.8	82.1	77.0	34.4	112.9	123.9
25.5	11.4	37.4	41.0	51.5	23.0	75.5	82.9	77.5	34.6	113.7	124.7
26.0	11.6	38.1	41.8	52.0	23.2	76.3	83.7	78.0	34.9	114.4	125.5

MILES PER HOUR INTO FEET PER SECOND.

1 mile per hour $= \frac{44}{30}$ feet per second.

Miles per hour.	0	1	2	3	4	5	6	7	8	9
	Feet per sec.	Feet per sec.	Feet per sec.	Feet per sec.	Feet per sec	Feet per sec.	Feet per sec.	Feet per sec.	Feet per sec.	Feet per sec.
0	0.0	1.5	2.9	4.4	5.9	7.3	8.8	10.3	11.7	13.2
10	14.7	16.1	17.6	19.1	20.5	22.0	23.5	24.9	26.4	27.9
20	29.3	30.8	32.3	33.7	35.2	36.7	38.1	39.6	41.1	42.5
30	44.0	45.5	46.9	48.4	49.9	51.3	52.8	54.3	55.7	57.2
40	58.7	60.1	61.6	63.1	64.5	66.0	67.5	68.9	70.4	71.9
50	73.3	74.8	76.3	77.7	79.2	80.7	82.1	83.6	85.1	86.5
60	88.0	89.5	90.9	92.4	93.9	95.3	96.8	98.3	99.7	101.2
70	102.7	104.1	105.6	107.1	108.5	110.0	111.5	112.9	114.4	115.9
80	117.3	118.8	120.3	121.7	123.2	124.7	126.1	127.6	129.1	130.5
90	132.0	133.5	134.9	136.4	137.9	139.3	140.8	142.3	143.7	145.2
100	146.7	148.1	149.6	151.1	152.5	154.0	155.5	156.9	158.4	159.9
110	161.3	162.8	164.3	165.7	167.2	168.7	170.1	171.6	173.1	174.5
120	176.0	177.5	178.9	180.4	181.9	183.3	184.8	186.3	187.7	189.2
130	190.7	192.1	193.6	195.1	196.5	198.0	199.5	200.9	202.4	203.9
140	205.3	206.8	208.3	209.7	211.2	212.7	214.1	215.6	217.1	218.5

TABLE 34.

FEET PER SECOND INTO MILES PER HOUR.

1 foot per second $= \frac{30}{44}$ miles per hour.

Feet per sec.	0	1	2	3	4	5	6	7	8	9
	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.
0	0.0	0.7	1.4	2.0	2.7	3.4	4.1	4.8	5.5	6.1
10	6.8	7.5	8.2	8.9	9.5	10.2	10.9	11.6	12.3	13.0
20	13.6	14.3	15.0	15.7	16.4	17.0	17.7	18.4	19.1	19.8
30	20.5	21.1	21.8	22.5	23.2	23.9	24.5	25.2	25.9	26.6
40	27.3	28.0	28.6	29.3	30.0	30.7	31.4	32.0	32.7	33.4
50	34.1	34.8	35.5	36.1	36.8	37.5	38.2	38.9	39.5	40.2
60	40.9	41.6	42.3	43.0	43.6	44.3	45.0	45.7	46.4	47.0
70	47.7	48.4	49.1	49.8	50.5	51.1	51.8	52.5	53.2	53.9
80	54.5	55.2	55.9	56.6	57.3	58.0	58.6	59.3	60.0	60.7
90	61.4	62.0	62.7	63.4	64.1	64.8	65.5	66.1	66.8	67.5
100	68.2	68.9	69.5	70.2	70.9	71.6	72.3	73.0	73.6	74.3
110	75.0	75.7	76.4	77.0	77.7	78.4	79.1	79.8	80.5	81.1
120	81.8	82.5	83.2	83.9	84.5	85.2	85.9	86.6	87.3	88.0
130	88.6	89.3	90.0	90.7	91.4	92.0	92.7	93.4	94.1	94.8
140	95.5	96.1	96.8	97.5	98.2	98.9	99.5	100.2	100.9	101.6
150	102.3	103.0	103.6	104.3	105.0	105.7	106.4	107.0	107.7	108.4
160	109.1	109.8	110.5	111.1	111.8	112.5	113.2	113.9	114.5	115.2
170	115.9	116.6	117.3	118.0	118.6	119.3	120.0	120.7	121.4	120.0
180	122.7	123.4	124.1	124.8	125.5	126.1	126.8	127.5	128.2	128.9
190	129.5	130.2	130.9	131.6	132.3	133.0	133.6	134.3	135.0	135.7

TABLE 35.

METERS PER SECOND INTO MILES PER HOUR.

1 meter per second = 2.236932 miles per hour.

Meters per second.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.
0	0.0	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.0
1	2.2	2.5	2.7	2.9	3.1	3.4	3.6	3.8	4.0	4.3
2	4.5	4.7	4.9	5.1	5.4	5.6	5.8	6.0	6.3	6.5
3	6.7	6.9	7.2	7.4	7.6	7.8	8.1	8.3	8.5	8.7
4	8.9	9.2	9.4	9.6	9.8	10.1	10.3	10.5	10.7	11.0
5	11.2	11.4	11.6	11.9	12.1	12.3	12.5	12.8	13.0	13.2
6	13.4	13.6	13.9	14.1	14.3	14.5	14.8	15.0	15.2	15.4
7	15.7	15.9	16.1	16.3	16.6	16.8	17.0	17.2	17.4	17.7
8	17.9	18.1	18.3	18.6	18.8	19.0	19.2	19.5	19.7	19.9
9	20.1	20.4	20.6	20.8	21.0	21.3	21.5	21.7	21.9	22.1
10	22.4	22.6	22.8	23.0	23.3	23.5	23.7	23.9	24.2	24.4
11	24.6	24.8	25.1	25.3	25.5	25.7	25.9	26.2	26.4	26.6
12	26.8	27.1	27.3	27.5	27.7	28.0	28.2	28.4	28.6	28.9
13	29.1	29.3	29.5	29.8	30.0	30.2	30.4	30.6	30.9	31.1
14	31.3	31.5	31.8	32.0	32.2	32.4	32.7	32.9	33.1	33.3
15	33.6	33.8	34.0	34.2	34.4	34.7	34.9	35.1	35.3	35.6
16	35.8	36.0	36.2	36.5	36.7	36.9	37.1	37.4	37.6	37.8
17	38.0	38.3	38.5	38.7	38.9	39.1	39.4	39.6	39.8	40.0
18	40.3	40.5	40.7	40.9	41.2	41.4	41.6	41.8	42.1	42.3
19	42.5	42.7	43.0	43.2	43.4	43.6	43.8	44.1	44.3	44.5
20	44.7	45.0	45.2	45.4	45.6	45.9	46.1	46.3	46.5	46.8
21	47.0	47.2	47.4	47.6	47.9	48.1	48.3	48.5	48.8	49.0
22	49.2	49.4	49.7	49.9	50.1	50.3	50.6	50.8	51.0	51.2
23	51.5	51.7	51.9	52.1	52.3	52.6	52.8	53.0	53.2	53.5
24	53.7	53.9	54.1	54.4	54.6	54.8	55.0	55.3	55.5	55.7
25	55.9	56.1	56.4	56.6	56.8	57.0	57.3	57.5	57.7	57.9
26	58.2	58.4	58.6	58.8	59.1	59.3	59.5	59.7	60.0	60.2
27	60.4	60.6	60.8	61.1	61.3	61.5	61.7	62.0	62.2	62.4
28	62.6	62.9	63.1	63.3	63.5	63.8	64.0	64.2	64.4	64.6
29	64.9	65.1	65.3	65.5	65.8	66.0	66.2	66.4	66.7	66.9
30	67.1	67.3	67.6	67.8	68.0	68.2	68.5	68.7	68.9	69.1
31	69.3	69.6	69.8	70.0	70.2	70.5	70.7	70.9	71.1	71.4
32	71.6	71.8	72.0	72.3	72.5	72.7	72.9	73.1	73.4	73.6
33	73.8	74.0	74.3	74.5	74.7	74.9	75.2	75.4	75.6	75.8
34	76.1	76.3	76.5	76.7	77.0	77.2	77.4	77.6	77.8	78.1
35	78.3	78.5	78.7	79.0	79.2	79.4	79.6	79.9	80.1	80.3
36	80.5	80.8	81.0	81.2	81.4	81.6	81.9	82.1	82.3	82.5
37	82.8	83.0	83.2	83.4	83.7	84.0	84.1	84.3	84.6	84.8
38	85.0	85.2	85.5	85.7	85.9	86.1	86.3	86.6	86.8	87.0
39	87.2	87.5	87.7	87.9	88.1	88.4	88.6	88.8	89.0	89.3
40	89.5	89.7	89.9	90.2	90.4	90.6	90.8	91.0	91.3	91.5
41	91.7	91.9	92.2	92.4	92.6	92.8	93.1	93.3	93.5	93.7
42	94.0	94.2	94.4	94.6	94.8	95.1	95.3	95.5	95.7	96.0
43	96.2	96.4	96.6	96.9	97.1	97.3	97.5	97.8	98.0	98.2
44	98.4	98.7	98.9	99.1	99.3	99.5	99.8	100.0	100.2	100.4

METERS PER SECOND INTO MILES PER HOUR.

Meters per second.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.	Miles per hr.
45	100.7	100.9	101.1	101.3	101.6	101.8	102.0	102.2	102.5	102.7
46	102.9	103.1	103.3	103.6	103.8	104.0	104.2	104.5	104.7	104.9
47	105.1	105.4	105.6	105.8	106.0	106.3	106.5	106.7	106.9	107.2
48	107.4	107.6	107.8	108.0	108.3	108.5	108.7	108.9	109.2	109.4
49	109.6	109.8	110.1	110.3	110.5	110.7	111.0	111.2	111.4	111.6
50	111.8	112.1	112.3	112.5	112.7	113.0	113.2	113.4	113.6	113.9
51	114.1	114.3	114.5	114.8	115.0	115.2	115.4	115.7	115.9	116.1
52	116.3	116.6	116.8	117.0	117.2	117.4	117.7	117.9	118.1	118.3
53	118.6	118.8	119.0	119.2	119.5	119.7	119.9	120.1	120.4	120.6
54	120.8	121.0	121.3	121.5	121.7	121.9	122.1	122.4	122.6	122.8
55	123.0	123.3	123.5	123.7	123.9	124.2	124.4	124.6	124.8	125.1
56	125.3	125.5	125.7	126.0	126.2	126.4	126.6	126.8	127.1	127.3
57	127.5	127.8	128.0	128.2	128.4	128.6	128.9	129.1	129.3	129.5
58	129.7	130.0	130.2	130.4	130.7	130.9	131.1	131.3	131.6	131.8
59	132.0	132.2	132.5	132.7	132.9	133.1	133.3	133.6	133.8	134.0

MILES PER HOUR INTO METERS PER SECOND.

1 mile per hour = 0.4470409 meters per second.

Miles per hour.	0	1	2	3	4	5	6	7	8	9
	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.
0	0.00	0.45	0.89	1.34	1.79	2.24	2.68	3.13	3.58	4.02
10	4.47	4.92	5.36	5.81	6.26	6.71	7.15	7.60	8.05	8.49
20	8.94	9.39	9.83	10.28	10.73	11.18	11.62	12.07	12.52	12.96
30	13.41	13.86	14.31	14.75	15.20	15.65	16.09	16.54	16.99	17.43
40	17.88	18.33	18.78	19.22	19.67	20.12	20.56	21.01	21.46	21.90
50	22.35	22.80	23.25	23.69	24.14	24.59	25.03	25.48	25.93	26.37
60	26.82	27.27	27.72	28.16	28.61	29.06	29.50	29.95	30.40	30.85
70	31.29	31.74	32.19	32.63	33.08	33.53	33.98	34.42	34.87	35.32
80	35.76	36.21	36.66	37.10	37.55	38.00	38.44	38.89	39.34	39.79
90	40.23	40.68	41.13	41.57	42.02	42.47	42.92	43.36	43.81	44.26
100	44.70	45.15	45.60	46.04	46.49	46.94	47.39	47.83	48.28	48.73
110	49.17	49.62	50.07	50.51	50.96	51.41	51.86	52.30	52.75	53.20
120	53.64	54.09	54.54	54.98	55.43	55.88	56.33	56.77	57.22	57.67
130	58.12	58.56	59.01	59.46	59.90	60.35	60.80	61.24	61.69	62.14
140	62.59	63.03	63.48	63.93	64.37	64.82	65.27	65.72	66.16	66.61

TABLE 37.

METERS PER SECOND INTO KILOMETERS PER HOUR.

1 meter per second = 3.6 kilometers per hour.

Meters per second.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.
0	0.0	0.4	0.7	1.1	1.4	1.8	2.2	2.5	2.9	3.2
1	3.6	4.0	4.3	4.7	5.0	5.4	5.8	6.1	6.5	6.8
2	7.2	7.6	7.9	8.3	8.6	9.0	9.4	9.7	10.1	10.4
3	10.8	11.2	11.5	11.9	12.2	12.6	13.0	13.3	13.7	14.0
4	14.4	14.8	15.1	15.5	15.8	16.2	16.6	16.9	17.3	17.6
5	18.0	18.4	18.7	19.1	19.4	19.8	20.2	20.5	20.9	21.2
6	21.6	22.0	22.3	22.7	23.0	23.4	23.8	24.1	24.5	24.8
7	25.2	25.6	25.9	26.3	26.6	27.0	27.4	27.7	28.1	28.4
8	28.8	29.2	29.5	29.9	30.2	30.6	31.0	31.3	31.7	32.0
9	32.4	32.8	33.1	33.5	33.8	34.2	34.6	34.9	35.3	35.6
10	36.0	36.4	36.7	37.1	37.4	37.8	38.2	38.5	38.9	39.2
11	39.6	40.0	40.3	40.7	41.0	41.4	41.8	42.1	42.5	42.8
12	43.2	43.6	43.9	44.3	44.6	45.0	45.4	45.7	46.1	46.4
13	46.8	47.2	47.5	47.9	48.2	48.6	49.0	49.3	49.7	50.0
14	50.4	50.8	51.1	51.5	51.8	52.2	52.6	52.9	53.3	53.6
15	54.0	54.4	54.7	55.1	55.4	55.8	56.2	56.5	56.9	57.2
16	57.6	58.0	58.3	58.7	59.0	59.4	59.8	60.1	60.5	60.8
17	61.2	61.6	61.9	62.3	62.6	63.0	63.4	63.7	64.1	64.4
18	64.8	65.2	65.5	65.9	66.2	66.6	67.0	67.3	67.7	68.0
19	68.4	68.8	69.1	69.5	69.8	70.2	70.6	70.9	71.3	71.6
20	72.0	72.4	72.7	73.1	73.4	73.8	74.2	74.5	74.9	75.2
21	75.6	76.0	76.3	76.7	77.0	77.4	77.8	78.1	78.5	78.8
22	79.2	79.6	79.9	80.3	80.6	81.0	81.4	81.7	82.1	82.4
23	82.8	83.2	83.5	83.9	84.2	84.6	85.0	85.3	85.7	86.0
24	86.4	86.8	87.1	87.5	87.8	88.2	88.6	88.9	89.3	89.6
25	90.0	90.4	90.7	91.1	91.4	91.8	92.2	92.5	92.9	93.2
26	93.6	94.0	94.3	94.7	95.0	95.4	95.8	96.1	96.5	96.8
27	97.2	97.6	97.9	98.3	98.6	99.0	99.4	99.7	100.1	100.4
28	100.8	101.2	101.5	101.9	102.2	102.6	103.0	103.3	103.7	104.0
29	104.4	104.8	105.1	105.5	105.8	106.2	106.6	106.9	107.3	107.6
30	108.0	108.4	108.7	109.1	109.4	109.8	110.2	110.5	110.9	111.2
31	111.6	112.0	112.3	112.7	113.0	113.4	113.8	114.1	114.5	114.8
32	115.2	115.6	115.9	116.3	116.6	117.0	117.4	117.7	118.1	118.4
33	118.8	119.2	119.5	119.9	120.2	120.6	121.0	121.3	121.7	122.0
34	122.4	122.8	123.1	123.5	123.8	124.2	124.6	124.9	125.3	125.6
35	126.0	126.4	126.7	127.1	127.4	127.8	128.2	128.5	128.9	129.2
36	129.6	130.0	130.3	130.7	131.0	131.4	131.8	132.1	132.5	132.8
37	133.2	133.6	133.9	134.3	134.6	135.0	135.4	135.7	136.1	136.4
38	136.8	137.2	137.5	137.9	138.2	138.6	139.0	139.3	139.7	140.0
39	140.4	140.8	141.1	141.5	141.8	142.2	142.6	142.9	143.3	143.6
40	144.0	144.4	144.7	145.1	145.4	145.8	146.2	146.5	146.9	147.2
41	147.6	148.0	148.3	148.7	149.0	149.4	149.8	150.1	150.5	150.8
42	151.2	151.6	151.9	152.3	152.6	153.0	153.4	153.7	154.1	154.4
43	154.8	155.2	155.5	155.9	156.2	156.6	157.0	157.3	157.7	158.0
44	158.4	158.8	159.1	159.5	159.8	160.2	160.6	160.9	161.3	161.6

METERS PER SECOND INTO KILOMETERS PER HOUR.

Meters per second.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.	km. per hr.
45	162.0	162.4	162.7	163.1	163.4	163.8	164.2	164.5	164.9	165.2
46	165.6	166.0	166.3	166.7	167.0	167.4	167.8	168.1	168.5	168.8
47	169.2	169.6	169.9	170.3	170.6	171.0	171.4	171.7	172.1	172.4
48	172.8	173.2	173.5	173.9	174.2	174.6	175.0	175.3	175.7	176.0
49	176.4	176.8	177.1	177.5	177.8	178.2	178.6	178.9	179.3	179.6
50	180.0	180.4	180.7	181.1	181.4	181.8	182.2	182.5	182.9	183.2
51	183.6	184.0	184.3	184.7	185.0	185.4	185.8	186.1	186.5	186.8
52	187.2	187.6	187.9	188.3	188.6	189.0	189.4	189.7	190.1	190.4
53	190.8	191.2	191.5	191.9	192.2	192.6	193.0	193.3	193.7	194.0
54	194.4	194.8	195.1	195.5	195.8	196.2	196.6	196.9	197.3	197.6
55	198.0	198.4	198.7	199.1	199.4	199.8	200.2	200.5	200.9	201.2
56	201.6	202.0	202.3	202.7	203.0	203.4	203.8	204.1	204.5	204.8
57	205.2	205.6	205.9	206.3	206.6	207.0	207.4	207.7	208.1	208.4
58	208.8	209.2	209.5	209.9	210.2	210.6	211.0	211.3	211.7	212.0
59	212.4	212.8	213.1	213.5	213.8	214.2	214.6	214.9	215.3	215.6

KILOMETERS PER HOUR INTO METERS PER SECOND.

1 kilometer per hour $= \frac{10}{36}$ meters per second.

Kilometers per hour.	0	1	2	3	4	5	6	7	8	9
	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.	meters per sec.
0	0.00	0.28	0.56	0.83	1.11	1.39	1.67	1.94	2.22	2.50
10	2.78	3.06	3.33	3.61	3.89	4.17	4.44	4.72	5.00	5.28
20	5.56	5.83	6.11	6.39	6.67	6.94	7.22	7.50	7.78	8.06
30	8.33	8.61	8.89	9.17	9.44	9.72	10.00	10.28	10.56	10.83
40	11.11	11.39	11.67	11.94	12.22	12.50	12.78	13.06	13.33	13.61
50	13.89	14.17	14.44	14.72	15.00	15.28	15.56	15.83	16.11	16.39
60	16.67	16.94	17.22	17.50	17.78	18.06	18.33	18.61	18.89	19.17
70	19.44	19.72	20.00	20.28	20.56	20.83	21.11	21.39	21.67	21.94
80	22.22	22.50	22.78	23.06	23.33	23.61	23.89	24.17	24.44	24.72
90	25.00	25.28	25.56	25.83	26.11	26.39	26.67	26.94	27.22	27.50
100	27.78	28.06	28.33	28.61	28.89	29.17	29.44	29.72	30.00	30.28
110	30.56	30.83	31.11	31.39	31.67	31.94	32.22	32.50	32.78	33.06
120	33.33	33.61	33.89	34.17	34.44	34.72	35.00	35.28	35.56	35.83
130	36.11	36.39	36.67	36.94	37.22	37.50	37.78	38.06	38.33	38.61
140	38.89	39.17	39.44	39.72	40.00	40.28	40.56	40.83	41.11	41.39
150	41.67	41.94	42.22	42.50	42.78	43.06	43.33	43.61	43.89	44.17
160	44.44	44.72	45.00	45.28	45.56	45.83	46.11	46.39	46.67	46.94
170	47.22	47.50	47.78	48.06	48.33	48.61	48.89	49.17	49.44	49.72
180	50.00	50.28	50.56	50.83	51.11	51.39	51.67	51.94	52.22	52.50
190	52.78	53.06	53.33	53.61	53.89	54.17	54.44	54.72	55.00	55.28

TABLE 39.

SCALE OF VELOCITY EQUIVALENTS OF THE SO-CALLED BEAUFORT SCALE OF WIND.

Beaufort Number.	Explanatory titles.	Mode of estimating aboard sailing vessels.	Specification for use on land.	Meters per second	Miles per hour.
0	Calm		Calm, smoke rises vertically.	Less than 0.3	Less than 1
1	Light air	Sufficient wind for working ship	Direction of wind shown by smoke drift, but not by wind vanes.	0.3–1.5	1–3
2	Slight breeze		Wind felt on face; leaves rustle; ordinary vane moved by wind.	1.6–3.3	4–7
3	Gentle breeze		Leaves and small twigs in constant motion; wind extends light flag.	3.4–5.4	8–12
4	Moderate breeze	Forces most advantageous for sailing with leading wind and all sail drawing	Raises dust and loose paper; small branches are moved.	5.5–7.9	13–18
5	Fresh breeze		Small trees in leaf begin to sway; crested wavelets form on inland waters.	8.0–10.7	19–24
6	Strong breeze	Reduction of sail necessary with leading wind	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	10.8–13.8	25–31
7	High wind		Whole trees in motion; inconvenience felt when walking against wind.	13.9–17.1	32–38
8	Gale	Considerable reduction of sail necessary even with wind quartering	Breaks twigs off trees; generally impedes progress.	17.2–20.7	39–46
9	Strong gale		Slight structural damage occurs (chimney pots and slate removed).	20.8–24.4	47–54
10	Whole gale	Close reefed sail running, or hove to under storm sail	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	24.5–28.4	55–63
11	Storm		Very rarely experienced, accompanied by widespread damage.	28.5–33.5	64–75
12	Hurricane	No sail can stand even when running		33.6 or above	Above 75

MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

$$\tan \alpha = \frac{E - W + (NE + SE - NW - SW) \cos 45^\circ}{N - S + (NE + NW - SE - SW) \cos 45^\circ}$$

Multiples of cos 45°.

Number.	0	1	2	3	4	5	6	7	8	9
0	0.0	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.7	6.4
10	7.1	7.8	8.5	9.2	9.9	10.6	11.3	12.0	12.7	13.4
20	14.1	14.8	15.6	16.3	17.0	17.7	18.4	19.1	19.8	20.5
30	21.2	21.9	22.6	23.3	24.0	24.7	25.5	26.2	26.9	27.6
40	28.3	29.0	29.7	30.4	31.1	31.8	32.5	33.2	33.9	34.6
50	35.4	36.1	36.8	37.5	38.2	38.9	39.6	40.3	41.0	41.7
60	42.4	43.1	43.8	44.5	45.3	46.0	46.7	47.4	48.1	48.8
70	49.5	50.2	50.9	51.6	52.3	53.0	53.7	54.4	55.2	55.9
80	56.6	57.3	58.0	58.7	59.4	60.1	60.8	61.5	62.2	62.9
90	63.6	64.3	65.1	65.8	66.5	67.2	67.9	68.6	69.3	70.0
100	70.7	71.4	72.1	72.8	73.5	74.2	75.0	75.7	76.4	77.1
110	77.8	78.5	79.2	79.9	80.6	81.3	82.0	82.7	83.4	84.1
120	84.9	85.6	86.3	87.0	87.7	88.4	89.1	89.8	90.5	91.2
130	91.9	92.6	93.3	94.0	94.8	95.5	96.2	96.9	97.6	98.3
140	99.0	99.7	100.4	101.1	101.8	102.5	103.2	103.9	104.7	105.4
150	106.1	106.8	107.5	108.2	108.9	109.6	110.3	111.0	111.7	112.4
160	113.1	113.8	114.6	115.3	116.0	116.7	117.4	118.1	118.8	119.5
170	120.2	120.9	121.6	122.3	123.0	123.7	124.5	125.2	125.9	126.6
180	127.3	128.0	128.7	129.4	130.1	130.8	131.5	132.2	132.9	133.6
190	134.4	135.1	135.8	136.5	137.2	137.9	138.6	139.3	140.0	140.7
200	141.4	142.1	142.8	143.5	144.2	145.0	145.7	146.4	147.1	147.8

Form for Computing the Numerator and Denominator.

Directions.	E	W	N	S	NE	SW	SE	NW	
bserved values.	7	12	6	26	13	45	2	24	
	$E-W$		$N-S$		$NE-SW$		$SE-NW$		
	[−5]		[−20]		[−32] × cos 45°		[−22] × cos 45°		
Numerator(n).	[−5]		+		[−22.6]	+	[−15.6]		= [−43.2]
enominator(d).			[−20]	+	[−22.6]	−	[−15.6]		= [−27.0]

is the angle between the mean wind direction and the meridian.

he signs of the numerator (n) and denominator (d) determine the quadrant in which α lies.

When n and d are positive, α lies between N and E: $\frac{+}{+} = NE.$

When n is positive and d negative, α lies between S and E: $\frac{+}{-} = SE.$

When n and d are negative, α lies between S and W: $\frac{-}{-} = SW.$

When n is negative and d positive, α lies between N and W: $\frac{-}{+} = NW.$

MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

Values of the mean direction (α) or its complement ($90° - \alpha$).

$$\alpha = \tan^{-1} n/d$$

n or d.	DENOMINATOR OR NUMERATOR (d OR n).																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1	6°	4°	3°	2°	2°	2°	1°	1°	1°	1°	1°	1°	1°	1°	1°	1°	1°	1°	1°
2	11	8	6	5	4	3	3	3	2	2	2	2	2	2	1	1	1	1	1
3	17	11	9	7	6	5	4	4	3	3	3	3	2	2	2	2	2	2	2
4	22	15	11	9	8	7	6	5	5	4	4	4	3	3	3	3	3	2	2
5	27	18	14	11	9	8	7	6	6	5	5	4	4	4	4	3	3	3	3
6	31	22	17	13	11	10	9	8	7	6	6	5	5	5	4	4	4	4	3
7	35	25	19	16	13	11	10	9	8	7	7	6	6	5	5	5	4	4	4
8	39	28	22	18	15	13	11	10	9	8	8	7	7	6	6	5	5	5	5
9	42	31	24	20	17	14	13	11	10	9	9	8	7	7	6	6	6	5	5
10	45	34	27	22	18	16	14	13	11	10	9	9	8	8	7	7	6	6	6
11		36	29	24	20	17	15	14	12	11	10	10	9	8	8	7	7	7	6
12		39	31	26	22	19	17	15	13	12	11	10	10	9	9	8	8	7	7
13		41	33	27	23	20	18	16	15	13	12	11	11	10	9	9	8	8	7
14		43	35	29	25	22	19	17	16	14	13	12	11	11	10	9	9	8	8
15		45	37	31	27	23	21	18	17	15	14	13	12	11	11	10	9	9	9
16			39	33	28	25	22	20	18	16	15	14	13	12	11	11	10	10	9
17			40	34	30	26	23	21	19	17	16	15	14	13	12	11	11	10	10
18			42	36	31	27	24	22	20	18	17	15	14	13	13	12	11	11	10
19			44	37	32	28	25	23	21	19	18	16	15	14	13	13	12	11	11
20			45	39	34	30	27	24	22	20	18	17	16	15	14	13	13	12	11
21				40	35	31	28	25	23	21	19	18	17	16	15	14	13	12	12
22				41	36	32	29	26	24	22	20	19	17	16	15	15	14	13	12
23				43	37	33	30	27	25	23	21	19	18	17	16	15	14	14	13
24				44	39	34	31	28	26	24	22	20	19	18	17	16	15	14	13
25				45	40	36	32	29	27	24	23	21	20	18	17	16	16	15	14
26					41	37	33	30	27	25	23	22	20	19	18	17	16	15	15
27					42	38	34	31	28	26	24	22	21	20	19	18	17	16	15
28					43	39	35	32	29	27	25	23	22	20	19	18	17	16	16
29					44	40	36	33	30	28	26	24	23	21	20	19	18	17	16
30					45	41	37	34	31	29	27	25	23	22	21	19	18	18	17
31						42	38	35	32	29	27	25	24	22	21	20	19	18	17
32						42	39	35	33	30	28	26	25	23	22	21	20	19	18
33						43	40	36	33	31	29	27	25	24	22	21	20	19	18
34						44	40	37	34	32	30	28	26	24	23	22	21	20	19
35						45	41	38	35	32	30	28	27	25	24	22	21	20	19
36							42	39	36	33	31	29	27	26	24	23	22	21	20
37							43	39	37	34	32	30	28	26	25	24	22	21	20
38							44	40	37	35	32	30	28	27	25	24	23	22	21
39							44	41	38	35	33	31	29	27	26	25	23	22	21
40							45	42	39	36	34	32	30	28	27	25	24	23	22
41								42	39	37	34	32	30	29	27	26	24	23	22
42								43	40	37	35	33	31	29	28	26	25	24	23
43								44	41	38	36	33	32	30	28	27	26	24	23
44								44	41	39	36	34	32	30	29	27	26	25	24
45								45	42	39	37	35	33	31	29	28	27	25	24
46									43	40	37	35	33	32	30	28	27	26	25
47									43	41	38	36	34	32	30	29	28	26	25
48									44	41	39	36	34	33	31	29	28	27	26
49									44	42	39	37	35	33	31	30	29	27	26
50									45	42	40	38	36	34	32	30	29	28	27

MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

Values of the mean direction (α) or its complement ($90° - \alpha$).

n or *d*.	DENOMINATOR OR NUMERATOR (*d* OR *n*).									
	105	110	115	120	125	130	135	140	145	150
1	1°	1°	0°	0°	0°	0°	0°	0°	0°	0°
2	1	1	1	1	1	1	1	1	1	1
3	2	2	1	1	1	1	1	1	1	1
4	2	2	2	2	2	2	2	2	2	2
5	3	3	2	2	2	2	2	2	2	2
6	3	3	3	3	3	3	3	2	2	2
7	4	4	3	3	3	3	3	3	3	3
8	4	4	4	4	4	4	3	3	3	3
9	4	4	4	4	4	4	4	4	4	3
10	5	5	5	5	5	4	4	4	4	4
11	6	6	5	5	5	5	5	4	4	4
12	7	6	6	6	5	5	5	5	5	5
13	7	7	6	6	6	6	6	5	5	5
14	8	7	7	7	6	6	6	6	6	5
15	8	8	7	7	7	7	6	6	6	6
16	9	8	8	8	7	7	7	7	6	6
17	9	9	8	8	8	7	7	7	7	6
18	10	9	9	9	8	8	8	7	7	7
19	10	10	9	9	9	8	8	8	7	7
20	11	10	10	9	9	9	8	8	8	8
21	11	11	10	10	10	9	9	9	8	8
22	12	11	11	10	10	10	9	9	9	8
23	12	12	11	11	10	10	10	9	9	9
24	13	12	12	11	11	10	10	10	9	9
25	13	13	12	12	11	11	10	10	10	9
26	14	13	13	12	12	11	11	11	10	10
27	14	14	13	13	12	12	11	11	11	10
28	15	14	14	13	13	12	12	11	11	11
29	15	15	14	14	13	13	12	12	11	11
30	16	15	15	14	13	13	13	12	12	11
31	16	16	15	14	14	13	13	12	12	12
32	17	16	16	15	14	14	13	13	12	12
33	17	17	16	15	15	14	14	13	13	12
34	18	17	16	16	15	15	14	14	13	13
35	18	18	17	16	16	15	15	14	14	13
36	19	18	17	17	16	15	15	14	14	13
37	19	19	18	17	16	16	15	15	14	14
38	20	19	18	18	17	16	16	15	15	14
39	20	20	19	18	17	17	16	16	15	15
40	21	20	19	18	18	17	17	16	15	15
41	21	20	20	19	18	18	17	16	16	15
42	22	21	20	19	19	18	17	17	16	16
43	22	21	21	20	19	18	18	17	17	16
44	23	22	21	20	19	19	18	17	17	16
45	23	22	21	21	20	19	18	18	17	17
46	24	23	22	21	20	19	19	18	18	17
47	24	23	22	21	21	20	19	19	18	17
48	25	24	23	22	21	20	20	19	18	18
49	25	24	23	22	21	21	20	19	19	18
50	25	24	23	23	22	21	20	20	19	18

MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

Values of the mean direction (α) or its complement ($90° - \alpha$).

n or d.	DENOMINATOR OR NUMERATOR (d OR n).									
	155	160	165	170	175	180	185	190	195	200
1	0°	0°	0°	0°	0°	0°	0°	0°	0°	0°
2	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1
5	2	2	2	2	2	2	2	2	1	1
6	2	2	2	2	2	2	2	2	2	2
7	3	3	2	2	2	2	2	2	2	2
8	3	3	3	3	3	3	2	2	2	2
9	3	3	3	3	3	3	3	3	3	3
10	4	4	3	3	3	3	3	3	3	3
11	4	4	4	4	4	3	3	3	3	3
12	4	4	4	4	4	4	4	4	4	3
13	5	5	5	4	4	4	4	4	4	4
14	5	5	5	5	5	4	4	4	4	4
15	6	5	5	5	5	5	5	5	4	4
16	6	6	6	5	5	5	5	5	5	5
17	6	6	6	6	6	5	5	5	5	5
18	7	7	6	6	6	6	6	6	5	5
19	7	7	7	6	6	6	6	6	6	5
20	7	7	7	7	7	6	6	6	6	6
21	8	7	7	7	7	7	6	6	6	6
22	8	8	8	7	7	7	7	7	6	6
23	8	8	8	8	7	7	7	7	7	7
24	9	9	8	8	8	8	7	7	7	7
25	9	9	9	8	8	8	8	7	7	7
26	10	9	9	9	8	8	8	8	8	7
27	10	10	9	9	9	9	8	8	8	8
28	10	10	10	9	9	9	9	8	8	8
29	11	10	10	10	9	9	9	9	8	8
30	11	11	10	10	10	9	9	9	9	9
31	11	11	11	10	10	10	10	9	9	9
32	12	11	11	11	10	10	10	10	9	9
33	12	12	11	11	11	10	10	10	10	9
34	12	12	12	11	11	11	10	10	10	10
35	13	12	12	12	11	11	11	10	10	10
36	13	13	12	12	12	11	11	11	10	10
37	13	13	13	12	12	12	11	11	11	10
38	14	13	13	13	12	12	12	11	11	11
39	14	14	13	13	13	12	12	12	11	11
40	14	14	14	13	13	13	12	12	12	11
41	15	14	14	14	13	13	12	12	12	12
42	15	15	14	14	13	13	13	12	12	12
43	16	15	15	14	14	13	13	13	12	12
44	16	15	15	15	14	14	13	13	13	12
45	16	16	15	15	14	14	14	13	13	13
46	17	16	16	15	15	14	14	14	13	13
47	17	16	16	15	15	15	14	14	14	13
48	17	17	16	16	15	15	15	14	14	13
49	18	17	17	16	16	15	15	14	14	14
50	18	17	17	16	16	16	15	15	14	14

MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

Values of the mean direction (α) or its complement ($90° - \alpha$).

$$\alpha = tan^{-1} \frac{n}{d}.$$

n or *d*.	DENOMINATOR OR NUMERATOR (*d* OR *n*).															
	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
50	42°	40°	38°	36°	34°	32°	30°	29°	28°	27°	25°	24°	23°	23°	22°	21°
52	43	41	39	37	35	33	31	30	29	27	26	25	24	23	23	22
54	44	42	40	38	36	34	32	31	30	28	27	26	25	24	23	22
56		43	41	39	37	35	33	32	31	29	28	27	26	25	24	23
58		44	42	40	38	36	34	33	31	30	29	28	27	26	25	24
60		45	43	41	39	37	35	34	32	31	30	29	28	27	26	25
62			44	42	40	38	36	35	33	32	31	29	28	27	26	25
64			45	42	40	39	37	35	34	33	31	30	29	28	27	26
66				43	41	40	38	36	35	33	32	31	30	29	28	27
68				44	42	40	39	37	36	34	33	32	31	30	29	28
70				45	43	41	39	38	36	35	34	32	31	30	29	28
72					44	42	40	39	37	36	34	33	32	31	30	29
74					45	43	41	39	38	37	35	34	33	32	31	30
76						44	42	40	39	37	36	35	33	32	31	30
78						44	43	41	39	38	37	35	34	33	32	31
80						45	43	42	40	39	37	36	35	34	33	32
82							44	42	41	39	38	37	35	34	33	32
84							45	43	41	40	39	37	36	35	34	33
86								44	42	41	39	38	37	36	35	33
88								44	43	41	40	39	37	36	35	34
90								45	43	42	41	39	38	37	36	35
92									44	43	41	40	39	37	36	35
94									45	43	42	41	39	38	37	36
96										44	42	41	40	39	38	36
98										44	43	42	40	39	38	37
100										45	44	42	41	40	39	38
102											44	43	42	40	39	38
104											45	43	42	41	40	39
106												44	43	41	40	39
108												44	43	42	41	40
110												45	44	43	41	40
112													44	43	42	41
114													45	44	42	41
116														44	43	42
118														45	43	42
120														45	44	43
122															44	43
124															45	44
126																44
128																45
130																45

MEAN DIRECTION OF THE WIND BY LAMBERT'S FORMULA.

Values of the mean direction (α) or its complement ($90° - \alpha$).

n or *d*.	DENOMINATOR OR NUMERATOR (*d* OR *n*).														
	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
50	21°	20°	20°	19°	18°	18°	17°	17°	16°	16°	16°	15°	15°	14°	14°
52	22	21	20	20	19	19	18	17	17	17	16	16	15	15	15
54	22	22	21	20	20	19	19	18	18	17	17	16	16	15	15
56	23	23	22	21	20	20	19	19	18	18	17	17	16	16	16
58	24	23	23	22	21	21	20	19	19	18	18	17	17	17	16
60	25	24	23	22	22	21	21	20	19	19	18	18	18	17	17
62	25	25	24	23	22	22	21	21	20	20	19	19	18	18	17
64	26	25	25	24	23	22	22	21	21	20	20	19	19	18	18
66	27	26	25	24	24	23	22	22	21	21	20	20	19	19	18
68	28	27	26	25	24	24	23	22	22	21	21	20	20	19	19
70	28	27	27	26	25	24	24	23	22	22	21	21	20	20	19
72	29	28	27	26	26	25	24	24	23	22	22	21	21	20	20
74	30	29	28	27	26	26	25	24	24	23	22	22	21	21	20
76	30	29	28	28	27	26	25	25	24	23	23	22	22	21	21
78	31	30	29	28	27	27	26	25	25	24	23	23	22	22	21
80	32	31	30	29	28	27	27	26	25	25	24	23	23	22	22
82	32	31	30	29	29	28	27	26	26	25	24	24	23	23	22
84	33	32	31	30	29	28	28	27	26	26	25	24	24	23	23
86	33	32	32	31	30	29	28	28	27	26	26	25	24	24	23
88	34	33	32	31	30	30	29	28	27	27	26	25	25	24	24
90	35	34	33	32	31	30	29	29	28	27	27	26	25	25	24
92	35	34	33	32	32	31	30	29	28	28	27	26	26	25	25
94	36	35	34	33	32	31	30	30	29	28	28	27	26	26	25
96	36	35	34	34	33	32	31	30	29	29	28	27	27	26	26
98	37	36	35	34	33	32	31	31	30	29	29	28	27	27	26
100	38	37	36	35	34	33	32	31	30	30	29	28	28	27	27
102	38	37	36	35	34	33	33	32	31	30	30	29	28	28	27
104	39	38	37	36	35	34	33	32	31	31	30	29	29	28	27
106	39	38	37	36	35	34	34	33	32	31	30	30	29	29	28
108	40	39	38	37	36	35	34	33	32	32	31	30	30	29	28
110	40	39	38	37	36	35	35	34	33	32	31	31	30	29	29
112	41	40	39	38	37	36	35	34	33	33	32	31	31	30	29
114	41	40	39	38	37	36	35	35	34	33	32	32	31	30	30
116	42	41	40	39	38	37	36	35	34	34	33	32	31	31	30
118	42	41	40	39	38	37	36	36	35	34	33	33	32	31	31
120	43	42	41	40	39	38	37	36	35	34	34	33	32	32	31
122	43	42	41	40	39	38	37	36	36	35	34	33	33	32	31
124	44	43	42	41	40	39	38	37	36	35	35	34	33	32	32
126	44	43	42	41	40	39	38	37	37	36	35	34	34	33	32
128	45	43	42	41	40	40	39	38	37	36	35	35	34	33	33
130	45	44	43	42	41	40	39	38	37	37	36	35	34	34	33
132		44	43	42	41	40	40	39	38	37	36	35	35	34	33
134		45	44	43	42	41	40	39	38	37	37	36	35	34	34
136			44	43	42	41	40	39	39	38	37	36	36	35	34
138			45	44	43	42	41	40	39	38	37	37	36	35	35
140			45	44	43	42	41	40	39	39	38	37	36	36	35
142				44	43	42	42	41	40	39	38	38	37	36	35
144				45	44	43	42	41	40	39	39	38	37	36	36
146					44	43	42	42	41	40	39	38	38	37	36
148					45	44	43	42	41	40	39	39	38	37	37
150					45	44	43	42	41	41	40	39	38	38	37

RADIUS OF CRITICAL CURVATURE AND VELOCITIES OF GRADIENT WINDS FOR FRICTIONLESS MOTION IN *HIGHS* AND *LOWS*.

ENGLISH MEASURES.

R_c = radius of critical curvature in miles. V_c High = maximum speed in miles per hour on isobar of critical curvature. V_s = speed along straight line isobars = 0.5 V_c. V Low = speed in Low along isobar of curvature R_c. V Low = 0.4142 V_c.

The table is computed for a density of the air, ρ = .0010, which represents the conditions in the free air at an elevation of, roughly, one mile. Values for any other density can be readily found by dividing each or any of the tabulated values by the ratio of the densities, as, for example, for surface conditions divide by $1.2 = \frac{.0010}{.0012}$ and so on.

Latitude: φ		d (miles)										
		100	125	150	175	200	250	300	400	500	600	800
10°	R_c	8160	6530	5440	4660	4080	3260	2720	2040	1630	1360	1020
	V_c High	372	298	248	212	186	149	124	93.0	74.4	62.0	46.5
	V_s	186	149	124	106	93.0	74.4	62.0	46.5	37.2	31.0	23.2
	V Low	154	123	103	88.0	77.0	61.6	51.3	38.5	30.8	25.7	19.2
20	R_c	2100	1680	1400	1200	1050	841	701	526	420	350	263
	V_c High	189	151	126	108	94.4	75.5	62.9	47.2	37.8	31.5	23.6
	V_s	94.4	75.5	62.9	54.0	47.2	37.8	31.4	23.6	18.9	15.8	11.8
	V Low	78.2	62.5	52.1	44.7	39.1	31.3	26.1	19.6	15.7	13.0	9.8
25	R_c	1380	1100	918	787	688	551	459	344	275	230	172
	V_c High	153	122	102	87.3	76.4	61.1	50.9	38.2	30.6	25.5	19.1
	V_s	76.4	61.1	50.9	43.6	38.2	30.6	25.4	19.1	15.3	12.8	9.5
	V Low	63.3	50.6	42.2	36.2	31.6	25.3	21.1	15.8	12.7	10.6	7.9
30	R_c	984	787	656	562	492	393	328	246	197	164	123
	V_c High	129	103	86.1	73.8	64.5	51.6	43.0	32.3	25.8	21.5	16.1
	V_s	64.5	51.6	43.0	36.9	32.2	25.8	21.5	16.2	12.9	10.8	8.1
	V Low	53.5	42.8	35.7	30.6	26.7	21.4	17.8	13.4	10.7	8.9	6.7
35	R_c	747	598	498	427	374	299	249	187	150	125	93.4
	V_c High	112	90.0	75.0	64.3	56.3	45.0	37.5	28.1	22.5	18.8	14.1
	V_s	56.3	45.0	37.5	32.2	28.2	22.5	18.8	14.0	11.2	9.4	7.0
	V Low	46.6	37.3	31.1	26.6	23.3	18.6	15.5	11.6	9.3	7.8	5.8
40	R_c	595	476	397	340	298	238	198	149	119	99.2	74.4
	V_c High	100	80.3	66.9	57.4	50.2	40.2	33.5	25.1	20.1	16.7	12.6
	V_s	50.2	40.2	33.4	28.7	25.1	20.1	16.8	12.6	10.0	8.4	6.3
	V Low	41.6	33.3	27.7	23.8	20.8	16.7	13.9	10.4	8.3	6.9	5.2
45	R_c	492	393	328	281	246	197	164	123	98.4	82.0	61.5
	V_c High	91.3	73.0	60.9	52.2	45.6	36.5	30.4	22.8	18.3	15.2	11.4
	V_s	45.6	36.5	30.4	26.1	22.8	18.2	15.2	11.4	9.2	7.6	5.7
	V Low	37.8	30.2	25.2	21.6	18.9	15.1	12.6	9.4	7.6	6.3	4.7
50	R_c	419	335	279	240	210	168	140	105	83.8	69.9	52.4
	V_c High	84.3	67.4	56.2	48.2	42.1	33.7	28.1	21.1	16.9	14.0	10.5
	V_s	42.1	33.7	28.1	24.1	21.0	16.8	14.0	10.6	8.4	7.0	5.3
	V Low	34.9	27.9	23.3	20.0	17.4	14.0	11.6	8.7	7.0	5.8	4.4
55	R_c	366	293	244	209	183	147	122	91.6	73.3	61.1	45.8
	V_c High	78.8	63.0	52.5	45.0	39.4	31.5	26.3	19.7	15.8	13.1	9.8
	V_s	39.4	31.5	26.2	22.5	19.7	15.8	13.2	9.8	7.9	6.6	4.9
	V Low	32.6	26.1	21.7	18.6	16.3	13.0	10.9	8.2	6.5	5.4	4.1
60	R_c	328	262	219	187	164	131	109	82.0	65.6	54.7	41.0
	V_c High	74.5	59.6	49.7	42.6	37.3	29.8	24.8	18.6	14.9	12.4	9.3
	V_s	37.3	29.8	24.8	21.3	18.6	14.9	12.4	9.3	7.4	6.2	4.7
	V Low	30.9	24.7	20.6	17.6	15.5	12.3	10.3	7.7	6.2	5.1	3.9
65	R_c	299	240	200	171	150	120	99.8	74.8	59.9	49.9	37.4
	V_c High	71.2	57.0	47.5	40.7	35.6	28.5	23.7	17.8	14.2	11.9	8.9
	V_s	35.6	28.5	23.8	20.4	17.8	14.2	11.8	8.9	7.1	6.0	4.4
	V Low	29.5	23.6	19.7	16.9	14.7	11.8	9.8	7.4	5.9	4.9	3.7

TABLE 42.

RADIUS OF CRITICAL CURVATURE AND VELOCITIES OF GRADIENT WINDS FOR FRICTIONLESS MOTION IN *HIGHS* AND *LOWS*.

ENGLISH MEASURES.

Latitude: ϕ		d (miles)										
		100	125	150	175	200	250	300	400	500	600	800
70°	R_c	278	223	186	159	139	111	92.8	69.6	55.7	46.4	34.8
	V_c High	68.7	55.0	45.8	39.3	34.3	27.5	22.9	17.2	13.7	11.4	8.6
	V_s	34.3	27.5	22.9	19.6	17.2	13.8	11.4	8.6	6.8	5.7	4.3
	V Low	28.5	22.8	19.0	16.3	14.2	11.4	9.5	7.1	5.7	4.7	3.6
75	R_c	264	211	176	151	132	105	87.9	65.9	52.7	43.9	33.0
	V_c High	66.8	53.5	44.6	38.2	33.4	26.7	22.3	16.7	13.4	11.1	8.4
	V_s	33.4	26.8	22.3	19.1	16.7	13.4	11.2	8.4	6.7	5.6	4.2
	V Low	27.7	22.2	18.5	15.8	13.8	11.1	9.2	6.9	5.6	4.6	3.5
80	R_c	254	203	169	145	127	101	84.5	63.4	50.7	42.3	31.7
	V_c High	65.5	52.4	43.7	37.5	32.8	26.2	21.8	16.4	13.1	10.9	8.2
	V_s	32.8	26.2	21.8	18.8	16.4	13.1	10.9	8.2	6.6	5.4	4.1
	V Low	27.1	21.7	18.1	15.5	13.6	10.9	9.0	6.8	5.4	4.5	3.4
85	R_c	248	198	165	142	124	99.1	82.6	62.0	49.6	41.3	31.0
	V_c High	64.8	51.8	43.2	37.0	32.4	25.9	21.6	16.2	13.0	10.8	8.1
	V_s	32.4	25.9	21.6	18.5	16.2	13.0	10.8	8.1	6.5	5.4	4.0
	V Low	26.8	21.5	17.9	15.3	13.4	10.7	8.9	6.7	5.4	4.5	3.4
90	R_c	246	197	164	140	123	98.4	82.0	61.5	49.2	41.0	30.7
	V_c High	64.6	51.6	43.0	36.9	32.3	25.8	21.5	16.1	12.9	10.8	8.1
	V_s	32.3	25.8	21.5	18.4	16.2	12.9	10.8	8.0	6.4	5.4	4.0
	V Low	26.8	21.4	17.8	15.3	13.4	10.7	8.9	6.7	5.3	4.5	3.3

TABLE 43.

RADIUS OF CRITICAL CURVATURE AND VELOCITIES OF GRADIENT WINDS FOR FRICTIONLESS MOTION IN *HIGHS* AND *LOWS*.

METRIC MEASURES.

R_c = radius of critical curvature in kilometers. V_c High = maximum speed in meters per second on isobar of critical curvature. V_s = speed along straight line isobars = 0.5 V_c. V Low = speed in Low along isobar of curvature R_c. V Low = 0.4142 V_c.

The remarks in heading of Table 42 relative to the density of the air apply equally to Table 43.

Latitude: ϕ		d (kilometers)										
		100	125	150	175	200	250	300	400	500	600	800
10°	R_c	8330	6660	5550	4760	4160	3330	2780	2080	1670	1390	1040
	V_c High	105	84.3	70.2	60.2	52.7	42.1	35.1	26.3	21.1	17.6	13.2
	V_s	52.7	42.2	35.1	30.1	26.4	21.0	17.6	13.2	10.6	8.8	6.6
	V Low	43.5	34.9	29.1	24.9	21.8	17.4	14.5	10.9	8.7	7.3	5.5
20	R_c	2140	1710	1430	1220	1070	857	714	536	429	357	268
	V_c High	53.5	42.8	35.6	30.5	26.7	21.4	17.8	13.4	10.7	8.9	6.7
	V_s	26.7	21.4	17.8	15.2	13.4	10.7	8.9	6.7	5.4	4.4	3.4
	V Low	22.2	17.7	14.7	12.6	11.1	8.9	7.4	5.6	4.4	3.7	2.8
25	R_c	1400	1120	936	802	702	562	468	351	281	234	175
	V_c High	43.3	34.6	28.8	24.7	21.6	17.3	14.4	10.8	8.7	7.2	5.4
	V_s	21.6	17.3	14.4	12.4	10.8	8.6	7.2	5.4	4.4	3.6	2.7
	V Low	17.9	14.3	11.9	10.2	8.9	7.2	6.0	4.5	3.6	3.0	2.2
30	R_c	1003	802	669	573	501	401	334	251	201	167	125
	V_c High	36.6	29.3	24.4	20.9	18.3	14.6	12.2	9.1	7.3	6.1	4.6
	V_s	18.3	14.6	12.2	10.4	9.2	7.3	6.1	4.6	3.6	3.0	2.3
	V Low	15.2	12.1	10.1	8.7	7.6	6.0	5.1	3.8	3.0	2.5	1.9

RADIUS OF CRITICAL CURVATURE AND VELOCITIES OF GRADIENT WINDS FOR FRICTIONLESS MOTION IN *HIGHS* AND *LOWS*.

METRIC MEASURES.

Latitude: ϕ		*d* (kilometers)										
		100	125	150	175	200	250	300	400	500	600	800
35°	R_c	762	610	508	435	381	305	254	191	152	127	95.3
	V_c High	31.9	25.5	21.3	18.2	15.9	12.8	10.6	8.0	6.4	5.3	4.0
	V_s	15.9	12.8	10.6	9.1	8.0	6.4	5.3	4.0	3.2	2.6	2.0
	V Low	13.2	10.6	8.8	7.5	6.6	5.3	4.4	3.3	2.7	2.2	1.7
40	R_c	607	485	405	347	303	243	202	152	121	101	75.8
	V_c High	28.4	22.8	19.0	16.3	14.2	11.4	9.5	7.1	5.7	4.7	3.6
	V_s	14.2	11.4	9.5	8.2	7.1	5.7	4.8	3.6	2.8	2.4	1.8
	V Low	11.8	9.4	7.9	6.8	5.9	4.7	3.9	2.9	2.4	1.9	1.5
45	R_c	501	401	334	287	251	201	167	125	100	83.6	62.7
	V_c High	25.9	20.7	17.2	14.8	12.9	10.3	8.6	6.5	5.2	4.3	3.2
	V_s	12.9	10.4	8.6	7.4	6.4	5.2	4.3	3.2	2.6	2.2	1.6
	V Low	10.7	8.6	7.1	6.1	5.3	4.3	3.6	2.7	2.2	1.8	1.3
50	R_c	427	342	285	244	214	171	142	107	85.5	71.2	53.4
	V_c High	23.9	19.1	15.9	13.6	11.9	9.5	8.0	6.0	4.8	4.0	3.0
	V_s	11.9	9.6	8.0	6.8	6.0	4.8	4.0	3.0	2.4	2.0	1.5
	V Low	9.9	7.9	6.6	5.6	4.9	3.9	3.3	2.5	2.0	1.7	1.2
55	R_c	374	299	249	213	187	149	125	93.4	74.7	62.3	46.7
	V_c High	22.3	17.9	14.9	12.8	11.2	8.9	7.4	5.6	4.5	3.7	2.8
	V_s	11.2	9.0	7.4	6.4	5.6	4.4	3.7	2.8	2.2	1.8	1.4
	V Low	9.2	7.4	6.2	5.3	4.6	3.7	3.1	2.3	1.9	1.5	1.2
60	R_c	334	267	223	191	167	134	111	83.6	66.9	55.7	41.8
	V_c High	21.1	16.9	14.1	12.1	10.6	8.4	7.0	5.3	4.2	3.5	2.6
	V_s	10.6	8.4	7.0	6.0	5.3	4.2	3.5	2.6	2.1	1.8	1.3
	V Low	8.7	7.0	5.8	5.0	4.4	3.5	2.9	2.2	1.7	1.4	1.1
65	R_c	305	244	204	174	153	122	102	76.3	61.0	50.9	38.2
	V_c High	20.2	16.1	13.4	11.5	10.1	8.1	6.7	5.0	4.0	3.4	2.5
	V_s	10.1	8.0	6.7	5.8	5.0	4.0	3.4	2.5	2.0	1.7	1.2
	V Low	8.4	6.7	5.6	4.8	4.2	3.4	2.8	2.1	1.7	1.4	1.0
70	R_c	284	227	189	162	142	114	94.6	71.0	56.8	47.3	35.5
	V_c High	19.5	15.6	13.0	11.1	9.7	7.8	6.5	4.9	3.9	3.2	2.4
	V_s	9.7	7.8	6.5	5.6	4.8	3.9	3.2	2.4	2.0	1.6	1.2
	V Low	8.1	6.5	5.4	4.6	4.0	3.2	2.7	2.0	1.6	1.3	1.0
75	R_c	269	215	179	154	134	107	89.6	67.2	53.7	44.8	33.6
	V_c High	18.9	15.1	12.6	10.8	9.5	7.6	6.3	4.7	3.8	3.2	2.4
	V_s	9.5	7.6	6.3	5.4	4.8	3.8	3.2	2.4	1.9	1.6	1.2
	V Low	7.8	6.3	5.2	4.5	3.9	3.1	2.6	1.9	1.6	1.3	1.0
80	R_c	259	207	172	148	129	103	86.2	64.6	51.7	43.1	32.3
	V_c High	18.6	14.9	12.4	10.6	9.3	7.4	6.2	4.6	3.7	3.1	2.3
	V_s	9.3	7.4	6.2	5.3	4.6	3.7	3.1	2.3	1.8	1.6	1.2
	V Low	7.7	6.2	5.1	4.4	3.9	3.1	2.6	1.9	1.5	1.3	1.0
85	R_c	253	202	168	144	126	101	84.2	63.2	50.5	42.1	31.6
	V_c High	18.4	14.7	12.2	10.5	9.2	7.3	6.1	4.6	3.7	3.1	2.3
	V_s	9.2	7.4	6.1	5.2	4.6	3.6	3.0	2.3	1.8	1.6	1.2
	V Low	7.6	6.1	5.1	4.3	3.8	3.0	2.5	1.9	1.5	1.3	1.0
90	R_c	251	201	167	143	125	100	83.6	62.7	50.1	41.8	31.3
	V_c High	18.3	14.6	12.2	10.4	9.1	7.3	6.1	4.6	3.7	3.0	2.3
	V_s	9.1	7.3	6.1	5.2	4.6	3.6	3.0	2.3	1.8	1.5	1.2
	V Low	7.6	6.0	5.1	4.3	3.8	3.0	2.5	1.9	1.5	1.2	1.0

REDUCTION OF TEMPERATURE TO SEA LEVEL.

REDUCTION OF TEMPERATURE TO SEA LEVEL.

ENGLISH MEASURES.

Rate of decrease of temperature. 1°F. for every	DIFFERENCES BETWEEN THE TEMPERATURE AT ANY ALTITUDE AND AT SEA LEVEL. ALTITUDE IN FEET.													
	100	200	300	400	500	600	700	800	900	1000	2000	3000	4000	5000
Feet.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
200	0°.50	1°.00	1°.50	2°.00	2°.50	3°.00	3°.50	4°.00	4°.50	5°.00	10°.00	15°.00	20°.00	25°.00
205	0.49	0.98	1.46	1.95	2.44	2.93	3.41	3.90	4.39	4.88	9.76	14.63	19.51	24.39
210	0.48	0.95	1.43	1.90	2.38	2.86	3.33	3.81	4.29	4.76	9.52	14.29	19.05	23.81
215	0.47	0.93	1.40	1.86	2.33	2.79	3.26	3.72	4.19	4.65	9.30	13.95	18.60	23.26
220	0.45	0.91	1.36	1.82	2.27	2.73	3.18	3.64	4.09	4.55	9.09	13.63	18.18	22.72
230	0.43	0.87	1.30	1.74	2.17	2.61	3.04	3.48	3.91	4.35	8.70	13.04	17.39	21.74
240	0.42	0.83	1.25	1.67	2.08	2.50	2.92	3.33	3.75	4.17	8.33	12.50	16.67	20.83
250	0.40	0.80	1.20	1.60	2.00	2.40	2.80	3.20	3.60	4.00	8.00	12.00	16.00	20.00
260	0.38	0.77	1.15	1.54	1.92	2.31	2.69	3.08	3.46	3.85	7.69	11.54	15.38	19.23
270	0.37	0.74	1.11	1.48	1.85	2.22	2.59	2.96	3.33	3.70	7.41	11.11	14.81	18.52
280	0.36	0.71	1.07	1.43	1.79	2.14	2.50	2.86	3.21	3.57	7.14	10.71	14.29	17.86
290	0.34	0.69	1.03	1.38	1.73	2.07	2.41	2.76	3.10	3.45	6.90	10.34	13.79	17.24
300	0.33	0.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	6.67	10.00	13.33	16.67
310	0.32	0.65	0.97	1.29	1.61	1.94	2.26	2.58	2.90	3.23	6.45	9.68	12.90	16.13
320	0.31	0.62	0.94	1.25	1.56	1.87	2.19	2.50	2.81	3.12	6.25	9.37	12.50	15.62
340	0.29	0.59	0.88	1.18	1.47	1.76	2.06	2.35	2.65	2.94	5.88	8.82	11.76	14.71
360	0.28	0.56	0.83	1.11	1.39	1.67	1.94	2.22	2.50	2.78	5.56	8.33	11.11	13.89
380	0.26	0.53	0.79	1.05	1.32	1.58	1.84	2.10	2.37	2.63	5.26	7.89	10.53	13.16
400	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	5.00	7.50	10.00	12.50
420	0.24	0.48	0.71	0.95	1.19	1.43	1.67	1.90	2.14	2.38	4.76	7.14	9.52	11.90
440	0.23	0.45	0.68	0.91	1.14	1.36	1.59	1.82	2.05	2.27	4.55	6.82	9.09	11.36
460	0.22	0.43	0.65	0.87	1.09	1.30	1.52	1.74	1.96	2.17	4.35	6.52	8.70	10.87
480	0.21	0.42	0.62	0.83	1.04	1.25	1.46	1.67	1.87	2.08	4.17	6.25	8.33	10.42
500	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	4.00	6.00	8.00	10.00
520	0.19	0.38	0.58	0.77	0.96	1.15	1.35	1.54	1.73	1.92	3.85	5.77	7.69	9.62
540	0.19	0.37	0.56	0.74	0.93	1.11	1.30	1.48	1.67	1.85	3.70	5.56	7.41	9.26
560	0.18	0.36	0.54	0.71	0.89	1.07	1.25	1.43	1.61	1.79	3.57	5.36	7.14	8.93
580	0.17	0.34	0.52	0.69	0.86	1.03	1.21	1.38	1.55	1.72	3.45	5.17	6.90	8.62
600	0.17	0.33	0.50	0.67	0.83	1.00	1.17	1.33	1.50	1.67	3.33	5.00	6.67	8.33
620	0.16	0.32	0.48	0.65	0.81	0.97	1.13	1.29	1.45	1.61	3.23	4.84	6.45	8.06
650	0.15	0.31	0.46	0.62	0.77	0.92	1.08	1.23	1.38	1.54	3.08	4.62	6.15	7.69
700	0.14	0.29	0.43	0.57	0.71	0.86	1.00	1.14	1.29	1.43	2.86	4.29	5.71	7.14
750	0.13	0.27	0.40	0.53	0.67	0.80	0.93	1.07	1.20	1.33	2.67	4.00	5.33	6.67
800	0.12	0.25	0.37	0.50	0.62	0.75	0.87	1.00	1.12	1.25	2.50	3.75	5.00	6.25
850	0.12	0.24	0.35	0.47	0.59	0.71	0.82	0.94	1.06	1.18	2.35	3.53	4.71	5.88
900	0.11	0.22	0.33	0.44	0.56	0.67	0.78	0.89	1.00	1.11	2.22	3.33	4.44	5.56

Tabular values are to be added to the observed temperature to obtain the temperature at sea level.

REDUCTION OF TEMPERATURE TO SEA LEVEL.

METRIC MEASURES.

Rate of decrease of temperature. 1°C. for every	DIFFERENCES BETWEEN THE TEMPERATURE AT ANY ALTITUDE AND AT SEA LEVEL. ALTITUDE IN METERS.											
	100	200	300	400	500	600	700	800	900	1000	2000	3000
m.	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.	C.
100	1°.00	2°.00	3°.00	4°.00	5°.00	6°.00	7°.00	8°.00	9°.00	10°.00	20°.00	30°.00
102	0.98	1.96	2.94	3.92	4.90	5.88	6.86	7.84	8.82	9.80	19.61	29.41
104	0.96	1.92	2.88	3.85	4.81	5.77	6.73	7.69	8.65	9.62	19.23	28.85
106	0.94	1.89	2.83	3.77	4.72	5.66	6.60	7.55	8.49	9.43	18.87	28.30
108	0.93	1.85	2.78	3.70	4.63	5.56	6.48	7.41	8.33	9.26	18.52	27.78
110	0.91	1.82	2.73	3.64	4.55	5.45	6.36	7.27	8.18	9.09	18.18	27.27
115	0.87	1.74	2.61	3.48	4.35	5.22	6.09	6.96	7.83	8.70	17.39	26.09
120	0.83	1.67	2.50	3.33	4.17	5.00	5.83	6.67	7.50	8.33	16.67	25.00
125	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00	16.00	24.00
130	0.77	1.54	2.31	3.08	3.85	4.62	5.38	6.15	6.92	7.69	15.38	23.08
135	0.74	1.48	2.22	2.96	3.70	4.44	5.19	5.93	6.66	7.41	14.81	22.22
140	0.71	1.43	2.14	2.86	3.57	4.29	5.00	5.71	6.43	7.14	14.29	21.43
145	0.69	1.38	2.07	2.76	3.45	4.14	4.83	5.52	6.21	6.90	13.79	20.69
150	0.67	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	13.33	20.00
155	0.65	1.29	1.94	2.58	3.23	3.87	4.52	5.16	5.81	6.45	12.90	19.35
160	0.62	1.25	1.87	2.50	3.12	3.75	4.37	5.00	5.62	6.25	12.50	18.75
170	0.59	1.18	1.76	2.35	2.94	3.53	4.12	4.70	5.29	5.88	11.76	17.65
180	0.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.00	5.56	11.11	16.67
190	0.53	1.05	1.58	2.10	2.63	3.16	3.68	4.21	4.74	5.26	10.53	15.79
200	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	10.00	15.00
210	0.48	0.95	1.43	1.90	2.38	2.86	3.33	3.81	4.29	4.76	9.52	14.29
220	0.45	0.91	1.36	1.82	2.27	2.73	3.18	3.64	4.09	4.55	9.09	13.64
230	0.43	0.87	1.30	1.74	2.17	2.61	3.04	3.48	3.91	4.35	8.70	13.04
240	0.42	0.83	1.25	1.67	2.08	2.50	2.92	3.33	3.75	4.17	8.33	12.50
250	0.40	0.80	1.20	1.60	2.00	2.40	2.80	3.20	3.60	4.00	8.00	12.00
260	0.38	0.77	1.15	1.54	1.92	2.31	2.69	3.08	3.46	3.85	7.69	11.54
270	0.37	0.74	1.11	1.48	1.85	2.22	2.59	2.96	3.33	3.70	7.41	11.11
280	0.36	0.71	1.07	1.43	1.79	2.14	2.50	2.86	3.21	3.57	7.14	10.71
290	0.34	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	3.45	6.90	10.34
300	0.33	0.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	6.67	10.00
320	0.31	0.62	0.94	1.25	1.56	1.87	2.19	2.50	2.81	3.12	6.25	9.37
340	0.29	0.59	0.88	1.18	1.47	1.76	2.06	2.35	2.65	2.94	5.88	8.82
360	0.28	0.56	0.83	1.11	1.39	1.67	1.94	2.22	2.50	2.78	5.56	8.33
380	0.26	0.53	0.79	1.05	1.32	1.58	1.84	2.10	2.37	2.63	5.26	7.89
400	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	5.00	7.50
420	0.24	0.48	0.71	0.95	1.19	1.43	1.67	1.90	2.14	2.38	4.76	7.14
440	0.23	0.45	0.68	0.91	1.14	1.36	1.59	1.82	2.05	2.27	4.55	6.82
460	0.22	0.43	0.65	0.87	1.09	1.30	1.52	1.74	1.96	2.17	4.35	6.52
480	0.21	0.42	0.62	0.83	1.04	1.25	1.46	1.67	1.87	2.08	4.17	6.25
500	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	4.00	6.00

Tabular values are to be added to the observed temperature to obtain the temperature at sea level.

BAROMETRICAL TABLES.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°.0	+0.050	+0.051	+0.052	+0.053	+0.055	+0.056	+0.057	+0.059	+0.060	+0.061
+0.5	+0.049	+0.050	+0.051	+0.053	+0.054	+0.055	+0.056	+0.058	+0.059	+0.060
1.0	.048	.049	.050	.052	.053	.054	.055	.057	.058	.059
1.5	.047	.048	.049	.051	.052	.053	.054	.056	.057	.058
2.0	.046	.047	.049	.050	.051	.052	.053	.055	.056	.057
2.5	.045	.046	.048	.049	.050	.051	.052	.054	.055	.056
3.0	+0.044	+0.046	+0.047	+0.048	+0.049	+0.050	+0.051	+0.053	+0.054	+0.055
3.5	.043	.045	.046	.047	.048	.049	.050	.051	.053	.054
4.0	.043	.044	.045	.046	.047	.048	.049	.050	.052	.053
4.5	.042	.043	.044	.045	.046	.047	.048	.049	.051	.052
5.0	.041	.042	.043	.044	.045	.046	.047	.048	.049	.051
5.5	+0.040	+0.041	+0.042	+0.043	+0.044	+0.045	+0.046	+0.047	+0.048	+0.049
6.0	.039	.040	.041	.042	.043	.044	.045	.046	.047	.048
6.5	.038	.039	.040	.041	.042	.043	.044	.045	.046	.047
7.0	.037	.038	.039	.040	.041	.042	.043	.044	.045	.046
7.5	.037	.038	.038	.039	.040	.041	.042	.043	.044	.045
8.0	+0.036	+0.037	+0.038	+0.038	+0.039	+0.040	+0.041	+0.042	+0.043	+0.044
8.5	.035	.036	.037	.038	.038	.039	.040	.041	.042	.043
9.0	.034	.035	.036	.037	.038	.038	.039	.040	.041	.042
9.5	.033	.034	.035	.036	.037	.037	.038	.039	.040	.041
10.0	.032	.033	.034	.035	.036	.036	.037	.038	.039	.040
10.5	+0.031	+0.032	+0.033	+0.034	+0.035	+0.035	+0.036	+0.037	+0.038	+0.039
11.0	.030	.031	.032	.033	.034	.034	.035	.036	.037	.038
11.5	.030	.030	.031	.032	.033	.034	.034	.035	.036	.037
12.0	.029	.030	.030	.031	.032	.033	.033	.034	.035	.036
12.5	.028	.029	.029	.030	.031	.032	.032	.033	.034	.034
13.0	+0.027	+0.028	+0.028	+0.029	+0.030	+0.031	+0.031	+0.032	+0.033	+0.033
13.5	.026	.027	.028	.028	.029	.030	.030	.031	.032	.032
14.0	.025	.026	.027	.027	.028	.029	.029	.030	.031	.031
14.5	.024	.025	.026	.026	.027	.028	.028	.029	.030	.030
15.0	.024	.024	.025	.025	.026	.027	.027	.028	.029	.029
15.5	+0.023	+0.023	+0.024	+0.024	+0.025	+0.026	+0.026	+0.027	+0.027	+0.028
16.0	.022	.023	.023	.024	.024	.025	.025	.026	.026	.027
16.5	.021	.022	.022	.023	.023	.024	.024	.025	.025	.026
17.0	.020	.021	.021	.022	.022	.023	.023	.024	.024	.025
17.5	.019	.020	.020	.021	.021	.022	.022	.023	.023	.024
18.0	+0.018	+0.019	+0.019	+0.020	+0.020	+0.021	+0.021	+0.022	+0.022	+0.023
18.5	.017	.018	.018	.019	.019	.020	.020	.021	.021	.022
19.0	.017	.017	.018	.018	.018	.019	.019	.020	.020	.021
19.5	.016	.016	.017	.017	.017	.018	.018	.019	.019	.020
20.0	.015	.015	.016	.016	.016	.017	.017	.018	.018	.018
20.5	+0.014	+0.014	+0.015	+0.015	+0.016	+0.016	+0.016	+0.017	+0.017	+0.017
21.0	.013	.014	.014	.014	.015	.015	.015	.016	.016	.016
21.5	.012	.013	.013	.013	.014	.014	.014	.015	.015	.015
22.0	.011	.012	.012	.012	.013	.013	.013	.014	.014	.014
22.5	.011	.011	.011	.011	.012	.012	.012	.013	.013	.013
23.0	+0.010	+0.010	+0.010	+0.010	+0.011	+0.011	+0.011	+0.012	+0.012	+0.012
23.5	.009	.009	.009	.010	.010	.010	.010	.011	.011	.011
24.0	.008	.008	.008	.009	.009	.009	.009	.010	.010	.010
24.5	.007	.007	.008	.008	.008	.008	.008	.009	.009	.009
25.0	.006	.006	.007	.007	.007	.007	.007	.008	.008	.008

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
25°.5	+0.005	+0.006	+0.006	+0.006	+0.006	+0.006	+0.006	+0.006	+0.007	+0.007
26.0	.005	.005	.005	.005	.005	.005	.005	.005	.005	.006
26.5	.004	.004	.004	.004	.004	.004	.004	.004	.004	.005
27.0	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
27.5	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
28.0	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001
28.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29.0	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
29.5	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
30.0	.002	.002	.002	.003	.003	.003	.003	.003	.003	.003
30.5	−0.003	−0.003	−0.003	−0.003	−0.004	−0.004	−0.004	−0.004	−0.004	−0.004
31.0	.004	.004	.004	.004	.005	.005	.005	.005	.005	.005
31.5	.005	.005	.005	.005	.005	.006	.006	.006	.006	.006
32.0	.006	.006	.006	.006	.006	.007	.007	.007	.007	.007
32.5	.007	.007	.007	.007	.007	.008	.008	.008	.008	.008
33.0	−0.008	−0.008	−0.008	−0.008	−0.008	−0.009	−0.009	−0.009	−0.009	−0.009
33.5	.008	.009	.009	.009	.009	.010	.010	.010	.010	.010
34.0	.009	.010	.010	.010	.010	.010	.011	.011	.011	.011
34.5	.010	.010	.011	.011	.011	.011	.012	.012	.012	.013
35.0	.011	.011	.012	.012	.012	.012	.013	.013	.013	.014
35.5	−0.012	−0.012	−0.012	−0.013	−0.013	−0.013	−0.014	−0.014	−0.014	−0.015
36.0	.013	.013	.013	.014	.014	.014	.015	.015	.015	.016
36.5	.014	.014	.014	.015	.015	.015	.016	.016	.016	.017
37.0	.014	.015	.015	.016	.016	.016	.017	.017	.017	.018
37.5	.015	.016	.016	.017	.017	.017	.018	.018	.019	.019
38.0	−0.016	−0.017	−0.017	−0.017	−0.018	−0.018	−0.019	−0.019	−0.020	−0.020
38.5	.017	.017	.018	.018	.019	.019	.020	.020	.021	.021
39.0	.018	.018	.019	.019	.020	.020	.021	.021	.022	.022
39.5	.019	.019	.020	.020	.021	.021	.022	.022	.023	.023
40.0	.020	.020	.021	.021	.022	.022	.023	.023	.024	.024
40.5	−0.020	−0.021	−0.022	−0.022	−0.023	−0.023	−0.024	−0.024	−0.025	−0.025
41.0	.021	.022	.022	.023	.024	.024	.025	.025	.026	.026
41.5	.022	.023	.023	.024	.025	.025	.026	.026	.027	.027
42.0	.023	.024	.024	.025	.025	.026	.027	.027	.028	.029
42.5	.024	.025	.025	.026	.026	.027	.028	.028	.029	.030
43.0	−0.025	−0.025	−0.026	−0.027	−0.027	−0.028	−0.029	−0.029	−0.030	−0.031
43.5	.026	.026	.027	.028	.028	.029	.030	.030	.031	.032
44.0	.026	.027	.028	.029	.029	.030	.031	.031	.032	.033
44.5	.027	.028	.029	.030	.030	.031	.032	.032	.033	.034
45.0	.028	.029	.030	.030	.031	.032	.033	.033	.034	.035
45.5	−0.029	−0.030	−0.031	−0.031	−0.032	−0.033	−0.034	−0.034	−0.035	−0.036
46.0	.030	.031	.031	.032	.033	.034	.035	.035	.036	.037
46.5	.031	.032	.032	.033	.034	.035	.036	.036	.037	.038
47.0	.032	.032	.033	.034	.035	.036	.037	.037	.038	.039
47.5	.033	.033	.034	.035	.036	.037	.038	.038	.039	.040
48.0	−0.033	−0.034	−0.035	−0.036	−0.037	−0.038	−0.039	−0.040	−0.040	−0.041
48.5	.034	.035	.036	.037	.038	.039	.040	.041	.041	.042
49.0	.035	.036	.037	.038	.039	.040	.041	.042	.042	.043
49.5	.036	.037	.038	.039	.040	.041	.042	.043	.044	.044
50.0	.037	.038	.039	.040	.041	.042	.043	.044	0.45	.046

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
50°.5	−0.038	−0.039	−0.040	−0.041	−0.042	−0.043	−0.044	−0.045	−0.046	−0.047
51.0	.039	.040	.041	.042	.043	.044	.045	.046	0.47	.048
51.5	.039	.040	.041	.042	.044	.045	.046	.047	.048	.049
52.0	.040	.041	.042	.043	.044	.046	.047	.048	.049	.050
52.5	.041	.042	.043	.044	.045	.047	.048	.049	.050	.051
53.0	−0.042	−0.043	−0.044	−0.045	−0.046	−0.047	−0.049	−0.050	−0.051	−0.052
53.5	.043	.044	.045	.046	.047	.048	.050	.051	.052	.053
54.0	.044	.045	.046	.047	.048	.049	.051	.052	.053	.054
54.5	.045	.046	.047	.048	.049	.050	.052	.053	.054	.055
55.0	.045	.047	.048	.049	.050	.051	.053	.054	.055	.056
55.5	−0.046	−0.047	−0.049	−0.050	−0.051	−0.052	−0.054	−0.055	−0.056	−0.057
56.0	.047	.048	.050	.051	.052	.053	.055	.056	.057	.058
56.5	.048	.049	.050	.052	.053	.054	.056	.057	.058	.059
57.0	.049	.050	.051	.053	.054	.055	.057	.058	.059	.060
57.5	.050	.051	.052	.054	.055	.056	.058	.059	.060	.061
58.0	−0.051	−0.052	−0.053	−0.055	−0.056	−0.057	−0.059	−0.060	−0.061	−0.063
58.5	.051	.053	.054	.055	.057	.058	.060	.061	.062	.064
59.0	.052	.054	.055	.056	.058	.059	.061	.062	.063	.065
59.5	.053	.055	.056	.057	.059	.060	.061	.063	.064	.066
60.0	.054	.055	.057	.058	.060	.061	.062	.064	.065	.067
60.5	−0.055	−0.056	−0.058	−0.059	−0.061	−0.062	−0.063	−0.065	−0.066	−0.068
61.0	.056	.057	.059	.060	.062	.063	.064	.066	.067	.069
61.5	.057	.058	.060	.061	.062	.064	.065	.067	.068	.070
62.0	.057	.059	.060	.062	.063	.065	.066	.068	.069	.071
62.5	.058	.060	.061	.063	.064	.066	.067	.069	.071	.072
63.0	−0.059	−0.061	−0.062	−0.064	−0.065	−0.067	−0.068	−0.070	−0.072	−0.073
63.5	.060	.062	.063	.065	.066	0.68	.069	.071	.073	.074
64.0	.061	.062	.064	.066	.067	.069	.070	.072	.074	.075
64.5	.062	.063	.065	.067	.068	.070	.071	.073	.075	.076
65.0	.063	.064	.066	.067	.069	.071	.072	.074	.076	.077
65.5	−0.063	−0.065	−0.067	−0.068	−0.070	−0.072	−0.073	−0.075	−0.077	−0.078
66.0	.064	.066	.068	.069	.071	.073	.074	.076	.078	.079
66.5	.065	.067	.069	.070	.072	.074	.075	.077	.079	.081
67.0	.066	.068	.069	.071	.073	.075	.076	.078	.080	.082
67.5	.067	.069	.070	.072	.074	.076	.077	.079	.081	.083
68.0	−0.068	−0.069	−0.071	−0.073	−0.075	−0.077	−0.078	−0.080	−0.082	−0.084
68.5	.069	.070	.072	.074	.076	.078	.079	.081	.083	.085
69.0	.069	.071	.073	.075	.077	.079	.080	.082	.084	.086
69.5	.070	.072	.074	.076	.078	.079	.081	.083	.085	.087
70.0	.071	.073	.075	.077	.079	.080	.082	.084	.086	.088
70.5	−0.072	−0.074	−0.076	−0.078	−0.080	−0.081	−0.083	−0.085	−0.087	−0.089
71.0	.073	.075	.077	.079	.080	.082	.084	.086	.088	.090
71.5	.074	.076	.078	.079	.081	.083	.085	.087	.089	.091
72.0	.075	.076	.078	.080	.082	.084	.086	.088	.090	.092
72.5	.075	.077	.079	.081	.083	.085	.087	.089	.091	.093
73.0	−0.076	−0.078	−0.080	−0.082	−0.084	−0.086	−0.088	−0.090	−0.092	−0.094
73.5	.077	.079	.081	.083	.085	.087	.089	.091	.093	.095
74.0	.078	.080	.082	.084	.086	.088	.090	.092	.094	.096
74.5	.079	.081	.083	.085	.087	.089	.091	.093	.095	.097
75.0	.080	.082	.084	.086	.088	.090	.092	.094	.096	.099

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
75°.5	−0.081	−0.083	−0.085	−0.087	−0.089	−0.091	−0.093	−0.095	−0.097	−0.100
76.0	.081	.084	.086	.088	.090	.092	.094	.096	.098	.101
76.5	.082	.084	.087	.089	.091	.093	.095	.097	.100	.102
77.0	.083	.085	.087	.090	.092	.094	.096	.098	.101	.103
77.5	.084	.086	.088	.091	.093	.095	.097	.099	.102	.104
78.0	−0.085	−0.087	−0.089	−0.091	−0.094	−0.096	−0.098	−0.100	−0.103	−0.105
78.5	.086	.088	.090	.092	.095	.097	.099	.101	.104	.106
79.0	.086	.089	.091	.093	.096	.098	.100	.102	.105	.107
79.5	.087	.090	.092	.094	.097	.099	.101	.103	.106	.108
80.0	.088	.091	.093	.095	.097	.100	.102	.104	.107	.109
80.5	−0.089	−0.091	−0.094	−0.096	−0.098	−0.101	−0.103	−0.105	−0.108	−0.110
81.0	.090	.092	.095	.097	.099	.102	.104	.106	.109	.111
81.5	.091	.093	.096	.098	.100	.103	.105	.107	.110	.112
82.0	.092	.094	.096	.099	.101	.104	.106	.108	.111	.113
82.5	.092	.095	.097	.100	.102	.105	.107	.109	.112	.114
83.0	−0.093	−0.096	−0.098	−0.101	−0.103	−0.106	−0.108	−0.111	−0.113	−0.115
83.5	.094	.097	.099	.102	.104	.107	.109	.112	.114	.117
84.0	.095	.098	.100	.103	.105	.108	.110	.113	.115	.118
84.5	.096	.098	.101	.103	.106	.108	.111	.114	.116	.119
85.0	.097	.099	.102	.104	.107	.109	.112	.115	.117	.120
85.5	−0.098	−0.100	−0.103	−0.105	−0.108	−0.110	−0.113	−0.116	−0.118	−0.121
86.0	.098	.101	.104	.106	.109	.111	.114	.117	.119	.122
86.5	.099	.102	.105	.107	.110	.112	.115	.118	.120	.123
87.0	.100	.103	.105	.108	.111	.113	.116	.119	.121	.124
87.5	.101	.104	.106	.109	.112	.114	.117	.120	.122	.125
88.0	−0.102	−0.105	−0.107	−0.110	−0.113	−0.115	−0.118	−0.121	−0.123	−0.126
88.5	.103	.105	.108	.111	.114	.116	.119	.122	.124	.127
89.0	.104	.106	.109	.112	.114	.117	.120	.123	.125	.128
89.5	.104	.107	.110	.113	.115	.118	.121	.124	.126	.129
90.0	.105	.108	.111	.114	.116	.119	.122	.125	.127	.130
90.5	−0.106	−0.109	−0.112	−0.114	−0.117	−0.120	−0.123	−0.126	−0.128	−0.131
91.0	.107	.110	.113	.115	.118	.121	.124	.127	.129	.132
91.5	.108	.111	.113	.116	.119	.122	.125	.128	.131	.133
92.0	.109	.112	.114	.117	.120	.123	.126	.129	.132	.134
92.5	.110	.112	.115	.118	.121	.124	.127	.130	.133	.135
93.0	−0.110	−0.113	−0.116	−0.119	−0.122	−0.125	−0.128	−0.131	−0.134	−0.137
93.5	.111	.114	.117	.120	.123	.126	.129	.132	.135	.138
94.0	.112	.115	.118	.121	.124	.127	.130	.133	.136	.139
94.5	.113	.116	.119	.122	.125	.128	.131	.134	.137	.140
95.0	.114	.117	.120	.123	.126	.129	.132	.135	.138	.141
95.5	−0.115	−0.118	−0.121	−0.124	−0.127	−0.130	−0.133	−0.136	−0.139	−0.142
96.0	.115	.119	.122	.125	.128	.131	.134	.137	.140	.143
96.5	.116	.119	.122	.126	.129	.132	.135	.138	.141	.144
97.0	.117	.120	.123	.126	.130	.133	.136	.139	.142	.145
97.5	.118	.121	.124	.127	.130	.134	.137	.140	.143	.146
98.0	−0.119	−0.122	−0.125	−0.128	−0.131	−0.135	−0.138	−0.141	−0.144	−0.147
98.5	.120	.123	.126	.129	.132	.135	.139	.142	.145	.148
99.0	.121	.124	.127	.130	.133	.136	.140	.143	.146	.149
99.5	.121	.125	.128	.131	.134	.137	.141	.144	.147	.150
100.0	.122	.126	.129	.132	.135	.138	.142	.145	.148	.151

TABLE 46.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°.0	+0.063	+0.063	+0.064	+0.064	+0.065	+0.065	+0.066	+0.066	+0.067	+0.067
+0.5	+0.061	+0.062	+0.063	+0.063	+0.064	+0.064	+0.065	+0.065	+0.066	+0.066
1.0	.060	.061	.061	.062	.062	.063	.063	.064	.064	.065
1.5	.059	.060	.060	.061	.061	.062	.062	.063	.063	.064
2.0	.058	.059	.059	.060	.060	.061	.061	.062	.062	.063
2.5	.057	.058	.058	.059	.059	.059	.060	.060	.061	.061
3.0	+0.056	+0.056	+0.057	+0.057	+0.058	+0.058	+0.059	+0.059	+0.060	+0.060
3.5	.055	.055	.056	.056	.057	.057	.058	.058	.059	.059
4.0	.054	.054	.055	.055	.056	.056	.057	.057	.057	.058
4.5	.053	.053	.054	.054	.054	.055	.055	.056	.056	.057
5.0	.052	.052	.052	.053	.053	.054	.054	.055	.055	.056
5.5	+0.051	+0.051	+0.051	+0.052	+0.052	+0.053	+0.053	+0.053	+0.054	+0.054
6.0	.049	.050	.050	.051	.051	.052	.052	.052	.053	.053
6.5	.048	.049	.049	.050	.050	.050	.051	.051	.052	.052
7.0	.047	.048	.048	.048	.049	.049	.050	.050	.050	.051
7.5	.046	.047	.047	.047	.048	.048	.048	.049	.049	.050
8.0	+0.045	+0.045	+0.046	+0.046	+0.047	+0.047	+0.047	+0.048	+0.048	+0.048
8.5	.044	.044	.045	.045	.045	.046	.046	.047	.047	.047
9.0	.043	.043	.044	.044	.044	.045	.045	.045	.046	.046
9.5	.042	.042	.042	.043	.043	.044	.044	.044	.045	.045
10.0	.041	.041	.041	.042	.042	.042	.043	.043	.043	.044
10.5	+0.040	+0.040	+0.040	+0.041	+0.041	+0.041	+0.042	+0.042	+0.042	+0.043
11.0	.039	.039	.039	.039	.040	.040	.040	.041	.041	.041
11.5	.037	.038	.038	.038	.039	.039	.039	.040	.040	.040
12.0	.036	.037	.037	.037	.038	.038	.038	.038	.039	.039
12.5	.035	.036	.036	.036	.036	.037	.037	.037	.038	.038
13.0	+0.034	+0.034	+0.035	+0.035	+0.035	+0.036	+0.036	+0.036	+0.036	+0.037
13.5	.033	.033	.034	.034	.034	.034	.035	.035	.035	.036
14.0	.032	.032	.032	.033	.033	.033	.034	.034	.034	.034
14.5	.031	.031	.031	.032	.032	.032	.032	.033	.033	.033
15.0	.030	.030	.030	.030	.031	.031	.031	.031	.032	.032
15.5	+0.029	+0.029	+0.029	+0.029	+0.030	+0.030	+0.030	+0.030	+0.031	+0.031
16.0	.028	.028	.028	.028	.028	.029	.029	.029	.029	.030
16.5	.026	.027	.027	.027	.027	.028	.028	.028	.028	.028
17.0	.025	.026	.026	.026	.026	.026	.027	.027	.027	.027
17.5	.024	.024	.025	.025	.025	.025	.026	.026	.026	.026
18.0	+0.023	+0.023	+0.024	+0.024	+0.024	+0.024	+0.024	+0.025	+0.025	+0.025
18.5	.022	.022	.022	.023	.023	.023	.023	.023	.024	.024
19.0	.021	.021	.021	.022	.022	.022	.022	.022	.022	.023
19.5	.020	.020	.020	.020	.021	.021	.021	.021	.021	.021
20.0	.019	.019	.019	.019	.019	.020	.020	.020	.020	.020
20.5	+0.018	+0.018	+0.018	+0.018	+0.018	+0.018	+0.019	+0.019	+0.019	+0.019
21.0	.017	.017	.017	.017	.017	.017	.017	.018	.018	.018
21.5	.016	.016	.016	.016	.016	.016	.016	.016	.017	.017
22.0	.014	.015	.015	.015	.015	.015	.015	.015	.015	.016
22.5	.013	.013	.014	.014	.014	.014	.014	.014	.014	.014
23.0	+0.012	+0.012	+0.012	+0.013	+0.013	+0.013	+0.013	+0.013	+0.013	+0.013
23.5	.011	.011	.011	.011	.012	.012	.012	.012	.012	.012
24.0	.010	.010	.010	.010	.010	.011	.011	.011	.011	.011
24.5	.009	.009	.009	.009	.009	.009	.009	.010	.010	.010
25.0	.008	.008	.008	.008	.008	.008	.008	.008	.008	.009

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
25°.5	+0.007	+0.007	+0.007	+0.007	+0.007	+0.007	+0.007	+0.007	+0.007	+0.007
26.0	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
26.5	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
27.0	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004
27.5	.002	.002	.003	.003	.003	.003	.003	.003	.003	.003
28.0	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001
28.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29.0	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
29.5	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
30.0	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
30.5	−0.004	−0.004	−0.004	−0.004	−0.004	−0.004	−0.004	−0.004	−0.004	−0.004
31.0	.005	.005	.005	.005	.005	.005	.005	.005	.006	.006
31.5	.006	.006	.006	.006	.006	.007	.007	.007	.007	.007
32.0	.007	.007	.007	.008	.008	.008	.008	.008	.008	.008
32.5	.008	.009	.009	.009	.009	.009	.009	.009	.009	.009
33.0	−0.010	−0.010	−0.010	−0.010	−0.010	−0.010	−0.010	−0.010	−0.010	−0.010
33.5	.011	.011	.011	.011	.011	.011	.011	.011	.011	.011
34.0	.012	.012	.012	.012	.012	.012	.012	.012	.012	.013
34.5	.013	.013	.013	.013	.013	.013	.013	.014	.014	.014
35.0	.014	.014	.014	.014	.014	.014	.015	.015	.015	.015
35.5	−0.015	−0.015	−0.015	−0.015	−0.015	−0.016	−0.016	−0.016	−0.016	−0.016
36.0	.016	.016	.016	.016	.017	.017	.017	.017	.017	.017
36.5	.017	.017	.017	.018	.018	.018	.018	.018	.018	.018
37.0	.018	.018	.019	.019	.019	.019	.019	.019	.019	.019
37.5	.019	.019	.020	.020	.020	.020	.020	.020	.021	.021
38.0	−0.020	−0.021	−0.021	−0.021	−0.021	−0.021	−0.021	−0.022	−0.022	−0.022
38.5	.021	.022	.022	.022	.022	.022	.023	.023	.023	.023
39.0	.023	.023	.023	.023	.023	.024	.024	.024	.024	.024
39.5	.024	.024	.024	.024	.024	.025	.025	.025	.025	.025
40.0	.025	.025	.025	.025	.026	.026	.026	.026	.026	.027
40.5	−0.026	−0.026	−0.026	−0.026	−0.027	−0.027	−0.027	−0.027	−0.028	−0.028
41.0	.027	.027	.027	.028	.028	.028	.028	.029	.029	.029
41.5	.028	.028	.028	.029	.029	.029	.029	.030	.030	.030
42.0	.029	.029	.030	.030	.030	.030	.031	.031	.031	.031
42.5	.030	.030	.031	.031	.031	.031	.032	.032	.032	.032
43.0	−0.031	−0.032	−0.032	−0.032	−0.032	−0.033	−0.033	−0.033	−0.033	−0.034
43.5	.032	.033	.033	.033	.033	.034	.034	.034	.035	.035
44.0	.033	.034	.034	.034	.035	.035	.035	.035	.036	.036
44.5	.035	.035	.035	.035	.036	.036	.036	.037	.037	.037
45.0	.036	.036	.036	.037	.037	.037	.037	.038	.038	.038
45.5	−0.037	−0.037	−0.037	−0.038	−0.038	−0.038	−0.039	−0.039	−0.039	−0.039
46.0	.038	.038	.038	.039	.039	.039	.040	.040	.040	.041
46.5	.039	.039	.040	.040	.040	.041	.041	.041	.041	.042
47.0	.040	.040	.041	.041	.041	.042	.042	.042	.043	.043
47.5	.041	.041	.042	.042	.042	.043	.043	.043	.044	.044
48.0	−0.042	−0.042	−0.043	−0.043	−0.044	−0.044	−0.044	−0.045	−0.045	−0.045
48.5	.043	.044	.044	.044	.045	.045	.045	.046	.046	.046
49.0	.044	.045	.045	.045	.046	.046	.047	.047	.047	.048
49.5	.045	.046	.046	.047	.047	.047	.048	.048	.048	.049
50.0	.046	.047	.047	.048	.048	.048	.049	.049	.050	.050

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
50°.5	−0.048	−0.048	−0.048	−0.049	−0.049	−0.050	−0.050	−0.050	−0.051	−0.051
51.0	.049	.049	.049	.050	.050	.051	.051	.051	.052	.052
51.5	.050	.050	.051	.051	.051	.052	.052	.053	.053	.053
52.0	.051	.051	.052	.052	.053	.053	.053	.054	.054	.055
52.5	.052	.052	.053	.053	.054	.054	.055	.055	.055	.056
53.0	−0.053	−0.053	−0.054	−0.054	−0.055	−0.055	−0.056	−0.056	−0.057	−0.057
53.5	.054	.055	.055	.055	.056	.056	.057	.057	.058	.058
54.0	.055	.056	.056	.057	.057	.057	.058	.058	.059	.059
54.5	.056	.057	.057	.058	.058	.059	.059	.060	.060	.060
55.0	.057	.058	.058	.059	.059	.060	.060	.061	.061	.062
55.5	−0.058	−0.059	−0.059	−0.060	−0.060	−0.061	−0.061	−0.062	−0.062	−0.063
56.0	.060	.060	.060	.061	.061	.062	.062	.063	.063	.064
56.5	.061	.061	.062	.062	.063	.063	.064	.064	.065	.065
57.0	.062	.062	.063	.063	.064	.064	.065	.065	.066	.066
57.5	.063	.063	.064	.064	.065	.065	.066	.066	.067	.067
58.0	−0.064	−0.064	−0.065	−0.065	−0.066	−0.066	−0.067	−0.068	−0.068	−0.069
58.5	.065	.065	.066	.067	.067	.068	.068	.069	.069	.070
59.0	.066	.067	.067	.068	.068	.069	.069	.070	.070	.071
59.5	.067	.068	.068	.069	.069	.070	.070	.071	.072	.072
60.0	.068	.069	.069	.070	.070	.071	.072	.072	.073	.073
60.5	−0.069	−0.070	−0.070	−0.071	−0.072	−0.072	−0.073	−0.073	−0.074	−0.074
61.0	.070	.071	.072	.072	.073	.073	.074	.074	.075	.076
61.5	.071	.072	.073	.073	.074	.074	.075	.076	.076	.077
62.0	.073	.073	.074	.074	.075	.076	.076	.077	.077	.078
62.5	.074	.074	.075	.075	.076	.077	.077	.078	.078	.079
63.0	−0.075	−0.075	−0.076	−0.077	−0.077	−0.078	−0.078	−0.079	−0.080	−0.080
63.5	.076	.076	.077	.078	.078	.079	.080	.080	.081	.081
64.0	.077	.077	.078	.079	.079	.080	.081	.081	.082	.082
64.5	.078	.079	.079	.080	.081	.081	.082	.082	.083	.084
65.0	.079	.080	.080	.081	.082	.082	.083	.084	.084	.085
65.5	−0.080	−0.081	−0.081	−0.082	−0.083	−0.083	−0.084	−0.085	−0.085	−0.086
66.0	.081	.082	.083	.083	.084	.085	.085	.086	.087	.087
66.5	.082	.083	.084	.084	.085	.086	.086	.087	.088	.088
67.0	.083	.084	.085	.085	.086	.087	.087	.088	.089	.090
67.5	.084	.085	.086	.087	.087	.088	.089	.089	.090	.091
68.0	−0.085	−0.086	−0.087	−0.088	−0.088	−0.089	−0.090	−0.090	−0.091	−0.092
68.5	.087	.087	.088	.089	.089	.090	.091	.092	.092	.093
69.0	.088	.088	.089	.090	.091	.091	.092	.093	.093	.094
69.5	.089	.089	.090	.091	.092	.092	.093	.094	.095	.095
70.0	.090	.091	.091	.092	.093	.094	.094	.095	.096	.097
70.5	−0.091	−0.092	−0.092	−0.093	−0.094	−0.095	−0.095	−0.096	−0.097	−0.098
71.0	.092	.093	.094	.094	.095	.096	.097	.097	.098	.099
71.5	.093	.094	.095	.095	.096	.097	.098	.098	.099	.100
72.0	.094	.095	.096	.096	.097	.098	.099	.100	.100	.101
72.5	.095	.096	.097	.098	.098	.099	.100	.101	.102	.102
73.0	−0.096	−0.097	−0.098	−0.099	−0.100	−0.100	−0.101	−0.102	−0.103	−0.104
73.5	.097	.098	.099	.100	.101	.101	.102	.103	.104	.105
74.0	.098	.099	.100	.101	.102	.103	.103	.104	.105	.106
74.5	.100	.100	.101	.102	.103	.104	.105	.105	.106	.107
75.0	.101	.101	.102	.103	.104	.105	.106	.106	.107	.108

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
75°.5	−0.102	−0.103	−0.103	−0.104	−0.105	−0.106	−0.107	−0.108	−0.108	−0.109
76.0	.103	.104	.104	.105	.106	.107	.108	.109	.110	.110
76.5	.104	.105	.106	.106	.107	.108	.109	.110	.111	.112
77.0	.105	.106	.107	.108	.108	.109	.110	.111	.112	.113
77.5	.106	.107	.108	.109	.110	.110	.111	.112	.113	.114
78.0	−0.107	−0.108	−0.109	−0.110	−0.111	−0.112	−0.112	−0.113	−0.114	−0.115
78.5	.108	.109	.110	.111	.112	.113	.114	.114	.115	.116
79.0	.109	.110	.111	.112	.113	.114	.115	.116	.117	.117
79.5	.110	.111	.112	.113	.114	.115	.116	.117	.118	.119
80.0	.111	.112	.113	.114	.115	.116	.117	.118	.119	.120
80.5	−0.112	−0.113	−0.114	−0.115	−0.116	−0.117	−0.118	−0.119	−0.120	−0.121
81.0	.114	.115	.115	.116	.117	.118	.119	.120	.121	.122
81.5	.115	.116	.117	.118	.118	.119	.120	.121	.122	.123
82.0	.116	.117	.118	.119	.120	.121	.122	.122	.123	.124
82.5	.117	.118	.119	.120	.121	.122	.123	.124	.125	.126
83.0	−0.118	−0.119	−0.120	−0.121	−0.122	−0.123	−0.124	−0.125	−0.126	−0.127
83.5	.119	.120	.121	.122	.123	.124	.125	.126	.127	.128
84.0	.120	.121	.122	.123	.124	.125	.126	.127	.128	.129
84.5	.121	.122	.123	.124	.125	.126	.127	.128	.129	.130
85.0	.122	.123	.124	.125	.126	.127	.128	.129	.130	.131
85.5	−0.123	−0.124	−0.125	−0.126	−0.127	−0.128	−0.129	−0.130	−0.131	−0.133
86.0	.124	.125	.126	.127	.128	.130	.131	.132	.133	.134
86.5	.125	.126	.128	.129	.130	.131	.132	.133	.134	.135
87.0	.126	.128	.129	.130	.131	.132	.133	.134	.135	.136
87.5	.128	.129	.130	.131	.132	.133	.134	.135	.136	.137
88.0	−0.129	−0.130	−0.131	−0.132	−0.133	−0.134	−0.135	−0.136	−0.137	−0.138
88.5	.130	.131	.132	.133	.134	.135	.136	.137	.138	.139
89.0	.131	.132	.133	.134	.135	.136	.137	.138	.140	.141
89.5	.132	.133	.134	.135	.136	.137	.138	.140	.141	.142
90.0	.133	.134	.135	.136	.137	.138	.140	.141	.142	.143
90.5	−0.134	−0.135	−0.136	−0.137	−01.39	−0.140	−0.141	−0.142	−0.143	−0.144
91.0	.135	.136	.137	.138	.140	.141	.142	.143	.144	.145
91.5	.136	.137	.138	.140	.141	.142	.143	.144	.145	.146
92.0	.137	.138	.140	.141	.142	.143	.144	.145	.146	.148
92.5	.138	.139	.141	.142	.143	.144	.145	.146	.148	.149
93.0	−0.139	−0.141	−0.142	−0.143	−0.144	−0.145	−0.146	−0.148	−0.149	−0.150
93.5	.140	.142	.143	.144	.145	.146	.148	.149	.150	.151
94.0	.142	.143	.144	.145	.146	.147	.149	.150	.151	.152
94.5	.143	.144	.145	.146	.147	.149	.150	.151	.152	.153
95.0	.144	.145	.146	.147	.149	.150	.151	.152	.153	.154
95.5	−0.145	−0.146	−0.147	−0.148	−0.150	−0.151	−0.152	−0.153	−0.154	−0.156
96.0	.146	.147	.148	.150	.151	.152	.153	.154	.156	.157
96.5	.147	.148	.149	.151	.152	.153	.154	.156	.157	.158
97.0	.148	.149	.150	.152	.153	.154	.155	.157	.158	.159
97.5	.149	.150	.152	.153	.154	.155	.157	.158	.159	.160
98.0	−0.150	−0.151	−0.153	−0.154	−0.155	−0.156	−0.158	−0.159	−0.160	−0.161
98.5	.151	.153	.154	.155	.156	.158	.159	.160	.161	.163
99.0	.152	.154	.155	.156	.157	.159	.160	.161	.162	.164
99.5	.153	.155	.156	.157	.159	.160	.161	.162	.164	.165
100.0	.154	.156	.157	.158	.160	.161	.162	.163	.165	.166

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	26.0	26.2	26.4	26.6	26.8	27.0	27.2	27.4	27.6	27.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°.0	+0.068	+0.068	+0.069	+0.069	+0.070	+0.070	+0.071	+0.071	+0.072	+0.072
+0.5	+0.067	+0.067	+0.068	+0.068	+0.069	+0.069	+0.070	+0.070	+0.071	+0.071
1.0	.065	.066	.066	.067	.067	.068	.068	.069	.069	.070
1.5	.064	.065	.065	.066	.066	.067	.067	.068	.068	.069
2.0	.063	.064	.064	.065	.065	.065	.066	.066	.067	.067
2.5	.062	.062	.063	.063	.064	.064	.065	.065	.066	.066
3.0	+0.061	+0.061	+0.062	+0.062	+0.063	+0.063	+0.063	+0.064	+0.064	+0.065
3.5	.059	.060	.060	.061	.061	.062	.062	.063	.063	.064
4.0	.058	.059	.059	.060	.060	.061	.061	.061	.062	.062
4.5	.057	.058	.058	.058	.059	.059	.060	.060	.061	.061
5.0	.056	.056	.057	.057	.058	.058	.059	.059	.059	.060
5.5	+0.055	+0.055	+0.056	+0.056	+0.056	+0.057	+0.057	+0.058	+0.058	+0.059
6.0	.054	.054	.054	.055	.055	.056	.056	.056	.057	.057
6.5	.052	.053	.053	.054	.054	.054	.055	.055	.056	.056
7.0	.051	.052	.052	.052	.053	.053	.054	.054	.054	.055
7.5	.050	.050	.051	.051	.052	.052	.052	.053	.053	.053
8.0	+0.049	+0.049	+0.050	+0.050	+0.050	+0.051	+0.051	+0.051	+0.052	+0.052
8.5	.048	.048	.048	.049	.049	.049	.050	.050	.051	.051
9.0	.046	.047	.047	.048	.048	.048	.049	.049	.049	.050
9.5	.045	.046	.046	.046	.047	.047	.047	.048	.048	.048
10.0	.044	.044	.045	.045	.045	.046	.046	.046	.047	.047
10.5	+0.043	+0.043	+0.044	+0.044	+0.044	+0.045	+0.045	+0.045	+0.046	+0.046
11.0	.042	.042	.042	.043	.043	.043	.044	.044	.044	.045
11.5	.041	.041	.041	.041	.042	.042	.042	.043	.043	.043
12.0	.039	.040	.040	.040	.041	.041	.041	.041	.042	.042
12.5	.038	.038	.039	.039	.039	.040	.040	.040	.040	.041
13.0	+0.037	+0.037	+0.038	+0.038	+0.038	+0.038	+0.039	+0.039	+0.039	+0.040
13.5	.036	.036	.036	.037	.037	.037	.037	.038	.038	.038
14.0	.035	.035	.035	.035	.036	.036	.036	.036	.037	.037
14.5	.033	.034	.034	.034	.034	.035	.035	.035	.035	.036
15.0	.032	.032	.033	.033	.033	.033	.034	.034	.034	.034
15.5	+0.031	+0.031	+0.032	+0.032	+0.032	+0.032	+0.032	+0.033	+0.033	+0.033
16.0	.030	.030	.030	.031	.031	.031	.031	.031	.032	.032
16.5	.029	.029	.029	.029	.030	.030	.030	.030	.030	.031
17.0	.027	.028	.028	.028	.028	.029	.029	.029	.029	.029
17.5	.026	.027	.027	.027	.027	.027	.028	.028	.028	.028
18.0	+0.025	+0.025	+0.026	+0.026	+0.026	+0.026	+0.026	+0.026	+0.027	+0.027
18.5	.024	.024	.024	.024	.025	.025	.025	.025	.025	.026
19.0	.023	.023	.023	.023	.023	.024	.024	.024	.024	.024
19.5	.022	.022	.022	.022	.022	.022	.023	.023	.023	.023
20.0	.020	.021	.021	.021	.021	.021	.021	.021	.022	.022
20.5	+0.019	+0.019	+0.020	+0.020	+0.020	+0.020	+0.020	+0.020	+0.020	+0.021
21.0	.018	.018	.018	.018	.019	.019	.019	.019	.019	.019
21.5	.017	.017	.017	.017	.017	.017	.018	.018	.018	.018
22.0	.016	.016	.016	.016	.016	.016	.016	.017	.017	.017
22.5	.014	.015	.015	.015	.015	.015	.015	.015	.015	.015
23.0	+0.013	+0.013	+0.014	+0.014	+0.014	+0.014	+0.014	+0.014	+0.014	+0.014
23.5	.012	.012	.012	.012	.012	.013	.013	.013	.013	.013
24.0	.011	.011	.011	.011	.011	.011	.011	.012	.012	.012
24.5	.010	.010	.010	.010	.010	.010	.010	.010	.010	.110
25.0	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	26.0	26.2	26.4	26.6	26.8	27.0	27.2	27.4	27.6	27.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
25°.5	+0.007	+0.007	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008
26.0	.006	.006	.006	.006	.006	.006	.006	.007	.007	.007
26.5	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005
27.0	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004
27.5	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
28.0	+0.001	+0.001	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002
28.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29.0	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
29.5	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
30.0	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
30.5	−0.004	−0.004	−0.004	−0 005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005
31.0	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
31.5	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
32.0	.008	.008	.008	.008	.008	.008	.008	.008	.008	.009
32.5	.009	.009	.009	.009	.009	.009	.010	.010	.010	.010
33.0	−0.010	−0.010	−0.010	−0.011	−0.011	−0.011	−0.011	−0.011	−0.011	−0.011
33.5	.011	.012	.012	.012	.012	.012	.012	.012	.012	.012
34.0	.013	.013	.013	.013	.013	.013	.013	.013	.013	.014
34.5	.014	.014	.014	.014	.014	.014	.014	.015	.015	.015
35.0	.015	.015	.015	.015	.015	.016	.016	.016	.016	.016
35.5	−0.016	−0.016	−0.016	−0.017	−0.017	−0.017	−0.017	−0.017	−0.017	−0.017
36.0	.017	.018	.018	.018	.018	.018	.018	.018	.018	.019
36.5	.019	.019	.019	.019	.019	.019	.019	.020	.020	.020
37.0	.020	.020	.020	.020	.020	.021	.021	.021	.021	.021
37.5	.021	.021	.021	.021	.022	.022	.022	.022	.022	.022
38.0	−0.022	−0.022	−0.022	−0.023	−0.023	−0.023	−0.023	−0.023	−0.023	−0.024
38.5	.023	.023	.024	.024	.024	.024	.024	.025	.025	.025
39.0	.024	.025	.025	.025	.025	.025	.026	.026	.026	.026
39.5	.026	.026	.026	.026	.026	.027	.027	.027	.027	.027
40.0	.027	.027	.027	.027	.028	.028	.028	.028	.028	.029
40.5	−0.028	−0.028	−0.028	−0.029	−0.029	−0.029	−0.029	−0.030	−0.030	−0.030
41.0	.029	.029	.030	.030	.030	.030	.031	.031	.031	.031
41.5	.030	.031	.031	.031	.031	.032	.032	.032	.032	.032
42.0	.032	.032	.032	.032	.033	.033	.033	.033	.033	.034
42.5	.033	.033	.033	.033	.034	.034	.034	.034	.035	.035
43.0	−0.034	−0.034	−0.034	−0.035	−0.035	−0.035	−0.035	−0.036	−0.036	−0.036
43.5	.035	.035	.036	.036	.036	.036	.037	.037	.037	.037
44.0	.036	.037	.037	.037	.037	.038	.038	.038	.038	.039
44.5	.037	.038	.038	.038	.039	.039	.039	.039	.040	.040
45.0	.039	.039	.039	.039	.040	.040	.040	.041	.041	.041
45.5	−0.040	−0.040	−0.040	−0.041	−0.041	−0.041	−0.042	−0.042	−0.042	−0.043
46.0	.041	.041	.042	.042	.042	.043	.043	.043	.043	.044
46.5	.042	.042	.043	.043	.043	.044	.044	.044	.045	.045
47.0	.043	.044	.044	.044	.045	.045	.045	.046	.046	.046
47.5	.045	.045	.045	.046	.046	.046	.047	.047	.047	.048
48.0	−0.046	−0.046	−0.046	−0.047	−0.047	−0.047	−0.048	−0.048	−0.048	−0.049
48.5	.047	.047	.048	.048	.048	.049	.049	.049	.050	.050
49.0	.048	.048	.049	.049	.049	.050	.050	.051	.051	.051
49.5	.049	.050	.050	.050	.051	.051	.051	.052	.052	.053
50.0	.050	.051	.051	.052	.052	.052	.053	.053	.053	.054

TABLE 46.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	26.0	26.2	26.4	26.6	26.8	27.0	27.2	27.4	27.6	27.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
50°.5	−0.052	−0.052	−0.052	−0.053	−0.053	−0.054	−0.054	−0.054	−0.055	−0.055
51.0	.053	.053	.054	.054	.054	.055	.055	.056	.056	.056
51.5	.054	.054	.055	.055	.056	.056	.056	.057	.057	.058
52.0	.055	.055	.056	.056	.057	.057	.058	.058	.058	.059
52.5	.056	.057	.057	.058	.058	.058	.059	.059	.060	.060
53.0	−0.057	−0.058	−0.058	−0.059	−0.059	−0.060	−0.060	−0.061	−0.061	−0.061
53.5	.059	.059	.059	.060	.060	.061	.061	.062	.062	.063
54.0	.060	.060	.061	.061	.062	.062	.063	.063	.063	.064
54.5	.061	.061	.062	.062	.063	.063	.064	.064	.065	.065
55.0	.062	.063	.063	.064	.064	.064	.065	.065	.066	.066
55.5	−0.063	−0.064	−0.064	−0.065	−0.065	−0.066	−0.066	−0.067	−0.067	−0.068
56.0	.064	.065	.065	.066	.066	.067	.067	.068	.068	.069
56.5	.066	.066	.067	.067	.068	.068	.069	.069	.070	.070
57.0	.067	.067	.068	.068	.069	.069	.070	.070	.071	.071
57.5	.068	.069	.069	.070	.070	.071	.071	.072	.072	.073
58.0	−0.069	−0.070	−0.070	−0.071	−0.071	−0.072	−0.072	−0.073	−0.073	−0.074
58.5	.070	.071	.071	.072	.072	.073	.074	.074	.075	.075
59.0	.072	.072	.073	.073	.074	.074	.075	.075	.076	.076
59.5	.073	.073	.074	.074	.075	.075	.076	.077	.077	.078
60.0	.074	.074	.075	.076	.076	.077	.077	.078	.078	.079
60.5	−0.075	−0.076	−0.076	−0.077	−0.077	−0.078	−0.078	−0.079	−0.080	−0.080
61.0	.076	.077	.077	.078	.079	.079	.080	.080	.081	.081
61.5	.077	.078	.079	.079	.080	.080	.081	.082	.082	.083
62.0	.079	.079	.080	.080	.081	.082	.082	.083	.083	.084
62.5	.080	.080	.081	.082	.082	.083	.083	.084	.085	.085
63.0	−0.081	−0.082	−0.082	−0.083	−0.083	−0.084	−0.085	−0.085	−0.086	−0.086
63.5	.082	.083	.083	.084	.085	.085	.086	.086	.087	.088
64.0	.083	.084	.085	.085	.086	.086	.087	.088	.088	.089
64.5	.084	.085	.086	.086	.087	.088	.088	.089	.090	.090
65.0	.086	.086	.087	.088	.088	.089	.090	.090	.091	.092
65.5	−0.087	−0.087	0.088	−0.089	−0.089	−0.090	−0.091	−0.091	−0.092	−0.093
66.0	.088	.089	.089	.090	.091	.091	.092	.093	.093	.094
66.5	.089	.090	.090	.091	.092	.093	.093	.094	.095	.095
67.0	.090	.091	.092	.092	.093	.094	.094	.095	.096	.097
67.5	.092	.092	.093	.094	.094	.095	.096	.096	.097	.098
68.0	−0.093	−0.093	−0.094	−0.095	−0.095	−0.096	−0.097	−0.098	−0.098	−0.099
68.5	.094	.095	.095	.096	.097	.097	.098	.099	.100	.100
69.0	.095	.096	.096	.097	.098	.099	.099	.100	.101	.102
69.5	.096	.097	.098	.098	.099	.100	.101	.101	.102	.103
70.0	.097	.098	.099	.100	.100	.101	.102	.103	.103	.104
70.5	−0.098	−0.099	−0.100	−0.101	−0.101	−0.102	−0.103	−0.104	−0.105	−0.105
71.0	.100	.100	.101	.102	.103	.103	.104	.105	.106	.107
71.5	.101	.102	.102	.103	.104	.105	.105	.106	.107	.108
72.0	.102	.103	.104	.104	.105	.106	.107	.107	.108	.109
72.5	.103	.104	.105	.106	.106	.107	.108	.109	.109	.110
73.0	−0.104	−0.105	−0.106	−0.107	−0.108	−0.108	−0.109	−0.110	−0.111	−0.112
73.5	.105	.106	.107	.108	.109	.110	.110	.111	.112	.113
74.0	.107	.107	.108	.109	.110	.111	.112	.112	.113	.114
74.5	.108	.109	.109	.110	.111	.112	.113	.114	114	.115
75.0	.109	.110	.111	.112	.112	.113	.114	.115	116	.117

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	26.0	26.2	26.4	26.6	26.8	27.0	27.2	27.4	27.6	27.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
75°.5	−0.110	−0.111	−0.112	−0.113	−0.114	−0.114	−0.115	−0.116	−0.117	−0.118
76.0	.111	.112	.113	.114	.115	.116	.116	.117	.118	.119
76.5	.113	.113	.114	.115	.116	.117	.118	.119	.119	.120
77.0	.114	.115	.115	.116	.117	.118	.119	.120	.121	.122
77.5	.115	.116	.117	.117	.118	.119	.120	.121	.122	.123
78.0	−0.116	−0.117	−0.118	−0.119	−0.120	−0.120	−0.121	−0.122	−0.123	−0.124
78.5	.117	.118	.119	.120	.121	.122	.123	.123	.124	.125
79.0	.118	.119	.120	.121	.122	.123	.124	.125	.126	.127
79.5	.120	.120	.121	.122	.123	.124	.125	.126	.127	.128
80.0	.121	.122	.123	.123	.124	.125	.126	.127	.128	.129
80.5	−0.122	−0.123	−0.124	−0.125	−0.126	−0.127	−0.127	−0.128	−0.129	−0.130
81.0	.123	.124	.125	.126	.127	.128	.129	.130	.131	.132
81.5	.124	.125	.126	.127	.128	.129	.130	.131	.132	.133
82.0	.125	.126	.127	.128	.129	.130	.131	.132	.133	.134
82.5	.127	.128	.128	.129	.130	.131	.132	.133	.134	.135
83.0	−0.128	−0.129	−0.130	−0.131	−0.132	−0.133	−0.134	−0.135	−0.136	−0.137
83.5	.129	.130	.131	.132	.133	.134	.135	.136	.137	.138
84.0	.130	.131	.132	.133	.134	.135	.136	.137	.138	.139
84.5	.131	.132	.133	.134	.135	.136	.137	.138	.139	.140
85.0	.132	.133	.134	.135	.136	.137	.138	.139	.141	.142
85.5	−0.134	−0.135	−0.136	−0.137	−0.138	−0.139	−0.140	−0.141	−0.142	−0.143
86.0	.135	.136	.137	.138	.139	.140	.141	.142	.143	.144
86.5	.136	.137	.138	.139	.140	.141	.142	.143	.144	.145
87.0	.137	.138	.139	.140	.141	.142	.143	.144	.145	.147
87.5	.138	.139	.140	.141	.142	.144	.145	.146	.147	.148
88.0	−0.139	−0.140	−0.142	−0.143	−0.144	−0.145	−0.146	−0.147	−0.148	−0.149
88.5	.141	.142	.143	.144	.145	.146	.147	.148	.149	.150
89.0	.142	.143	.144	.145	.146	.147	.148	.149	.150	.152
89.5	.143	.144	.145	.146	.147	.148	.149	.151	.152	.153
90.0	.144	.145	.146	.147	.148	.150	.151	.152	.153	.154
90.5	−0.145	−0.146	−0.147	−0.149	−0.150	−0.151	−0.152	−0.153	−0.154	−0.155
91.0	.146	.147	.149	.150	.151	.152	.153	.154	.155	.157
91.5	.148	.149	.150	.151	.152	.153	.154	.155	.157	.158
92.0	.149	.150	.151	.152	.153	.154	.156	.157	.158	.159
92.5	.150	.151	.152	.153	.154	.156	.157	.158	.159	.160
93.0	−0.151	−0.152	−0.153	−0.155	−0.156	−0.157	−0.158	−0.159	−0.160	−0.161
93.5	.152	.153	.155	.156	.157	.158	.159	.160	.162	.163
94.0	.153	.155	.156	.157	.158	.159	.160	.162	.163	.164
94.5	.155	.156	.157	.158	.159	.160	.162	.163	.164	.165
95.0	.156	.157	.158	.159	.160	.162	.163	.164	.165	.166
95.5	−0.157	−0.158	−0.159	−0.160	−0.162	−0.163	−0.164	−0.165	−0.167	−0.168
96.0	.158	.159	.160	.162	.163	.164	.165	.167	.168	.169
96.5	.159	.160	.162	.163	.164	.165	.167	.168	.169	.170
97.0	.160	.162	.163	.164	.165	.167	.168	.169	.170	.171
97.5	.162	.163	.164	.165	.166	.168	.169	.170	.171	.173
98.0	−0.163	−0.164	−0.165	−0.166	−0.168	−0.169	−0.170	−0.171	−0.173	−0.174
98.5	.164	.165	.166	.168	.169	.170	.171	.173	.174	.175
99.0	.165	.166	.168	.169	.170	.171	.173	.174	.175	.176
99.5	.166	.167	.169	.170	.171	.173	.174	.175	.176	.178
100.0	.167	.169	.170	.171	.172	.174	.175	.176	.178	.179

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	28.0	28.2	28.4	28.6	28.8	29.0	29.2	29.4	29.6	29.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°.0	+0.073	+0.074	+0.074	+0.075	+0.075	+0.076	+0.076	+0.077	+0.077	+0.078
+0.5	+0.072	+0.072	+0.073	+0.073	+0.074	+0.074	+0.075	+0.075	+0.076	+0.076
1.0	.070	.071	.071	.072	.072	.073	.073	.074	.074	.075
1.5	.069	.070	.070	.071	.071	.072	.072	.073	.073	.074
2.0	.068	.068	.069	.069	.070	.070	.071	.071	.072	.072
2.5	.067	.067	.068	.068	.069	.069	.069	.070	.070	.071
3.0	+0.065	+0.066	+0.066	+0.067	+0.067	+0.068	+0.068	+0.069	+0.069	+0.070
3.5	.064	.065	.065	.065	.066	.066	.067	.067	.068	.068
4.0	.063	.063	.064	.064	.065	.065	.065	.066	.066	.067
4.5	.062	.062	.062	.063	.063	.064	.064	.065	.065	.065
5.0	.060	.061	.061	.062	.062	.062	.063	.063	.064	.064
5.5	+0.059	+0.059	+0.060	+0.060	+0.061	+0.061	+0.062	+0.062	+0.062	+0.063
6.0	.058	.058	.059	.059	.059	.060	.060	.061	.061	.061
6.5	.056	.057	.057	.058	.058	.058	.059	.059	.060	.060
7.0	.055	.056	.056	.056	.057	.057	.057	.058	.058	.059
7.5	.054	.054	.055	.055	.055	.056	.056	.057	.057	.057
8.0	+0.053	+0.053	+0.053	+0.054	+0.054	+0.054	+0.055	+0.055	+0.056	+0.056
8.5	.051	.052	.052	.052	.053	.053	.053	.054	.054	.055
9.0	.050	.050	.051	.051	.051	.052	.052	.053	.053	.053
9.5	.049	.049	.049	.050	.050	.050	.051	.051	.052	.052
10.0	.047	.048	.048	.048	.049	.049	.050	.050	.050	.051
10.5	+0.046	+0.047	+0.047	+0.047	+0.048	+0.048	+0.048	+0.049	+0.049	+0.049
11.0	.045	.045	.046	.046	.046	.047	.047	.047	.047	.048
11.5	.044	.044	.044	.045	.045	.045	.046	.046	.046	.046
12.0	.042	.043	.043	.043	.044	.044	.044	.044	.045	.045
12.5	.041	.041	.042	.042	.042	.043	.043	.043	.043	.044
13.0	+0.040	+0.040	+0.040	+0.041	+0.041	+0.041	+0.042	+0.042	+0.042	+0.042
13.5	.039	.039	.039	.039	.040	.040	.040	.040	.041	.041
14.0	.037	.038	.038	.038	.038	.039	.039	.039	.039	.040
14.5	.036	.036	.037	.037	.037	.037	.038	.038	.038	.038
15.0	.035	.035	.035	.035	.036	.036	.036	.036	.037	.037
15.5	+0.033	+0.034	+0.034	+0.034	+0.034	+0.035	+0.035	+0.035	+0.035	+0.036
16.0	.032	.032	.033	.033	.033	.033	.034	.034	.034	.034
16.5	.031	.031	.031	.032	.032	.032	.032	.032	.033	.033
17.0	.030	.030	.030	.030	.030	.031	.031	.031	.031	.032
17.5	.028	.029	.029	.029	.029	.029	.030	.030	.030	.030
18.0	+0.027	+0.027	+0.027	+0.028	+0.028	+0.028	+0.028	+0.028	+0.029	+0.029
18.5	.026	.026	.026	.026	.027	.027	.027	.027	.027	.027
19.0	.025	.025	.025	.025	.025	.025	.026	.026	.026	.026
19.5	.023	.023	.024	.024	.024	.024	.024	.024	.025	.025
20.0	.022	.022	.022	.022	.023	.023	.023	.023	.023	.023
20.5	+0.021	+0.021	+0.021	+0.021	+0.021	+0.021	+0.022	+0.022	+0.022	+0.022
21.0	.019	.020	.020	.020	.020	.020	.020	.020	.021	.021
21.5	.018	.018	.018	.019	.019	.019	.019	.019	.019	.019
22.0	.017	.017	.017	.017	.017	.017	.018	.018	.018	.018
22.5	.016	.016	.016	.016	.016	.016	.016	.016	.016	.017
23.0	+0.014	+0.014	+0.015	+0.015	+0.015	+0.015	+0.015	+0.015	+0.015	+0.015
23.5	.013	.013	.013	.013	.013	.014	.014	.014	.014	.014
24.0	.012	.012	.012	.012	.012	.012	.012	.012	.012	.013
24.5	.011	.011	.011	.011	.011	.011	.011	.011	.011	.011
25.0	.009	.009	.009	.009	.009	.010	.010	.010	.010	.010

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	28.0	28.2	28.4	28.6	28.8	29.0	29.2	29.4	29.6	29.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
25°.5	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008	+0.008
26.0	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
26.5	.005	.005	.005	.006	.006	.006	.006	.006	.006	.006
27.0	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004
27.5	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
28.0	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002
28.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29.0	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
29.5	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
30.0	.003	.004	.004	.004	.004	.004	.004	.004	.004	.004
30.5	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005
31.0	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
31.5	.007	.007	.007	.007	.008	.008	.008	.008	.008	.008
32.0	.009	.009	.009	.009	.009	.009	.009	009	.009	.009
32.5	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
33.0	−0.011	−0.011	−0.011	−0.011	−0.011	−0.012	−0.012	−0.012	−0.012	−0.012
33.5	.012	.012	.013	.013	.013	.013	.013	.013	.013	.013
34.0	.014	.014	.014	.014	.014	.014	.014	.014	.014	.015
34.5	.015	.015	.015	.015	.015	.015	.016	.016	.016	.016
35.0	.016	.016	.016	.017	.017	.017	.017	.017	.017	.017
35.5	−0.017	−0.018	−0.018	−0.018	−0.018	−0.018	−0.018	−0.018	−0.018	−0.019
36.0	.019	.019	.019	.019	.019	.019	.020	.020	.020	.020
36.5	.020	.020	.020	.020	.021	.021	.021	.021	.021	.021
37.0	.021	.021	.022	.022	.022	.022	.022	.022	.022	.023
37.5	.023	.023	.023	.023	.023	.023	.024	.024	.024	.024
38.0	−0.024	−0.024	−0.024	−0.024	−0.024	−0.025	−0.025	−0.025	−0.025	−0.025
38.5	.025	.025	.025	.026	.026	.026	.026	.026	.027	.027
39.0	.026	.027	.027	.027	.027	.027	.027	.028	.028	.028
39.5	.028	.028	.028	.028	.028	.029	.029	.029	.029	.029
40.0	.029	.029	.029	.030	.030	.030	.030	.030	.031	.031
40.5	−0.030	−0.030	−0.031	−0.031	−0.031	−0.031	−0.031	−0.032	−0.032	−0.032
41.0	.031	.032	.032	.032	.032	.033	.033	.033	.033	.033
41.5	.033	.033	.033	.033	.034	.034	.034	.034	.035	.035
42.0	.034	.034	.034	.035	.035	.035	.035	.036	.036	.036
42.5	.035	.035	.036	.036	.036	.036	.037	.037	.037	.037
43.0	−0.036	−0.037	−0.037	−0.037	−0.038	−0.038	−0.038	−0.038	−0.039	−0.039
43.5	.038	.038	.038	.039	.039	.039	.039	.040	.040	.040
44.0	.039	.039	.040	.040	.040	.040	.041	.041	.041	.042
44.5	.040	.041	.041	.041	.041	.042	.042	.042	.043	.043
45.0	.042	.042	.042	.042	.043	.043	.043	.044	.044	.044
45.5	−0.043	−0.043	−0.043	−0.044	−0.044	−0.044	−0.045	−0.045	−0.045	−0.046
46.0	.044	.044	.045	.045	.045	.046	.046	.046	.047	.047
46.5	.045	.046	.046	.046	.047	.047	.047	.048	.048	.048
47.0	.047	.047	.047	.048	.048	.048	.049	.049	.049	.050
47.5	.048	.048	.049	.049	.049	.050	.050	.050	.051	.051
48.0	−0.049	−0.050	−0.050	−0.050	−0.051	−0.051	−0.051	−0.052	−0.052	−0.052
48.5	.050	.051	.051	.052	.052	.052	.053	.053	.053	.054
49.0	.052	.052	.052	.053	.053	.054	.054	.054	.055	.055
49.5	.053	.053	.054	.054	.054	.055	.055	.056	.056	.056
50.0	.054	.055	.055	.055	.056	.056	.057	.057	.057	.058

TABLE 46.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	28.0	28.2	28.4	28.6	28.8	29.0	29.2	29.4	29.6	29.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
50°.5	−0.055	−0.056	−0.056	−0.057	−0.057	−0.057	−0.058	−0.058	−0.059	−0.059
51.0	.057	.057	.058	.058	.058	.059	.059	.060	.060	.060
51.5	.058	.058	.059	.059	.060	.060	.061	.061	.061	.062
52.0	.059	.060	.060	.061	.061	.061	.062	.062	.063	.063
52.5	.061	.061	.061	.062	.062	.063	.063	.064	.064	.064
53.0	−0.062	−0.062	−0.063	−0.063	−0.064	−0.064	−0.064	−0.065	−0.065	−0.066
53.5	.063	.064	.064	.064	.065	.065	.066	.066	.067	.067
54.0	.064	.065	.065	.066	.066	.067	.067	.068	.068	.068
54.5	.066	.066	.067	.067	.067	.068	.068	.069	.069	.070
55.0	.067	.067	.068	.068	.069	.069	.070	.070	.071	.071
55.5	−0.068	−0.069	−0.069	−0.070	−0.070	−0.071	−0.071	−0.072	−0.072	−0.073
56.0	.069	.070	.070	.071	.071	.072	.072	.073	.073	.074
56.5	.071	.071	.072	.072	.073	.073	.074	.074	.075	.075
57.0	.072	.072	.073	.073	.074	.075	.075	.076	.076	.077
57.5	.073	.074	.074	.075	.075	.076	.076	.077	.077	.078
58.0	−0.074	−0.075	−0.076	−0.076	−0.077	−0.077	−0.078	−0.078	−0.079	−0.079
58.5	.076	.076	.077	.077	.078	.078	.079	.080	.080	.081
59.0	.077	.078	.078	.079	.079	.080	.080	.081	.081	.082
59.5	.078	.079	.079	.080	.081	.081	.082	.082	.083	.083
60.0	.080	.080	.081	.081	.082	.082	.083	.084	.084	.085
60.5	−0.081	−0.081	−0.082	−0.083	−0.083	−0.084	−0.084	−0.085	−0.085	−0.086
61.0	.082	.083	.083	.084	.084	.085	.086	.086	.087	.087
61.5	.083	.084	.085	.085	.086	.086	.087	.087	.088	.089
62.0	.085	.085	.086	.086	.087	.088	.088	.089	.089	.090
62.5	.086	.086	.087	.088	.088	.089	.090	.090	.091	.091
63.0	−0.087	−0.088	−0.088	−0.089	−0.090	−0.090	−0.091	−0.091	−0.092	−0.093
63.5	.088	.089	.090	.090	.091	.092	.092	.093	.093	.094
64.0	.090	.090	.091	.092	.092	.093	.093	.094	.095	.095
64.5	.091	.092	.092	.093	.093	.094	.095	.095	.096	.097
65.0	.092	.093	.093	.094	.095	.095	.096	.097	.097	.098
65.5	−0.093	−0.094	−0.095	−0.095	−0.096	−0.097	−0.097	−0.098	−0.099	−0.099
66.0	.095	.095	.096	.097	.097	.098	.099	.099	.100	.101
66.5	.096	.097	.097	.098	.099	.099	.100	.101	.101	.102
67.0	.097	.098	.099	.099	.100	.101	.101	.102	.103	.103
67.5	.098	.099	.100	.101	.101	.102	.103	.103	.104	.105
68.0	−0.100	−0.100	−0.101	−0.102	−0.103	−0.103	−0.104	−0.105	−0.105	−0.106
68.5	.101	.102	.102	.103	.104	.105	.105	.106	.107	.107
69.0	.102	.103	.104	.104	.105	.106	.107	.107	.108	.109
69.5	.104	.104	.105	.106	.106	.107	.108	.109	.109	.110
70.0	.105	.106	.106	.107	.108	.109	.109	.110	.111	.112
70.5	−0.106	−0.107	−0.108	−0.108	−0.109	−0.110	−0.111	−0.111	−0.112	−0.113
71.0	.107	.108	.109	.110	.110	.111	.112	.113	.113	.114
71.5	.109	.109	.110	.111	.112	.112	.113	.114	.115	.116
72.0	.110	.111	.111	.112	.113	.114	.115	.115	.116	.117
72.5	.111	.112	.113	.113	.114	.115	.116	.117	.117	.118
73.0	−0.112	−0.113	−0.114	−0.115	−0.116	−0.116	−0.117	−0.118	−0.119	−0.120
73.5	.114	.114	.115	.116	.117	.118	.118	.119	.120	.121
74.0	.115	.116	.117	.117	.118	.119	.120	.121	.121	.122
74.5	.116	.117	.118	.119	.119	.120	.121	.122	.123	.124
75.0	.117	.118	.119	.120	.121	.122	.122	.123	.124	.125

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	28.0	28.2	28.4	28.6	28.8	29.0	29.2	29.4	29.6	29.8
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
75°.5	−0.119	−0.119	−0.120	−0.121	−0.122	−0.123	−0.124	−0.125	−0.125	−0.126
76.0	.120	.121	.122	.122	.123	.124	.125	.126	.127	.128
76.5	.121	.122	.123	.124	.125	.125	.126	.127	.128	.129
77.0	.122	.123	.124	.125	.126	.127	.128	.129	.129	.130
77.5	.124	.125	.125	.126	.127	.128	.129	.130	.131	.132
78.0	−0.125	−0.126	−0.127	−0.128	−0.129	−0.129	−0.130	−0.131	−0.132	−0.133
78.5	.126	.127	.128	.129	.130	.131	.132	.133	.133	.134
79.0	.127	.128	.129	.130	.131	.132	.133	.134	.135	.136
79.5	.129	.130	.131	.131	.132	.133	.134	.135	.136	.137
80.0	.130	.131	.132	.133	.134	.135	.136	.136	.137	.138
80.5	−0.131	−0.132	−0.133	−0.134	−0.135	−0.136	−0.137	−0.138	−0.139	−0.140
81.0	.132	.133	.134	.135	.136	.137	.138	.139	.140	.141
81.5	.134	.135	.136	.137	.138	.139	.139	.140	.141	.142
82.0	.135	.136	.137	.138	.139	.140	.141	.142	.143	.144
82.5	.136	.137	.138	.139	.140	.141	.142	.143	.144	.145
83.0	−0.138	−0.139	−0.139	−0.140	−0.141	−0.142	−0.143	−0.144	−0.145	−0.146
83.5	.139	.140	.141	.142	.143	.144	.145	.146	.147	.148
84.0	.140	.141	.142	.143	.144	.145	.146	.147	.148	.149
84.5	.141	.142	.143	.144	.145	.146	.147	.148	.149	.150
85.0	.143	.144	.145	.146	.147	.148	.149	.150	.151	.152
85.5	−0.144	−0.145	−0.146	−0.147	−0.148	−0.149	−0.150	−0.151	−0.152	−0.153
86.0	.145	.146	.147	.148	.149	.150	.151	.152	.153	.154
86.5	.146	.147	.148	.149	.151	.152	.153	.154	.155	.156
87.0	.148	.149	.150	.151	.152	.153	.154	.155	.156	.157
87.5	.149	.150	.151	.152	.153	.154	.155	.156	.157	.158
88.0	−0.150	−0.151	−0.152	−0.153	−0.154	−0.155	−0.157	−0.158	−0.159	−0.160
88.5	.151	.152	.154	.155	.156	.157	.158	.159	.160	.161
89.0	.153	.154	.155	.156	.157	.158	.159	.160	.161	.162
89.5	.154	.155	.156	.157	.158	.159	.160	.162	.163	.164
90.0	.155	.156	.157	.158	.160	.161	.162	.163	.164	.165
90.5	−0.156	−0.157	−0.159	−0.160	−0.161	−0.162	−0.163	−0.164	−0.165	−0.166
91.0	.158	.159	.160	.161	.162	.163	.164	.166	.167	.168
91.5	.159	.160	.161	.162	.163	.165	.166	.167	.168	.169
92.0	.160	.161	.162	.164	.165	.166	.167	.168	.169	.170
92.5	.161	.163	.164	.165	.166	.167	.168	.169	.171	.172
93.0	−0.163	−0.164	−0.165	−0.166	−0.167	−0.168	−0.170	−0.171	−0.172	−0.173
93.5	.164	.165	.166	.167	.169	.170	.171	.172	.173	.174
94.0	.165	.166	.168	.169	.170	.171	.172	.173	.175	.176
94.5	.166	.168	.169	.170	.171	.172	.174	.175	.176	.177
95.0	.168	.169	.170	.171	.172	.174	.175	.176	.177	.178
95.5	−0.169	−0.170	−0.171	−0.173	−0.174	−0.175	−0.176	−0.177	−0.179	−0.180
96.0	.170	.171	.173	.174	.175	.176	.177	.179	.180	.181
96.5	.171	.173	.174	.175	.176	.178	.179	.180	.181	.182
97.0	.173	.174	.175	.176	.178	.179	.180	.181	.183	.184
97.5	.174	.175	.176	.178	.179	.180	.181	.183	.184	.185
98.0	−0.175	−0.176	−0.178	−0.179	−0.180	−0.181	−0.183	−0.184	−0.185	−0.186
98.5	.176	.178	.179	.180	.181	.183	.184	.185	.187	.188
99.0	.178	.179	.180	.182	.183	.184	.185	.187	.188	.189
99.5	.179	.180	.182	.183	.184	.185	.187	.188	.189	.190
100.0	.180	.182	.183	.184	.185	.187	.188	.189	.191	.192

TABLE 46.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	29.8	30.0	30.2	30.4	30.6	30.8	31.0	31.2	31.4	31.6
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°.0	+0.078	+0.078	+0.079	+0.079	+0.080	+0.080	+0.081	+0.081	+0.082	+0.082
0.5	+0.076	+0.077	+0.077	+0.078	+0.078	+0.079	+0.079	+0.080	+0.080	+0.081
1.0	.075	.076	.076	.077	.077	.078	.078	.079	.079	.080
1.5	.074	.074	.075	.075	.076	.076	.077	.077	.078	.078
2.0	.072	.073	.073	.074	.074	.075	.075	.076	.076	.077
2.5	.071	.071	.072	.072	.073	.073	.074	.074	.075	.075
3.0	+0.070	+0.070	+0.070	+0.071	+0.071	+0.072	+0.072	+0.073	+0.073	+0.074
3.5	.068	.069	.069	.070	.070	.070	.071	.071	.072	.072
4.0	.067	.067	.068	.068	.069	.069	.070	.070	.070	.071
4.5	.065	.066	.066	.067	.067	.068	.068	.069	.069	.069
5.0	.064	.065	.065	.065	.066	.066	.067	.067	.068	.068
5.5	+0.063	+0.063	+0.064	+0.064	+0.064	+0.065	+0.065	+0.066	+0.066	+0.067
6.0	.061	.062	.062	.063	.063	.063	.064	.064	.065	.065
6.5	.060	.060	.061	.061	.062	.062	.062	.063	.063	.064
7.0	.059	.059	.059	.060	.060	.061	.061	.061	.062	.062
7.5	.057	.058	.058	.058	.059	.059	.060	.060	.060	.061
8.0	+0.056	+0.056	+0.057	+0.057	+0.057	+0.058	+0.058	+0.059	+0.059	+0.059
8.5	.055	.055	.055	.056	.056	.056	.057	.057	.058	.058
9.0	.053	.054	.054	.054	.055	.055	.055	.056	.056	.056
9.5	.052	.052	.053	.053	.053	.054	.054	.054	.055	.055
10.0	.051	.051	.051	.052	.052	.052	.053	.053	.053	.054
10.5	+0.049	+0.049	+0.050	+0.050	+0.050	+0.051	+0.051	+0.051	+0.052	+0.052
11.0	.048	.048	.048	.049	.049	.049	.050	.050	.050	.051
11.5	.046	.047	.047	.047	.048	.048	.048	.049	.049	.049
12.0	.045	.045	.046	.046	.046	.047	.047	.047	.048	.048
12.5	.044	.044	.044	.045	.045	.045	.045	.046	.046	.046
13.0	+0.042	+0.043	+0.043	+0.043	+0.044	+0.044	+0.044	+0.044	+0.045	+0.045
13.5	.041	.041	.042	.042	.042	.042	.043	.043	.043	.043
14.0	.040	.040	.040	.040	.041	.041	.041	.042	.042	.042
14.5	.038	.039	.039	.039	.039	.040	.040	.040	.040	.041
15.0	.037	.037	.037	.038	.038	.038	.038	.039	.039	.039
15.5	+0.036	+0.036	+0.036	+0.036	+0.037	+0.037	+0.037	+0.037	+0.037	+0.038
16.0	.034	.034	.035	.035	.035	.035	.036	.036	.036	.036
16.5	.033	.033	.033	.034	.034	.034	.034	.034	.035	.035
17.0	.032	.032	.032	.032	.032	.033	.033	.033	.033	.033
17.5	.030	.030	.031	.031	.031	.031	.031	.032	.032	.032
18.0	+0.029	+0.029	+0.029	+0.029	+0.030	+0.030	+0.030	+0.030	+0.030	+0.031
18.5	.027	.028	.028	.028	.028	.028	.029	.029	.029	.029
19.0	.026	.026	.026	.027	.027	.027	.027	.027	.027	.028
19.5	.025	.025	.025	.025	.025	.026	.026	.026	.026	.026
20.0	.023	.024	.024	.024	.024	.024	.024	.024	.025	.025
20.5	+0.022	+0.022	+0.022	+0.022	+0.023	+0.023	+0.023	+0.023	+0.023	+0.023
21.0	.021	.021	.021	.021	.021	.021	.022	.022	.022	.022
21.5	.019	.019	.020	.020	.020	.020	.020	.020	.020	.020
22.0	.018	.018	.018	.018	.018	.019	.019	.019	.019	.019
22.5	.017	.017	.017	.017	.017	.017	.017	.017	.017	.018
23.0	+0.015	+0.015	+0.015	+0.016	+0.016	+0.016	+0.016	+0.016	+0.016	+0.016
23.5	.014	.014	.014	.014	.014	.014	.014	.015	.015	.015
24.0	.013	.013	.013	.013	.013	.013	.013	.013	.013	.013
24.5	.011	.011	.011	.011	.011	.012	.012	.012	.012	.012
25.0	.010	.010	.010	.010	.010	.010	.010	.010	0.10	.010

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	29.8	30.0	30.2	30.4	30.6	30.8	31.0	31.2	31.4	31.6
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
25°.5	+0.008	+0.009	+0.009	+0.009	+0.009	+0.009	+0.009	+0.009	+0.009	+0.009
26.0	.007	.007	.007	.007	.007	.007	.007	.007	.008	.008
26.5	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
27.0	.004	.004	.004	.005	.005	.005	.005	.005	.005	.005
27.5	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
28.0	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002	+0.002
28.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29.0	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
29.5	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
30.0	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004
30.5	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005	−0.005
31.0	.006	.006	.006	.007	.007	.007	.007	.007	.007	.007
31.5	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
32.0	.009	.009	.009	.009	.009	.009	.009	.010	.010	.010
32.5	.010	.011	.011	.011	.011	.011	.011	.011	.011	.011
33.0	−0.012	−0.012	−0.012	−0.012	−0.012	−0.012	−0.012	−0.012	−0.012	−0.013
33.5	.013	.013	.013	.013	.014	.014	.014	.014	.014	.014
34.0	.015	.015	.015	.015	.015	.015	.015	.015	.015	.015
34.5	.016	.016	.016	.016	.016	.016	.017	.017	.017	.017
35.0	.017	.017	.017	.018	.018	.018	.018	.018	.018	.018
35.5	−0.019	−0.019	−0.019	−0.019	−0.019	−0.019	−0.019	−0.019	−0.020	−0.020
36.0	.020	.020	.020	.020	.020	.021	.021	.021	.021	.021
36.5	.021	.021	.022	.022	.022	.022	.022	.022	.022	.023
37.0	.023	.023	.023	.023	.023	.023	.024	.024	.024	.024
37.5	.024	.024	.024	.024	.025	.025	.025	.025	.025	.025
38.0	−0.025	−0.026	−0.026	−0.026	−0.026	−0.026	−0.026	−0.027	−0.027	−0.027
38.5	.027	.027	.027	.027	.027	.028	.028	.028	.028	.028
39.0	.028	.028	.028	.029	.029	.029	.029	.029	.030	.030
39.5	.029	.030	.030	.030	.030	.030	.031	.031	.031	.031
40.0	.031	.031	.031	.031	.032	.032	.032	.032	.032	.033
40.5	−0.032	−0.032	−0.033	−0.033	−0.033	−0.033	−0.033	−0.034	−0.034	−0.034
41.0	.033	.034	.034	.034	.034	.035	.035	.035	.035	.035
41.5	.035	.035	.035	.035	.036	.036	.036	.036	.037	.037
42.0	.036	.036	.037	.037	.037	.037	.038	.038	.038	.038
42.5	.037	.038	.038	.038	.038	.039	.039	.039	.040	.040
43.0	−0.039	−0.039	−0.039	−0.040	−0.040	−0.040	−0.040	−0.041	−0.041	−0.041
43.5	.040	.040	.041	.041	.041	.042	.042	.042	.042	.043
44.0	.042	.042	.042	.042	.043	.043	.043	.043	.044	.044
44.5	.043	.043	.043	.044	.044	.044	.045	.045	.045	.045
45.0	.044	.045	.045	.045	.045	.046	.046	.046	.047	.047
45.5	−0.046	−0.046	−0.046	−0.047	−0.047	−0.047	−0.047	−0.048	−0.048	−0.048
46.0	.047	.047	.048	.048	.048	.049	.049	.049	.049	.050
46.5	.048	.049	.049	.049	.050	.050	.050	.051	.051	.051
47.0	.050	.050	.050	.051	.051	.051	.052	.052	.052	.053
47.5	.051	.051	.052	.052	.052	.053	.053	.053	.054	.054
48.0	−0.052	−0.053	−0.053	−0.053	−0.054	−0.054	−0.054	−0.055	−0.055	−0.055
48.5	.054	.054	.054	.055	.055	.055	.056	.056	.057	.057
49.0	.055	.055	.056	.056	.057	.057	.057	.058	.058	.058
49.5	.056	.057	.057	.058	.058	.058	.059	.059	.059	.060
50.0	.058	.058	.058	.059	.059	.060	.060	.060	.061	.061

TABLE 46.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	29.8	30.0	30.2	30.4	30.6	30.8	31.0	31.2	31.4	31.6
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
50°.5	−0.059	−0.059	−0.060	−0.060	−0.061	−0.061	−0.061	−0.062	−0.062	−0.063
51.0	.060	.061	.061	.062	.062	.062	.063	.063	.064	.064
51.5	.062	.062	.063	.063	.063	.064	.064	.065	.065	.065
52.0	.063	.064	.064	.064	.065	.065	.066	.066	.066	.067
52.5	.064	.065	.065	.066	.066	.067	.067	.067	.068	.068
53.0	−0.066	−0.066	−0.067	−0.067	−0.068	−0.068	−0.068	−0.069	−0.069	−0.070
53.5	.067	.068	.068	.069	.069	.069	.070	.070	.071	.071
54.0	.068	.069	.069	.070	.070	.071	.071	.072	.072	.073
54.5	.070	.070	.071	.071	.072	.072	.073	.073	.074	.074
55.0	.071	.072	.072	.073	.073	.074	.074	.075	.075	.075
55.5	−0.073	−0.073	−0.074	−0.074	−0.074	−0.075	−0.075	−0.076	−0.076	−0.077
56.0	.074	.074	.075	.075	.076	.076	.077	.077	.078	.078
56.5	.075	.076	.076	.077	.077	.078	.078	.079	.079	.080
57.0	.077	.077	.078	.078	.079	.079	.080	.080	.081	.081
57.5	.078	.078	.079	.079	.080	.081	.081	.082	.082	.083
58.0	−0.079	−0.080	−0.080	−0.081	−0.081	−0.082	−0.082	−0.083	−0.084	−0.084
58.5	.081	.081	.082	.082	.083	.083	.084	.084	.085	.085
59.0	.082	.083	.083	.084	.084	.085	.085	.086	.086	.087
59.5	.083	.084	.084	.085	.086	.086	.087	.087	.088	.088
60.0	.085	.085	.086	.086	.087	.087	.088	.089	.089	.090
60.5	−0.086	−0.087	−0.087	−0.088	−0.088	−0.089	−0.089	−0.090	−0.091	−0.091
61.0	.087	.088	.089	.089	.090	.090	.091	.091	.092	.093
61.5	.089	.089	.090	.090	.091	.092	.092	.093	.093	.094
62.0	.090	.091	.091	.092	.092	.093	.094	.094	.095	.095
62.5	.091	.092	.093	.093	.094	.094	.095	.096	.096	.097
63.0	−0.093	−0.093	−0.094	−0.095	−0.095	−0.096	−0.096	−0.097	−0.098	−0.098
63.5	.094	.095	.095	.096	.097	.097	.098	.098	.099	.100
64.0	.095	.096	.097	.097	.098	.099	.099	.100	.101	.101
64.5	.097	.097	.098	.099	.099	.100	.101	.101	.102	.103
65.0	.098	.099	.099	.100	.101	.101	.102	.103	.103	.104
65.5	−0.099	−0.100	−0.101	−0.101	−0.102	−0.103	−0.103	−0.104	−0.105	−0.105
66.0	.101	.101	.102	.103	.103	.104	.105	.106	.106	.107
66.5	.102	.103	.103	.104	.105	.106	.106	.107	.108	.108
67.0	.103	.104	.105	.106	.106	.107	.108	.108	.109	.110
67.5	.105	.106	.106	.107	.108	.108	.109	.110	.110	.111
68.0	−0.106	−0.107	−0.108	−0.108	−0.109	−0.110	−0.110	−0.111	−0.112	−0.113
68.5	.107	.108	.109	.110	.110	.111	.112	.113	.113	.114
69.0	.109	.110	.110	.111	.112	.112	.113	.114	.115	.115
69.5	.110	.111	.112	.112	.113	.114	.115	.115	.116	.117
70.0	.112	.112	.113	.114	.115	.115	.116	.117	.117	.118
70.5	−0.113	−0.114	−0.114	−0.115	−0.116	−0.117	−0.117	−0.118	−0.119	−0.120
71.0	.114	.115	.116	.116	.117	.118	.119	.120	.120	.121
71.5	.116	.116	.117	.118	.119	.119	.120	.121	.122	.123
72.0	.117	.118	.118	.119	.120	.121	.122	.122	.123	.124
72.5	.118	.119	.120	.121	.121	.122	.123	.124	.125	.125
73.0	−0.120	−0.120	−0.121	−0.122	−0.123	−0.124	−0.124	−0.125	−0.126	−0.127
73.5	.121	.122	.123	.123	.124	.125	.126	.127	.127	.128
74.0	.122	.123	.124	.125	.126	.126	.127	.128	.129	.130
74.5	.124	.124	.125	.126	.127	.128	.129	.129	.130	.131
75.0	.125	.126	.127	.127	.128	.129	.130	.131	.132	.132

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

ENGLISH MEASURES.

Attached Thermometer Fahrenheit.	HEIGHT OF THE BAROMETER IN INCHES.									
	29.8	30.0	30.2	30.4	30.6	30.8	31.0	31.2	31.4	31.6
F.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
75°.5	−0.126	−0.127	−0.128	−0.129	−0.130	−0.131	−0.131	−0.132	−0.133	−0.134
76.0	.128	.128	.129	.130	.131	.132	.133	.134	.134	.135
76.5	.129	.130	.131	.132	.132	.133	.134	.135	.136	.137
77.0	.130	.131	.132	.133	.134	.135	.136	.136	.137	.138
77.5	.132	.133	.133	.134	.135	.136	.137	.138	.139	.140
78.0	−0.133	−0.134	−0.135	−0.136	−0.137	−0.137	−0.138	−0.139	−0.140	−0.141
78.5	.134	.135	.136	.137	.138	.139	.140	.141	.142	.142
79.0	.136	.137	.137	.138	.139	.140	.141	.142	.143	.144
79.5	.137	.138	.139	.140	.141	.142	.143	.143	.144	.145
80.0	.138	.139	.140	.141	.142	.143	.144	.145	.146	.147
80.5	−0.140	−0.141	−0.142	−0.142	−0.143	−0.144	−0.145	−0.146	−0.147	−0.148
81.0	.141	.142	.143	.144	.145	.146	.147	.148	.149	.150
81.5	.142	.143	.144	.145	.146	.147	.148	.149	.150	.151
82.0	.144	.145	.146	.147	.148	.149	.149	.150	.151	.152
82.5	.145	.146	.147	.148	.149	.150	.151	.152	.153	.154
83.0	−0.146	−0.147	−0.148	−0.149	−0.150	−0.151	−0.152	−0.153	−0.154	−0.155
83.5	.148	.149	.150	.151	.152	.153	.154	.155	.156	.157
84.0	.149	.150	.151	.152	.153	.154	.155	.156	.157	.158
84.5	.150	.151	.152	.153	.154	.155	.156	.157	.158	.159
85.0	.152	.153	.154	.155	.156	.157	.158	.159	.160	.161
85.5	−0.153	−0.154	−0.155	−0.156	−0.157	−0.158	−0.159	−0.160	−0.161	−0.162
86.0	.154	.155	.156	.158	.159	.160	.161	.162	.163	.164
86.5	.156	.157	.158	.159	.160	.161	.162	.163	.164	.165
87.0	.157	.158	.159	.160	.161	.162	.163	.164	.166	.167
87.5	.158	.159	.161	.162	.163	.164	.165	.166	.167	.168
88.0	−0.160	−0.161	−0.162	−0.163	−0.164	−0.165	−0.166	−0.167	−0.168	−0.169
88.5	.161	.162	.163	.164	.165	.166	.168	.169	.170	.171
89.0	.162	.164	.165	.166	.167	.168	.169	.170	.171	.172
89.5	.164	.165	.166	.167	.168	.169	.170	.171	.173	.174
90.0	.165	.166	.167	.168	.170	.171	.172	.173	.174	.175
90.5	−0.166	−0.168	−0.169	−0.170	−0.171	−0.172	−0.173	−0.174	−0.175	−0.176
91.0	.168	.169	.170	.171	.172	.173	.175	.176	.177	.178
91.5	.169	.170	.171	.173	.174	.175	.176	.177	.178	.179
92.0	.170	.172	.173	.174	.175	.176	.177	.178	.180	.181
92.5	.172	.173	.174	.175	.176	.178	.179	.180	.181	.182
93.0	−0.173	−0.174	−0.175	−0.177	−0.178	−0.179	−0.180	−0.181	−0.182	−0.184
93.5	.174	.176	.177	.178	.179	.180	.181	.183	.184	.185
94.0	.176	.177	.178	.179	.180	.182	.183	.184	.185	.186
94.5	.177	.178	.179	.181	.182	.183	.184	.185	.187	.188
95.0	.178	.180	.181	.182	.183	.184	.186	.187	.188	.189
95.5	−0.180	−0.181	−0.182	−0.183	−0.185	−0.186	−0.187	−0.188	−0.189	−0.191
96.0	.181	.182	.184	.185	.186	.187	.188	.190	.191	.192
96.5	.182	.184	.185	.186	.187	.189	.190	.191	.192	.193
97.0	.184	.185	.186	.187	.189	.190	.191	.192	.194	.195
97.5	.185	.186	.188	.189	.190	.191	.193	.194	.195	.196
98.0	−0.186	−0.188	−0.189	−0.190	−0.191	−0.193	−0.194	−0.195	−0.196	−0.198
98.5	.188	.189	.190	.192	.193	.194	.195	.197	.198	.199
99.0	.189	.190	.192	.193	.194	.195	.197	.198	.199	.201
99.5	.190	.192	.193	.194	.196	.197	.198	.199	.201	.202
100.0	.192	.193	.194	.196	.197	.198	.200	.201	.202	.203

TABLE 47.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION TO BE SUBTRACTED.

Attached Thermometer Centigrade.	HEIGHT OF THE BAROMETER IN MILLIMETERS.												
	440	450	460	470	480	490	500	510	520	530	540	550	560
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°.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
0.5	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.05
1.0	.07	.07	.08	.08	.08	.08	.08	.08	.08	.09	.09	.09	.09
1.5	.11	.11	.11	.12	.12	.12	.12	.12	.13	.13	.13	.13	.14
2.0	.14	.15	.15	.15	.16	.16	.16	.17	.17	.17	.18	.18	.18
2.5	0.18	0.18	0.19	0.19	0.20	0.20	0.20	0.21	0.21	0.22	0.22	0.22	0.23
3.0	.22	.22	.23	.23	.24	.24	.24	.25	.25	.26	.26	.27	.27
3.5	.25	.26	.26	.27	.27	.28	.29	.29	.30	.30	.31	.31	.32
4.0	.29	.29	.30	.31	.31	.32	.33	.33	.34	.35	.35	.36	.37
4.5	.32	.33	.34	.35	.35	.36	.37	.37	.38	.39	.40	.40	.41
5.0	0.36	0.37	0.38	0.38	0.39	0.40	0.41	0.42	0.42	0.43	0.44	0.45	0.46
5.5	.40	.40	.41	.42	.43	.44	.45	.46	.47	.48	.48	.49	.50
6.0	.43	.44	.45	.46	.47	.48	.49	.50	.51	.52	.53	.54	.55
6.5	.47	.48	.49	.50	.51	.52	.53	.54	.55	.56	.57	.58	.59
7.0	.50	.51	.53	.54	.55	.56	.57	.58	.59	.61	.62	.63	.64
7.5	0.54	0.55	0.56	0.58	0.59	0.60	0.61	0.62	0.64	0.65	0.66	0.67	0.69
8.0	.57	.59	.60	.61	.63	.64	.65	.67	.68	.69	.70	.72	.73
8.5	.61	.62	.64	.65	.67	.68	.69	.71	.72	.73	.75	.76	.78
9.0	.65	.66	.68	.69	.70	.72	.73	.75	.76	.78	.79	.81	.82
9.5	.68	.70	.71	.73	.74	.76	.77	.79	.81	.82	.84	.85	.87
10.0	0.72	0.73	0.75	0.77	0.78	0.80	0.82	0.83	0.85	0.86	0.88	0.90	0.91
10.5	.75	.77	.79	.80	.82	.84	.86	.87	.89	.91	.92	.94	.96
11.0	.79	.81	.83	.84	.86	.88	.90	.91	.93	.95	.97	.99	1.00
11.5	.83	.84	.86	.88	.90	.92	.94	.96	.98	.99	1.01	1.03	1.05
12.0	.86	.88	.90	.92	.94	.96	.98	1.00	1.02	1.04	1.06	1.08	1.10
13.0	0.93	0.95	0.97	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.17	1.19
14.0	1.00	1.03	1.05	1.07	1.10	1.12	1.14	1.16	1.19	1.21	1.23	1.25	1.28
15.0	1.08	1.10	1.12	1.15	1.17	1.20	1.22	1.25	1.27	1.30	1.32	1.34	1.37
16.0	1.15	1.17	1.20	1.23	1.25	1.28	1.30	1.33	1.36	1.38	1.41	1.43	1.46
17.0	1.22	1.25	1.27	1.30	1.33	1.36	1.38	1.41	1.44	1.47	1.50	1.52	1.55
18.0	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50	1.52	1.55	1.58	1.61	1.64
19.0	1.36	1.39	1.42	1.45	1.49	1.52	1.55	1.58	1.61	1.64	1.67	1.70	1.73
20.0	1.43	1.47	1.50	1.53	1.56	1.60	1.63	1.66	1.69	1.73	1.76	1.79	1.82
21.0	1.50	1.54	1.57	1.61	1.64	1.67	1.71	1.74	1.78	1.81	1.85	1.88	1.91
22.0	1.58	1.61	1.65	1.68	1.72	1.75	1.79	1.83	1.86	1.90	1.93	1.97	2.01
23.0	1.65	1.68	1.72	1.76	1.80	1.83	1.87	1.91	1.95	1.98	2.02	2.06	2.10
24.0	1.72	1.76	1.80	1.84	1.87	1.91	1.95	1.99	2.03	2.07	2.11	2.15	2.19
25.0	1.79	1.83	1.87	1.91	1.95	1.99	2.03	2.07	2.11	2.16	2.20	2.24	2.28
26.0	1.86	1.90	1.95	1.99	2.03	2.07	2.11	2.16	2.20	2.24	2.28	2.33	2.37
27.0	1.93	1.98	2.02	2.06	2.11	2.15	2.20	2.24	2.28	2.33	2.37	2.41	2.46
28.0	2.00	2.05	2.09	2.14	2.18	2.23	2.28	2.32	2.37	2.41	2.46	2.50	2.55
29.0	2.07	2.12	2.17	2.22	2.26	2.31	2.36	2.40	2.45	2.50	2.55	2.59	2.64
30.0	2.15	2.19	2.24	2.29	2.34	2.39	2.44	2.49	2.54	2.58	2.63	2.68	2.73
31.0	2.22	2.27	2.32	2.37	2.42	2.47	2.52	2.57	2.62	2.67	2.72	2.77	2.82
32.0	2.29	2.34	2.39	2.44	2.50	2.55	2.60	2.65	2.70	2.76	2.81	2.86	2.91
33.0	2.36	2.41	2.47	2.52	2.57	2.63	2.68	2.73	2.79	2.84	2.89	2.95	3.00
34.0	2.43	2.48	2.54	2.60	2.65	2.71	2.76	2.82	2.87	2.93	2.98	3.04	3.09
35.0	2.50	2.55	2.61	2.67	2.73	2.78	2.84	2.90	2.96	3.01	3.07	3.13	3.18

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

Attached Thermometer.	HEIGHT OF THE BAROMETER 560 mm.					HEIGHT OF THE BAROMETER 570 mm.				
	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.05	0.07	0.00	0.02	0.04	0.06	0.07
1	.09	.11	.13	.15	.16	.09	.11	.13	.15	.17
2	.18	.20	.22	.24	.26	.19	.20	.22	.24	.26
3	.27	.29	.31	.33	.35	.28	.30	.32	.34	.35
4	.37	.38	.40	.42	.44	.37	.39	.41	.43	.45
5	0.46	0.48	0.49	0.51	0.53	0.47	0.48	0.50	0.52	0.54
6	.55	.57	.58	.60	.62	.56	.58	.60	.61	.63
7	.64	.66	.68	.69	.71	.65	.67	.69	.71	.73
8	.73	.75	.77	.79	.80	.74	.76	.78	.80	.82
9	.82	.84	.86	.88	.90	.84	.86	.87	.89	.91
10	0.91	0.93	0.95	0.97	0.99	0.93	0.95	0.97	0.99	1.00
11	1.00	1.02	1.04	1.06	1.08	1.02	1.04	1.06	1.08	1.10
12	1.10	1.11	1.13	1.15	1.17	1.12	1.13	1.15	1.17	1.19
13	1.19	1.20	1.22	1.24	1.26	1.21	1.23	1.25	1.26	1.28
14	1.28	1.30	1.31	1.33	1.35	1.30	1.32	1.34	1.36	1.37
15	1.37	1.39	1.41	1.42	1.44	1.39	1.41	1.43	1.45	1.47
16	1.46	1.48	1.50	1.51	1.53	1.49	1.50	1.52	1.54	1.56
17	1.55	1.57	1.59	1.61	1.62	1.58	1.60	1.62	1.63	1.65
18	1.64	1.66	1.68	1.70	1.71	1.67	1.69	1.71	1.73	1.75
19	1.73	1.75	1.77	1.79	1.81	1.76	1.78	1.80	1.82	1.84
20	1.82	1.84	1.86	1.88	1.90	1.86	1.87	1.89	1.91	1.93
21	1.91	1.93	1.95	1.97	1.99	1.95	1.97	1.99	2.00	2.02
22	2.01	2.02	2.04	2.06	2.08	2.04	2.06	2.08	2.10	2.11
23	2.10	2.11	2.13	2.15	2.17	2.13	2.15	2.17	2.19	2.21
24	2.19	2.20	2.22	2.24	2.26	2.23	2.24	2.26	2.28	2.30
25	2.28	2.30	2.31	2.33	2.35	2.32	2.34	2.35	2.37	2.39
26	2.37	2.39	2.40	2.42	2.44	2.41	2.43	2.45	2.47	2.48
27	2.46	2.48	2.49	2.51	2.53	2.50	2.52	2.54	2.56	2.58
28	2.55	2.57	2.59	2.60	2.62	2.59	2.61	2.63	2.65	2.67
29	2.64	2.66	2.68	2.69	2.71	2.69	2.71	2.72	2.74	2.76
30	2.73	2.75	2.77	2.78	2.80	2.78	2.80	2.82	2.83	2.85
31	2.82	2.84	2.86	2.87	2.89	2.87	2.89	2.91	2.93	2.94
32	2.91	2.93	2.95	2.97	2.98	2.96	2.98	3.00	3.02	3.04
33	3.00	3.02	3.04	3.06	3.07	3.06	3.07	3.09	3.11	3.13
34	3.09	3.11	3.13	3.15	3.16	3.15	3.17	3.18	3.20	3.22
35	3.18	3.20	3.22	3.24	3.25	3.24	3.26	3.28	3.29	3.31

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 580 mm.					HEIGHT OF THE BAROMETER 590 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.08
1	.09	.11	.13	.15	.17	.10	.12	.13	.15	.17
2	.19	.21	.23	.25	.27	.19	.21	.23	.25	.27
3	.28	.30	.32	.34	.36	.29	.31	.33	.35	.37
4	.38	.40	.42	.44	.45	.39	.40	.42	.44	.46
5	0.47	0.49	0.51	0.53	0.55	0.48	0.50	0.52	0.54	0.56
6	.57	.59	.61	.62	.64	.58	.60	.62	.64	.65
7	.66	.68	.70	.72	.74	.67	.69	.71	.73	.75
8	.76	.78	.79	.81	.83	.77	.79	.81	.83	.85
9	.85	.87	.89	.91	.93	.87	.89	.90	.92	.94
10	0.95	0.96	0.98	1.00	1.02	0.96	0.98	1.00	1.02	1.04
11	1.04	1.06	1.08	1.10	1.12	1.06	1.08	1.10	1.12	1.14
12	1.13	1.15	1.17	1.19	1.21	1.15	1.17	1.19	1.21	1.23
13	1.23	1.25	1.27	1.29	1.30	1.25	1.27	1.29	1.31	1.33
14	1.32	1.34	1.36	1.38	1.40	1.35	1.37	1.38	1.40	1.42
15	1.42	1.44	1.46	1.47	1.49	1.44	1.46	1.48	1.50	1.52
16	1.51	1.53	1.55	1.57	1.59	1.54	1.56	1.58	1.60	1.61
17	1.61	1.62	1.64	1.66	1.68	1.63	1.65	1.67	1.69	1.71
18	1.70	1.72	1.74	1.76	1.78	1.73	1.75	1.77	1.79	1.81
19	1.79	1.81	1.83	1.85	1.87	1.83	1.84	1.86	1.88	1.90
20	1.89	1.91	1.93	1.95	1.96	1.92	1.94	1.96	1.98	2.00
21	1.98	2.00	2.02	2.04	2.06	2.02	2.04	2.06	2.07	2.09
22	2.08	2.10	2.11	2.13	2.15	2.11	2.13	2.15	2.17	2.19
23	2.17	2.19	2.21	2.23	2.25	2.21	2.23	2.25	2.27	2.28
24	2.26	2.28	2.30	2.32	2.34	2.30	2.32	2.34	2.36	2.38
25	2.36	2.38	2.40	2.41	2.43	2.40	2.42	2.44	2.46	2.48
26	2.45	2.47	2.49	2.51	2.53	2.49	2.51	2.53	2.55	2.57
27	2.55	2.57	2.58	2.60	2.62	2.59	2.61	2.63	2.65	2.67
28	2.64	2.66	2.68	2.70	2.72	2.69	2.70	2.72	2.74	2.76
29	2.73	2.75	2.77	2.79	2.81	2.78	2.80	2.82	2.84	2.86
30	2.83	2.85	2.87	2.88	2.90	2.88	2.90	2.91	2.93	2.95
31	2.92	2.94	2.96	2.98	3.00	2.97	2.99	3.01	3.03	3.05
32	3.02	3.03	3.05	3.07	3.09	3.07	3.09	3.11	3.12	3.14
33	3.11	3.13	3.15	3.16	3.18	3.16	3.18	3.20	3.22	3.24
34	3.20	3.22	3.24	3.26	3.28	3.26	3.28	3.30	3.31	3.33
35	3.30	3.31	3.33	3.35	3.37	3.35	3.37	3.39	3.41	3.43

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 600 mm.					HEIGHT OF THE BAROMETER 605 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.08
1	.10	.12	.14	.16	.18	.10	.12	.14	.16	.18
2	.20	.22	.24	.25	.27	.20	.22	.24	.26	.28
3	.29	.31	.33	.35	.37	.30	.32	.34	.36	.38
4	.39	.41	.43	.45	.47	.40	.41	.43	.45	.47
5	0.49	0.51	0.53	0.55	0.57	0.49	0.51	0.53	0.55	0.57
6	.59	.61	.63	.65	.67	.59	.61	.63	.65	.67
7	.69	.70	.72	.74	.76	.69	.71	.73	.75	.77
8	.78	.80	.82	.84	.86	.79	.81	.83	.85	.87
9	.88	.90	.92	.94	.96	.89	.91	.93	.95	.97
10	0.98	1.00	1.02	1.04	1.06	0.99	1.01	1.03	1.05	1.07
11	1.08	1.10	1.12	1.13	1.15	1.09	1.10	1.12	1.14	1.16
12	1.17	1.19	1.21	1.23	1.25	1.18	1.20	1.22	1.24	1.26
13	1.27	1.29	1.31	1.33	1.35	1.28	1.30	1.32	1.34	1.36
14	1.37	1.39	1.41	1.43	1.45	1.38	1.40	1.42	1.44	1.46
15	1.47	1.49	1.51	1.53	1.54	1.48	1.50	1.52	1.54	1.56
16	1.56	1.58	1.60	1.62	1.64	1.58	1.60	1.62	1.64	1.66
17	1.66	1.68	1.70	1.72	1.74	1.68	1.70	1.71	1.73	1.75
18	1.76	1.78	1.80	1.82	1.84	1.77	1.79	1.81	1.83	1.85
19	1.86	1.88	1.90	1.91	1.93	1.87	1.89	1.91	1.93	1.95
20	1.95	1.97	1.99	2.01	2.03	1.97	1.99	2.01	2.03	2.05
21	2.05	2.07	2.09	2.11	2.13	2.07	2.09	2.11	2.13	2.15
22	2.15	2.17	2.19	2.21	2.23	2.17	2.19	2.21	2.23	2.24
23	2.25	2.26	2.28	2.30	2.32	2.26	2.28	2.30	2.32	2.34
24	2.34	2.36	2.38	2.40	2.42	2.36	2.38	2.40	2.42	2.44
25	2.44	2.46	2.48	2.50	2.52	2.46	2.48	2.50	2.52	2.54
26	2.54	2.56	2.58	2.60	2.61	2.56	2.58	2.60	2.62	2.64
27	2.63	2.65	2.67	2.69	2.71	2.66	2.68	2.70	2.71	2.73
28	2.73	2.75	2.77	2.79	2.81	2.75	2.77	2.79	2.81	2.83
29	2.83	2.85	2.87	2.89	2.91	2.85	2.87	2.89	2.91	2.93
30	2.93	2.94	2.96	2.98	3.00	2.95	2.97	2.99	3.01	3.03
31	3.02	3.04	3.06	3.08	3.10	3.05	3.07	3.09	3.11	3.13
32	3.12	3.14	3.16	3.18	3.20	3.15	3.16	3.18	3.20	3.22
33	3.22	3.24	3.25	3.27	3.29	3.24	3.26	3.28	3.30	3.32
34	3.31	3.33	3.35	3.37	3.39	3.34	3.36	3.38	3.40	3.42
35	3.41	3.43	3.45	3.47	3.49	3.44	3.46	3.48	3.50	3.52

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 610 mm.					HEIGHT OF THE BAROMETER 615 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.08
1	.10	.12	.14	.16	.18	.10	.12	.14	.16	.18
2	.20	.22	.24	.26	.28	.20	.22	.24	.26	.28
3	.30	.32	.34	.36	.38	.30	.32	.34	.36	.38
4	.40	.42	.44	.46	.48	.40	.42	.44	.46	.48
5	0.50	0.52	0.54	0.56	0.58	0.50	0.52	0.54	0.56	0.58
6	.60	.62	.64	.66	.68	.60	.62	.64	.66	.68
7	.70	.72	.74	.76	.78	.70	.72	.74	.76	.78
8	.80	.82	.84	.86	.88	.80	.82	.84	.86	.88
9	.90	.92	.94	.96	.98	.90	.92	.94	.96	.98
10	0.99	1.01	1.03	1.05	1.07	1.00	1.02	1.04	1.06	1.08
11	1.09	1.11	1.13	1.15	1.17	1.10	1.12	1.14	1.16	1.18
12	1.19	1.21	1.23	1.25	1.27	1.20	1.22	1.24	1.26	1.28
13	1.29	1.31	1.33	1.35	1.37	1.30	1.32	1.34	1.36	1.38
14	1.39	1.41	1.43	1.45	1.47	1.40	1.42	1.44	1.46	1.48
15	1.49	1.51	1.53	1.55	1.57	1.50	1.52	1.54	1.56	1.58
16	1.59	1.61	1.63	1.65	1.67	1.60	1.62	1.64	1.66	1.68
17	1.69	1.71	1.73	1.75	1.77	1.70	1.72	1.74	1.76	1.78
18	1.79	1.81	1.83	1.85	1.87	1.80	1.82	1.84	1.86	1.88
19	1.89	1.91	1.93	1.95	1.97	1.90	1.92	1.94	1.96	1.98
20	1.99	2.01	2.03	2.05	2.07	2.00	2.02	2.04	2.06	2.08
21	2.09	2.10	2.12	2.14	2.16	2.10	2.12	2.14	2.16	2.18
22	2.18	2.20	2.22	2.24	2.26	2.20	2.22	2.24	2.26	2.28
23	2.28	2.30	2.32	2.34	2.36	2.30	2.32	2.34	2.36	2.38
24	2.38	2.40	2.42	2.44	2.46	2.40	2.42	2.44	2.46	2.48
25	2.48	2.50	2.52	2.54	2.56	2.50	2.52	2.54	2.56	2.58
26	2.58	2.60	2.62	2.64	2.66	2.60	2.62	2.64	2.66	2.68
27	2.68	2.70	2.72	2.74	2.76	2.70	2.72	2.74	2.76	2.78
28	2.78	2.80	2.82	2.84	2.86	2.80	2.82	2.84	2.86	2.88
29	2.88	2.90	2.91	2.93	2.95	2.90	2.92	2.94	2.96	2.98
30	2.97	2.99	3.01	3.03	3.05	3.00	3.02	3.04	3.06	3.08
31	3.07	3.09	3.11	3.13	3.15	3.10	3.12	3.14	3.16	3.18
32	3.17	3.19	3.21	3.23	3.25	3.20	3.22	3.24	3.26	3.28
33	3.27	3.29	3.31	3.33	3.35	3.30	3.32	3.34	3.36	3.38
34	3.37	3.39	3.41	3.43	3.45	3.40	3.42	3.44	3.46	3.48
35	3.47	3.49	3.51	3.53	3.55	3.49	3.51	3.53	3.55	3.57

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 620 mm.					HEIGHT OF THE BAROMETER 625 mm.				
Attached Ther-mometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.08
1	.10	.12	.14	.16	.18	.10	.12	.14	.16	.18
2	.20	.22	.24	.26	.28	.20	.22	.24	.27	.29
3	.30	.32	.34	.36	.38	.31	.33	.35	.37	.39
4	.40	.43	.45	.47	.49	.41	.43	.45	.47	.49
5	0.51	0.53	0.55	0.57	0.59	0.51	0.53	0.55	0.57	0.59
6	.61	.63	.65	.67	.69	.61	.63	.65	.67	.69
7	.71	.73	.75	.77	.79	.71	.73	.75	.78	.80
8	.81	.83	.85	.87	.89	.82	.84	.86	.88	.90
9	.91	.93	.95	.97	.99	.92	.94	.96	.98	1.00
10	1.01	1.03	1.05	1.07	1.09	1.02	1.04	1.06	1.08	1.10
11	1.11	1.13	1.15	1.17	1.19	1.12	1.14	1.16	1.18	1.20
12	1.21	1.23	1.25	1.27	1.29	1.22	1.24	1.26	1.28	1.30
13	1.31	1.33	1.35	1.37	1.39	1.32	1.34	1.37	1.39	1.41
14	1.41	1.43	1.46	1.48	1.50	1.43	1.45	1.47	1.49	1.51
15	1.52	1.54	1.56	1.58	1.60	1.53	1.55	1.57	1.59	1.61
16	1.62	1.64	1.66	1.68	1.70	1.63	1.65	1.67	1.69	1.71
17	1.72	1.74	1.76	1.78	1.80	1.73	1.75	1.77	1.79	1.81
18	1.82	1.84	1.86	1.88	1.90	1.83	1.85	1.87	1.89	1.91
19	1.92	1.94	1.96	1.98	2.00	1.93	1.95	1.97	1.99	2.01
20	2.02	2.04	2.06	2.08	2.10	2.04	2.06	2.08	2.10	2.12
21	2.12	2.14	2.16	2.18	2.20	2.14	2.16	2.18	2.20	2.22
22	2.22	2.24	2.26	2.28	2.30	2.24	2.26	2.28	2.30	2.32
23	2.32	2.34	2.36	2.38	2.40	2.34	2.36	2.38	2.40	2.42
24	2.42	2.44	2.46	2.48	2.50	2.44	2.46	2.48	2.50	2.52
25	2.52	2.54	2.56	2.58	2.60	2.54	2.56	2.58	2.60	2.62
26	2.62	2.64	2.66	2.68	2.70	2.64	2.66	2.68	2.70	2.72
27	2.72	2.74	2.76	2.78	2.80	2.74	2.76	2.78	2.80	2.82
28	2.82	2.84	2.86	2.88	2.90	2.85	2.87	2.89	2.91	2.93
29	2.92	2.94	2.96	2.98	3.00	2.95	2.97	2.99	3.01	3.03
30	3.02	3.04	3.06	3.08	3.10	3.05	3.07	3.09	3.11	3.13
31	3.12	3.14	3.16	3.18	3.20	3.15	3.17	3.19	3.21	3.23
32	3.22	3.24	3.26	3.28	3.30	3.25	3.27	3.29	3.31	3.33
33	3.32	3.34	3.36	3.38	3.40	3.35	3.37	3.39	3.41	3.43
34	3.42	3.44	3.46	3.48	3.50	3.45	3.47	3.49	3.51	3.53
35	3.52	3.54	3.56	3.58	3.60	3.55	3.57	3.59	3.61	3.63

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED

	HEIGHT OF THE BAROMETER 630 mm.					HEIGHT OF THE BAROMETER 635 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.08
1	.10	.12	.14	.16	.19	.10	.12	.15	.17	.19
2	.21	.23	.25	.27	.29	.21	.23	.25	.27	.29
3	.31	.33	.35	.37	.39	.31	.33	.35	.37	.39
4	.41	.43	.45	.47	.49	.41	.44	.46	.48	.50
5	0.51	0.53	0.56	0.58	0.60	0.52	0.54	0.56	0.58	0.60
6	.62	.64	.66	.68	.70	.62	.64	.66	.68	.70
7	.72	.74	.76	.78	.80	.73	.75	.77	.79	.81
8	.82	.84	.86	.88	.90	.83	.85	.87	.89	.91
9	.92	.95	.97	.99	1.01	.93	.95	.97	.99	1.02
10	1.03	1.05	1.07	1.09	1.11	1.04	1.06	1.08	1.10	1.12
11	1.13	1.15	1.17	1.19	1.21	1.14	1.16	1.18	1.20	1.22
12	1.23	1.25	1.27	1.29	1.31	1.24	1.26	1.28	1.30	1.33
13	1.34	1.36	1.38	1.40	1.42	1.35	1.37	1.39	1.41	1.43
14	1.44	1.46	1.48	1.50	1.52	1.45	1.47	1.49	1.51	1.53
15	1.54	1.56	1.58	1.60	1.62	1.55	1.57	1.59	1.61	1.63
16	1.64	1.66	1.68	1.70	1.72	1.66	1.68	1.70	1.72	1.74
17	1.74	1.77	1.79	1.81	1.83	1.76	1.78	1.80	1.82	1.84
18	1.85	1.87	1.89	1.91	1.93	1.86	1.88	1.90	1.92	1.94
19	1.95	1.97	1.99	2.01	2.03	1.96	1.99	2.01	2.03	2.05
20	2.05	2.07	2.09	2.11	2.13	2.07	2.09	2.11	2.13	2.15
21	2.15	2.17	2.19	2.21	2.24	2.17	2.19	2.21	2.23	2.25
22	2.26	2.28	2.30	2.32	2.34	2.27	2.29	2.31	2.34	2.36
23	2.36	2.38	2.40	2.42	2.44	2.38	2.40	2.42	2.44	2.46
24	2.46	2.48	2.50	2.52	2.54	2.48	2.50	2.52	2.54	2.56
25	2.56	2.58	2.60	2.62	2.64	2.58	2.60	2.62	2.64	2.66
26	2.66	2.68	2.70	2.73	2.75	2.69	2.71	2.73	2.75	2.77
27	2.77	2.79	2.81	2.83	2.85	2.79	2.81	2.83	2.85	2.87
28	2.87	2.89	2.91	2.93	2.95	2.89	2.91	2.93	2.95	2.97
29	2.97	2.99	3.01	3.03	3.05	2.99	3.01	3.03	3.05	3.08
30	3.07	3.09	3.11	3.13	3.15	3.10	3.12	3.14	3.16	3.18
31	3.17	3.19	3.21	3.23	3.25	3.20	3.22	3.24	3.26	3.28
32	3.28	3.30	3.32	3.34	3.36	3.30	3.32	3.34	3.36	3.38
33	3.38	3.40	3.42	3.44	3.46	3.40	3.42	3.44	3.47	3.49
34	3.48	3.50	3.52	3.54	3.56	3.51	3.53	3.55	3.57	3.59
35	3.58	3.60	3.62	3.64	3.66	3.61	3.63	3.65	3.67	3.69

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

Attached Thermometer.	Height of the Barometer 640 mm.					Height of the Barometer 645 mm.				
	0°0	0°2	0°4	0°6	0°8	0°0	0°2	0°4	0°6	0°8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.08
1	.10	.13	.15	.17	.19	.11	.13	.15	.17	.19
2	.21	.23	.25	.27	.29	.21	.23	.25	.27	.29
3	.31	.33	.36	.38	.40	.32	.34	.36	.38	.40
4	.42	.44	.46	.48	.50	.42	.44	.46	.48	.51
5	0.52	0.54	0.56	0.59	0.61	0.53	0.55	0.57	0.59	0.61
6	.63	.65	.67	.69	.71	.63	.65	.67	.69	.72
7	.73	.75	.77	.79	.81	.74	.76	.78	.80	.82
8	.84	.86	.88	.90	.92	.84	.86	.88	.90	.93
9	.94	.96	.98	1.00	1.02	.95	.97	.99	1.01	1.03
10	1.04	1.06	1.09	1.11	1.13	1.05	1.07	1.09	1.12	1.14
11	1.15	1.17	1.19	1.21	1.23	1.16	1.18	1.20	1.22	1.24
12	1.25	1.27	1.29	1.31	1.34	1.26	1.28	1.30	1.32	1.35
13	1.36	1.38	1.40	1.42	1.44	1.37	1.39	1.41	1.43	1.45
14	1.46	1.48	1.50	1.52	1.54	1.47	1.49	1.51	1.53	1.56
15	1.56	1.59	1.61	1.63	1.65	1.58	1.60	1.62	1.64	1.66
16	1.67	1.69	1.71	1.73	1.75	1.68	1.70	1.72	1.74	1.77
17	1.77	1.79	1.81	1.83	1.86	1.79	1.81	1.83	1.85	1.87
18	1.88	1.90	1.92	1.94	1.96	1.89	1.91	1.93	1.95	1.97
19	1.98	2.00	2.02	2.04	2.06	2.00	2.02	2.04	2.06	2.08
20	2.08	2.10	2.13	2.15	2.17	2.10	2.12	2.14	2.16	2.18
21	2.19	2.21	2.23	2.25	2.27	2.20	2.23	2.25	2.27	2.29
22	2.29	2.31	2.33	2.35	2.37	2.31	2.33	2.35	2.37	2.39
23	2.40	2.42	2.44	2.46	2.48	2.41	2.43	2.46	2.48	2.50
24	2.50	2.52	2.54	2.56	2.58	2.52	2.54	2.56	2.58	2.60
25	2.60	2.62	2.64	2.66	2.69	2.62	2.64	2.66	2.69	2.71
26	2.71	2.73	2.75	2.77	2.79	2.73	2.75	2.77	2.79	2.81
27	2.81	2.83	2.85	2.87	2.89	2.83	2.85	2.87	2.89	2.92
28	2.91	2.93	2.95	2.98	3.00	2.94	2.96	2.98	3.00	3.02
29	3.02	3.04	3.06	3.08	3.10	3.04	3.06	3.08	3.10	3.12
30	3.12	3.14	3.16	3.18	3.20	3.14	3.17	3.19	3.21	3.23
31	3.22	3.24	3.27	3.29	3.31	3.25	3.27	3.29	3.31	3.33
32	3.33	3.35	3.37	3.39	3.41	3.35	3.37	3.39	3.42	3.44
33	3.43	3.45	3.47	3.49	3.51	3.46	3.48	3.50	3.52	3.54
34	3.53	3.55	3.58	3 60	3.62	3.56	3.58	3.60	3.62	3.64
35	3.64	3.66	3.68	3.70	3.72	3.67	3.69	3.71	3.73	3.75

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 650 mm.					HEIGHT OF THE BAROMETER 655 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.08	0.00	0.02	0.04	0.06	0.09
1	.11	.13	.15	.17	.19	.11	.13	.15	.17	.19
2	.21	.23	.25	.28	.30	.21	.24	.26	.28	.30
3	.32	.34	.36	.38	.40	.32	.34	.36	.39	.41
4	.42	.45	.47	.49	.51	.43	.45	.47	.49	.51
5	0.53	0.55	0.57	0.59	0.62	0.53	0.56	0.58	0.60	0.62
6	.64	.66	.68	.70	.72	.64	.66	.68	.71	.73
7	.74	.76	.78	.81	.83	.75	.77	.79	.81	.83
8	.85	.87	.89	.91	.93	.85	.88	.90	.92	.94
9	.95	.98	1.00	1.02	1.04	.96	.98	1.00	1.03	1.05
10	1.06	1.08	1.10	1.12	1.14	1.07	1.09	1.11	1.13	1.15
11	1.17	1.19	1.21	1.23	1.25	1.17	1.20	1.22	1.24	1.26
12	1.27	1.29	1.31	1.34	1.36	1.28	1.30	1.32	1.35	1.37
13	1.38	1.40	1.42	1.44	1.46	1.39	1.41	1.43	1.45	1.47
14	1.48	1.50	1.53	1.55	1.57	1.49	1.52	1.54	1.56	1.58
15	1.59	1.61	1.63	1.65	1.67	1.60	1.62	1.64	1.66	1.69
16	1.69	1.72	1.74	1.76	1.78	1.71	1.73	1.75	1.77	1.79
17	1.80	1.82	1.84	1.86	1.88	1.81	1.84	1.86	1.88	1.90
18	1.91	1.93	1.95	1.97	1.99	1.92	1.94	1.96	1.98	2.01
19	2.01	2.03	2.05	2.07	2.10	2.03	2.05	2.07	2.09	2.11
20	2.12	2.14	2.16	2.18	2.20	2.13	2.15	2.18	2.20	2.22
21	2.22	2.24	2.26	2.29	2.31	2.24	2.26	2.28	2.30	2.32
22	2.33	2.35	2.37	2.39	2.41	2.35	2.37	2.39	2.41	2.43
23	2.43	2.45	2.47	2.50	2.52	2.45	2.47	2.49	2.52	2.54
24	2.54	2.56	2.58	2.60	2.62	2.56	2.58	2.60	2.62	2.64
25	2.64	2.66	2.69	2.71	2.73	2.66	2.68	2.71	2.73	2.75
26	2.75	2.77	2.79	2.81	2.83	2.77	2.79	2.81	2.83	2.85
27	2.85	2.87	2.90	2.92	2.94	2.88	2.90	2.92	2.94	2.96
28	2.96	2.98	3.00	3.02	3.04	2.98	3.00	3.02	3.05	3.07
29	3.06	3.08	3.11	3.13	3.15	3.09	3.11	3.13	3.15	3.17
30	3.17	3.19	3.21	3.23	3.25	3.19	3.21	3.24	3.26	3.28
31	3.27	3.30	3.32	3.34	3.36	3.30	3.32	3.34	3.36	3.38
32	3.38	3.40	3.42	3.44	3.46	3.41	3.43	3.45	3.47	3.49
33	3.48	3.51	3.53	3.55	3.57	3.51	3.53	3.55	3.57	3.60
34	3.59	3.61	3.63	3.65	3.67	3.62	3.64	3.66	3.68	3.70
35	3.69	3.71	3.74	3.76	3.78	3.72	3.74	3.76	3.79	3.81

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 660 mm.					HEIGHT OF THE BAROMETER 665 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.06	0.09	0.00	0.02	0.04	0.07	0.09
1	.11	.13	.15	.17	.19	.11	.13	.15	.17	.20
2	.22	.24	.26	.28	.30	.22	.24	.26	.28	.30
3	.32	.34	.37	.39	.41	.33	.35	.37	.39	.41
4	.43	.45	.47	.50	.52	.43	.46	.48	.50	.52
5	0.54	0.56	0.58	0.60	0.62	0.54	0.56	0.59	0.61	0.63
6	.65	.67	.69	.71	.73	.65	.67	.69	.72	.74
7	.75	.78	.80	.82	.84	.76	.78	.80	.82	.85
8	.86	.88	.90	.93	.95	.87	.89	.91	.93	.95
9	.97	.99	1.01	1.03	1.05	.98	1.00	1.02	1.04	1.06
10	1.08	1.10	1.12	1.14	1.16	1.08	1.11	1.13	1.15	1.17
11	1.18	1.21	1.23	1.25	1.27	1.19	1.21	1.24	1.26	1.28
12	1.29	1.31	1.33	1.36	1.38	1.30	1.32	1.34	1.37	1.39
13	1.40	1.42	1.44	1.46	1.48	1.41	1.43	1.45	1.47	1.50
14	1.51	1.53	1.55	1.57	1.59	1.52	1.54	1.56	1.58	1.60
15	1.61	1.63	1.66	1.68	1.70	1.63	1.65	1.67	1.69	1.71
16	1.72	1.74	1.76	1.78	1.81	1.73	1.76	1.78	1.80	1.82
17	1.83	1.85	1.87	1.89	1.91	1.84	1.86	1.88	1.91	1.93
18	1.93	1.96	1.98	2.00	2.02	1.95	1.97	1.99	2.01	2.04
19	2.04	2.06	2.08	2.11	2.13	2.06	2.08	2.10	2.12	2.14
20	2.15	2.17	2.19	2.21	2.23	2.17	2.19	2.21	2.23	2.25
21	2.26	2.28	2.30	2.32	2.34	2.27	2.29	2.32	2.34	2.36
22	2.36	2.38	2.41	2.43	2.45	2.38	2.40	2.42	2.45	2.47
23	2.47	2.49	2.51	2.53	2.56	2.49	2.51	2.53	2.55	2.57
24	2.58	2.60	2.62	2.64	2.66	2.60	2.62	2.64	2.66	2.68
25	2.68	2.71	2.73	2.75	2.77	2.70	2.73	2.75	2.77	2.79
26	2.79	2.81	2.83	2.85	2.88	2.81	2.83	2.85	2.88	2.90
27	2.90	2.92	2.94	2.96	2.98	2.92	2.94	2.96	2.98	3.01
28	3.00	3.03	3.05	3.07	3.09	3.03	3.05	3.07	3.09	3.11
29	3.11	3.13	3.15	3.18	3.20	3.13	3.16	3.18	3.20	3.22
30	3.22	3.24	3.26	3.28	3.30	3.24	3.26	3.29	3.31	3.33
31	3.32	3.35	3.37	3.39	3.41	3.35	3.37	3.39	3.41	3.44
32	3.43	3.45	3.47	3.49	3.52	3.46	3.48	3.50	3.52	3.54
33	3.54	3.56	3.58	3.60	3.62	3.56	3.59	3.61	3.63	3.65
34	3.64	3.67	3.69	3.71	3.73	3.67	3.69	3.71	3.74	3.76
35	3.75	3.77	3.79	3.81	3.84	3.78	3.80	3.82	3.84	3.86

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

Attached Thermometer.	HEIGHT OF THE BAROMETER 670 mm.					HEIGHT OF THE BAROMETER 675 mm.				
	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.07	0.09	0.00	0.02	0.04	0.07	0.09
1	.11	.13	.15	.18	.20	.11	.13	.15	.18	.20
2	.22	.24	.26	.28	.31	.22	.24	.26	.29	.31
3	.33	.35	.37	.39	.42	.33	.35	.37	.40	.42
4	.44	.46	.48	.50	.53	.44	.46	.48	.51	.53
5	0.55	0.57	0.59	0.61	0.63	0.55	0.57	0.60	0.62	0.64
6	.66	.68	.70	.72	.74	.66	.68	.71	.73	.75
7	.77	.79	.81	.83	.85	.77	.79	.82	.84	.86
8	.87	.90	.92	.94	.96	.88	.90	.93	.95	.97
9	.98	1.01	1.03	1.05	1.07	.99	1.01	1.04	1.06	1.08
10	1.09	1.11	1.14	1.16	1.18	1.10	1.12	1.14	1.17	1.19
11	1.20	1.22	1.25	1.27	1.29	1.21	1.23	1.25	1.28	1.30
12	1.31	1.33	1.35	1.38	1.40	1.32	1.34	1.36	1.39	1.41
13	1.42	1.44	1.46	1.49	1.51	1.43	1.45	1.47	1.50	1.52
14	1.53	1.55	1.57	1.59	1.62	1.54	1.56	1.58	1.61	1.63
15	1.64	1.66	1.68	1.70	1.72	1.65	1.67	1.69	1.72	1.74
16	1.75	1.77	1.79	1.81	1.83	1.76	1.78	1.80	1.83	1.85
17	1.86	1.88	1.90	1.92	1.94	1.87	1.89	1.91	1.94	1.96
18	1.96	1.99	2.01	2.03	2.05	1.98	2.00	2.02	2.04	2.07
19	2.07	2.09	2.12	2.14	2.16	2.09	2.11	2.13	2.15	2.18
20	2.18	2.20	2.23	2.25	2.27	2.20	2.22	2.24	2.26	2.29
21	2.29	2.31	2.33	2.36	2.38	2.31	2.33	2.35	2.37	2.39
22	2.40	2.42	2.44	2.46	2.49	2.42	2.44	2.46	2.48	2.50
23	2.51	2.53	2.55	2.57	2.59	2.53	2.55	2.57	2.59	2.61
24	2.62	2.64	2.66	2.68	2.70	2.64	2.66	2.68	2.70	2.72
25	2.72	2.75	2.77	2.79	2.81	2.74	2.77	2.79	2.81	2.83
26	2.83	2.85	2.88	2.90	2.92	2.85	2.88	2.90	2.92	2.94
27	2.94	2.96	2.98	3.01	3.03	2.96	2.99	3.01	3.03	3.05
28	3.05	3.07	3.09	3.11	3.14	3.07	3.09	3.12	3.14	3.16
29	3.16	3.18	3.20	3.22	3.24	3.18	3.20	3.23	3.25	3.27
30	3.27	3.29	3.31	3.33	3.35	3.29	3.31	3.33	3.36	3.38
31	3.37	3.40	3.42	3.44	3.46	3.40	3.42	3.44	3.47	3.49
33	3.48	3.50	3.53	3.55	3.57	3.51	3.53	3.55	3.57	3.60
33	3.59	3.61	3.63	3.66	3.68	3.62	3.64	3.66	3.68	3.71
34	3.70	3.72	3.74	3.76	3.79	3.73	3.75	3.77	3.79	3.81
35	3.81	3.83	3.85	3.87	3.89	3.84	3.86	3.88	3.90	3.92

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 680 mm.					HEIGHT OF THE BAROMETER 685 mm.				
Attached Ther-mometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.04	0.07	0.09	0.00	0.02	0.04	0.07	0.09
1	.11	.13	.16	.18	.20	.11	.13	.16	.18	.20
2	.22	.24	.27	.29	.31	.22	.25	.27	.29	.31
3	.33	.36	.38	.40	.42	.34	.36	.38	.40	.43
4	.44	.47	.49	.51	.53	.45	.47	.49	.51	.54
5	0.56	0.58	0.60	0.62	0.64	0.56	0.58	0.60	0.63	0.65
6	.67	.69	.71	.73	.75	.67	.69	.72	.74	.76
7	.78	.80	.82	.84	.87	.78	.80	.83	.85	.87
8	.89	.91	.93	.95	.98	.89	.92	.94	.96	.98
9	1.00	1.02	1.04	1.06	1.09	1.01	1.03	1.05	1.07	1.09
10	1.11	1.13	1.15	1.18	1.20	1.12	1.14	1.16	1.18	1.21
11	1.22	1.24	1.26	1.29	1.31	1.23	1.25	1.27	1.30	1.32
12	1.33	1.35	1.37	1.40	1.42	1.34	1.36	1.38	1.41	1.43
13	1.44	1.46	1.49	1.51	1.53	1.45	1.47	1.50	1.52	1.54
14	1.55	1.57	1.60	1.62	1.64	1.56	1.59	1.61	1.63	1.65
15	1.66	1.68	1.71	1.73	1.75	1.67	1.70	1.72	1.74	1.76
16	1.77	1.79	1.82	1.84	1.86	1.79	1.81	1.83	1.85	1.87
17	1.88	1.91	1.93	1.95	1.97	1.90	1.92	1.94	1.96	1.99
18	1.99	2.02	2.04	2.06	2.08	2.01	2.03	2.05	2.07	2.10
19	2.10	2.13	2.15	2.17	2.19	2.12	2.14	2.16	2.19	2.21
20	2.21	2.24	2.26	2.28	2.30	2.23	2.25	2.27	2.30	2.32
21	2.32	2.35	2.37	2.39	2.41	2.34	2.36	2.39	2.41	2.43
22	2.43	2.46	2.48	2.50	2.52	2.45	2.47	2.50	2.52	2.54
23	2.54	2.57	2.59	2.61	2.63	2.56	2.59	2.61	2.63	2.65
24	2.66	2.68	2.70	2.72	2.74	2.67	2.70	2.72	2.74	2.76
25	2.77	2.79	2.81	2.83	2.85	2.79	2.81	2.83	2.85	2.87
26	2.88	2.90	2.92	2.94	2.96	2.90	2.92	2.94	2.96	2.99
27	2.99	3.01	3.03	3.05	3.07	3.01	3.03	3.05	3.07	3.10
28	3.10	3.12	3.14	3.16	3.18	3.12	3.14	3.16	3.18	3.21
29	3.21	3.23	3.25	3.27	3.29	3.23	3.25	3.27	3.30	3.32
30	3.32	3.34	3.36	3.38	3.40	3.34	3.36	3.38	3.41	3.43
31	3.43	3.45	3.47	3.49	3.51	3.45	3.47	3.49	3.52	3.54
32	3.54	3.56	3.58	3.60	3.62	3.56	3.58	3.61	3.63	3.65
33	3.64	3.67	3.69	3.71	3.73	3.67	3.69	3.72	3.74	3.76
34	3.75	3.78	3.80	3.82	3.84	3.78	3.80	3.83	3.85	3.87
35	3.86	3.89	3.91	3.93	3.95	3.89	3.91	3.94	3.96	3.98

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

Attached Thermometer.	HEIGHT OF THE BAROMETER 690 mm.					HEIGHT OF THE BAROMETER 695 mm.				
	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.09	0.00	0.02	0.05	0.07	0.09
1	.11	.14	.16	.18	.20	.11	.14	.16	.18	.20
2	.23	.25	.27	.29	.32	.23	.25	.27	.30	.32
3	.34	.36	.38	.41	.43	.34	.36	.39	.41	.43
4	.45	.47	.50	.52	.54	.45	.48	.50	.52	.54
5	0.56	0.59	0.61	0.63	0.65	0.57	0.59	0.61	0.64	0.66
6	.68	.70	.72	.74	.77	.68	.70	.73	.75	.77
7	.79	.81	.83	.86	.88	.79	.82	.84	.86	.88
8	.90	.92	.95	.97	.99	.91	.93	.95	.98	1.00
9	1.01	1.04	1.06	1.08	1.10	1.02	1.04	1.07	1.09	1.11
10	1.13	1.15	1.17	1.19	1.22	1.13	1.16	1.18	1.20	1.22
11	1.24	1.26	1.28	1.31	1.33	1.25	1.27	1.29	1.31	1.34
12	1.35	1.37	1.39	1.42	1.44	1.36	1.38	1.41	1.43	1.45
13	1.46	1.48	1.51	1.53	1.55	1.47	1.50	1.52	1.54	1.56
14	1.57	1.60	1.62	1.64	1.66	1.59	1.61	1.63	1.65	1.68
15	1.69	1.71	1.73	1.75	1.78	1.70	1.72	1.74	1.77	1.79
16	1.80	1.82	1.84	1.87	1.89	1.81	1.83	1.86	1.88	1.90
17	1.91	1.93	1.96	1.98	2.00	1.92	1.95	1.97	1.99	2.01
18	2.02	2.05	2.07	2.09	2.11	2.04	2.06	2.08	2.11	2.13
19	2.13	2.16	2.18	2.20	2.22	2.15	2.17	2.20	2.22	2.24
20	2.25	2.27	2.29	2.31	2.34	2.26	2.29	2.31	2.33	2.35
21	2.36	2.38	2.40	2.43	2.45	2.38	2.40	2.42	2.44	2.47
22	2.47	2.49	2.52	2.54	2.56	2.49	2.51	2.53	2.56	2.58
23	2.58	2.60	2.63	2.65	2.67	2.60	2.62	2.65	2.67	2.69
24	2.69	2.72	2.74	2.76	2.78	2.71	2.74	2.76	2.78	2.80
25	2.81	2.83	2.85	2.87	2.90	2.83	2.85	2.87	2.89	2.92
26	2.92	2.94	2.96	2.99	3.01	2.94	2.96	2.98	3.01	3.03
27	3.03	3.05	3.07	3.10	3.12	3.05	3.07	3.10	3.12	3.14
28	3.14	3.16	3.19	3.21	3.23	3.16	3.19	3.21	3.23	3.25
29	3.25	3.27	3.30	3.32	3.34	3.28	3.30	3.32	3.34	3.37
30	3.36	3.39	3.41	3.43	3.45	3.39	3.41	3.43	3.46	3.48
31	3.48	3.50	3.52	3.54	3.56	3.50	3.52	3.55	3.57	3.59
32	3.59	3.61	3.63	3.65	3.68	3.61	3.64	3.66	3.68	3.70
33	3.70	3.72	3.74	3.77	3.79	3.73	3.75	3.77	3.79	3.81
34	3.81	3.83	3.85	3.88	3.90	3.84	3.86	3.88	3.90	3.93
35	3.92	3.94	3.97	3.99	4.01	3.95	3.97	3.99	4.02	4.04

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	Height of the Barometer 700 mm.					Height of the Barometer 705 mm.				
Attached Ther-mometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.09	0.00	0.02	0.05	0.07	0.09
1	.11	.14	.16	.18	.21	.12	.14	.16	.18	.21
2	.23	.25	.27	.30	.32	.23	.25	.28	.30	.32
3	.34	.37	.39	.41	.43	.35	.37	.39	.41	.44
4	.46	.48	.50	.53	.55	.46	.48	.51	.53	.55
5	0.57	0.59	0.62	0.64	0.66	0.58	0.60	0.62	0.64	0.67
6	.69	.71	.73	.75	.78	.69	.71	.74	.76	.78
7	.80	.82	.85	.87	.89	.81	.83	.85	.87	.90
8	.91	.94	.96	.98	1.00	.92	.94	.97	.99	1.01
9	1.03	1.05	1.07	1.10	1.12	1.04	1.06	1.08	1.10	1.13
10	1.14	1.16	1.19	1.21	1.23	1.15	1.17	1.20	1.22	1.24
11	1.26	1.28	1.30	1.32	1.35	1.26	1.29	1.31	1.33	1.36
12	1.37	1.39	1.42	1.44	1.46	1.38	1.40	1.43	1.45	1.47
13	1.48	1.51	1.53	1.55	1.57	1.49	1.52	1.54	1.56	1.59
14	1.60	1.62	1.64	1.67	1.69	1.61	1.63	1.65	1.68	1.70
15	1.71	1.73	1.76	1.78	1.80	1.72	1.75	1.77	1.79	1.81
16	1.82	1.85	1.87	1.89	1.92	1.84	1.86	1.88	1.91	1.93
17	1.94	1.96	1.98	2.01	2.03	1.95	1.98	2.00	2.02	2.04
18	2.05	2.07	2.10	2.12	2.14	2.07	2.09	2.11	2.14	2.16
19	2.17	2.19	2.21	2.23	2.26	2.18	2.20	2.23	2.25	2.27
20	2.28	2.30	2.32	2.35	2.37	2.30	2.32	2.34	2.36	2.39
21	2.39	2.42	2.44	2.46	2.48	2.41	2.43	2.46	2.48	2.50
22	2.51	2.53	2.55	2.57	2.60	2.52	2.55	2.57	2.59	2.62
23	2.62	2.64	2.67	2.69	2.71	2.64	2.66	2.68	2.71	2.73
24	2.73	2.76	2.78	2.80	2.82	2.75	2.78	2.80	2.82	2.84
25	2.85	2.87	2.89	2.91	2.94	2.87	2.89	2.91	2.94	2.96
26	2.96	2.98	3.01	3.03	3.05	2.98	3.00	3.03	3.05	3.07
27	3.07	3.10	3.12	3.14	3.16	3.10	3.12	3.14	3.16	3.19
28	3.19	3.21	3.23	3.25	3.28	3.21	3.23	3.25	3.28	3.30
29	3.30	3.32	3.34	3.37	3.39	3.32	3.35	3.37	3.39	3.41
30	3.41	3.44	3.46	3.48	3.50	3.44	3.46	3.48	3.51	3.53
31	3.53	3.55	3.57	3.59	3.62	3.55	3.57	3.60	3.62	3.64
32	3.64	3.66	3.68	3.71	3.73	3.66	3.69	3.71	3.73	3.76
33	3.75	3.77	3.80	3.82	3.84	3.78	3.80	3.82	3.85	3.87
34	3.87	3.89	3.91	3.93	3.96	3.89	3.92	3.94	3.96	3.98
35	3.98	4.00	4.02	4.05	4.07	4.01	4.03	4.05	4.07	4.10

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 710 mm.					HEIGHT OF THE BAROMETER 715 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.09	0.00	0.02	0.05	0.07	0.09
1	.12	.14	.16	.19	.21	.12	.14	.16	.19	.21
2	.23	.26	.28	.30	.32	.23	.26	.28	.30	.33
3	.35	.37	.39	.42	.44	.35	.37	.40	.42	.44
4	.46	.49	.51	.53	.56	.47	.49	.51	.54	.56
5	0.58	0.60	0.63	0.65	0.67	0.58	0.61	0.63	0.65	0.68
6	.70	.72	.74	.76	.79	.70	.72	.75	.77	.79
7	.81	.83	.86	.88	.90	.82	.84	.86	.89	.91
8	.93	.95	.97	1.00	1.02	.93	.96	.98	1.00	1.03
9	1.04	1.07	1.09	1.11	1.13	1.05	1.07	1.10	1.12	1.14
10	1.16	1.18	1.20	1.23	1.25	1.17	1.19	1.21	1.24	1.26
11	1.27	1.30	1.32	1.34	1.37	1.28	1.31	1.33	1.35	1.38
12	1.39	1.41	1.44	1.46	1.48	1.40	1.42	1.45	1.47	1.49
13	1.50	1.53	1.55	1.57	1.60	1.52	1.54	1.56	1.58	1.61
14	1.62	1.64	1.67	1.69	1.71	1.63	1.65	1.68	1.70	1.72
15	1.74	1.76	1.78	1.80	1.83	1.75	1.77	1.79	1.82	1.84
16	1.85	1.87	1.90	1.92	1.94	1.86	1.89	1.91	1.93	1.96
17	1.97	1.99	2.01	2.04	2.06	1.98	2.00	2.03	2.05	2.07
18	2.08	2.10	2.13	2.15	2.17	2.10	2.12	2.14	2.17	2.19
19	2.20	2.22	2.24	2.27	2.29	2.21	2.24	2.26	2.28	2.30
20	2.31	2.33	2.36	2.38	2.40	2.33	2.35	2.37	2.40	2.42
21	2.43	2.45	2.47	2.50	2.52	2.44	2.47	2.49	2.51	2.54
22	2.54	2.57	2.59	2.61	2.63	2.56	2.58	2.61	2.63	2.65
23	2.66	2.68	2.70	2.73	2.75	2.68	2.70	2.72	2.75	2.77
24	2.77	2.80	2.82	2.84	2.86	2.79	2.81	2.84	2.86	2.88
25	2.89	2.91	2.93	2.96	2.98	2.91	2.93	2.95	2.98	3.00
26	3.00	3.03	3.05	3.07	3.09	3.02	3.05	3.07	3.09	3.12
27	3.12	3.14	3.16	3.19	3.21	3.14	3.16	3.19	3.21	3.23
28	3.23	3.25	3.28	3.30	3.32	3.25	3.28	3.30	3.32	3.35
29	3.35	3.37	3.39	3.42	3.44	3.37	3.39	3.42	3.44	3.46
30	3.46	3.48	3.51	3.53	3.55	3.49	3.51	3.53	3.56	3.58
31	3.58	3.60	3.62	3.65	3.67	3.60	3.62	3.65	3.67	3.69
32	3.69	3.71	3.74	3.76	3.78	3.72	3.74	3.76	3.79	3.81
33	3.81	3.83	3.85	3.87	3.90	3.83	3.86	3.88	3.90	3.92
34	3.92	3.94	3.97	3.99	4.01	3.95	3.97	3.99	4.02	4.04
35	4.03	4.06	4.08	4.10	4.13	4.06	4.09	4.11	4.13	4.16

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 720 mm.					HEIGHT OF THE BAROMETER 725 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.09	0.00	0.02	0.05	0.07	0.09
1	.12	.14	.16	.19	.21	.12	.14	.17	.19	.21
2	.24	.26	.28	.31	.33	.24	.26	.28	.31	.33
3	.35	.38	.40	.42	.45	.36	.38	.40	.43	.45
4	.47	.49	.52	.54	.56	.47	.50	.52	.54	.57
5	0.59	0.61	0.63	0.66	0.68	0.59	0.62	0.64	0.66	0.69
6	.71	.73	.75	.78	.80	.71	.73	.76	.78	.80
7	.82	.85	.87	.89	.92	.83	.85	.88	.90	.92
8	.94	.96	.99	1.01	1.03	.95	.97	.99	1.02	1.04
9	1.06	1.08	1.10	1.13	1.15	1.06	1.09	1.11	1.14	1.16
10	1.17	1.20	1.22	1.24	1.27	1.18	1.21	1.23	1.25	1.28
11	1.29	1.31	1.34	1.36	1.39	1.30	1.32	1.35	1.37	1.39
12	1.41	1.43	1.46	1.48	1.50	1.42	1.44	1.47	1.49	1.51
13	1.53	1.55	1.57	1.60	1.62	1.54	1.56	1.58	1.61	1.63
14	1.64	1.67	1.69	1.71	1.74	1.65	1.68	1.70	1.73	1.75
15	1.76	1.78	1.81	1.83	1.85	1.77	1.80	1.82	1.84	1.87
16	1.88	1.90	1.92	1.95	1.97	1.89	1.91	1.94	1.96	1.98
17	1.99	2.02	2.04	2.06	2.09	2.01	2.03	2.05	2.08	2.10
18	2.11	2.13	2.16	2.18	2.20	2.13	2.15	2.17	2.20	2.22
19	2.23	2.25	2.27	2.30	2.32	2.24	2.27	2.29	2.31	2.34
20	2.34	2.37	2.39	2.41	2.44	2.36	2.38	2.41	2.43	2.45
21	2.46	2.48	2.51	2.53	2.55	2.48	2.50	2.53	2.55	2.57
22	2.58	2.60	2.62	2.65	2.67	2.60	2.62	2.64	2.67	2.69
23	2.69	2.72	2.74	2.76	2.79	2.71	2.74	2.76	2.78	2.81
24	2.81	2.83	2.86	2.88	2.90	2.83	2.85	2.88	2.90	2.92
25	2.93	2.95	2.97	3.00	3.02	2.95	2.97	3.00	3.02	3.04
26	3.04	3.07	3.09	3.11	3.14	3.07	3.09	3.11	3.14	3.16
27	3.16	3.18	3.21	3.23	3.25	3.18	3.21	3.23	3.25	3.28
28	3.28	3.30	3.32	3.35	3.37	3.30	3.32	3.35	3.37	3.39
29	3.39	3.42	3.44	3.46	3.49	3.42	3.44	3.46	3.49	3.51
30	3.51	3.53	3.56	3.58	3.60	3.53	3.56	3.58	3.60	3.63
31	3.63	3.65	3.67	3.70	3.72	3.65	3.68	3.70	3.72	3.75
32	3.74	3.77	3.79	3.81	3.84	3.77	3.79	3.82	3.84	3.86
33	3.86	3.88	3.91	3.93	3.95	3.89	3.91	3.93	3.96	3.98
24	3.98	4.00	4.02	4.05	4.07	4.00	4.03	4.05	4.07	4.10
35	4.09	4.11	4.14	4.16	4.18	4.12	4.14	4.17	4.19	4.21

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 730 mm.					HEIGHT OF THE BAROMETER 735 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.10	0.00	0.02	0.05	0.07	0.10
1	.12	.14	.17	.19	.21	.12	.14	.17	.19	.22
2	.24	.26	.29	.31	.33	.24	.26	.29	.31	.34
3	.36	.38	.41	.43	.45	.36	.38	.41	.43	.46
4	.48	.50	.52	.55	.57	.48	.50	.53	.55	.58
5	0.60	0.62	0.64	0.67	0.69	0.60	0.62	0.65	0.67	0.70
6	.71	.74	.76	.79	.81	.72	.74	.77	.79	.82
7	.83	.86	.88	.91	.93	.84	.86	.89	.91	.94
8	.95	.98	1.00	1.02	1.05	.96	.98	1.01	1.03	1.06
9	1.07	1.10	1.12	1.14	1.17	1.08	1.10	1.13	1.15	1.17
10	1.19	1.21	1.24	1.26	1.29	1.20	1.22	1.25	1.27	1.29
11	1.31	1.33	1.36	1.38	1.40	1.32	1.34	1.37	1.39	1.41
12	1.43	1.45	1.48	1.50	1.52	1.44	1.46	1.49	1.51	1.53
13	1.55	1.57	1.59	1.62	1.64	1.56	1.58	1.61	1.63	1.65
14	1.67	1.69	1.71	1.74	1.76	1.68	1.70	1.72	1.75	1.77
15	1.78	1.81	1.83	1.86	1.88	1.80	1.82	1.84	1.87	1.89
16	1.90	1.93	1.95	1.97	2.00	1.92	1.94	1.96	1.99	2.01
17	2.02	2.05	2.07	2.09	2.12	2.04	2.06	2.08	2.11	2.13
18	2.14	2.16	2.19	2.21	2.23	2.15	2.18	2.20	2.23	2.25
19	2.26	2.28	2.31	2.33	2.35	2.27	2.30	2.32	2.35	2.37
20	2.38	2.40	2.42	2.45	2.47	2.39	2.42	2.44	2.46	2.49
21	2.50	2.52	2.54	2.57	2.59	2.51	2.54	2.56	2.58	2.61
22	2.61	2.64	2.66	2.68	2.71	2.63	2.66	2.68	2.70	2.73
23	2.73	2.76	2.78	2.80	2.83	2.75	2.77	2.80	2.82	2.85
24	2.85	2.87	2.90	2.92	2.94	2.87	2.89	2.92	2.94	2.97
25	2.97	2.99	3.02	3.04	3.06	2.99	3.01	3.04	3.06	3.08
26	3.09	3.11	3.13	3.16	3.18	3.11	3.13	3.16	3.18	3.20
27	3.20	3.23	3.25	3.28	3.30	3.23	3.25	3.27	3.30	3.32
28	3.32	3.35	3.37	3.39	3.42	3.35	3.37	3.39	3.42	3.44
29	3.44	3.46	3.49	3.51	3.54	3.46	3.49	3.51	3.54	3.56
30	3.56	3.58	3.61	3.63	3.65	3.58	3.61	3.63	3.65	3.68
31	3.68	3.70	3.72	3.75	3.77	3.70	3.73	3.75	3.77	3.80
32	3.79	3.82	3.84	3.87	3.89	3.82	3.84	3.87	3.89	3.92
33	3.91	3.94	3.96	3.98	4.01	3.94	3.96	3.99	4.01	4.03
34	4.03	4.05	4.08	4.10	4.12	4.06	4.08	4.11	4.13	4.15
35	4.15	4.17	4.20	4.22	4.24	4.18	4.20	4.22	4.25	4.27

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 740 mm.					HEIGHT OF THE BAROMETER 745 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.10	0.00	0.02	0.05	0.07	0.10
1	.12	.15	.17	.19	.22	.12	.15	.17	.19	.22
2	.24	.27	.29	.31	.34	.24	.27	.29	.32	.34
3	.36	.39	.41	.44	.46	.37	.39	.41	.44	.46
4	.48	.51	.53	.56	.58	.49	.51	.54	.56	.58
5	0.60	0.63	0.65	0.68	0.70	0.61	0.63	0.66	0.68	0.71
6	.72	.75	.77	.80	.82	.73	.75	.78	.80	.83
7	.85	.87	.89	.92	.94	.85	.88	.90	.92	.95
8	.97	.99	1.01	1.04	1.06	.97	1.00	1.02	1.05	1.07
9	1.09	1.11	1.13	1.16	1.18	1.09	1.12	1.14	1.17	1.19
10	1.21	1.23	1.26	1.28	1.30	1.22	1.24	1.26	1.29	1.31
11	1.33	1.35	1.38	1.40	1.42	1.34	1.36	1.38	1.41	1.43
12	1.45	1.47	1.50	1.52	1.54	1.46	1.48	1.51	1.53	1.55
13	1.57	1.59	1.62	1.64	1.66	1.58	1.60	1.63	1.65	1.68
14	1.69	1.71	1.74	1.76	1.78	1.70	1.72	1.75	1.77	1.80
15	1.81	1.83	1.86	1.88	1.90	1.82	1.85	1.87	1.89	1.92
16	1.93	1.95	1.98	2.00	2.03	1.94	1.97	1.99	2.01	2.04
17	2.05	2.07	2.10	2.12	2.15	2.06	2.09	2.11	2.14	2.16
18	2.17	2.19	2.22	2.24	2.27	2.18	2.21	2.23	2.26	2.28
19	2.29	2.31	2.34	2.36	2.39	2.31	2.33	2.35	2.38	2.40
20	2.41	2.43	2.46	2.48	2.51	2.43	2.45	2.47	2.50	2.52
21	2.53	2.55	2.58	2.60	2.63	2.55	2.57	2.59	2.62	2.64
22	2.65	2.67	2.70	2.72	2.75	2.67	2.69	2.72	2.74	2.76
23	2.77	2.79	2.82	2.84	2.87	2.79	2.81	2.84	2.86	2.88
24	2.89	2.91	2.94	2.96	2.99	2.91	2.93	2.96	2.98	3.01
25	3.01	3.03	3.06	3.08	3.11	3.03	3.05	3.08	3.10	3.13
26	3.13	3.15	3.18	3.20	3.22	3.15	3.17	3.20	3.22	3.25
27	3.25	3.27	3.30	3.32	3.34	3.27	3.29	3.32	3.34	3.37
28	3.37	3.39	3.42	3.44	3.46	3.39	3.42	3.44	3.46	3.49
29	3.49	3.51	3.54	3.56	3.58	3.51	3.54	3.56	3.58	3.61
30	3.61	3.63	3.66	3.68	3.70	3.63	3.66	3.68	3.70	3.73
31	3.73	3.75	3.78	3.80	3.82	3.75	3.78	3.80	3.82	3.85
32	3.85	3.87	3.89	3.92	3.94	3.87	3.90	3.92	3.95	3.97
33	3.97	3.99	4.01	4.04	4.06	3.99	4.02	4.04	4.07	4.09
34	4.09	4.11	4.13	4.16	4.18	4.11	4.14	4.16	4.19	4.21
35	4.21	4.23	4.25	4.28	4.30	4.23	4.26	4.28	4.31	4.33

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 750 mm.					HEIGHT OF THE BAROMETER 755 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.10	0.00	0.02	0.05	0.07	0.10
1	.12	.15	.17	.20	.22	.12	.15	.17	.20	.22
2	.25	.27	.29	.32	.34	.25	.27	.30	.32	.35
3	.37	.39	.42	.44	.47	.37	.39	.42	.44	.47
4	.49	.51	.54	.56	.59	.49	.52	.54	.57	.59
5	0.61	0.64	0.66	0.69	0.71	0.62	0.64	0.67	0.69	0.71
6	.73	.76	.78	.81	.83	.74	.76	.79	.81	.84
7	.86	.88	.91	.93	.95	.86	.89	.91	.94	.96
8	.98	1.00	1.03	1.05	1.08	.99	1.01	1.03	1.06	1.08
9	1.10	1.13	1.15	1.17	1.20	1.11	1.13	1.16	1.18	1.21
10	1.22	1.25	1.27	1.30	1.32	1.23	1.26	1.28	1.31	1.33
11	1.35	1.37	1.39	1.42	1.44	1.35	1.38	1.40	1.43	1.45
12	1.47	1.49	1.52	1.54	1.56	1.48	1.50	1.53	1.55	1.58
13	1.59	1.61	1.64	1.66	1.69	1.60	1.62	1.65	1.67	1.70
14	1.71	1.74	1.76	1.78	1.81	1.72	1.75	1.77	1.80	1.82
15	1.83	1.86	1.88	1.91	1.93	1.85	1.87	1.89	1.92	1.94
16	1.96	1.98	2.00	2.03	2.05	1.97	1.99	2.02	2.04	2.07
17	2.08	2.10	2.13	2.15	2.17	2.09	2.12	2.14	2.16	2.19
18	2.20	2.22	2.25	2.27	2.30	2.21	2.24	2.26	2.29	2.31
19	2.32	2.34	2.37	2.39	2.42	2.34	2.36	2.38	2.41	2.43
20	2.44	2.47	2.49	2.52	2.54	2.46	2.48	2.51	2.53	2.56
21	2.56	2.59	2.61	2.64	2.66	2.58	2.61	2.63	2.65	2.68
22	2.69	2.71	2.73	2.76	2.78	2.70	2.73	2.75	2.78	2.80
23	2.81	2.83	2.86	2.88	2.90	2.83	2.85	2.87	2.90	2.92
24	2.93	2.95	2.98	3.00	3.03	2.95	2.97	3.00	3.02	3.05
25	3.05	3.07	3.10	3.12	3.15	3.07	3.09	3.12	3.14	3.17
26	3.17	3.20	3.22	3.24	3.27	3.19	3.22	3.24	3.27	3.29
27	3.29	3.32	3.34	3.37	3.39	3.31	3.34	3.36	3.39	3.41
28	3.41	3.44	3.46	3.49	3.51	3.44	3.46	3.49	3.51	3.53
29	3.54	3.56	3.58	3.61	3.63	3.56	3.58	3.61	3.63	3.66
30	3.66	3.68	3.71	3.73	3.75	3.68	3.71	3.73	3.75	3.78
31	3.78	3.80	3.83	3.85	3.87	3.80	3.83	3.85	3.88	3.90
32	3.90	3.92	3.95	3.97	4.00	3.92	3.95	3.97	4.00	4.02
33	4.02	4.04	4.07	4.09	4.12	4.05	4.07	4.10	4.12	4.14
34	4.14	4.17	4.19	4.21	4.24	4.17	4.19	4.22	4.24	4.27
35	4.26	4.29	4.31	4.33	4.36	4.29	4.31	4.34	4.36	4.39

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

Attached Thermometer.	HEIGHT OF THE BAROMETER 760 mm.					HEIGHT OF THE BAROMETER 765 mm.				
	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.02	0.05	0.07	0.10	0.00	0.03	0.05	0.07	0.10
1	.12	.15	.17	.20	.22	.13	.15	.17	.20	.22
2	.25	.27	.30	.32	.35	.25	.27	.30	.32	.35
3	.37	.40	.42	.45	.47	.37	.40	.42	.45	.47
4	.50	.52	.55	.57	.60	.50	.52	.55	.57	.60
5	0.62	0.65	0.67	0.69	0.72	0.62	0.65	0.67	0.70	0.72
6	.74	.77	.79	.82	.84	.75	.77	.80	.82	.85
7	.87	.89	.92	.94	.97	.87	.90	.92	.95	.97
8	.99	1.02	1.04	1.07	1.09	1.00	1.02	1.05	1.07	1.10
9	1.12	1.14	1.17	1.19	1.21	1.12	1.15	1.17	1.20	1.22
10	1.24	1.26	1.29	1.31	1.34	1.25	1.27	1.30	1.32	1.35
11	1.36	1.39	1.41	1.44	1.46	1.37	1.40	1.42	1.45	1.47
12	1.49	1.51	1.54	1.56	1.59	1.50	1.52	1.55	1.57	1.60
13	1.61	1.64	1.66	1.68	1.71	1.62	1.65	1.67	1.70	1.72
14	1.73	1.76	1.78	1.81	1.83	1.75	1.77	1.80	1.82	1.85
15	1.86	1.88	1.91	1.93	1.96	1.87	1.89	1.92	1.94	1.97
16	1.98	2.01	2.03	2.06	2.08	1.99	2.02	2.04	2.07	2.09
17	2.10	2.13	2.15	2.18	2.20	2.12	2.14	2.17	2.19	2.22
18	2.23	2.25	2.28	2.30	2.33	2.24	2.27	2.29	2.32	2.34
19	2.35	2.38	2.40	2.43	2.45	2.37	2.39	2.42	2.44	2.47
20	2.47	2.50	2.52	2.55	2.57	2.49	2.52	2.54	2.57	2.59
21	2.60	2.62	2.65	2.67	2.70	2.62	2.64	2.66	2.69	2.71
22	2.72	2.75	2.77	2.80	2.82	2.74	2.76	2.79	2.81	2.84
23	2.84	2.87	2.89	2.92	2.94	2.86	2.89	2.91	2.94	2.96
24	2.97	2.99	3.02	3.04	3.07	2.99	3.01	3.04	3.06	3.09
25	3.09	3.12	3.14	3.16	3.19	3.11	3.14	3.16	3.19	3.21
26	3.21	3.24	3.26	3.29	3.31	3.23	3.26	3.28	3.31	3.33
27	3.34	3.36	3.39	3.41	3.43	3.36	3.38	3.41	3.43	3.46
28	3.46	3.48	3.51	3.53	3.56	3.48	3.51	3.53	3.56	3.58
29	3.58	3.61	3.63	3.66	3.68	3.61	3.63	3.66	3.68	3.70
30	3.71	3.73	3.75	3.78	3.80	3.73	3.75	3.78	3.80	3.83
31	3.83	3.85	3.88	3.90	3.93	3.85	3.88	3.90	3.93	3.95
32	3.95	3.98	4.00	4.02	4.05	3.98	4.00	4.03	4.05	4.08
33	4.07	4.10	4.12	4.15	4.17	4.10	4.13	4.15	4.17	4.20
34	4.20	4.22	4.25	4.27	4.29	4.22	4.25	4.27	4.30	4.32
35	4.32	4.34	4.37	4.39	4.42	4.35	4.37	4.40	4.42	4.45

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	HEIGHT OF THE BAROMETER 770 mm.					HEIGHT OF THE BAROMETER 775 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.03	0.05	0.08	0.10	0.00	0.03	0.05	0.08	0.10
1	.13	.15	.18	.20	.23	.13	.15	.18	.20	.23
2	.25	.28	.30	.33	.35	.25	.28	.30	.33	.35
3	.38	.40	.43	.45	.48	.38	.40	.43	.46	.48
4	.50	.53	.55	.58	.60	.51	.53	.56	.58	.61
5	0.63	0.65	0.68	0.70	0.73	0.63	0.66	0.68	0.71	0.73
6	.75	.78	.80	.83	.85	.76	.78	.81	.83	.86
7	.88	.90	.93	.95	.98	.89	.91	.94	.96	.99
8	1.01	1.03	1.06	1.08	1.11	1.01	1.04	1.06	1.09	1.11
9	1.13	1.16	1.18	1.21	1.23	1.14	1.16	1.19	1.21	1.24
10	1.26	1.28	1.31	1.33	1.36	1.26	1.29	1.31	1.34	1.36
11	1.38	1.41	1.43	1.46	1.48	1.39	1.42	1.44	1.47	1.49
12	1.51	1.53	1.56	1.58	1.61	1.52	1.54	1.57	1.59	1.62
13	1.63	1.66	1.68	1.71	1.73	1.64	1.67	1.69	1.72	1.74
14	1.76	1.78	1.81	1.83	1.86	1.77	1.79	1.82	1.84	1.87
15	1.88	1.91	1.93	1.96	1.98	1.89	1.92	1.94	1.97	2.00
16	2.01	2.03	2.06	2.08	2.11	2.02	2.05	2.07	2.10	2.12
17	2.13	2.16	2.18	2.21	2.23	2.15	2.17	2.20	2.22	2.25
18	2.26	2.28	2.31	2.33	2.36	2.27	2.30	2.32	2.35	2.37
19	2.38	2.41	2.43	2.46	2.48	2.40	2.42	2.45	2.47	2.50
20	2.51	2.53	2.56	2.58	2.61	2.52	2.55	2.57	2.60	2.62
21	2.63	2.66	2.68	2.71	2.73	2.65	2.67	2.70	2.72	2.75
22	2.76	2.78	2.81	2.83	2.86	2.77	2.80	2.83	2.85	2.88
23	2.88	2.91	2.93	2.96	2.98	2.90	2.93	2.95	2.98	3.00
24	3.01	3.03	3.06	3.08	3.11	3.03	3.05	3.08	3.10	3.13
25	3.13	3.16	3.18	3.21	3.23	3.15	3.18	3.20	3.23	3.25
26	3.26	3.28	3.31	3.33	3.36	3.28	3.30	3.33	3.35	3.38
27	3.38	3.41	3.43	3.46	3.48	3.40	3.43	3.45	3.48	3.50
28	3.51	3.53	3.56	3.58	3.60	3.53	3.55	3.58	3.60	3.63
29	3.63	3.65	3.68	3.70	3.73	3.65	3.68	3.70	3.73	3.75
30	3.75	3.78	3.80	3.83	3.85	3.78	3.80	3.83	3.85	3.88
31	3.88	3.90	3.93	3.95	3.98	3.90	3.93	3.95	3.98	4.00
32	4.00	4.03	4.05	4.08	4.10	4.03	4.05	4.08	4.10	4.13
33	4.13	4.15	4.18	4.20	4.23	4.15	4.18	4.20	4.23	4.25
34	4.25	4.28	4.30	4.33	4.35	4.28	4.30	4.33	4.35	4.38
35	4.38	4.40	4.43	4.45	4.48	4.40	4.43	4.45	4.48	4.50

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

Attached Thermometer.	HEIGHT OF THE BAROMETER 780 mm.					HEIGHT OF THE BAROMETER 785 mm.				
	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.03	0.05	0.08	0.10	0.00	0.03	0.05	0.08	0.10
1	.13	.15	.18	.20	.23	.13	.15	.18	.21	.23
2	.25	.28	.31	.33	.36	.26	.28	.31	.33	.36
3	.38	.41	.43	.46	.48	.38	.41	.44	.46	.49
4	.51	.53	.56	.59	.61	.51	.54	.56	.59	.62
5	0.64	0.66	0.69	0.71	0.74	0.64	0.67	0.69	0.72	0.74
6	.76	.79	.81	.84	.87	.77	.79	.82	.85	.87
7	.89	.92	.94	.97	.99	.90	.92	.95	.97	1.00
8	1.02	1.04	1.07	1.09	1.12	1.02	1.05	1.08	1.10	1.13
9	1.15	1.17	1.20	1.22	1.25	1.15	1.18	1.20	1.23	1.25
10	1.27	1.30	1.32	1.35	1.37	1.28	1.31	1.33	1.36	1.38
11	1.40	1.42	1.45	1.48	1.50	1.41	1.43	1.46	1.48	1.51
12	1.53	1.55	1.58	1.60	1.63	1.54	1.56	1.59	1.61	1.64
13	1.65	1.68	1.70	1.73	1.75	1.66	1.69	1.71	1.74	1.77
14	1.78	1.81	1.83	1.86	1.88	1.79	1.82	1.84	1.87	1.89
15	1.91	1.93	1.96	1.98	2.01	1.92	1.94	1.97	2.00	2.02
16	2.03	2.06	2.08	2.11	2.13	2.05	2.07	2.10	2.12	2.15
17	2.16	2.19	2.21	2.24	2.26	2.17	2.20	2.22	2.25	2.28
18	2.29	2.31	2.34	2.36	2.39	2.30	2.33	2.35	2.38	2.40
19	2.41	2.44	2.46	2.49	2.51	2.43	2.45	2.48	2.51	2.53
20	2.54	2.57	2.59	2.62	2.64	2.56	2.58	2.61	2.63	2.66
21	2.67	2.69	2.72	2.74	2.77	2.68	2.71	2.73	2.76	2.79
22	2.79	2.82	2.84	2.87	2.89	2.81	2.84	2.86	2.89	2.91
23	2.92	2.94	2.97	3.00	3.02	2.94	2.96	2.99	3.01	3.04
24	3.05	3.07	3.10	3.12	3.15	3.07	3.09	3.12	3.14	3.17
25	3.17	3.20	3.22	3.25	3.27	3.19	3.22	3.24	3.27	3.29
26	3.30	3.32	3.35	3.37	3.40	3.32	3.34	3.37	3.40	3.42
27	3.42	3.45	3.47	3.50	3.53	3.45	3.47	3.50	3.52	3.55
28	3.55	3.58	3.60	3.63	3.65	3.57	3.60	3.62	3.65	3.67
29	3.68	3.70	3.73	3.75	3.78	3.70	3.73	3.75	3.78	3.80
30	3.80	3.83	3.85	3.88	3.90	3.83	3.85	3.88	3.90	3.93
31	3.93	3.95	3.98	4.00	4.03	3.95	3.98	4.00	4.03	4.06
32	4.05	4.08	4.11	4.13	4.16	4.08	4.11	4.13	4.16	4.18
33	4.18	4.21	4.23	4.26	4.28	4.21	4.23	4.26	4.28	4.31
34	4.31	4.33	4.36	4.38	4.41	4.33	4.36	4.39	4.41	4.44
35	4.43	4.46	4.48	4.51	4.53	4.46	4.49	4.51	4.54	4.56

TABLE 47.

REDUCTION OF THE BAROMETER TO STANDARD TEMPERATURE.

METRIC MEASURES.

FOR TEMPERATURES ABOVE 0° CENTIGRADE, THE CORRECTION IS TO BE SUBTRACTED.

	Height of the Barometer 790 mm.					Height of the Barometer 795 mm.				
Attached Thermometer.	0°.0	0°.2	0°.4	0°.6	0°.8	0°.0	0°.2	0°.4	0°.6	0°.8
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	0.00	0.03	0.05	0.08	0.10	0.00	0.03	0.05	0.08	0.10
1	.13	.15	.18	.21	.23	.13	.16	.18	.21	.23
2	.26	.28	.31	.34	.36	.26	.29	.31	.34	.36
3	.39	.41	.44	.46	.49	.39	.42	.44	.47	.49
4	.52	.54	.57	.59	.62	.52	.55	.57	.60	.62
5	0.64	0.67	0.70	0.72	0.75	0.65	0.67	0.70	0.73	0.75
6	.77	.80	.83	.85	.88	.78	.80	.83	.86	.88
7	.90	.93	.95	.98	1.01	.91	.93	.96	.99	1.01
8	1.03	1.06	1.08	1.11	1.13	1.04	1.06	1.09	1.12	1.14
9	1.16	1.19	1.21	1.24	1.26	1.17	1.19	1.22	1.24	1.27
10	1.29	1.31	1.34	1.37	1.39	1.30	1.32	1.35	1.37	1.40
11	1.42	1.44	1.47	1.49	1.52	1.43	1.45	1.48	1.50	1.53
12	1.55	1.57	1.60	1.62	1.65	1.56	1.58	1.61	1.63	1.66
13	1.67	1.70	1.73	1.75	1.78	1.68	1.71	1.74	1.76	1.79
14	1.80	1.83	1.85	1.88	1.91	1.81	1.84	1.87	1.89	1.92
15	1.93	1.96	1.98	2.01	2.03	1.94	1.97	1.99	2.02	2.05
16	2.06	2.09	2.11	2.14	2.16	2.07	2.10	2.12	2.15	2.18
17	2.19	2.21	2.24	2.26	2.29	2.20	2.23	2.25	2.28	2.30
18	2.32	2.34	2.37	2.39	2.42	2.33	2.36	2.38	2.41	2.43
19	2.44	2.47	2.50	2.52	2.55	2.46	2.49	2.51	2.54	2.56
20	2.57	2.60	2.62	2.65	2.67	2.59	2.61	2.64	2.67	2.69
21	2.70	2.73	2.75	2.78	2.80	2.72	2.74	2.77	2.79	2.82
22	2.83	2.85	2.88	2.91	2.93	2.85	2.87	2.90	2.92	2.95
23	2.96	2.98	3.01	3.03	3.06	2.98	3.00	3.03	3.05	3.08
24	3.08	3.11	3.14	3.16	3.19	3.10	3.13	3.16	3.18	3.21
25	3.21	3.24	3.26	3.29	3.31	3.23	3.26	3.28	3.31	3.34
26	3.34	3.37	3.39	3.42	3.44	3.36	3.39	3.41	3.44	3.46
27	3.47	3.49	3.52	3.54	3.57	3.49	3.52	3.54	3.57	3.59
28	3.60	3.62	3.65	3.67	3.70	3.62	3.64	3.67	3.70	3.72
29	3.72	3.75	3.77	3.80	3.83	3.75	3.77	3.80	3.82	3.85
30	3.85	3.88	3.90	3.93	3.95	3.88	3.90	3.93	3.95	3.98
31	3.98	4.00	4.03	4.06	4.08	4.00	4.03	4.06	4.08	4.11
32	4.11	4.13	4.16	4.18	4.21	4.13	4.16	4.18	4.21	4.24
33	4.23	4.26	4.29	4.31	4.34	4.26	4.29	4.31	4.34	4.36
34	4.36	4.39	4.41	4.44	4.46	4.39	4.42	4.44	4.47	4.49
35	4.49	4.51	4.54	4.57	4.59	4.52	4.54	4.57	4.59	4.62

CORRECTIONS TO REDUCE BAROMETRIC READINGS TO STANDARD GRAVITY.

$$C = \frac{(g_l - g)}{g} B$$

(WITH $g_l < g$ THE CORRECTION IS TO BE SUBTRACTED; WITH $g_l > g$, IT IS TO BE ADDED.)

$g_l - g$	BAROMETER READING B.									
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Dynes.										
0.1	0.00010	0.00020	0.00031	0.00041	0.00051	0.00061	0.00071	0.00082	0.00092	0.00102
0.2	00020	00041	00061	00082	00102	00122	00143	00163	00184	00204
0.3	00031	00061	00092	00122	00153	00184	00214	00245	00275	00306
0.4	00041	00082	00122	00163	00204	00245	00286	00326	00367	00408
0.5	00051	00102	00153	00204	00255	00306	00357	00408	00459	00510
0.6	0.00061	0.00122	0.00184	0.00245	0.00306	0.00367	0.00428	0.00489	0.00551	0.00612
0.7	00071	00143	00214	00286	00357	00428	00500	00571	00642	00714
0.8	00082	00163	00245	00326	00408	00489	00571	00653	00734	00816
0.9	00092	00184	00275	00367	00459	00551	00642	00734	00826	00918
1.0	00102	00204	00306	00408	00510	00612	00714	00816	00918	01020
1.1	0.00112	0.00224	0.00337	0.00449	0.00561	0.00673	0.00785	0.00897	0.01010	0.01122
1.2	00122	00245	00367	00489	00612	00734	00857	00979	01101	01224
1.3	00133	00265	00398	00530	00663	00795	00928	01061	01193	01326
1.4	00143	00286	00428	00571	00714	00857	00999	01142	01285	01428
1.5	00153	00306	00459	00612	00765	00918	01071	01224	01377	01530
1.6	0.00163	0.00326	0.00489	0.00653	0.00816	0.00979	0.01142	0.01305	0.01468	0.01632
1.7	00173	00347	00520	00693	00867	01040	01213	01387	01560	01734
1.8	00184	00367	00551	00734	00918	01101	01285	01468	01652	01835
1.9	00194	00387	00581	00775	00969	01162	01356	01550	01744	01937
2.0	00204	00408	00612	00816	01020	01224	01428	01632	01835	02039
2.1	0.00214	0.00428	0.00642	0.00857	0.01071	0.01285	0.01499	0.01713	0.01927	0.02141
2.2	00224	00449	00673	00897	01122	01346	01570	01795	02019	02243
2.3	00235	00469	00704	00938	01173	01407	01642	01876	02111	02345
2.4	00245	00489	00734	00979	01224	01468	01713	01958	02203	02447
2.5	00255	00510	00765	01020	01275	01530	01785	02039	02294	02549
2.6	0.00265	0.00530	0.00795	0.01061	0.01326	0.01591	0.01856	0.02121	0.02386	0.02651
2.7	00275	00551	00826	01101	01377	01652	01927	02203	02478	02753
2.8	00286	00571	00857	01142	01428	01713	01999	02284	02570	02855
2.9	00296	00591	00887	01183	01479	01774	02070	02366	02661	02958
3.0	00306	00612	00918	01224	01530	01835	02141	02447	02753	03059
3.1	0.00316	0.00632	0.00948	0.01264	0.01581	0.01897	0.02213	0.02529	0.02845	0.03161
3.2	00326	00653	00979	01305	01632	01958	02284	02610	02937	03263
3.3	00337	00673	01010	01346	01683	02019	02356	02692	03029	03365
3.4	00347	00693	01040	01387	01734	02080	02427	02774	03120	03467
3.5	00357	00714	01071	01428	01785	02141	02498	02855	03212	03569
3.6	0.00367	0.00734	0.01101	0.01468	0.01835	0.02203	0.02570	0.02937	0.03304	0.03671
3.7	00377	00755	01132	01509	01886	02264	02641	03018	03396	03773
3.8	00387	00775	01162	01550	01937	02325	02712	03100	03487	03875
3.9	00398	00795	01193	01591	01988	02386	02784	03182	03579	03977
4.0	00408	00816	01224	01632	02039	02447	02855	03263	03671	04079

REDUCTION OF THE BAROMETER TO STANDARD GRAVITY.
ENGLISH MEASURES.

FROM LATITUDE 0° TO 45°, THE CORRECTION IS TO BE SUBTRACTED.

Latitude.	HEIGHT OF THE BAROMETER IN INCHES.											
	19	20	21	22	23	24	25	26	27	28	29	30
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
0°	−0.051	−0.054	−0.056	−0.059	−0.062	−0.064	−0.067	−0.070	−0.072	−0.075	−0.078	−0.080
5	−0.050	−0.053	−0.055	−0.058	−0.061	−0.063	−0.066	−0.069	−0.071	−0.074	−0.077	−0.079
6	0.050	0.052	0.055	0.058	0.060	0.063	0.066	0.068	0.071	0.073	0.076	0.079
7	0.049	0.052	0.055	0.057	0.060	0.062	0.065	0.068	0.070	0.073	0.075	0.078
8	0.049	0.052	0.054	0.057	0.059	0.062	0.064	0.067	0.070	0.072	0.075	0.077
9	0.048	0.051	0.054	0.056	0.059	0.061	0.064	0.066	0.069	0.071	0.074	0.076
10	−0.048	−0.050	−0.053	−0.055	−0.058	−0.060	−0.063	−0.066	−0.068	−0.071	−0.073	−0.076
11	0.047	0.050	0.052	0.055	0.057	0.060	0.062	0.065	0.067	0.070	0.072	0.075
12	0.047	0.049	0.051	0.054	0.056	0.059	0.061	0.064	0.066	0.069	0.071	0.074
13	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.063	0.065	0.068	0.070	0.072
14	0.045	0.047	0.050	0.052	0.055	0.057	0.059	0.062	0.064	0.066	0.069	0.071
15	−0.044	−0.047	−0.049	−0.051	−0.053	−0.056	−0.058	−0.060	−0.063	−0.065	−0.067	−0.070
16	0.043	0.046	0.048	0.050	0.052	0.055	0.057	0.059	0.062	0.064	0.066	0.068
17	0.042	0.045	0.047	0.049	0.051	0.053	0.056	0.058	0.060	0.062	0.065	0.067
18	0.041	0.044	0.046	0.048	0.050	0.052	0.054	0.057	0.059	0.061	0.063	0.065
19	0.040	0.042	0.045	0.047	0.049	0.051	0.053	0.055	0.057	0.059	0.062	0.064
20	−0.039	−0.041	−0.043	−0.045	−0.047	−0.050	−0.052	−0.054	−0.056	−0.058	−0.060	−0.062
21	0.038	0.040	0.042	0.044	0.046	0.048	0.050	0.052	0.054	0.056	0.058	0.060
22	0.037	0.039	0.041	0.043	0.045	0.047	0.049	0.050	0.052	0.054	0.056	0.058
23	0.036	0.038	0.039	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.054	0.056
24	0.034	0.036	0.038	0.040	0.042	0.043	0.045	0.047	0.049	0.051	0.052	0.054
25	−0.033	−0.035	−0.037	−0.038	−0.040	−0.042	−0.043	−0.045	−0.047	−0.049	−0.050	−0.052
26	0.032	0.033	0.035	0.037	0.038	0.040	0.042	0.043	0.045	0.047	0.048	0.050
27	0.030	0.032	0.033	0.035	0.037	0.038	0.040	0.041	0.043	0.045	0.046	0.048
28	0.029	0.030	0.032	0.033	0.035	0.036	0.038	0.039	0.041	0.043	0.044	0.046
29	0.027	0.029	0.030	0.032	0.033	0.035	0.036	0.037	0.039	0.040	0.042	0.043
30	−0.026	−0.027	−0.029	−0.030	−0.031	−0.033	−0.034	−0.035	−0.037	−0.038	−0.040	−0.041
31	0.024	0.026	0.027	0.028	0.030	0.031	0.032	0.033	0.035	0.036	0.037	0.038
32	0.023	0.024	0.025	0.026	0.028	0.029	0.030	0.031	0.032	0.034	0.035	0.036
33	0.021	0.022	0.023	0.025	0.026	0.027	0.028	0.029	0.030	0.031	0.032	0.034
34	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.030	0.031
35	−0.018	−0.019	−0.020	−0.021	−0.022	−0.023	−0.024	−0.025	−0.026	−0.027	−0.027	−0.028
36	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.022	0.023	0.024	0.025	0.026
37	0.015	0.015	0.016	0.017	0.018	0.019	0.019	0.020	0.021	0.022	0.022	0.023
38	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.020	0.020
39	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.015	0.016	0.017	0.017	0.018
40	−0.010	−0.010	−0.011	−0.011	−0.012	−0.012	−0.013	−0.013	−0.014	−0.014	−0.015	−0.015
41	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.012	0.012
42	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.010
43	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007
44	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
45	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001

REDUCTION OF THE BAROMETER TO STANDARD GRAVITY.

ENGLISH MEASURES.

FROM LATITUDE 46° TO 90° THE CORRECTION IS TO BE ADDED.

Latitude.	HEIGHT OF THE BAROMETER IN INCHES.											
	19	20	21	22	23	24	25	26	27	28	29	30
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
45°	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
46	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001	+0.001
47	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
48	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007
49	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.010
50	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.012	0.012	0.012
51	+0.010	+0.010	+0.011	+0.011	+0.012	+0.012	+0.013	+0.013	+0.014	+0.014	+0.015	+0.015
52	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.015	0.016	0.016	0.017	0.018
53	0.013	0.014	0.014	0.015	0.016	0.016	0.017	0.018	0.018	0.019	0.020	0.020
54	0.015	0.015	0.016	0.017	0.018	0.019	0.019	0.020	0.021	0.022	0.022	0.023
55	0.016	0.017	0.018	0.019	0.020	0.021	0.021	0.022	0.023	0.024	0.025	0.026
56	+0.018	+0.019	+0.020	+0.021	+0.022	+0.023	+0.024	+0.024	+0.026	+0.026	+0.027	+0.028
57	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.030	0.031
58	0.021	0.022	0.023	0.025	0.026	0.027	0.028	0.029	0.030	0.031	0.032	0.033
59	0.023	0.024	0.025	0.026	0.028	0.029	0.030	0.031	0.032	0.033	0.035	0.036
60	0.024	0.026	0.027	0.028	0.029	0.031	0.032	0.033	0.034	0.036	0.037	0.038
61	+0.026	+0.027	+0.028	+0.030	+0.031	+0.033	+0.034	+0.035	+0.037	+0.038	+0.039	+0.041
62	0.027	0.029	0.030	0.032	0.033	0.034	0.036	0.037	0.039	0.040	0.042	0.043
63	0.029	0.030	0.032	0.033	0.035	0.036	0.038	0.039	0.041	0.042	0.044	0.045
64	0.030	0.032	0.033	0.035	0.036	0.038	0.040	0.041	0.043	0.044	0.046	0.047
65	0.031	0.033	0.035	0.036	0.038	0.040	0.041	0.043	0.045	0.046	0.048	0.050
66	+0.033	+0.034	+0.036	+0.038	+0.040	+0.041	+0.043	+0.045	+0.047	+0.048	+0.050	+0.052
67	0.034	0.036	0.038	0.039	0.041	0.043	0.045	0.047	0.048	0.050	0.052	0.054
68	0.035	0.037	0.039	0.041	0.043	0.045	0.046	0.048	0.050	0.052	0.054	0.056
69	0.036	0.038	0.040	0.042	0.044	0.046	0.048	0.050	0.052	0.054	0.056	0.058
70	0.038	0.040	0.042	0.044	0.046	0.048	0.050	0.052	0.053	0.055	0.057	0.059
71	+0.039	+0.041	+0.043	+0.045	+0.047	+0.049	+0.051	+0.053	+0.055	+0.057	+0.059	+0.061
72	0.040	0.042	0.044	0.046	0.048	0.050	0.052	0.054	0.057	0.059	0.061	0.063
73	0.041	0.043	0.045	0.047	0.049	0.052	0.054	0.056	0.058	0.060	0.062	0.064
74	0.042	0.044	0.046	0.048	0.051	0.053	0.055	0.057	0.059	0.062	0.064	0.066
75	0.043	0.045	0.047	0.049	0.052	0.054	0.056	0.058	0.061	0.063	0.065	0.067
76	+0.044	+0.046	+0.048	+0.050	+0.053	+0.055	+0.057	+0.060	+0.062	+0.064	+0.066	+0.069
77	0.044	0.047	0.049	0.051	0.054	0.056	0.058	0.061	0.063	0.065	0.068	0.070
78	0.045	0.047	0.050	0.052	0.055	0.057	0.059	0.062	0.064	0.066	0.069	0.071
79	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.063	0.065	0.067	0.070	0.072
80	0.046	0.049	0.051	0.054	0.056	0.059	0.061	0.063	0.066	0.068	0.071	0.073
81	+0.047	+0.049	+0.052	+0.054	+0.057	+0.059	+0.062	+0.064	+0.067	+0.069	+0.072	+0.074
82	0.047	0.050	0.052	0.055	0.057	0.060	0.062	0.065	0.067	0.070	0.072	0.075
83	0.048	0.050	0.053	0.056	0.058	0.061	0.063	0.066	0.068	0.071	0.073	0.076
84	0.048	0.051	0.053	0.056	0.059	0.061	0.064	0.066	0.069	0.071	0.074	0.076
85	0.049	0.051	0.054	0.056	0.059	0.061	0.064	0.067	0.069	0.072	0.074	0.077
90	+0.049	+0.052	+0.055	+0.057	+0.060	+0.062	+0.065	+0.068	+0.070	+0.073	+0.075	+0.078

TABLE 50.

REDUCTION OF THE BAROMETER TO STANDARD GRAVITY.

METRIC MEASURES.

FROM LATITUDE 0° TO 45°, THE CORRECTION IS TO BE SUBTRACTED.

Latitude.	HEIGHT OF THE BAROMETER IN MILLIMETERS.													
	520	540	560	580	600	620	640	660	680	700	720	740	760	780
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	−1.39	−1.45	−1.50	−1.55	−1.61	−1.66	−1.71	−1.77	−1.82	−1.87	−1.93	−1.98	−2.04	−2.09
5	−1.37	−1.42	−1.48	−1.53	−1.58	−1.64	−1.69	−1.74	−1.79	−1.85	−1.90	−1.95	−2.00	−2.06
6	1.36	1.42	1.47	1.52	1.57	1.63	1.68	1.73	1.78	1.83	1.89	1.94	1.99	2.04
7	1.35	1.40	1.46	1.51	1.56	1.61	1.66	1.72	1.77	1.82	1.87	1.92	1.98	2.03
8	1.34	1.39	1.44	1.49	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.91	1.96	2.01
9	1.33	1.38	1.43	1.48	1.53	1.58	1.63	1.68	1.73	1.78	1.84	1.89	1.94	1.99
10	−1.31	−1.36	−1.41	−1.46	−1.51	−1.56	−1.61	−1.66	−1.71	−1.76	−1.81	−1.86	−1.92	−1.97
11	1.29	1.34	1.39	1.44	1.49	1.54	1.59	1.64	1.69	1.74	1.79	1.84	1.89	1.94
12	1.27	1.32	1.37	1.42	1.47	1.52	1.57	1.62	1.67	1.72	1.76	1.81	1.86	1.91
13	1.25	1.30	1.35	1.40	1.45	1.50	1.54	1.59	1.64	1.69	1.74	1.78	1.83	1.88
14	1.23	1.28	1.33	1.38	1.42	1.47	1.52	1.56	1.61	1.66	1.71	1.75	1.80	1.85
15	−1.21	−1.26	−1.30	−1.35	−1.40	−1.44	−1.49	−1.54	−1.58	−1.63	−1.67	−1.72	−1.77	−1.81
16	1.19	1.23	1.28	1.32	1.37	1.41	1.46	1.50	1.55	1.60	1.64	1.69	1.73	1.78
17	1.16	1.20	1.25	1.29	1.34	1.38	1.43	1.47	1.52	1.56	1.60	1.65	1.69	1.74
18	1.13	1.18	1.22	1.26	1.31	1.35	1.39	1.44	1.48	1.52	1.57	1.61	1.65	1.70
19	1.10	1.15	1.19	1.23	1.27	1.32	1.36	1.40	1.44	1.48	1.53	1.57	1.61	1.65
20	−1.07	−1.11	−1.16	−1.20	−1.24	−1.28	−1.32	−1.36	−1.40	−1.44	−1.49	−1.53	−1.57	−1.61
21	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36	1.40	1.44	1.48	1.52	1.56
22	1.01	1.05	1.09	1.13	1.16	1.20	1.24	1.28	1.32	1.36	1.40	1.44	1.48	1.51
23	0.98	1.01	1.05	1.09	1.13	1.16	1.20	1.24	1.28	1.31	1.35	1.39	1.43	1.46
24	0.94	0.98	1.01	1.05	1.08	1.12	1.16	1.19	1.23	1.27	1.30	1.34	1.37	1.41
25	−0.90	−0.94	−0.97	−1.01	−1.04	−1.08	−1.11	−1.15	−1.18	−1.22	−1.25	−1.29	−1.32	−1.36
26	0.87	0.90	0.93	0.97	1.00	1.03	1.07	1.10	1.13	1.17	1.20	1.23	1.27	1.30
27	0.83	0.86	0.89	0.92	0.96	0.99	1.02	1.05	1.08	1.12	1.15	1.18	1.21	1.24
28	0.79	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18
29	0.75	0.78	0.81	0.84	0.86	0.89	0.92	0.95	0.98	1.01	1.04	1.07	1.10	1.12
30	−0.71	−0.74	−0.76	−0.79	−0.82	−0.85	−0.87	−0.90	−0.93	−0.95	−0.98	−1.01	−1.04	−1.06
31	0.67	0.69	0.72	0.74	0.77	0.80	0.82	0.85	0.87	0.90	0.92	0.95	0.98	1.00
32	0.62	0.65	0.67	0.70	0.72	0.74	0.77	0.79	0.82	0.84	0.86	0.89	0.91	0.94
33	0.58	0.60	0.63	0.65	0.67	0.69	0.72	0.74	0.76	0.78	0.80	0.83	0.85	0.87
34	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.79	0.81
35	−0.49	−0.51	−0.53	−0.55	−0.57	−0.59	−0.61	−0.63	−0.64	−0.66	−0.68	−0.70	−0.72	−0.74
36	0.45	0.46	0.48	0.50	0.52	0.53	0.55	0.57	0.58	0.60	0.62	0.64	0.65	0.67
37	0.40	0.42	0.43	0.45	0.46	0.48	0.49	0.51	0.52	0.54	0.56	0.57	0.59	0.60
38	0.36	0.37	0.38	0.40	0.41	0.42	0.44	0.45	0.46	0.48	0.49	0.51	0.52	0.53
39	0.31	0.32	0.33	0.34	0.36	0.37	0.38	0.39	0.40	0.42	0.43	0.44	0.45	0.46
40	−0.26	−0.27	−0.28	−0.29	−0.30	−0.31	−0.32	−0.33	−0.34	−0.35	−0.36	−0.37	−0.38	−0.39
41	0.21	0.22	0.23	0.24	0.25	0.26	0.26	0.27	0.28	0.29	0.30	0.30	0.31	0.32
42	0.17	0.17	0.18	0.19	0.19	0.20	0.21	0.21	0.22	0.22	0.23	0.24	0.24	0.25
43	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.18
44	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11
45	−0.02	−0.02	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.04

REDUCTION OF THE BAROMETER TO STANDARD GRAVITY.

METRIC MEASURES.

FROM LATITUDE 46° TO 90°, THE CORRECTION IS TO BE ADDED.

Latitude.	HEIGHT OF THE BAROMETER IN MILLIMETERS.													
	520	540	560	580	600	620	640	660	680	700	720	740	760	780
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
45°	−0.02	−0.02	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.04
46	+0.02	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.04	+0.04
47	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11
48	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18
49	0.17	0.17	0.18	0.19	0.19	0.20	0.21	0.21	0.22	0.23	0.23	0.24	0.25	0.25
50	0.22	0.22	0.23	0.24	0.25	0.26	0.26	0.27	0.28	0.29	0.30	0.31	0.31	0.32
51	+0.26	+0.27	+0.28	+0.29	+0.30	+0.31	+0.32	+0.33	+0.34	+0.35	+0.36	+0.37	+0.38	+0.39
52	0.31	0.32	0.33	0.34	0.36	0.37	0.38	0.39	0.40	0.42	0.43	0.44	0.45	0.46
53	0.36	0.37	0.38	0.40	0.41	0.42	0.44	0.45	0.46	0.48	0.49	0.51	0.52	0.53
54	0.40	0.42	0.43	0.45	0.46	0.48	0.49	0.51	0.52	0.54	0.56	0.57	0.59	0.60
55	0.45	0.46	0.48	0.50	0.52	0.53	0.55	0.57	0.58	0.60	0.62	0.64	0.65	0.67
56	+0.49	+0.51	+0.53	+0.55	+0.57	+0.59	+0.60	+0.62	+0.64	+0.66	+0.68	+0.70	+0.72	+0.74
57	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80
58	0.58	0.60	0.62	0.65	0.67	0.69	0.71	0.74	0.76	0.78	0.80	0.82	0.85	0.87
59	0.62	0.65	0.67	0.69	0.72	0.74	0.77	0.79	0.81	0.84	0.86	0.89	0.91	0.93
60	0.66	0.69	0.72	0.74	0.77	0.79	0.82	0.84	0.87	0.89	0.92	0.94	0.97	1.00
61	+0.71	+0.73	+0.76	+0.79	+0.81	+0.84	+0.87	+0.89	+0.92	+0.95	+0.98	+1.00	+1.03	+1.06
62	0.74	0.77	0.80	0.83	0.85	0.88	0.91	0.94	0.97	1.00	1.02	1.05	1.08	1.11
63	0.78	0.81	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18
64	0.82	0.85	0.89	0.92	0.95	0.98	1.01	1.04	1.08	1.11	1.14	1.17	1.20	1.23
65	0.86	0.89	0.93	0.96	0.99	1.03	1.06	1.09	1.13	1.16	1.19	1.22	1.26	1.29
66	+0.90	+0.93	+0.97	+1.00	+1.04	+1.07	+1.10	+1.14	+1.17	+1.21	+1.24	+1.28	+1.31	+1.35
67	0.93	0.97	1.00	1.04	1.08	1.11	1.15	1.18	1.22	1.25	1.29	1.33	1.36	1.40
68	0.97	1.00	1.04	1.08	1.11	1.15	1.19	1.23	1.26	1.30	1.34	1.37	1.41	1.45
69	1.00	1.04	1.08	1.11	1.15	1.19	1.23	1.27	1.31	1.34	1.38	1.42	1.46	1.50
70	1.03	1.07	1.11	1.15	1.19	1.23	1.27	1.31	1.35	1.39	1.43	1.47	1.51	1.55
71	+1.06	+1.10	+1.14	+1.18	+1.22	+1.26	+1.31	+1.35	+1.39	+1.43	+1.47	+1.51	+1.55	+1.59
72	1.09	1.13	1.17	1.22	1.26	1.30	1.34	1.38	1.42	1.47	1.51	1.55	1.59	1.63
73	1.12	1.16	1.20	1.25	1.29	1.33	1.37	1.42	1.46	1.50	1.55	1.59	1.63	1.67
74	1.14	1.19	1.23	1.28	1.32	1.36	1.41	1.45	1.50	1.54	1.58	1.63	1.67	1.72
75	1.17	1.21	1.26	1.30	1.35	1.39	1.44	1.48	1.53	1.57	1.62	1.66	1.71	1.75
76	+1.19	+1.24	+1.28	+1.33	+1.37	+1.42	+1.47	+1.51	+1.56	+1.60	+1.65	+1.70	+1.74	+1.79
77	1.21	1.26	1.31	1.35	1.40	1.45	1.49	1.54	1.59	1.63	1.68	1.73	1.77	1.82
78	1.23	1.28	1.33	1.38	1.42	1.47	1.52	1.57	1.61	1.66	1.71	1.76	1.80	1.85
79	1.25	1.30	1.35	1.40	1.45	1.49	1.54	1.59	1.64	1.69	1.73	1.78	1.83	1.88
80	1.27	1.32	1.37	1.42	.147	1.51	1.56	1.61	1.66	1.71	1.76	1.81	1.86	1.90
81	+1.29	+1.33	+1.38	+1.43	+1.48	+1.53	+1.58	+1.63	+1.68	+1.73	+1.78	+1.83	+1.88	+1.93
82	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95
83	1.31	1.36	1.41	1.46	1.51	1.56	1.61	1.67	1.72	1.77	1.82	1.87	1.92	1.97
84	1.32	1.37	1.42	1.48	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.88	1.93	1.98
85	1.33	1.38	1.43	1.49	1.54	1.59	1.64	1.69	1.74	1.79	1.84	1.90	1.95	2.00
90	+1.35	+1.41	+1.46	+1.51	+1.56	+1.61	+1.67	+1.72	+1.77	+1.82	+1.87	+1.93	+1.98	+2.03

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Values of $60368\,[1+0.0010195\times 36]\,\log \dfrac{29.90}{B}$.

Barometric Pressure. B.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Inches.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
12.00	24814	24791	24769	24746	24723	24701	24678	24656	24633	24611
12.10	24588	24566	24543	24521	24499	24476	24454	24431	24409	24387
12.20	24365	24342	24320	24298	24276	24253	24231	24209	24187	24165
12.30	24143	24121	24098	24076	24054	24032	24010	23988	23966	23944
12.40	23923	23901	23879	23857	23835	23813	23791	23770	23748	23726
12.50	23704	23682	23661	23639	23617	23596	23574	23552	23531	23509
12.60	23488	23466	23445	23423	23402	23380	23359	23337	23316	23294
12.70	23273	23251	23230	23209	23187	23166	23145	23123	23102	23081
12.80	23060	23038	23017	22996	22975	22954	22933	22911	22890	22869
12.90	22848	22827	22806	22785	22764	22743	22722	22701	22680	22659
13.00	22638	22617	22596	22576	22555	22534	22513	22492	22471	22451
13.10	22430	22409	22388	22368	22347	22326	22306	22285	22264	22244
13.20	22223	22203	22182	22162	22141	22121	22100	22080	22059	22039
13.30	22018	21998	21977	21957	21937	21916	21896	21876	21855	21835
13.40	21815	21794	21774	21754	21734	21713	21693	21673	21653	21633
13.50	21612	21592	21572	21552	21532	21512	21492	21472	21452	21432
13.60	21412	21392	21372	21352	21332	21312	21292	21272	21252	21233
13.70	21213	21193	21173	21153	21134	21114	21094	21074	21054	21035
13.80	21015	20995	20976	20956	20936	20917	20897	20878	20858	20838
13.90	20819	20799	20780	20760	20741	20721	20702	20682	20663	20643
14.00	20624	20605	20585	20566	20546	20527	20508	20488	20469	20450
14.10	20431	20411	20392	20373	20354	20334	20315	20296	20277	20258
14.20	20238	20219	20200	20181	20162	20143	20124	20105	20086	20067
14.30	20048	20029	20010	19991	19972	19953	19934	19915	19896	19877
14.40	19858	19839	19821	19802	19783	19764	19745	19727	19708	19689
14.50	19670	19651	19633	19614	19595	19577	19558	19539	19521	19502
14.60	19483	19465	19446	19428	19409	19390	19372	19353	19335	19316
14.70	19298	19279	19261	19242	19224	19206	19187	19169	19150	19132
14.80	19114	19095	19077	19059	19040	19022	19004	18985	18967	18949
14.90	18931	18912	18894	18876	18858	18840	18821	18803	18785	18767
15.00	18749	18731	18713	18694	18676	18658	18640	18622	18604	18586
15.10	18568	18550	18532	18514	18496	18478	18460	18442	18425	18407
15.20	18389	18371	18353	18335	18317	18300	18282	18264	18246	18228
15.30	18211	18193	18175	18157	18140	18122	18104	18086	18069	18051
15.40	18033	18016	17998	17981	17963	17945	17928	17910	17893	17875
15.50	17858	17840	17823	17805	17788	17770	17753	17735	17718	17700
15.60	17683	17665	17648	17631	17613	17596	17578	17561	17544	17526
15.70	17509	17492	17474	17457	17440	17423	17405	17388	17371	17354
15.80	17337	17319	17302	17285	17268	17251	17234	17216	17199	17182
15.90	17165	17148	17131	17114	17097	17080	17063	17046	17029	17012
16.00	16995	16978	16961	16944	16927	16910	16893	16876	16859	16842
16.10	16825	16808	16792	16775	16758	16741	16724	16707	16691	16674
16.20	16657	16640	16623	16607	16590	16573	16557	16540	16523	16506
16.30	16490	16473	16456	16440	16423	16406	16390	16373	16357	16340
16.40	16324	16307	16290	16274	16257	16241	16224	16208	16191	16175
16.50	16158	16142	16125	16109	16092	16076	16060	16043	16027	16010
16.60	15994	15978	15961	15945	15929	15912	15896	15880	15863	15847
16.70	15831	15815	15798	15782	15766	15750	15733	15717	15701	15685
16.80	15669	15652	15636	15620	15604	15588	15572	15556	15539	15523
16.90	15507	15491	15475	15459	15443	15427	15411	15395	15379	15363
17.00	15347	15331	15315	15299	15283	15267	15251	15235	15219	15203

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Values of $60368\,[1 + 0.0010195 \times 36]\,\log \frac{29.90}{B}$.

Barometric Pressure. B.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Inches.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
17.00	15347	15331	15315	15299	15283	15267	15251	15235	15219	15203
17.10	15187	15172	15156	15140	15124	15108	15092	15076	15061	15045
17.20	15029	15013	14997	14982	14966	14950	14934	14919	14903	14887
17.30	14871	14856	14840	14824	14809	14793	14777	14762	14746	14730
17.40	14715	14699	14684	14668	14652	14637	14621	14606	14590	14575
17.50	14559	14544	14528	14512	14497	14481	14466	14451	14435	14420
17.60	14404	14389	14373	14358	14342	14327	14312	14296	14281	14266
17.70	14250	14235	14219	14204	14189	14173	14158	14143	14128	14112
17.80	14097	14082	14067	14051	14036	14021	14006	13990	13975	13960
17.90	13945	13930	13914	13899	13884	13869	13854	13839	13824	13808
18.00	13793	13778	13763	13748	13733	13718	13703	13688	13673	13658
18.10	13643	13628	13613	13598	13583	13568	13553	13538	13523	13508
18.20	13493	13478	13463	13448	13433	13418	13404	13389	13374	13359
18.30	13344	13329	13314	13300	13285	13270	13255	13240	13226	13211
18.40	13196	13181	13166	13152	13137	13122	13107	13093	13078	13063
18.50	13049	13034	13019	13005	12990	12975	12961	12946	12931	12917
18.60	12902	12888	12873	12858	12844	12829	12815	12800	12785	12771
18.70	12756	12742	12727	12713	12698	12684	12669	12655	12640	12626
18.80	12611	12597	12583	12568	12554	12539	12525	12510	12496	12482
18.90	12467	12453	12438	12424	12410	12395	12381	12367	12352	12338
19.00	12324	12310	12295	12281	12267	12252	12238	12224	12210	12195
19.10	12181	12167	12153	12138	12124	12110	12096	12082	12068	12053
19.20	12039	12025	12011	11997	11983	11969	11954	11940	11926	11912
19.30	11898	11884	11870	11856	11842	11828	11814	11800	11786	11772
19.40	11758	11744	11730	11716	11702	11688	11674	11660	11646	11632
19.50	11618	11604	11590	11576	11562	11548	11534	11520	11507	11493
19.60	11479	11465	11451	11437	11423	11410	11396	11382	11368	11354
19.70	11340	11327	11313	11299	11285	11272	11258	11244	11230	11217
19.80	11203	11189	11175	11162	11148	11134	11121	11107	11093	11080
19.90	11066	11052	11039	11025	11011	10998	10984	10970	10957	10943
20.00	10930	10916	10903	10889	10875	10862	10848	10835	10821	10808
20.10	10794	10781	10767	10754	10740	10727	10713	10700	10686	10673
20.20	10659	10646	10632	10619	10605	10592	10579	10565	10552	10538
20.30	10525	10512	10498	10485	10472	10458	10445	10431	10418	10405
20.40	10391	10378	10365	10352	10338	10325	10312	10298	10285	10272
20.50	10259	10245	10232	10219	10206	10192	10179	10166	10153	10139
20.60	10126	10113	10100	10087	10074	10060	10047	10034	10021	10008
20.70	9995	9982	9968	9955	9942	9929	9916	9903	9890	9877
20.80	9864	9851	9838	9825	9812	9799	9786	9772	9759	9746
20.90	9733	9720	9707	9694	9681	9668	9655	9642	9629	9617
21.00	9604	9591	9578	9565	9552	9539	9526	9513	9500	9487
21.10	9474	9462	9449	9436	9423	9410	9397	9384	9372	9359
21.20	9346	9333	9320	9307	9295	9282	9269	9256	9244	9231
21.30	9218	9205	9193	9180	9167	9154	9142	9129	9116	9103
21.40	9091	9078	9065	9053	9040	9027	9015	9002	8989	8977
21.50	8964	8951	8939	8926	8913	8901	8888	8876	8863	8850
21.60	8838	8825	8813	8800	8788	8775	8762	8750	8737	8725
21.70	8712	8700	8687	8675	8662	8650	8637	8625	8612	8600
21.80	8587	8575	8562	8550	8538	8525	8513	8500	8488	8475
21.90	8463	8451	8438	8426	8413	8401	8389	8376	8364	8352
22.00	8339	8327	8314	8302	8290	8277	8265	8253	8240	8228

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Values of $60368\ [1 + 0.0010195 \times 36]\ \log \frac{29.90}{B}$.

Barometric Pressure. B.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Inches.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
22.00	8339	8327	8314	8302	8290	8277	8265	8253	8240	8228
22.10	8216	8204	8191	8179	8167	8154	8142	8130	8118	8105
22.20	8093	8081	8069	8056	8044	8032	8020	8008	7995	7983
22.30	7971	7959	7947	7935	7922	7910	7898	7886	7874	7862
22.40	7849	7837	7825	7813	7801	7789	7777	7765	7753	7740
22.50	7728	7716	7704	7692	7680	7668	7656	7644	7632	7620
22.60	7608	7596	7584	7572	7560	7548	7536	7524	7512	7500
22.70	7488	7476	7464	7452	7440	7428	7416	7404	7392	7380
22.80	7368	7356	7345	7333	7321	7309	7297	7285	7273	7261
22.90	7249	7238	7226	7214	7202	7190	7178	7166	7155	7143
23.00	7131	7119	7107	7096	7084	7072	7060	7048	7037	7025
23.10	7013	7001	6990	6978	6966	6954	6943	6931	6919	6907
23.20	6896	6884	6872	6861	6849	6837	6825	6814	6802	6790
23.30	6779	6767	6755	6744	6732	6721	6709	6697	6686	6674
23.40	6662	6651	6639	6628	6616	6604	6593	6581	6570	6558
23.50	6546	6535	6523	6512	6500	6489	6477	6466	6454	6443
23.60	6431	6420	6408	6397	6385	6374	6362	6351	6339	6328
23.70	6316	6305	6293	6282	6270	6259	6247	6236	6225	6213
23.80	6202	6190	6179	6167	6156	6145	6133	6122	6110	6099
23.90	6088	6076	6065	6054	6042	6031	6020	6008	5997	5986
24.00	5974	5963	5952	5940	5929	5918	5906	5895	5884	5872
24.10	5861	5850	5839	5827	5816	5805	5794	5782	5771	5760
24.20	5749	5737	5726	5715	5704	5693	5681	5670	5659	5648
24.30	5637	5625	5614	5603	5592	5581	5570	5558	5547	5536
24.40	5525	5514	5503	5492	5480	5469	5458	5447	5436	5425
24.50	5414	5403	5392	5381	5369	5358	5347	5336	5325	5314
24.60	5303	5292	5281	5270	5259	5248	5237	5226	5215	5204
24.70	5193	5182	5171	5160	5149	5138	5127	5116	5105	5094
24.80	5083	5072	5061	5050	5039	5028	5017	5006	4995	4985
24.90	4974	4963	4952	4941	4930	4919	4908	4897	4886	4876
25.00	4865	4854	4843	4832	4821	4810	4800	4789	4778	4767
25.10	4756	4745	4735	4724	4713	4702	4691	4681	4670	4659
25.20	4648	4637	4627	4616	4605	4594	4584	4573	4562	4551
25.30	4540	4530	4519	4508	4498	4487	4476	4465	4455	4444
25.40	4433	4423	4412	4401	4391	4380	4369	4358	4348	4337
25.50	4326	4316	4305	4295	4284	4273	4263	4252	4241	4231
25.60	4220	4209	4199	4188	4178	4167	4156	4146	4135	4125
25.70	4114	4104	4093	4082	4072	4061	4051	4040	4030	4019
25.80	4009	3998	3988	3977	3966	3956	3945	3935	3924	3914
25.90	3903	3893	3882	3872	3861	3851	3841	3830	3820	3809
26.00	3799	3788	3778	3767	3757	3746	3736	3726	3715	3705
26.10	3694	3684	3674	3663	3653	3642	3632	3622	3611	3601
26.20	3590	3580	3570	3559	3549	3539	3528	3518	3508	3497
26.30	3487	3477	3466	3456	3446	3435	3425	3415	3404	3394
26.40	3384	3373	3363	3353	3343	3332	3322	3312	3301	3291
26.50	3281	3270	3260	3250	3240	3230	3219	3209	3199	3189

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Values of $60368\,[1 + 0.0010195 \times 36] \log \frac{29.90}{B}$.

Barometric Pressure. B.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
Inches.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
26.50	3281	3270	3260	3250	3240	3230	3219	3209	3199	3189
26.60	3179	3168	3158	3148	3138	3128	3117	3107	3097	3087
26.70	3077	3066	3056	3046	3036	3026	3016	3005	2995	2985
26.80	2975	2965	2955	2945	2934	2924	2914	2904	2894	2884
26.90	2874	2864	2854	2843	2833	2823	2813	2803	2793	2783
27.00	2773	2763	2753	2743	2733	2723	2713	2703	2692	2682
27.10	2672	2662	2652	2642	2632	2622	2612	2602	2592	2582
27.20	2572	2562	2552	2542	2532	2522	2512	2502	2493	2483
27.30	2473	2463	2453	2443	2433	2423	2413	2403	2393	2383
27.40	2373	2363	2353	2343	2334	2324	2314	2304	2294	2284
27.50	2274	2264	2254	2245	2235	2225	2215	2205	2195	2185
27.60	2176	2166	2156	2146	2136	2126	2116	2107	2097	2087
27.70	2077	2067	2058	2048	2038	2028	2018	2009	1999	1989
27.80	1979	1970	1960	1950	1940	1930	1921	1911	1901	1891
27.90	1882	1872	1862	1852	1843	1833	1823	1814	1804	1794
28.00	1784	1775	1765	1755	1746	1736	1726	1717	1707	1697
28.10	1688	1678	1668	1659	1649	1639	1630	1620	1610	1601
28.20	1591	1581	1572	1562	1552	1543	1533	1524	1514	1504
28.30	1495	1485	1476	1466	1456	1447	1437	1428	1418	1408
28.40	1399	1389	1380	1370	1361	1351	1342	1332	1322	1313
28.50	1303	1294	1284	1275	1265	1256	1246	1237	1227	1218
28.60	1208	1199	1189	1180	1170	1161	1151	1142	1132	1123
28.70	1113	1104	1094	1085	1075	1066	1057	1047	1038	1028
28.80	1019	1009	1000	990	981	972	962	953	943	934
28.90	925	915	906	896	887	878	868	859	849	840
29.00	831	821	812	803	793	784	775	765	756	746
29.10	737	728	718	709	700	690	681	672	663	653
29.20	644	635	625	616	607	597	588	579	570	560
29.30	551	542	532	523	514	505	495	486	477	468
29.40	458	449	440	431	421	412	403	394	384	375
29.50	366	357	348	338	329	320	311	302	292	283
29.60	274	265	256	247	237	228	219	210	201	192
29.70	182	173	164	155	146	137	128	118	109	100
29.80	+ 91	+ 82	+ 73	+ 64	+ 55	+ 45	+ 36	+ 27	+ 18	+ 9
29.90	0	− 9	− 18	− 27	− 36	− 45	− 55	− 64	− 73	− 82
30.00	− 91	− 100	− 109	− 118	− 127	− 136	− 145	− 154	− 163	− 172
30.10	− 181	− 190	− 199	− 208	− 217	− 226	− 235	− 244	− 253	− 262
30.20	− 271	− 280	− 289	− 298	− 307	− 316	− 325	− 334	− 343	− 352
30.30	− 361	− 370	− 379	− 388	− 397	− 406	− 415	− 424	− 433	− 442
30.40	− 451	− 460	− 469	− 478	− 486	− 495	− 504	− 513	− 522	− 531
30.50	− 540	− 549	− 558	− 567	− 576	− 585	− 593	− 602	− 611	− 620
30.60	− 629	− 638	− 647	− 656	− 665	− 673	− 682	− 691	− 700	− 709
30.70	− 718	− 727	− 735	− 744	− 753	− 762	− 771	− 780	− 788	− 797
30.80	− 806	− 815	− 824	− 833	− 841	− 850	− 859	− 868	− 877	− 885

TABLE 52.

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Term for Temperature: $0.002039\ (\theta - 50^\circ)\ z.$

For temperatures { above 50° F. / below 50° F. } the values are to be { added. / subtracted.

Mean Temperature. θ.		APPROXIMATE DIFFERENCE OF HEIGHT OBTAINED FROM TABLE 51.												
		20	40	60	80	100	200	300	400	500	600	700	800	900
F.	F.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
49°	51°	0	0	0	0	0	0	1	1	1	1	1	2	2
48	52	0	0	0	0	0	1	1	2	2	2	3	3	4
47	53	0	0	0	0	1	1	2	2	3	4	4	5	6
46	54	0	0	0	1	1	2	2	3	4	5	6	7	7
45	**55**	0	0	1	1	1	2	3	4	5	6	7	8	9
44	56	0	0	1	1	1	2	4	5	6	7	9	10	11
43	57	0	1	1	1	1	3	4	6	7	9	10	11	13
42	58	0	1	1	1	2	3	5	7	8	10	11	13	15
41	59	0	1	1	1	2	4	6	7	9	11	13	15	17
40	**60**	0	1	1	2	2	4	6	8	10	12	14	16	18
39	61	0	1	1	2	2	4	7	9	11	13	16	18	20
38	62	0	1	1	2	2	5	7	10	12	15	17	20	22
37	63	1	1	2	2	3	5	8	11	13	16	19	21	24
36	64	1	1	2	2	3	6	9	11	14	17	20	23	26
35	**65**	1	1	2	2	3	6	9	12	15	18	21	24	28
34	66	1	1	2	3	3	7	10	13	16	20	23	26	29
33	67	1	1	2	3	3	7	10	14	17	21	24	28	31
32	68	1	1	2	3	4	7	11	15	18	22	26	29	33
31	69	1	2	2	3	4	8	12	15	19	23	27	31	35
30	**70**	1	2	2	3	4	8	12	16	20	24	29	33	37
29	71	1	2	3	3	4	9	13	17	21	26	30	34	39
28	72	1	2	3	4	4	9	13	18	22	27	31	36	40
27	73	1	2	3	4	5	9	14	19	23	28	33	38	42
26	74	1	2	3	4	5	10	15	20	24	29	34	39	44
25	**75**	1	2	3	4	5	10	15	20	25	31	36	41	46
24	76	1	2	3	4	5	11	16	21	27	32	37	42	48
23	77	1	2	3	4	6	11	17	22	28	33	39	44	50
22	78	1	2	3	5	6	11	17	23	29	34	40	46	51
21	79	1	2	4	5	6	12	18	24	30	35	41	47	53
20	**80**	1	2	4	5	6	12	18	24	31	37	43	49	55
19	81	1	3	4	5	6	13	19	25	32	38	44	51	57
18	82	1	3	4	5	7	13	20	26	33	39	46	52	59
17	83	1	3	4	5	7	13	20	27	34	40	47	54	61
16	84	1	3	4	6	7	14	21	28	35	42	49	55	62
15	**85**	1	3	4	6	7	14	21	29	36	43	50	57	64
14	86	1	3	4	6	7	15	22	29	37	44	51	59	66
13	87	2	3	5	6	8	15	23	30	38	45	53	60	68
12	88	2	3	5	6	8	15	23	31	39	46	54	62	70
11	89	2	3	5	6	8	16	24	32	40	48	56	64	72
10	**90**	2	3	5	7	8	16	24	33	41	49	57	65	73
9	91	2	3	5	7	8	17	25	33	42	50	59	67	75
8	92	2	3	5	7	9	17	26	34	43	51	60	69	77
7	93	2	4	5	7	9	18	26	35	44	53	61	70	79
6	94	2	4	5	7	9	18	27	36	45	54	63	72	81
5	**95**	2	4	6	7	9	18	28	37	46	55	64	73	83
4	96	2	4	6	8	9	19	28	38	47	56	66	75	84
3	97	2	4	6	8	10	19	29	38	48	57	67	77	86
2	98	2	4	6	8	10	20	29	39	49	59	69	78	88
1	99	2	4	6	8	10	20	30	40	50	60	70	80	90
0	**100**	2	4	6	8	10	20	31	41	51	61	71	82	92

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Term for Temperature: $0.002039\ (\theta - 50°)\ z.$

For temperatures { above 50° F. / below 50° F. } the values are to be { added. / subtracted.

Mean Temperature. θ.		APPROXIMATE DIFFERENCE OF HEIGHT OBTAINED FROM TABLE 51.										
		1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	20000
F.	F.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
49°	**51°**	2	4	6	8	10	12	14	16	18	20	41
48	52	4	8	12	16	20	24	29	33	37	41	82
47	53	6	12	18	24	31	37	43	49	55	61	122
46	54	8	16	24	33	41	49	57	65	73	82	163
45	**55**	10	20	31	41	51	61	71	82	92	102	204
44	56	12	24	37	49	61	73	86	98	110	122	245
43	57	14	29	43	57	71	86	100	114	128	143	285
42	58	16	33	49	65	82	98	114	130	147	163	326
41	59	18	37	55	73	92	110	128	147	165	184	367
40	**60**	20	41	61	82	102	122	143	163	184	204	408
39	61	22	45	67	90	112	135	157	179	202	224	449
38	62	24	49	73	98	122	147	171	196	220	245	489
37	63	27	53	80	106	133	159	186	212	239	265	530
36	64	29	57	86	114	143	171	200	228	257	285	571
35	**65**	31	61	92	122	153	184	214	245	275	306	612
34	66	33	65	98	130	163	196	228	261	294	326	652
33	67	35	69	104	139	173	208	243	277	312	347	693
32	68	37	73	110	147	184	220	257	294	330	367	734
31	69	39	77	116	155	194	232	271	310	349	387	775
30	**70**	41	82	122	163	204	245	285	326	367	408	816
29	71	43	86	128	171	214	257	300	343	385	428	856
28	72	45	90	135	179	224	269	314	359	404	449	897
27	73	47	94	141	188	234	281	328	375	422	469	938
26	74	49	98	147	196	245	294	343	391	440	489	979
25	**75**	51	102	153	204	255	306	357	408	459	510	1020
24	76	53	106	159	212	265	318	371	424	477	530	1060
23	77	55	110	165	220	275	330	385	440	495	551	1101
22	78	57	114	171	228	285	343	400	457	514	571	1142
21	79	59	118	177	236	296	355	414	473	532	591	1183
20	**80**	61	122	184	245	306	367	428	489	551	612	1223
19	81	63	126	190	253	316	379	442	506	569	632	1264
18	82	65	130	196	261	326	391	457	522	587	652	1305
17	83	67	135	202	269	336	404	471	538	606	673	1346
16	84	69	139	208	277	347	416	485	555	624	693	1387
15	**85**	71	143	214	285	357	428	500	571	642	714	1427
14	86	73	147	220	294	367	440	514	587	661	734	1468
13	87	75	151	226	302	377	453	528	604	679	754	1509
12	88	77	155	232	310	387	465	542	620	697	775	1550
11	89	80	159	239	318	398	477	557	636	716	795	1590
10	**90**	82	163	245	326	408	489	571	652	734	816	1631
9	91	84	167	251	334	418	502	585	669	752	836	1672
8	92	86	171	257	343	428	514	599	685	771	856	1713
7	93	88	175	263	351	438	526	614	701	789	877	1754
6	94	90	179	269	359	449	538	628	718	807	897	1794
5	**95**	92	184	275	367	459	551	642	734	826	918	1835
4	96	94	188	281	375	469	563	657	750	844	938	1876
3	97	96	192	287	383	479	575	671	767	862	958	1917
2	98	98	196	294	391	489	587	685	783	881	979	1957
1	99	100	200	300	400	500	599	699	799	899	999	1998
0	**100**	102	204	306	408	510	612	714	816	918	1020	2039

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Correction for Gravity and Weight of Mercury: $z(0.002640 \cos 2\phi - 0.000007 \cos^2 2\phi + 0.00244)$.

Latitude. ϕ	APPROXIMATE DIFFERENCE OF HEIGHT OBTAINED FROM TABLES 51-52.										
	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0°	+3	+5	+8	+10	+13	+15	+18	+20	+23	+25	+28
2	3	5	8	10	13	15	18	20	23	25	28
4	3	5	8	10	13	15	18	20	23	25	28
6	3	5	8	10	13	15	18	20	23	25	28
8	2	5	7	10	12	15	17	20	22	25	27
10	+2	+5	+7	+10	+12	+15	+17	+20	+22	+25	+27
12	2	5	7	10	12	15	17	19	22	24	27
14	2	5	7	10	12	14	17	19	21	24	26
16	2	5	7	9	12	14	16	19	21	23	26
18	2	5	7	9	11	14	16	18	21	23	25
20	+2	+4	+7	+ 9	+11	+13	+16	+18	+20	+22	+24
22	2	4	6	9	11	13	15	17	19	22	24
24	2	4	6	8	10	13	15	17	19	21	23
26	2	4	6	8	10	12	14	16	18	20	22
28	2	4	6	8	10	12	14	16	18	20	21
30	+2	+4	+6	+ 8	+ 9	+11	+13	+15	+17	+19	+21
32	2	4	5	7	9	11	13	14	16	18	20
34	2	3	5	7	9	10	12	14	15	17	19
36	2	3	5	6	8	10	11	13	15	16	18
38	2	3	5	6	8	9	11	12	14	15	17
40	+1	+3	+4	+ 6	+ 7	+ 9	+10	+12	+13	+14	+16
42	1	3	4	5	7	8	9	11	12	13	15
44	1	3	4	5	6	8	9	10	11	13	14
45	+1	+2	+4	+ 5	+ 6	+ 7	+ 9	+10	+11	+12	+13
46	+1	+2	+4	+ 5	+ 6	+ 7	+ 8	+ 9	+11	+12	+13
48	1	2	3	4	5	6	8	9	10	11	12
50	1	2	3	4	5	6	7	8	9	10	11
52	+1	+2	+3	+ 4	+ 4	+ 5	+ 6	+ 7	+ 8	+ 9	+10
54	1	2	2	3	4	5	6	6	7	8	9
56	1	1	2	3	4	4	5	6	7	7	8
58	1	1	2	3	3	4	4	5	6	6	7
60	1	1	2	2	3	3	4	4	5	6	6
62	0	+1	+1	+ 2	+ 2	+ 3	+ 3	+ 4	+ 4	+ 5	+ 5
64	0	1	1	2	2	2	3	4	3	4	4
66	0	1	1	1	2	2	2	3	3	3	3
68	0	1	1	1	1	2	2	2	2	3	3
70	0	0	1	1	1	1	1	2	2	2	2
72	0	0	0	0	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1
74	0	0	0	0	0	1	1	1	1	1	1
76	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Correction for Gravity and Weight of Mercury : $z(0.002640 \cos 2\phi - 0.000007 \cos^2 2\phi + 0.00244)$.

Latitude. ϕ	APPROXIMATE DIFFERENCE OF HEIGHT OBTAINED FROM TABLES 51-52.										
	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	20000
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0°	+30	+35	+41	+46	+51	+56	+61	+66	+71	+76	+101
2	30	35	40	46	51	56	61	66	71	76	101
4	30	35	40	45	50	55	61	66	71	76	101
6	30	35	40	45	50	55	61	66	71	76	100
8	30	35	40	45	50	55	60	65	70	75	99
10	+29	+34	+39	+44	+49	+54	+59	+64	+69	+74	+ 98
12	29	34	39	44	48	53	58	63	68	73	97
14	29	33	38	43	48	52	57	62	67	71	95
16	28	33	37	42	47	51	56	61	65	70	93
18	27	32	37	41	46	50	55	59	64	68	91
20	+27	+31	+36	+40	+45	+49	+53	+58	+62	+67	+ 89
22	26	30	35	39	43	48	52	56	61	65	87
24	25	29	34	38	42	46	50	55	59	63	84
26	24	28	32	37	41	45	49	53	57	61	81
28	23	27	31	35	39	43	47	51	55	59	78
30	+23	+26	+30	+34	+38	+41	+45	+49	+53	+56	+ 75
32	22	25	29	32	36	40	43	47	50	54	72
34	21	24	27	31	34	38	41	44	48	51	68
36	20	23	26	29	32	36	39	42	46	49	65
38	18	22	25	28	31	34	37	40	43	46	61
40	+17	+20	+23	+26	+29	+32	+35	+38	+41	+43	+ 57
42	16	19	22	24	27	30	33	35	38	41	54
44	15	18	20	23	25	28	30	33	35	38	50
45	+15	+17	+19	+22	+24	+27	+29	+32	+34	+37	+ 49
46	+14	+16	+19	+21	+23	+26	+28	+30	+33	+35	+ 46
48	13	15	17	19	22	24	26	28	30	32	43
50	12	14	16	18	20	22	24	26	28	30	40
52	+11	+13	+14	+16	+18	+20	+22	+23	+25	+27	+ 36
54	10	11	13	15	16	18	19	21	23	24	32
56	9	10	12	13	14	16	17	19	20	22	29
58	8	9	10	11	13	14	15	17	18	19	26
60	7	8	9	10	11	12	13	14	16	17	22
62	+ 6	+ 7	+ 8	+ 9	+10	+11	+11	+12	+13	+14	+ 19
64	5	6	6	7	8	9	10	10	11	12	16
66	4	5	5	6	7	7	8	9	9	10	13
68	3	4	4	5	5	6	6	7	7	8	11
70	2	3	3	4	4	4	5	5	6	6	8
72	+ 2	+ 2	+ 2	+ 3	+ 3						
74	+ 1	+ 1	+ 2	+ 2	+ 2						
76	+ 1	+ 1	+ 1	+ 1	+ 1						
78	0	0	0	0	0						
80	0	0	0	0	− 1						

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Correction for an Average Degree of Humidity.

Mean Temperature.	APPROXIMATE DIFFERENCE OF HEIGHT OBTAINED FROM TABLES 51-52											
	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	20000
F.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
−20°	0	0	0	0	0	0	0	+1	+1	+1	+1	+2
−16	0	0	0	+1	+1	+1	+1	1	2	2	2	4
−12	0	0	+1	1	1	[illegible]	2	2	3	3	3	6
− 8	0	0	1	1	2	2	3	3	4	4	4	9
− 6	0	0	1	1	2	2	3	3	4	4	5	10
− 4	0	+1	1	2	2	3	3	4	4	5	6	11
− 2	0	1	1	2	2	3	4	4	5	6	6	12
0	0	1	1	2	3	3	4	5	5	6	7	14
+ 2	0	1	1	2	3	4	4	5	6	7	7	15
4	0	1	2	2	3	4	5	6	7	7	8	16
6	0	1	2	3	4	4	5	6	7	8	9	18
8	0	1	2	3	4	5	6	7	8	9	10	19
10	+1	1	2	3	4	5	6	7	8	9	10	21
12	1	1	2	3	4	6	7	8	9	10	11	22
14	1	1	2	4	5	6	7	8	9	11	12	24
16	1	1	3	4	5	6	8	9	10	11	13	25
18	1	1	3	4	5	7	8	9	11	12	13	27
20	1	1	3	4	6	7	9	10	11	13	14	29
22	1	2	3	5	6	8	9	11	12	14	15	31
24	1	2	3	5	7	8	10	11	13	15	16	33
26	1	2	3	5	7	9	10	12	14	16	17	35
28	1	2	4	6	7	9	11	13	15	17	19	37
30	1	2	4	6	8	10	12	14	16	18	20	41
32	1	2	4	7	9	11	13	16	18	20	22	44
34	1	2	5	7	10	12	15	17	19	22	24	49
36	1	3	5	8	11	13	16	19	21	24	27	53
38	1	3	6	9	12	15	18	21	23	26	29	59
40	2	3	6	10	13	16	19	23	26	29	32	64
42	2	4	7	11	14	18	21	25	28	32	35	71
44	2	4	8	12	15	19	23	27	31	35	39	77
46	2	4	8	13	17	21	25	29	34	38	42	84
48	2	5	9	14	18	23	27	32	37	41	46	92
50	2	5	10	15	20	25	30	35	40	45	50	99
52	3	5	11	16	21	27	32	37	43	48	53	107
54	3	6	11	17	23	29	34	40	46	51	57	114
56	3	6	12	18	24	30	37	43	49	55	61	122
58	3	6	13	19	26	32	39	45	52	58	65	130
60	3	7	14	21	27	34	41	48	55	62	69	137
62	4	7	14	22	29	36	43	51	58	65	72	145
64	4	8	15	23	30	38	46	53	61	69	76	152
66	4	8	16	24	32	40	48	56	64	72	80	160
68	4	8	17	25	34	42	50	59	67	76	84	168
70	4	9	18	26	35	44	53	61	70	79	88	175
72	5	9	18	27	37	46	55	64	73	82	91	183
76	5	10	20	30	40	49	59	69	79	89	99	198
80	5	11	21	32	43	53	64	75	85	96	106	213
84	6	11	23	34	46	57	68	80	91	103	114	228
88	6	12	24	37	49	61	73	85	97	110	122	243
92	6	13	26	39	52	65	78	91	103	116	129	259
96	7	14	27	41	55	68	82	96	110	123	137	274

DETERMINATION OF HEIGHTS BY THE BAROMETER.

ENGLISH MEASURES.

Correction for the Variation of Gravity with Altitude: $\frac{z(z+2h_0)}{R}$.

Approximate difference of height. Z.	HEIGHT OF LOWER STATION IN FEET (h_0).											
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	12000
Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
500	0	0	0	0	0	0	0	0	0	0	0	+1
1000	0	0	0	0	0	+1	+1	+1	+1	+1	+1	1
1500	0	0	0	+1	+1	1	1	1	1	1	2	2
2000	0	0	+1	1	1	1	1	2	2	2	2	2
2500	0	+1	1	1	1	1	2	2	2	2	3	3
3000	0	1	1	1	2	2	2	2	3	3	3	4
3500	+1	1	1	2	2	2	3	3	3	4	4	5
4000	1	1	2	2	2	3	3	3	4	4	5	5
4500	1	1	2	2	3	3	4	4	4	5	5	6
5000	1	2	2	3	3	4	4	5	5	6	6	7
5500	1	2	3	3	4	4	5	5	6	6	7	8
6000	2	2	3	3	4	5	5	6	6	7	7	9
6500	2	3	3	4	5	5	6	6	7	8	8	9
7000	2	3	4	4	5	6	6	7	8	8	9	10
7500	3	3	4	5	6	6	7	8	8	9	10	11
8000	3	4	5	5	6	7	8	8	9	10	11	12
8500	3	4	5	6	7	8	8	9	10	11	12	13
9000	4	5	6	6	7	8	9	10	11	12	12	14
9500	4	5	6	7	8	9	10	11	12	13	13	15
10000	5	6	7	8	9	10	11	11	12	13	14	16
11000	6	7	8	9	10	11	12	13	14	15	16	18
12000	7	8	9	10	11	13	14	15	16	17	18	21
13000	8	9	11	12	13	14	16	17	18	19	21	23
14000	9	11	12	13	15	16	17	19	20	21	23	25
15000	11	12	14	15	17	18	19	21	22	24	25	28
16000	12	14	15	17	18	20	21	23	25	26	28	31
17000	14	15	17	19	20	22	24	25	27	28	30	
18000	16	17	19	21	22	24	26	28	30	31		
19000	17	19	21	23	25	26	28	30	32			
20000	19	21	23	25	27	29	31					

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Values of 18400 log $\frac{760}{B}$.

Barometric Pressure.	0	1	2	3	4	5	6	7	8	9
mm.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
300	7428	7401	7375	7348	7322	7296	7270	7244	7218	7192
310	7166	7140	7115	7089	7064	7038	7013	6987	6962	6937
320	6912	6887	6862	6838	6813	6789	6764	6740	6715	6691
330	6666	6642	6618	6594	6570	6546	6522	6498	6475	6451
340	6428	6405	6381	6358	6334	6311	6288	6265	6242	6219
350	6196	6173	6151	6128	6106	6083	6061	6038	6016	5993
360	5971	5949	5927	5905	5883	5861	5839	5817	5795	5773
370	5752	5730	5709	5687	5666	5644	5623	5602	5581	5560
380	5539	5518	5497	5476	5455	5434	5414	5393	5373	5352
390	5332	5311	5291	5270	5250	5229	5209	5189	5169	5149
400	5129	5109	5089	5069	5049	5029	5010	4990	4971	4951
410	4932	4912	4893	4873	4854	4834	4815	4796	4777	4758
420	4739	4720	4701	4682	4663	4644	4625	4606	4588	4569
430	4551	4532	4514	4495	4477	4458	4440	4422	4404	4386
440	4368	4350	4332	4314	4296	4278	4260	4242	4224	4206
450	4188	4170	4152	4134	4117	4099	4082	4064	4047	4029
460	4012	3994	3977	3959	3942	3925	3908	3891	3874	3857
470	3840	3823	3806	3789	3772	3755	3738	3721	3705	3688
480	3672	3655	3639	3622	3606	3589	3573	3556	3540	3523
490	3507	3490	3474	3458	3442	3426	3410	3394	3378	3362
500	3346	3330	3314	3298	3282	3266	3250	3235	3219	3203
510	3188	3172	3157	3141	3126	3110	3095	3079	3064	3048
520	3033	3017	3002	2986	2971	2955	2940	2925	2910	2895
530	2880	2865	2850	2835	2820	2805	2790	2775	2760	2745
540	2731	2716	2701	2687	2672	2657	2643	2628	2613	2599
550	2584	2570	2555	2541	2526	2512	2497	2483	2468	2454
560	2440	2426	2411	2397	2383	2369	2355	2341	2327	2313
570	2299	2285	2271	2257	2243	2229	2215	2201	2188	2174
580	2160	2146	2133	2119	2105	2092	2078	2064	2051	2037
590	2023	2010	1996	1983	1969	1956	1942	1929	1915	1902
600	1889	1875	1862	1848	1835	1822	1809	1796	1783	1770
610	1757	1744	1731	1718	1705	1692	1679	1666	1653	1640
620	1627	1614	1601	1588	1576	1563	1550	1537	1525	1512
630	1499	1486	1474	1461	1448	1436	1423	1411	1398	1386
640	1373	1361	1348	1336	1323	1311	1298	1286	1273	1261
650	1249	1236	1224	1212	1199	1187	1175	1163	1151	1139
660	1127	1115	1103	1091	1079	1067	1055	1043	1031	1019
670	1007	995	983	971	960	948	936	924	913	901
680	889	877	866	854	842	831	819	807	796	784
690	772	761	749	738	726	715	703	692	680	669
700	657	646	635	623	612	601	589	578	567	555
710	544	533	521	510	499	487	476	465	454	443
720	432	421	410	399	388	377	366	355	344	333
730	322	311	300	289	278	267	256	245	234	224
740	213	202	192	181	170	160	149	138	128	117
750	+ 106	+ 95	+ 85	+ 74	+ 64	+ 53	+ 43	+ 32	+ 22	+ 11
760	0	− 10	− 21	− 31	− 42	− 52	− 63	− 73	− 83	− 94
770	− 104	− 115	− 125	− 136	− 146	− 156	− 166	− 177	− 187	− 197

DETERMINATION OF HEIGHTS BY THE BAROMETER.

DYNAMIC MEASURES.

Values of $18400 \log \frac{1013.3}{B}$

Barometric Pressure	0	1	2	3	4	5	6	7	8	9
mb.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
0	∞	55306	49767	46527	44228	42445	40988	39756	38689	37748
10	36906	36144	35448	34809	34217	33666	33150	32665	32209	31777
20	31367	30977	30605	30250	29910	29584	29270	28969	28678	28397
30	28127	27865	27611	27365	27126	26895	26670	26451	26238	26031
40	25828	25630	25438	25250	25066	24887	24711	24539	24371	24206
50	24043	23886	23731	23579	23430	23283	23139	22998	22859	22722
60	22588	22456	22326	22198	22072	21948	21827	21706	21587	21471
70	21356	21242	21131	21021	20912	20805	20699	20594	20491	20389
80	20289	20189	20092	19995	19899	19804	19711	19618	19527	19437
90	19348	19259	19172	19086	19000	18916	18832	18749	18667	18586
100	18506	18426	18347	18269	18192	18116	18040	17965	17891	17817
110	17744	17672	17600	17529	17459	17389	17320	17251	17183	17115
120	17049	16982	16917	16851	16787	16722	16659	16596	16533	16471
130	16409	16348	16287	16227	16167	16108	16048	15990	15932	15874
140	15817	15760	15703	15647	15592	15536	15482	15427	15373	15319
150	15266	15212	15160	15107	15055	15004	14952	14901	14850	14800
160	14750	14700	14650	14601	14553	14504	14456	14408	14360	14312
170	14265	14218	14172	14125	14079	14034	13988	13943	13898	13853
180	13809	13764	13720	13677	13633	13590	13547	13504	13461	13419
190	13377	13335	13293	13251	13210	13169	13128	13087	13047	13007
200	12967	12927	12887	12848	12808	12769	12730	12692	12653	12615
210	12577	12539	12501	12463	12426	12389	12352	12315	12278	12242
220	12205	12169	12133	12097	12061	12026	11990	11955	11920	11885
230	11850	11815	11781	11746	11712	11678	11644	11610	11577	11543
240	11510	11476	11443	11410	11378	11345	11312	11280	11248	11216
250	11184	11152	11120	11088	11057	11025	10994	10963	10932	10901
260	10870	10839	10809	10778	10748	10718	10688	10658	10628	10598
270	10569	10539	10510	10480	10451	10422	10393	10364	10335	10307
280	10278	10249	10221	10193	10165	10137	10108	10081	10053	10025
290	9997	9970	9943	9915	9888	9861	9834	9807	9780	9753
300	9727	9700	9674	9647	9621	9594	9568	9542	9516	9490
310	9465	9439	9413	9388	9362	9337	9311	9286	9261	9236
320	9211	9186	9161	9136	9111	9087	9062	9038	9014	8989
330	8965	8941	8917	8893	8869	8845	8821	8797	8773	8750
340	8726	8703	8679	8656	8633	8610	8587	8564	8541	8518
350	8495	8472	8449	8427	8404	8381	8359	8336	8314	8292
360	8270	8247	8225	8203	8181	8159	8138	8116	8094	8073
370	8051	8029	8008	7986	7965	7943	7922	7901	7880	7859
380	7838	7817	7796	7775	7754	7733	7712	7692	7671	7651
390	7630	7610	7589	7569	7548	7528	7508	7488	7468	7448
400	7428	7408	7388	7368	7348	7328	7309	7289	7269	7250
410	7230	7211	7191	7172	7153	7133	7114	7095	7076	7057
420	7038	7019	7000	6981	6962	6943	6924	6906	6887	6868
430	6850	6831	6813	6794	6776	6757	6739	6721	6703	6684
440	6666	6648	6630	6612	6594	6576	6558	6540	6522	6504
450	6487	6469	6451	6433	6416	6398	6381	6363	6346	6328
460	6311	6294	6276	6259	6242	6225	6207	6190	6173	6156
470	6139	6122	6105	6088	6071	6055	6038	6021	6004	5987
480	5971	5954	5937	5921	5904	5888	5871	5855	5839	5822
490	5806	5790	5773	5757	5741	5725	5709	5693	5677	5661

DETERMINATION OF HEIGHTS BY THE BAROMETER.

DYNAMIC MEASURES.

Values of $18400 \log \frac{1013.3}{B}$

Barometric Pressure	0	1	2	3	4	5	6	7	8	9
mb.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
500	5645	5629	5613	5597	5581	5565	5549	5533	5518	5502
510	5486	5471	5455	5439	5424	5408	5393	5377	5362	5346
520	5331	5316	5300	5285	5270	5255	5239	5224	5209	5194
530	5179	5164	5149	5134	5119	5104	5089	5074	5059	5044
540	5030	5015	5000	4985	4971	4956	4941	4927	4912	4898
550	4883	4868	4854	4839	4825	4811	4796	4782	4768	4753
560	4739	4725	4710	4696	4682	4668	4654	4640	4626	4612
570	4598	4583	4569	4556	4542	4528	4514	4500	4486	4472
580	4459	4445	4431	4417	4404	4390	4376	4363	4349	4335
590	4322	4308	4295	4281	4268	4254	4241	4228	4214	4201
600	4188	4174	4161	4148	4134	4121	4108	4095	4082	4069
610	4056	4042	4029	4016	4003	3990	3977	3964	3951	3939
620	3926	3913	3900	3887	3874	3861	3849	3836	3823	3810
630	3798	3785	3772	3760	3747	3735	3722	3709	3697	3684
640	3672	3659	3647	3635	3622	3610	3597	3585	3573	3560
650	3548	3536	3523	3511	3499	3487	3475	3462	3450	3438
660	3426	3414	3402	3390	3378	3366	3354	3342	3330	3318
670	3306	3294	3282	3270	3258	3246	3235	3223	3211	3199
680	3187	3176	3164	3152	3141	3129	3117	3106	3094	3082
690	3071	3059	3048	3036	3025	3013	3002	2990	2979	2967
700	2956	2944	2933	2922	2910	2899	2888	2876	2865	2854
710	2842	2831	2820	2809	2798	2786	2775	2764	2753	2742
720	2731	2720	2708	2697	2686	2675	2664	2653	2642	2631
730	2621	2609	2599	2588	2577	2566	2555	2544	2533	2523
740	2512	2501	2490	2479	2469	2458	2447	2437	2426	2415
750	2405	2394	2383	2373	2362	2351	2341	2330	2320	2309
760	2299	2288	2278	2267	2257	2246	2236	2225	2215	2205
770	2194	2184	2173	2163	2153	2142	2132	2122	2112	2101
780	2091	2081	2071	2060	2050	2040	2030	2020	2009	1999
790	1989	1979	1969	1959	1949	1939	1929	1919	1909	1899
800	1889	1879	1869	1859	1849	1839	1829	1819	1809	1799
810	1789	1780	1770	1760	1750	1740	1731	1721	1711	1701
820	1692	1682	1672	1662	1653	1643	1633	1623	1614	1604
830	1595	1585	1575	1566	1556	1547	1537	1527	1518	1508
840	1499	1489	1480	1470	1461	1451	1442	1433	1423	1414
850	1404	1395	1386	1376	1367	1357	1348	1339	1329	1320
860	1311	1302	1292	1283	1274	1264	1255	1246	1237	1228
870	1218	1209	1200	1191	1182	1173	1164	1154	1145	1136
880	1127	1118	1109	1100	1091	1082	1073	1064	1055	1046
890	1037	1028	1019	1010	1001	992	983	974	965	956
900	948	939	930	921	912	903	894	886	877	868
910	859	850	842	833	824	815	807	798	789	781
920	772	763	755	746	737	729	720	711	703	694
930	686	677	668	660	651	643	634	626	617	608
940	600	592	583	575	566	558	549	541	532	524
950	516	507	499	490	482	474	465	457	448	440
960	432	424	415	407	399	390	382	374	365	357
970	349	341	332	324	316	308	300	292	283	275
980	267	259	251	243	234	226	218	210	202	194
990	186	178	170	162	154	146	138	130	122	114
1000	106	98	90	82	74	66	58	50	42	34
1010	26	18	10	2	− 6	− 13	− 21	− 29	− 37	− 45
1020	− 53	− 61	− 68	− 76	− 84	− 92	−100	−107	−115	−123
1030	−131	−138	−146	−154	−162	−169	−177	−185	−192	−200
1040	−208	−215	−223	−231	−238	−246	−254	−261	−269	−277

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Temperature correction factor, $a = .00367\,\theta$.

Multiply approximate altitudes, determined from table 56 or 57, by values of a corresponding to mean temperature, θ, of air column. Add, if θ is above 0° C; subtract, if below 0° C.

Mean Temp. θ	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
°C.	a.	a.	a.	a.	a.	a.	a.	a.	a.	a.
0	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.003
1	.004	.004	.004	.005	.005	.006	.006	.006	.007	.007
2	.007	.008	.008	.008	.009	.009	.010	.010	.010	.011
3	.011	.011	.012	.012	.012	.013	.013	.014	.014	.014
4	.015	.015	.015	.016	.016	.017	.017	.017	.018	.018
5	.018	.019	.019	.019	.020	.020	.021	.021	.021	.022
6	.022	.022	.023	.023	.023	.024	.024	.025	.025	.025
7	.026	.026	.026	.027	.027	.028	.028	.028	.029	.029
8	.029	.030	.030	.030	.031	.031	.032	.032	.032	.033
9	.033	.033	.034	.034	.034	.035	.035	.036	.036	.036
10	.037	.037	.037	.038	.038	.039	.039	.039	.040	.040
11	.040	.041	.041	.041	.042	.042	.043	.043	.043	.044
12	.044	.044	.045	.045	.046	.046	.046	.047	.047	.047
13	.048	.048	.048	.049	.049	.050	.050	.050	.051	.051
14	.051	.052	.052	.052	.053	.053	.054	.054	.054	.055
15	.055	.055	.056	.056	.057	.057	.057	.058	.058	.058
16	.059	.059	.059	.060	.060	.061	.061	.061	.062	.062
17	.062	.063	.063	.063	.064	.064	.065	.065	.065	.066
18	.066	.066	.067	.067	.068	.068	.068	.069	.069	.069
19	.070	.070	.070	.071	.071	.072	.072	.072	.073	.073
20	.073	.074	.074	.075	.075	.075	.076	.076	.076	.077
21	.077	.077	.078	.078	.079	.079	.079	.080	.080	.080
22	.081	.081	.081	.082	.082	.083	.083	.083	.084	.084
23	.084	.085	.085	.086	.086	.086	.087	.087	.087	.088
24	.088	.088	.089	.089	.090	.090	.090	.091	.091	.091
25	.092	.092	.092	.093	.093	.094	.094	.094	.095	.095
26	.095	.096	.096	.097	.097	.097	.098	.098	.098	.099
27	.099	.099	.100	.100	.101	.101	.101	.102	.102	.102
28	.103	.103	.103	.104	.104	.105	.105	.105	.106	.106
29	.106	.107	.107	.108	.108	.108	.109	.109	.109	.110
30	.110	.110	.111	.111	.112	.112	.112	.113	.113	.113
31	.114	.114	.115	.115	.115	.116	.116	.116	.117	.117
32	.117	.118	.118	.119	.119	.119	.120	.120	.120	.121
33	.121	.121	.122	.122	.123	.123	.123	.124	.124	.124
34	.125	.125	.126	.126	.126	.127	.127	.127	.128	.128
35	.128	.129	.129	.130	.130	.130	.131	.131	.131	.132
36	.132	.132	.133	.133	.134	.134	.134	.135	.135	.135
37	.136	.136	.137	.137	.137	.138	.138	.138	.139	.139
38	.139	.140	.140	.141	.141	.141	.142	.142	.142	.143
39	.143	.143	.144	.144	.145	.145	.145	.146	.146	.146
40	.147	.147	.148	.148	.148	.149	.149	.149	.150	.150
41	.150	.151	.151	.152	.152	.152	.153	.153	.153	.154
42	.154	.155	.155	.155	.156	.156	.156	.157	.157	.157
43	.158	.158	.159	.159	.159	.160	.160	.160	.161	.161
44	.161	.162	.162	.163	.163	.163	.164	.164	.164	.165
45	.165	.166	.166	.166	.167	.167	.167	.168	.168	.168
46	.169	.169	.170	.170	.170	.171	.171	.171	.172	.172
47	.172	.173	.173	.174	.174	.174	.175	.175	.175	.176
48	.176	.177	.177	.177	.178	.178	.178	.179	.179	.179
49	.180	.180	.181	.181	.181	.182	.182	.182	.183	.183
50	.184	.184	.184	.185	.185	.185	.186	.186	.186	.187

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Term for Temperature: $0.00367\,\theta \times z$.

For temperatures {above 0° C. / below 0° C.} the values are to be {added. / subtracted.}

Approximate difference of height. z.	MEAN TEMPERATURE OF AIR COLUMN IN CENTIGRADE DEGREES (θ).												
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	20°	30°	40°
m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
100	0	1	1	1	2	2	3	3	3	4	7	11	15
200	1	1	2	3	4	4	5	6	7	7	15	22	29
300	1	2	3	4	6	7	8	9	10	11	22	33	44
400	1	3	4	6	7	9	10	12	13	15	29	44	59
500	2	4	6	7	9	11	13	15	17	18	37	55	73
600	2	4	7	9	11	13	15	18	20	22	44	66	88
700	3	5	8	10	13	15	18	21	23	26	51	77	103
800	3	6	9	12	15	18	21	23	26	29	59	88	117
900	3	7	10	13	17	20	23	26	30	33	66	99	132
1000	4	7	11	15	18	22	26	29	33	37	73	110	147
1100	4	8	12	16	20	24	28	32	36	40	81	121	161
1200	4	9	13	18	22	26	31	35	40	44	88	132	176
1300	5	10	14	19	24	29	33	38	43	48	95	143	191
1400	5	10	15	21	26	31	36	41	46	51	103	154	206
1500	6	11	17	22	28	33	39	44	50	55	110	165	220
1600	6	12	18	23	29	35	41	47	53	59	117	176	235
1700	6	12	19	25	31	37	44	50	56	62	125	187	250
1800	7	13	20	26	33	40	46	53	59	66	132	198	264
1900	7	14	21	28	35	42	49	56	63	70	139	209	279
2000	7	15	22	29	37	44	51	59	66	73	147	220	294
2100	8	15	23	31	39	46	54	62	69	77	154	231	308
2200	8	16	24	32	40	48	57	65	73	81	161	242	323
2300	8	17	25	34	42	51	59	68	76	84	169	253	338
2400	9	18	26	35	44	53	62	70	79	88	176	264	352
2500	9	18	28	37	46	55	64	73	83	92	184	275	367
2600	10	19	29	38	48	57	67	76	86	95	191	286	382
2700	10	20	30	40	50	59	69	79	89	99	198	297	396
2800	10	21	31	41	51	62	72	82	92	103	206	308	411
2900	11	21	32	43	53	64	75	85	96	106	213	319	426
3000	11	22	33	44	55	66	77	88	99	110	220	330	440
3100	11	23	34	46	57	68	80	91	102	114	228	341	455
3200	12	23	35	47	59	70	82	94	106	117	235	352	470
3300	12	24	36	48	61	73	85	97	109	121	242	363	484
3400	12	25	37	50	62	75	87	100	112	125	250	374	499
3500	13	26	39	51	64	77	90	103	116	128	257	385	514
3600	13	26	40	53	66	79	92	106	119	132	264	396	528
3700	14	27	41	54	68	81	95	109	122	136	272	407	543
3800	14	28	42	56	70	84	98	112	126	139	279	418	558
3900	14	29	43	57	72	86	100	115	129	143	286	429	573
4000	15	29	44	59	73	88	103	117	132	147	294	440	587
5000	18	37	55	73	92	110	128	147	165	183	367	551	734
6000	22	44	66	88	110	132	154	176	198	220	440	661	881
7000	26	51	77	103	128	154	180	206	231	257	514	771	1028

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Correction for Humidity: Values of 10000 β.

$$\beta = 0.378\frac{e}{b} = 0.378\frac{e_1 + e_0}{B + B_0}.$$

Mean Vapor Pressure. $e = \frac{e_1+e_0}{2}$	MEAN BAROMETRIC PRESSURE IN MILLIMETERS $\left(\frac{B+B_0}{2}\right)$.													
	500	520	540	560	580	600	620	640	660	680	700	720	740	760
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
1	8	7	7	7	7	6	6	6	6	6	5	5	5	5
2	15	15	14	14	13	13	12	12	11	11	11	11	10	10
3	23	22	21	20	20	19	18	18	17	17	16	16	15	15
4	30	29	28	27	26	25	24	24	23	22	22	21	20	20
5	38	36	35	34	33	31	30	30	29	28	27	26	26	25
6	45	44	42	41	39	38	37	35	34	33	32	32	31	30
7	53	51	49	47	46	44	43	41	40	39	38	37	36	35
8	60	58	56	54	52	50	49	47	46	44	43	42	41	40
9	68	65	63	61	59	57	55	53	52	50	49	47	46	45
10	76	73	70	68	65	63	61	59	57	56	54	53	51	50
11	83	80	77	74	72	69	67	65	63	61	59	58	56	55
12	91	87	84	81	78	76	73	71	69	67	65	63	61	60
13	98	95	91	88	85	82	79	77	74	72	70	68	66	65
14	106	102	98	95	91	88	85	83	80	78	76	74	72	70
15	113	109	105	101	98	95	91	89	86	83	81	79	77	75
16	121	116	112	108	104	101	98	94	92	89	86	84	82	80
17	129	124	119	115	111	107	104	100	97	94	92	89	87	85
18	136	131	126	122	117	113	110	106	103	100	97	95	92	90
19	144	138	133	128	124	120	116	112	109	106	103	100	97	95
20	151	145	140	135	130	126	122	118	115	111	108	105	102	99
21	159	153	147	142	137	132	128	124	120	117	113	110	107	104
22	166	160	154	149	143	139	134	130	126	122	119	116	112	109
23	174	167	161	155	150	145	140	136	132	128	124	121	117	114
24	181	174	168	162	156	151	146	142	137	133	130	126	123	119
25	189	182	175	169	163	157	152	148	143	139	135	131	128	124
26	197	189	182	175	169	164	159	154	149	145	140	137	133	129
27	204	196	189	182	176	170	165	159	155	150	146	142	138	134
28	212	204	196	189	182	176	171	165	160	156	151	147	143	139
29	219	211	203	196	189	183	177	171	166	161	157	152	148	144
30	227	218	210	203	196	189	183	177	172	167	162	158	153	149
31	234	225	217	209	202	195	189	183	178	172	167	163	158	154
32	242	233	224	216	209	202	195	189	183	178	173	168	163	159
33	249	240	231	223	215	208	201	195	189	183	178	173	169	164
34	257	247	238	230	222	214	207	201	195	189	184	179	174	169
35	265	254	245	236	228	220	213	207	200	195	189	184	179	174
36	272	262	252	243	235	227	219	213	206	200	194	189	184	179
37	280	269	259	250	241	233	226	219	212	206	200	194	189	184
38	287	276	266	257	248	239	232	224	218	211	205	200	194	189
39	295	283	273	263	254	246	238	230	223	217	211	205	199	194
40	302	291	280	270	261	252	244	236	229	222	216	210	204	199

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Correction for Humidity: $10000 \beta \times z$.

Top argument: Values of 10000β obtained from page

Side argument: Approximate difference of height (z).

Approximate Difference of Height. z.	10000 β.											
	25	50	75	100	125	150	175	200	225	250	275	300
m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
100	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0
200	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
300	0.8	1.5	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0
400	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
500	1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0
600	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0
700	1.8	3.5	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5	19.3	21.0
800	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0
900	2.3	4.5	6.8	9.0	11.3	13.5	15.8	18.0	20.3	22.5	24.8	27.0
1000	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
1100	2.8	5.5	8.3	11.0	13.8	16.5	19.3	22.0	24.8	27.5	30.3	33.0
1200	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0
1300	3.3	6.5	9.8	13.0	16.3	19.5	22.8	26.0	29.3	32.5	35.8	39.0
1400	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0	38.5	42.0
1500	3.8	7.5	11.3	15.0	18.8	22.5	26.3	30.0	33.8	37.5	41.3	45.0
1600	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0
1700	4.3	8.5	12.8	17.0	21.3	25.5	29.8	34.0	38.3	42.5	46.8	51.0
1800	4.5	9.0	13.5	18.0	22.5	27.0	31.5	36.0	40.5	45.0	49.5	54.0
1900	4.8	9.5	14.3	19.0	23.8	28.5	33.3	38.0	42.8	47.5	52.3	57.0
2000	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
2100	5.3	10.5	15.8	21.0	26.3	31.5	36.8	42.0	47.3	52.5	57.8	63.0
2200	5.5	11.0	16.5	22.0	27.5	33.0	38.5	44.0	49.5	55.0	60.5	66.0
2300	5.8	11.5	17.3	23.0	28.8	34.5	40.3	46.0	51.8	57.5	63.3	69.0
2400	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0
2500	6.3	12.5	18.8	25.0	31.3	37.5	43.8	50.0	56.3	62.5	68.8	75.0
2600	6.5	13.0	19.5	26.0	32.5	39.0	45.5	52.0	58.5	65.0	71.5	78.0
2700	6.8	13.5	20.3	27.0	33.8	40.5	47.3	54.0	60.8	67.5	74.3	81.0
2800	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	63.0	70.0	77.0	84.0
2900	7.3	14.5	21.8	29.0	36.3	43.5	50.8	58.0	65.3	72.5	79.8	87.0
3000	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0
3100	7.8	15.5	23.3	31.0	38.8	46.5	54.3	62.0	69.8	77.5	85.3	93.0
3200	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0
3300	8.3	16.5	24.8	33.0	41.3	49.5	57.8	66.0	74.3	82.5	90.8	99.0
3400	8.5	17.0	25.5	34.0	42.5	51.0	59.5	68.0	76.5	85.0	93.5	102.0
3500	8.8	17.5	26.3	35.0	43.8	52.5	61.3	70.0	78.8	87.5	96.3	105.0
3600	9.0	18.0	27.0	36.0	45.0	54.0	63.0	72.0	81.0	90.0	99.0	108.0
3700	9.3	18.5	27.8	37.0	46.3	55.5	64.8	74.0	83.3	92.5	101.8	111.0
3800	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.0	85.5	95.0	104.5	114.0
3900	9.8	19.5	29.3	39.0	48.8	58.5	68.3	78.0	87.8	97.5	107.3	117.0
4000	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0
5000	12.5	25.0	37.5	50.0	62.5	75.0	87.5	100.0	112.5	125.0	137.5	150.0
6000	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0
7000	17.5	35.0	52.5	70.0	87.5	105.0	122.5	140.0	157.5	175.0	192.5	210.0

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Correction for Humidity: Values of $\frac{1}{2}\left(\frac{0.378\frac{e}{b}}{0.00367}\right)$

Top argument: Values of *e*.
Side argument: Values of *b*. Auxiliary to Table 58.

Air Pressure.	VAPOR PRESSURE mm.												
	0.5	1	2	3	4	5	6	7	8	9	10	20	30
mm.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
780	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	1.3	2.0
760	.0	.1	.1	.2	.3	.3	.4	.5	.5	.6	.7	1.4	2.0
740	.0	.1	.1	.2	.3	.4	.4	.5	.6	.6	.7	1.4	2.1
720	.0	.1	.1	.2	.3	.4	.4	.5	.6	.6	.7	1.4	2.1
700	.0	.1	.2	.2	.3	.4	.4	.5	.6	.7	.7	1.5	2.2
680	.0	.1	.2	.2	.3	.4	.4	.5	.6	.7	.8	1.5	
660	.0	.1	.2	.2	.3	.4	.5	.5	.6	.7	.8	1.6	
640	.0	.1	.2	.2	.3	.4	.5	.6	.6	.7	.8	1.6	
620	.0	.1	.2	.2	.3	.4	.5	.6	.7	.8	.8	1.7	
600	.0	.1	.2	.3	.3	.4	.5	.6	.7	.8	.9	1.7	
580	.0	.1	.2	.3	.4	.4	.5	.6	.7	.8	.9		
560	.0	.1	.2	.3	.4	.5	.6	.6	.7	.8	.9		
540	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0		
520	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9			
500	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9			
480	.1	.1	.2	.3	.4	.5	.6	.8					
460	.1	.1	.2	.3	.4	.6	.7	.8					
440	.1	.1	.2	.4	.5	.6	.7						
420	.1	.1	.2	.4	.5	.6	.7						
400	.1	.1	.3	.4	.5	.6							
380	.1	.1	.3	.4	.5								
360	.1	.1	.3	.4	.6								
340	.1	.2	.3	.4									
320	.1	.2	.3	.5									
300	.1	.2	.3										
280	.1	.2	.4										
260	.1	.2	.4										
240	.1	.2	.4										
220	.1	.2											
200	.1	.3											
180	.1	.3											
160	.2	.3											
140	.2	.4											
120	.2	.4											
100	.3	.5											
80	.3												
60	.4												
40	.6												
20	1.3												
10	2.6												

Table 61.

DETERMINATION OF HEIGHTS BY THE BAROMETER.

DYNAMIC MEASURES.

Correction for Humidity: Values of $\frac{1}{2}\left(\frac{0.378\frac{e}{b}}{0.00367}\right)$

Top argument: Values of *e*.
Side argument: Values of *b*. Auxiliary to Table 58.

Air Pressure.	VAPOR PRESSURE mb.													
	0.5	1	2	3	4	5	6	7	8	9	10	20	30	40
mb.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1080	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	1.0	1.4	1.9
1060	.0	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	1.0	1.5	1.9
1040	.0	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	1.0	1.5	2.0
1020	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	.5	1.0	1.5	2.0
1000	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	.5	1.0	1.5	2.1
980	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	.5	1.1	1.6	2.1
960	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	.5	1.1	1.6	2.1
940	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	.5	1.1	1.6	2.2
920	.0	.1	.1	.2	.2	.3	.3	.4	.4	.5	.6	1.1	1.7	2.2
900	.0	.1	.1	.2	.2	.3	.3	.4	.5	.5	.6	1.1	1.7	2.3
880	.0	.1	.1	.2	.2	.3	.4	.4	.5	.5	.6	1.2	1.8	2.3
860	.0	.1	.1	.2	.2	.3	.4	.4	.5	.5	.6	1.2	1.8	2.4
840	.0	.1	.1	.2	.2	.3	.4	.4	.5	.6	.6	1.2	1.8	
820	.0	.1	.1	.2	.3	.3	.4	.4	.5	.6	.6	1.3	1.9	
800	.0	.1	.1	.2	.3	.3	.4	.5	.5	.6	.6	1.3	1.9	
780	.0	.1	.1	.2	.3	.3	.4	.5	.5	.6	.7	1.3	2.0	
760	.0	.1	.1	.2	.3	.3	.4	.5	.5	.6	.7	1.4		
740	.0	.1	.1	.2	.3	.3	.4	.5	.6	.6	.7	1.4		
720	.0	.1	.1	.2	.3	.4	.4	.5	.6	.6	.7	1.4		
700	.0	.1	.1	.2	.3	.4	.4	.5	.6	.7	.7	1.5		
680	.0	.1	.2	.2	.3	.4	.5	.5	.6	.7	.8			
660	.0	.1	.2	.2	.3	.4	.5	.5	.6	.7	.8			
640	.0	.1	.2	.2	.3	.4	.5	.6	.6	.7	.8			
620	.0	.1	.2	.2	.3	.4	.5	.6	.7	.7				
600	.0	.1	.2	.3	.3	.4	.5	.6	.7	.8				
580	.0	.1	.2	.3	.4	.4	.5	.6	.7	.8				
560	.0	.1	.2	.3	.4	.5	.6	.6	.7					
540	.0	.1	.2	.3	.4	.5	.6	.7	.8					
520	.0	.1	.2	.3	.4	.5	.6	.7	.8					
500	.1	.1	.2	.3	.4	.5	.6	.7						
480	.1	.1	.2	.3	.4	.5	.6	.8						
460	.1	.1	.2	.3	.4	.6	.7	.8						
440	.1	.1	.2	.4	.5	.6	.7							
420	.1	.1	.2	.4	.5	.6	.7							
400	.1	.1	.3	.4	.5	.6	.8							
380	.1	.1	.3	.4	.5	.7								
360	.1	.1	.3	.4	.6	.7								
340	.1	.2	.3	.5	.6	.8								
320	.1	.2	.3	.5	.6									
300	.1	.2	.3	.5	.7									
280	.1	.2	.4	.6	.7									
260	.1	.2	.4	.6										
240	.1	.2	.4	.6										
220	.1	.2	.5	.7										
200	.1	.3	.5											

Air Pressure.	VAPOR PRESSURE mb.		
	0.5	1	2
mb.	°C.	°C.	°C.
180	.1	.3	.6
160	.2	.3	.6
140	.2	.4	
120	.2	.4	
100	.3	.5	
80	.3		
60	.4		
40	.6		
20	1.3		
10	2.6		

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Correction for Gravity and Weight of Mercury : $z(0.002640 \cos 2\phi - 0.000007 \cos^2 2\phi + 0.00244)$.

Approximate difference of Height. Z.	LATITUDE (ϕ)															
	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°
Meters.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
100	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
300	2	2	1	1	1	1	1	1	1	1	1	0	0	0	0	0
400	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0
500	3	3	2	2	2	2	2	2	1	1	1	1	1	0	0	0
600	3	3	3	3	3	2	2	2	2	1	1	1	1	0	0	0
700	4	4	3	3	3	3	3	2	2	2	1	1	1	1	0	0
800	4	4	4	4	4	3	3	3	2	2	2	1	1	1	0	0
900	5	5	4	4	4	4	3	3	3	2	2	1	1	1	0	0
1000	5	5	5	5	4	4	4	3	3	2	2	2	1	1	0	0
1100	6	6	5	5	5	5	4	4	3	3	2	2	1	1	0	0
1200	6	6	6	6	5	5	5	4	3	3	2	2	1	1	0	0
1300	7	7	6	6	6	5	5	4	4	3	3	2	1	1	1	0
1400	7	7	7	7	6	6	5	5	4	3	3	2	2	1	1	0
1500	8	8	7	7	7	6	6	5	4	4	3	2	2	1	1	0
1600	8	8	8	8	7	7	6	5	5	4	3	2	2	1	1	0
1700	9	9	8	8	8	7	6	6	5	4	3	3	2	1	1	0
1800	9	9	9	8	8	7	7	6	5	4	4	3	2	1	1	0
1900	10	10	9	9	8	8	7	6	5	5	4	3	2	1	1	0
2000	10	10	10	9	9	8	8	7	6	5	4	3	2	1	1	0
2100	11	11	10	10	9	9	8	7	6	5	4	3	2	2	1	0
2200	11	11	11	10	10	9	8	7	6	5	4	3	2	2	1	0
2300	12	12	11	11	10	9	9	8	7	6	5	4	3	2	1	0
2400	12	12	12	11	11	10	9	8	7	6	5	4	3	2	1	0
2500	13	13	12	12	11	10	9	8	7	6	5	4	3	2	1	0
2600	13	13	13	12	12	11	10	9	8	6	5	4	3	2	1	0
2700	14	14	13	13	12	11	10	9	8	7	5	4	3	2	1	0
2800	14	14	14	13	12	12	11	9	8	7	6	4	3	2	1	0
2900	15	15	14	14	13	12	11	10	8	7	6	4	3	2	1	0
3000	15	15	15	14	13	12	11	10	9	7	6	5	3	2	1	0
3100	16	16	15	15	14	13	12	10	9	8	6	5	3	2	1	0
3200	16	16	16	15	14	13	12	11	9	8	6	5	4	2	1	0
3300	17	17	16	16	15	14	12	11	10	8	7	5	4	2	1	0
3400	17	17	17	16	15	14	13	11	10	8	7	5	4	2	1	0
3500	18	18	17	17	16	14	13	12	10	9	7	5	4	3	1	1
3600	18	18	18	17	16	15	14	12	10	9	7	5	4	3	1	1
3700	19	19	18	17	16	15	14	12	11	9	7	6	4	3	2	1
3800	19	19	19	18	17	16	14	13	11	9	8	6	4	3	2	1
3900	20	20	19	18	17	16	15	13	11	9	8	6	4	3	2	1
4000	20	20	20	19	18	17	15	13	12	10	8	6	4	3	2	1
4500	23	23	22	21	20	19	17	15	13	11	9	7	5	3	2	1
5000	25	25	25	24	22	21	19	17	14	12	10	8	6	4	2	1
5500	28	28	27	26	24	23	21	18	16	13	11	8	6	4	2	1
6000	30	30	29	28	27	25	23	20	17	15	12	9	7	4	2	1
6500	33	33	32	31	29	27	24	22	19	16	13	10	7	5	3	1
7000	35	35	34	33	31	29	26	23	20	17	14	11	8	5	3	1

DETERMINATION OF HEIGHTS BY THE BAROMETER.

METRIC MEASURES.

Correction for the variation of gravity with altitude: $\frac{z(z+2h_o)}{R}$

Approximate difference of height. Z.	HEIGHT OF LOWER STATION IN METERS (h_o).													
	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2500	3000	4000
meters.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	1
500	0	0	0	0	0	0	0	0	0	0	0	0	1	1
600	0	0	0	0	0	0	0	0	0	0	0	1	1	1
700	0	0	0	0	0	0	0	0	0	0	1	1	1	1
800	0	0	0	0	0	0	0	0	1	1	1	1	1	1
900	0	0	0	0	0	0	0	1	1	1	1	1	1	1
1000	0	0	0	0	0	0	1	1	1	1	1	1	1	1
1100	0	0	0	0	0	1	1	1	1	1	1	1	1	2
1200	0	0	0	0	1	1	1	1	1	1	1	1	1	2
1300	0	0	0	1	1	1	1	1	1	1	1	1	1	2
1400	0	0	0	1	1	1	1	1	1	1	1	1	2	2
1500	0	0	1	1	1	1	1	1	1	1	1	2	2	2
1600	0	1	1	1	1	1	1	1	1	1	1	2	2	2
1700	0	1	1	1	1	1	1	1	1	1	2	2	2	3
1800	1	1	1	1	1	1	1	1	1	2	2	2	2	3
1900	1	1	1	1	1	1	1	1	2	2	2	2	2	3
2000	1	1	1	1	1	1	1	2	2	2	2	2	3	3
2100	1	1	1	1	1	1	1	2	2	2	2	2	3	3
2200	1	1	1	1	1	1	2	2	2	2	2	2	3	4
2300	1	1	1	1	1	2	2	2	2	2	2	3	3	4
2400	1	1	1	1	2	2	2	2	2	2	2	3	3	4
2500	1	1	1	1	2	2	2	2	2	2	3	3	3	4
2600	1	1	1	2	2	2	2	2	2	3	3	3	4	4
2700	1	1	1	2	2	2	2	2	3	3	3	3	4	5
2800	1	1	2	2	2	2	2	2	3	3	3	3	4	5
2900	1	2	2	2	2	2	2	3	3	3	3	4	4	5
3000	1	2	2	2	2	2	3	3	3	3	3	4	4	5
3100	2	2	2	2	2	2	3	3	3	3	3	4	4	5
3200	2	2	2	2	2	3	3	3	3	3	4	4	5	6
3300	2	2	2	2	3	3	3	3	3	4	4	4	5	6
3400	2	2	2	2	3	3	3	3	4	4	4	4	5	6
3500	2	2	2	3	3	3	3	3	4	4	4	5	5	6
3600	2	2	2	3	3	3	3	4	4	4	4	5	5	7
3700	2	2	3	3	3	3	4	4	4	4	4	5	6	7
3800	2	3	3	3	3	3	4	4	4	4	5	5	6	7
3900	2	3	3	3	3	4	4	4	4	5	5	5	6	7
4000	3	3	3	3	4	4	4	4	5	5	5	6	6	8
4500	3	3	4	4	4	5	5	5	5	6	6	7	7	9
5000	4	4	5	5	5	5	6	6	6	7	7	8	9	10
5500	5	5	5	6	6	6	7	7	8	8	8	9	10	12
6000	6	6	6	7	7	8	8	8	9	9	9	10	11	13
6500	7	7	7	8	8	9	9	9	10	10	11	12	13	15
7000	8	8	9	9	9	10	10	11	11	12	12	13	14	16

DIFFERENCE OF HEIGHT CORRESPONDING TO A CHANGE OF 0.1 INCH IN THE BAROMETER.

ENGLISH MEASURES.

Barometric Pressure.	MEAN TEMPERATURE OF THE AIR IN FAHRENHEIT DEGREES.											
	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
Inches	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
22.0	119.2	120.5	121.8	123.1	124.4	125.8	127.1	128.5	129.8	131.2	132.5	133.9
.2	118.2	119.4	120.7	122.0	123.3	124.7	126.0	127.3	128.7	130.0	131.3	132.7
.4	117.1	118.3	119.6	120.9	122.2	123.6	124.9	126.2	127.5	128.8	130.2	131.5
.6	116.1	117.3	118.6	119.8	121.1	122.5	123.8	125.1	126.4	127.7	129.0	130.3
.8	115.0	116.3	117.5	118.8	120.1	121.4	122.7	124.0	125.3	126.6	127.9	129.2
23.0	114.0	115.3	116.5	117.8	119.0	120.3	121.6	122.9	124.2	125.5	126.8	128.1
.2	113.1	114.3	115.5	116.8	118.0	119.3	120.6	121.8	123.1	124.4	125.7	127.0
.4	112.1	113.3	114.5	115.8	117.0	118.3	119.5	120.8	122.1	123.3	124.6	125.9
.6	111.1	112.3	113.5	114.8	116.0	117.3	118.5	119.8	121.0	122.3	123.5	124.8
.8	110.2	111.4	112.6	113.8	115.1	116.3	117.5	118.8	120.0	121.3	122.5	123.8
24.0	109.3	110.5	111.7	112.9	114.1	115.3	116.5	117.8	119.0	120.2	121.5	122.7
.2	108.4	109.5	110.7	111.9	113.1	114.4	115.6	116.8	118.0	119.2	120.5	121.7
.4	107.5	108.6	109.8	111.0	112.2	113.4	114.6	115.9	117.1	118.3	119.5	120.7
.6	106.6	107.8	108.9	110.1	111.3	112.5	113.7	114.9	116.1	117.3	118.5	119.7
.8	105.8	106.9	108.1	109.2	110.4	111.6	112.8	114.0	115.2	116.4	117.6	118.8
25.0	104.9	106.0	107.2	108.3	109.5	110.7	111.9	113.1	114.2	115.4	116.6	117.8
.2	104.1	105.2	106.3	107.5	108.7	109.8	111.0	112.2	113.3	114.5	115.7	116.9
.4	103.3	104.4	105.5	106.6	107.8	109.0	110.1	111.3	112.4	113.6	114.8	116.0
.6	102.5	103.6	104.7	105.8	107.0	108.1	109.3	110.4	111.6	112.7	113.9	115.1
.8	101.7	102.8	103.9	105.0	106.1	107.3	108.4	109.6	110.7	111.9	113.0	114.2
26.0	100.9	102.0	103.1	104.2	105.3	106.4	107.6	108.7	109.9	111.0	112.1	113.3
.2	100.1	101.2	102.3	103.4	104.5	105.6	106.8	107.9	109.0	110.1	111.3	112.4
.4	99.4	100.4	101.5	102.6	103.7	104.8	106.0	107.1	108.2	109.3	110.4	111.6
.6	98.6	99.7	100.7	101.8	102.9	104.0	105.2	106.3	107.4	108.5	109.6	110.7
.8	97.9	98.9	100.0	101.1	102.2	103.3	104.4	105.5	106.6	107.7	108.8	109.9
27.0	97.1	98.2	99.2	100.3	101.4	102.5	103.6	104.7	105.8	106.9	108.0	109.1
.2	96.4	97.5	98.5	99.6	100.7	101.8	102.8	103.9	105.0	106.1	107.2	108.3
.4	95.7	96.8	97.8	98.9	99.9	101.0	102.1	103.2	104.2	105.3	106.4	107.5
.6	95.0	96.1	97.1	98.1	99.2	100.3	101.3	102.4	103.5	104.6	105.6	106.7
.8	94.3	95.4	96.4	97.4	98.5	99.6	100.6	101.7	102.7	103.8	104.9	105.9
28.0	93.7	94.7	95.7	96.7	97.8	98.8	99.9	101.0	102.0	103.1	104.1	105.2
.2	93.0	94.0	95.0	96.1	97.1	98.1	99.2	100.2	101.3	102.3	103.4	104.4
.4	92.4	93.4	94.4	95.4	96.4	97.5	98.5	99.5	100.6	101.6	102.7	103.7
.6	91.7	92.7	93.7	94.7	95.7	96.8	97.8	98.8	99.9	100.9	101.9	103.0
.8	91.1	92.1	93.1	94.1	95.1	96.1	97.1	98.2	99.2	100.2	101.2	102.3
29.0	90.4	91.4	92.4	93.4	94.4	95.4	96.5	97.5	98.5	99.5	100.5	101.6
.2	89.8	90.8	91.8	92.8	93.8	94.8	95.8	96.8	97.8	98.8	99.9	100.9
.4	89.2	90.2	91.1	92.1	93.1	94.1	95.1	96.1	97.1	98.2	99.2	100.2
.6	88.6	89.6	90.5	91.5	92.5	93.5	94.5	95.5	96.5	97.5	98.5	99.5
.8	88.0	89.0	89.9	90.9	91.9	92.9	93.9	94.9	95.8	96.8	97.8	98.8
30.0	87.4	88.4	89.3	90.3	91.3	92.3	93.2	94.2	95.2	96.2	97.2	98.2
.2	86.8	87.8	88.7	89.7	90.7	91.7	92.6	93.6	94.6	95.6	96.5	97.5
.4	86.3	87.2	88.2	89.1	90.1	91.1	92.0	93.0	94.0	94.9	95.9	96.9
.6	85.7	86.7	87.6	88.5	89.5	90.5	91.4	92.4	93.3	94.3	95.3	96.2
.8	85.2	86.1	87.0	88.0	88.9	89.9	90.8	91.8	92.7	93.7	94.7	95.6

DIFFERENCE OF HEIGHT CORRESPONDING TO A CHANGE OF 1 MILLIMETER IN THE BAROMETER.

METRIC MEASURES.

Barometric Pressure.	MEAN TEMPERATURE OF THE AIR IN CENTIGRADE DEGREES.									
	− 2°	0°	2°	4°	6°	8°	10°	12°	14°	16°
mm.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.
760	10.48	10.57	10.65	10.73	10.81	10.89	10.98	11.06	11.15	11.23
750	10.62	10.71	10.79	10.87	10.95	11.04	11.13	11.21	11.30	11.38
740	10.77	10.85	10.93	11.02	11.10	11.19	11.28	11.36	11.45	11.54
730	10.91	11.00	11.08	11.17	11.26	11.35	11.43	11.52	11.61	11.70
720	11.06	11.15	11.24	11.32	11.42	11.51	11.59	11.68	11.77	11.86
710	11.22	11.31	11.40	11.48	11.58	11.67	11.75	11.85	11.94	12.03
700	11.38	11.47	11.56	11.65	11.74	11.83	11.92	12.02	12.11	12.20
690	11.55	11.63	11.72	11.82	11.91	12.00	12.09	12.19	12.28	12.38
680	11.72	11.80	11.89	11.99	12.08	12.18	12.27	12.37	12.46	12.56
670	11.89	11.98	12.07	12.17	12.26	12.36	12.46	12.55	12.65	12.75
660	12.07	12.16	12.26	12.35	12.45	12.55	12.65	12.74	12.84	12.94
650	12.26	12.35	12.45	12.54	12.64	12.74	12.84	12.94	13.04	13.14
640	12.45	12.55	12.64	12.74	12.84	12.94	13.04	13.14	13.24	13.35
630	12.65	12.75	12.84	12.94	13.04	13.15	13.25	13.35	13.45	13.56
620	12.85	12.96	13.05	13.15	13.25	13.36	13.46	13.57	13.67	13.78
610	13.06	13.17	13.27	13.37	13.47	13.58	13.68	13.79	13.89	14.01
600	13.28	13.39	13.49	13.59	13.70	13.80	13.91	14.02	14.13	14.24
590	13.51	13.62	13.72	13.82	13.93	14.03	14.15	14.26	14.37	14.48
580	13.74	13.85	13.96	14.06	14.17	14.28	14.39	14.51	14.62	14.73
570	13.98	14.09	14.20	14.31	14.42	14.53	14.64	14.76	14.88	14.99
560	14.23	14.34	14.45	14.57	14.68	14.79	14.90	15.02	15.14	15.25

Barometric Pressure.	MEAN TEMPERATURE OF THE AIR IN CENTIGRADE DEGREES.									
	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°
mm.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.
760	11.32	11.41	11.49	11.58	11.66	11.75	11.84	11.92	12.01	12.10
750	11.47	11.56	11.64	11.73	11.82	11.91	12.00	12.08	12.17	12.26
740	11.63	11.72	11.80	11.89	11.98	12.07	12.16	12.24	12.33	12.42
730	11.79	11.88	11.96	12.05	12.15	12.23	12.32	12.41	12.50	12.59
720	11.95	12.04	12.13	12.22	12.32	12.40	12.49	12.58	12.68	12.77
710	12.12	12.21	12.30	12.39	12.49	12.58	12.67	12.76	12.86	12.95
700	12.29	12.39	12.48	12.57	12.67	12.76	12.85	12.94	13.04	13.13
690	12.47	12.57	12.66	12.75	12.85	12.94	13.04	13.13	13.23	13.32
680	12.66	12.75	12.85	12.94	13.04	13.13	13.23	13.32	13.42	13.52
670	12.85	12.94	13.04	13.14	13.23	13.33	13.43	13.52	13.62	13.72
660	13.04	13.14	13.24	13.34	13.43	13.53	13.63	13.73	13.83	13.93
650	13.24	13.34	13.44	13.54	13.64	13.74	13.84	13.94	14.04	14.15
640	13.45	13.55	13.65	13.75	13.85	13.96	14.06	14.15	14.26	14.37
630	13.66	13.76	13.87	13.97	14.07	14.18	14.28	14.38	14.49	14.60
620	13.88	13.98	14.09	14.20	14.30	14.41	14.51	14.62	14.72	14.83
610	14.11	14.21	14.32	14.43	14.54	14.64	14.75	14.86	14.96	15.07
600	14.35	14.45	14.56	14.67	14.78	14.89	15.00	15.11	15.21	15.32
590	14.59	14.70	14.81	14.92	15.03	15.14	15.25	15.36	15.47	15.59
580	14.84	14.95	15.07	15.17	15.29	15.40	15.52	15.63	15.74	15.86
570	15.10	15.21	15.33	15.44	15.56	15.67	15.79	15.91	16.02	16.14
560	15.37	15.48	15.60	15.72	15.84	15.95	16.07	16.19	16.30	16.42

DETERMINATION OF HEIGHTS BY THE BAROMETER.

Formula of Babinet.

$$Z = C\frac{B_0 - B}{B_0 + B}$$

$$C \text{ (in feet)} = 52494 \left[1 + \frac{t_0 + t - 64}{900}\right] \text{—English Measures.}$$

$$C \text{ (in metres)} = 16000 \left[1 + \frac{2(t_0 + t)}{1000}\right] \text{—Metric Measures.}$$

In which Z = Difference of height of two stations in feet or metres.

B_0, B = Barometric readings at the lower and upper stations respectively, corrected for all sources of instrumental error.

t_0, t = Air temperatures at the lower and upper stations respectively.

Values of C.

ENGLISH MEASURES.

½ (t_0 + t).	log C.	C.
F.		Feet.
10°	4.69834	49928
15	.70339	50511
20	.70837	51094
25	.71330	51677
30	.71818	52261
35	4.72300	52844
40	.72777	53428
45	.73248	54011
50	.73715	54595
55	.74177	55178
60	4.74633	55761
65	.75085	56344
70	.75532	56927
75	.75975	57511
80	.76413	58094
85	4.76847	58677
90	.77276	59260
95	.77702	59844
100	.78123	60427

METRIC MEASURES.

½ (t_0 + t).	log C.	C.
C.		Metres.
−10°	4.18639	15360
− 8	.19000	15488
− 6	.19357	15616
− 4	.19712	15744
− 2	.20063	15872
0	4.20412	16000
+ 2	.20758	16128
4	.21101	16256
6	.21442	16384
8	.21780	16512
10	4.22115	16640
12	.22448	16768
14	.22778	16896
16	.23106	17024
18	.23431	17152
20	4.23754	17280
22	.24075	17408
24	.24393	17536
26	.24709	17664
28	.25022	17792
30	4.25334	17920
32	.25643	18048
34	.25950	18176
36	.26255	18304

TABLE 67.

BAROMETRIC PRESSURES CORRESPONDING TO THE TEMPERATURE OF THE BOILING POINT OF WATER.

ENGLISH MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
185°	17.075	17.112	17.150	17.187	17.224	17.262	17.300	17.337	17.375	17.413
186	17.450	17.488	17.526	17.564	17.602	17.641	17.679	17.717	17.756	17.794
187	17.832	17.871	17.910	17.948	17.987	18.026	18.065	18.104	18.143	18.182
188	18.221	18.261	18.300	18.340	18.379	18.419	18.458	18.498	18.538	18.578
189	18.618	18.658	18.698	18.738	18.778	18.818	18.859	18.899	18.940	18.980
190	19.021	19.062	19.102	19.143	19.184	19.225	19.266	19.308	19.349	19.390
191	19.431	19.473	19.514	19.556	19.598	19.639	19.681	19.723	19.765	19.807
192	19.849	19.892	19.934	19.976	20.019	20.061	20.104	20.146	20.189	20.232
193	20.275	20.318	20.361	20.404	20.447	20.490	20.533	20.577	20.620	20.664
194	20.707	20.751	20.795	20.839	20.883	20.927	20.971	21.015	21.059	21.103
195	21.148	21.192	21.237	21.282	21.326	21.371	21.416	21.461	21.506	21.551
196	21.597	21.642	21.687	21.733	21.778	21.824	21.870	21.915	21.961	22.007
197	22.053	22.099	22.145	22.192	22.238	22.284	22.331	22.377	22.424	22.471
198	22.517	22.564	22.611	22.658	22.706	22.753	22.800	22.847	22.895	22.942
199	22.990	23.038	23.085	23.133	23.181	23.229	23.277	23.325	23.374	23.422
200	23.470	23.519	23.568	23.616	23.665	23.714	23.763	23.812	23.861	23.910
201	23.959	24.009	24.058	24.108	24.157	24.207	24.257	24.307	24.357	24.407
202	24.457	24.507	24.557	24.608	24.658	24.709	24.759	24.810	24.861	24.912
203	24.963	25.014	25.065	25.116	25.168	25.219	25.271	25.322	25.374	25.426
204	25.478	25.530	25.582	25.634	25.686	25.738	25.791	25.843	25.896	25.948
205	26.001	26.054	26.107	26.160	26.213	26.266	26.319	26.373	26.426	26.480
206	26.534	26.587	26.641	26.695	26.749	26.803	26.857	26.912	26.966	27.021
207	27.075	27.130	27.184	27.239	27.294	27.349	27.404	27.460	27.515	27.570
208	27.626	27.681	27.737	27.793	27.848	27.904	27.960	28.016	28.073	28.129
209	28.185	28.242	28.298	28.355	28.412	28.469	28.526	28.583	28.640	28.697
210	28.754	28.812	28.869	28.927	28.985	29.042	29.100	29.158	29.216	29.275
211	29.333	29.391	29.450	29.508	29.567	29.626	29.685	29.744	29.803	29.862
212	29.921	29.981	30.040	30.100	30.159	30.219	30.279	30.339	30.399	30.459
213	30.519	30.580	30.640	30.701	30.761	30.822	30.883	30.944	31.005	31.066
214	31.127	31.199	31.250	31.311	31.373	31.435	31.497	31.559	31.621	31.683

TABLE 68.

METRIC MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
80°	355.40	356.84	358.28	359.73	361.19	362.65	364.11	365.58	367.06	368.54
81	370.03	371.52	373.01	374.51	376.02	377.53	379.05	380.57	382.09	383.62
82	385.16	386.70	388.25	389.80	391.36	392.92	394.49	396.06	397.64	399.22
83	400.81	402.40	404.00	405.61	407.22	408.83	410.45	412.08	413.71	415.35
84	416.99	418.64	420.29	421.95	423.61	425.28	426.95	428.64	430.32	432.01
85	433.71	435.41	437.12	438.83	440.55	442.28	444.01	445.75	447.49	449.24
86	450.99	452.75	454.51	456.28	458.06	459.84	461.63	463.42	465.22	467.03
87	468.84	470.66	472.48	474.31	476.14	477.99	479.83	481.68	483.54	485.41
88	487.28	489.16	491.04	492.93	494.82	496.72	498.63	500.54	502.46	504.39
89	506.32	508.26	510.20	512.15	514.11	516.07	518.04	520.01	521.99	523.98
90	525.97	527.97	529.98	531.99	534.01	536.04	538.07	540.11	542.15	544.21
91	546.26	548.33	550.40	552.48	554.56	556.65	558.75	560.85	562.96	565.08
92	567.20	569.33	571.47	573.61	575.76	577.92	580.08	582.25	584.43	586.61
93	588.80	591.00	593.20	595.41	597.63	599.86	602.09	604.33	606.57	608.82
94	611.08	613.35	615.62	617.90	620.19	622.48	624.79	627.09	629.41	631.73
95	634.06	636.40	638.74	641.09	643.45	645.82	648.19	650.57	652.96	655.35
96	657.75	660.16	662.58	665.00	667.43	669.87	672.32	674.77	677.23	679.70
97	682.18	684.66	687.15	689.65	692.15	694.67	697.19	699.71	702.25	704.79
98	707.35	709.90	712.47	715.04	717.63	720.22	722.81	725.42	728.03	730.65
99	733.28	735.92	738.56	741.21	743.87	746.54	749.22	751.90	754.59	757.29
100	760.00	762.72	765.44	768.17	770.91	773.66	776.42	779.18	781.95	784.73

HYGROMETRICAL TABLES.

PRESSURE OF AQUEOUS VAPOR OVER ICE.

ENGLISH MEASURES.

Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.
F.	Inches.	F.	Inches.	F.	Inches.	F.	Inches.	F.	Inches.
−60°	0.00099	−45°	0.00275	−30°	0.00705	−15.0°	0.01690	−7.5°	0.02556
59	.00107	44	.00294	29	.00749	14.5	.01738	7.0	.02626
58	.00114	43	.00313	28	.00795	14.0	.01787	6.5	.02698
57	.00123	42	.00334	27	.00844	13.5	.01838	6.0	.02771
56	.00131	41	.00356	26	.00896	13.0	.01890	5.5	.02847
−55	.00141	−40	.00379	−25	.00951	−12.5	.01943	−5.0	.02924
54	.00151	39	.00404	24	.01008	12.0	.01998	4.5	.03003
53	.00161	38	.00431	23	.01069	11.5	.02054	4.0	.03084
52	.00173	37	.00458	22	.01133	11.0	.02111	3.5	.03168
51	.00185	36	.00488	21	.01201	10.5	.02170	3.0	.03253
−50	.00198	−35	.00519	−20	.01272	−10.0	.02230	−2.5	.03340
49	.00211	34	.00552	19	.01347	9.5	.02292	2.0	.03429
48	.00226	33	.00588	18	.01426	9.0	.02356	1.5	.03520
47	.00241	32	.00625	17	.01510	8.5	.02421	1.0	.03614
46	.00258	31	.00664	16	.01598	8.0	.02487	0.5	.03710

Temperat.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
0°	0.03809	0.03829	0.03849	0.03869	0.03890	0.03910	0.03930	0.03951	0.03971	0.03992
1	.04013	.04034	.04055	.04076	.04097	.04118	.04140	.04161	.04183	.04204
2	.04226	.04248	.04270	.04292	.04314	.04337	.04359	.04382	.04404	.04427
3	.04450	.04473	.04496	.04519	.04543	.04566	.04590	.04613	.04637	.04661
4	.04685	.04709	.04733	.04758	.04782	.04807	.04831	.04856	.04881	.04906
5	.04931	.04956	.04982	.05007	.05033	.05058	.05084	.05110	.05136	.05162
6	.05189	.05215	.05242	.05269	.05296	.05322	.05350	.05377	.05404	.05431
7	.05459	.05487	.05514	.05542	.05570	.05598	.05627	.05655	.05684	.05712
8	.05741	.05770	.05799	.05828	.05858	.05887	.05917	.05947	.05977	.06007
9	.06037	.06067	.06098	.06128	.06159	.06190	.06221	.06252	.06283	.06315
10	.06346	.06378	.06410	.06442	.06474	.06507	.06539	.06572	.06605	.06638
11	.06670	.06703	.06737	.06770	.06804	.06838	.06872	.06906	.06940	.06975
12	.07009	.07044	.07079	.07114	.07149	.07184	.07220	.07256	.07292	.07328
13	.07363	.07399	.07436	.07472	.07509	.07546	.07583	.07621	.07658	.07696
14	.07733	.07771	.07809	.07848	.07886	.07925	.07964	.08003	.08042	.08082
15	.08121	.08161	.08201	.08241	.08281	.08321	.08362	.08402	.08443	.08484
16	.08525	.08566	.08608	.08650	.08692	.08734	.08777	.08819	.08862	.08905
17	.08948	.08991	.09035	.09079	.09123	.09167	.09211	.09255	.09300	.09345
18	.09390	.09435	.09481	.09526	.09572	.09618	.09664	.09711	.09757	.09804
19	.09851	.09898	.09946	.09994	.10042	.10090	.10138	.10186	.10235	.10284
20	.10333	.10383	.10432	.10482	.10532	.10582	.10633	.10683	.10734	.10785
21	.10836	.10888	.10940	.10992	.11044	.11096	.11149	.11202	.11255	.11308
22	.11361	.11415	.11469	.11523	.11578	.11632	.11687	.11742	.11798	.11853
23	.11909	.11965	.12022	.12078	.12135	.12192	.12250	.12307	.12365	.12423
24	.12481	.12540	.12598	.12657	.12717	.12776	.12836	.12896	.12956	.13017
25	.13077	.13138	.13200	.13261	.13323	.13385	.13447	.13510	.13573	.13636
26	.13699	.13763	.13827	.13891	.13956	.14021	.14086	.14151	.14216	.14282
27	.14348	.14415	.14481	.14548	.14616	.14683	.14751	.14819	.14887	.14956
28	.15024	.15093	.15163	.15233	.15303	.15374	.15444	.15515	.15586	.15658
29	.15729	.15801	.15874	.15947	.16020	.16093	.16167	.16241	.16315	.16389
30	.16463	.16538	.16614	.16690	.16766	.16842	.16919	.16996	.17073	.17150
31	.17228	.17306	.17386	.17466	.17546	.17626	.17707	.17788	.17869	.17950
32	.18032									

PRESSURE OF AQUEOUS VAPOR OVER WATER.

ENGLISH MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
32°	0.1803	0.1810	0.1818	0.1825	0.1833	0.1840	0.1847	0.1855	0.1862	0.1870
33	.1877	.1885	.1893	.1900	.1908	.1915	.1923	.1931	.1939	.1946
34	.1954	.1962	.1970	.1978	.1986	.1994	.2002	.2010	.2018	.2026
35	.2034	.2042	.2050	.2059	.2067	.2075	.2083	.2091	.2100	.2108
36	.2117	.2125	.2133	.2142	.2150	.2159	.2168	.2176	.2185	.2193
37	.2202	.2211	.2220	.2228	.2237	.2246	.2255	.2264	.2273	.2282
38	.2291	.2300	.2309	.2318	.2327	.2336	.2345	.2355	.2364	.2373
39	.2382	.2392	.2401	.2410	.2420	.2429	.2439	.2448	.2458	.2467
40	.2477	.2487	.2496	.2506	.2516	.2526	.2536	.2545	.2555	.2565
41	.2575	.2585	.2595	.2606	.2616	.2626	.2636	.2646	.2656	.2667
42	.2677	.2687	.2698	.2708	.2719	.2729	.2740	.2750	.2761	.2771
43	.2782	.2793	.2804	.2814	.2825	.2836	.2847	.2858	.2869	.2880
44	.2891	.2902	.2913	.2924	.2935	.2946	.2958	.2969	.2981	.2992
45	.3003	.3014	.3026	.3037	.3049	.3061	.3073	.3084	.3096	.3108
46	.3120	.3132	.3144	.3156	.3167	.3179	.3191	.3203	.3216	.3228
47	.3240	.3252	.3265	.3277	.3289	.3301	.3314	.3326	.3339	.3352
48	.3365	.3377	.3390	.3402	.3415	.3428	.3441	.3454	.3467	.3480
49	.3493	.3506	.3519	.3532	.3546	.3559	.3572	.3585	.3599	.3612
50	.3626	.3639	.3653	.3666	.3680	.3694	.3708	.3722	.3736	.3749
51	.3763	.3777	.3791	.3805	.3820	.3834	.3848	.3862	.3876	.3890
52	.3905	.3919	.3934	.3948	.3963	.3978	.3993	.4007	.4022	.4037
53	.4052	.4067	.4082	.4097	.4112	.4127	.4142	.4157	.4172	.4187
54	.4203	.4218	.4234	.4249	.4265	.4280	.4296	.4312	.4328	.4343
55	.4359	.4375	.4391	.4407	.4423	.4439	.4455	.4471	.4488	.4504
56	.4521	.4537	.4554	.4570	.4587	.4603	.4620	.4637	.4654	.4670
57	.4687	.4704	.4721	.4738	.4755	.4772	.4790	.4807	.4824	.4841
58	.4859	.4876	.4894	.4912	.4930	.4947	.4965	.4983	.5001	.5019
59	.5037	.5055	.5073	.5091	.5110	.5128	.5146	.5164	.5183	.5201
60	.5220	.5239	.5258	.5276	.5295	.5314	.5333	.5352	.5371	.5390
61	.5409	.5428	.5448	.5467	.5486	.5505	.5525	.5545	.5565	.5584
62	.5604	.5624	.5644	.5663	.5683	.5703	.5724	.5744	.5764	.5784
63	.5805	.5825	.5846	.5866	.5887	.5908	.5929	.5950	.5971	.5992
64	.6013	.6034	.6055	.6076	.6097	.6118	.6140	.6161	.6183	.6204
65	.6226	.6248	.6270	.6292	.6314	.6336	.6358	.6380	.6402	.6424
66	.6447	.6469	.6492	.6514	.6537	.6559	.6582	.6605	.6628	.6651
67	.6674	.6697	.6721	.6744	.6767	.6790	.6814	.6837	.6861	.6885
68	.6909	.6932	.6956	.6980	.7004	.7028	.7053	.7077	.7101	.7125
69	.7150	.7174	.7199	.7224	.7249	.7274	.7299	.7324	.7348	.7373
70	.7399	.7424	.7449	.7474	.7500	.7526	.7552	.7577	.7603	.7629
71	.7655	.7681	.7707	.7733	.7760	.7786	.7813	.7839	.7866	.7892
72	.7919	.7946	.7973	.8000	.8027	.8054	.8081	.8108	.8136	.8163
73	.8191	.8219	.8247	.8274	.8302	.8330	.8358	.8386	.8414	.8442
74	.8471	.8499	.8528	.8556	.8585	.8614	.8643	.8672	.8701	.8730
75	.8760	.8789	.8818	.8847	.8877	.8907	.8937	.8966	.8996	.9026
76	.9056	.9086	.9117	.9147	.9178	.9208	.9239	.9269	.9300	.9331
77	.9362	.9393	.9424	.9455	.9487	.9518	.9550	.9581	.9613	.9645
78	.9677	.9709	.9741	.9773	.9805	.9837	.9870	.9902	.9935	.9968
79	1.0001	1.0033	1.0066	1.0099	1.0133	1.0166	1.0199	1.0232	1.0266	1.0300
80	1.0334	1.0367	1.0401	1.0435	1.0470	1.0504	1.0538	1.0572	1.0607	1.0641

TABLE 70.

PRESSURE OF AQUEOUS VAPOR OVER WATER.

ENGLISH MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
80°	1.0334	1.0367	1.0401	1.0435	1.0470	1.0504	1.0538	1.0572	1.0607	1.0641
81	1.0676	1.0711	1.0746	1.0781	1.0816	1.0851	1.0887	1.0922	1.0958	1.0993
82	1.1029	1.1065	1.1101	1.1137	1.1173	1.1209	1.1246	1.1282	1.1319	1.1355
83	1.1392	1.1429	1.1466	1.1503	1.1540	1.1577	1.1615	1.1652	1.1690	1.1727
84	1.1765	1.1803	1.1841	1.1879	1.1917	1.1955	1.1994	1.2032	1.2071	1.2110
85	1.2149	1.2188	1.2227	1.2266	1.2305	1.2344	1.2384	1.2423	1.2463	1.2503
86	1.2543	1.2583	1.2623	1.2663	1.2704	1.2744	1.2785	1.2826	1.2867	1.2908
87	1.2949	1.2990	1.3031	1.3072	1.3114	1.3155	1.3197	1.3239	1.3281	1.3323
88	1.3365	1.3407	1.3450	1.3492	1.3535	1.3578	1.3621	1.3664	1.3707	1.3750
89	1.3794	1.3837	1.3881	1.3925	1.3969	1.4013	1.4057	1.4101	1.4146	1.4190
90	1.4234	1.4279	1.4324	1.4369	1.4414	1.4459	1.4505	1.4550	1.4596	1.4642
91	1.4688	1.4734	1.4780	1.4826	1.4872	1.4918	1.4965	1.5012	1.5059	1.5106
92	1.5153	1.5200	1.5247	1.5294	1.5342	1.5390	1.5438	1.5486	1.5534	1.5582
93	1.5630	1.5678	1.5727	1.5776	1.5825	1.5874	1.5923	1.5972	1.6022	1.6071
94	1.6121	1.6171	1.6221	1.6271	1.6321	1.6371	1.6422	1.6472	1.6523	1.6574
95	1.6625	1.6676	1.6728	1.6779	1.6831	1.6882	1.6934	1.6986	1.7038	1.7090
96	1.7143	1.7195	1.7248	1.7301	1.7354	1.7407	1.7460	1.7513	1.7567	1.7620
97	1.7674	1.7728	1.7782	1.7836	1.7891	1.7945	1.8000	1.8055	1.8110	1.8165
98	1.8220	1.8275	1.8331	1.8386	1.8442	1.8498	1.8554	1.8610	1.8667	1.8723
99	1.8780	1.8837	1.8894	1.8951	1.9008	1.9065	1.9123	1.9181	1.9239	1.9297
100	1.9355	1.9413	1.9472	1.9530	1.9589	1.9648	1.9707	1.9766	1.9826	1.9885
101	1.9945	2.0005	2.0065	2.0125	2.0185	2.0245	2.0306	2.0367	2.0428	2.0489
102	2.0550	2.0611	2.0673	2.0735	2.0797	2.0859	2.0921	2.0983	2.1046	2.1108
103	2.1171	2.1234	2.1298	2.1361	2.1425	2.1488	2.1552	2.1616	2.1680	2.1744
104	2.1809	2.1874	2.1939	2.2004	2.2069	2.2134	2.2200	2.2265	2.2331	2.2397
105	2.2463	2.2529	2.2596	2.2663	2.2730	2.2797	2.2864	2.2931	2.2999	2.3067
106	2.3135	2.3203	2.3271	2.3339	2.3408	2.3477	2.3546	2.3615	2.3684	2.3753
107	2.3823	2.3893	2.3963	2.4033	2.4103	2.4173	2.4244	2.4315	2.4386	2.4457
108	2.4529	2.4600	2.4672	2.4744	2.4816	2.4888	2.4961	2.5033	2.5106	2.5179
109	2.5252	2.5325	2.5399	2.5473	2.5547	2.5621	2.5695	2.5770	2.5845	2.5919
110	2.5994	2.6069	2.6145	2.6220	2.6296	2.6372	2.6448	2.6524	2.6601	2.6678
111	2.6755	2.6832	2.6909	2.6986	2.7064	2.7142	2.7220	2.7298	2.7377	2.7456
112	2.7535	2.7614	2.7693	2.7772	2.7852	2.7932	2.8012	2.8092	2.8173	2.8253
113	2.8334	2.8415	2.8496	2.8577	2.8659	2.8741	2.8823	2.8905	2.8988	2.9070
114	2.9153	2.9236	2.9320	2.9403	2.9487	2.9571	2.9655	2.9739	2.9823	2.9908
115	2.9993	3.0078	3.0163	3.0248	3.0334	3.0420	3.0506	3.0592	3.0679	3.0766
116	3.0853	3.0940	3.1027	3.1115	3.1203	3.1291	3.1379	3.1467	3.1556	3.1645
117	3.1734	3.1823	3.1913	3.2003	3.2093	3.2183	3.2273	3.2364	3.2455	3.2546
118	3.2637	3.2728	3.2820	3.2912	3.3004	3.3096	3.3189	3.3282	3.3375	3.3468
119	3.3562	3.3655	3.3749	3.3843	3.3938	3.4032	3.4127	3.4222	3.4318	3.4413
120	3.4509	3.4605	3.4701	3.4797	3.4894	3.4991	3.5088	3.5185	3.5283	3.5381
121	3.5479	3.5577	3.5676	3.5774	3.5873	3.5972	3.6072	3.6172	3.6272	3.6372
122	3.6472	3.6573	3.6674	3.6775	3.6876	3.6977	3.7079	3.7181	3.7284	3.7386
123	3.7489	3.7592	3.7695	3.7799	3.7903	3.8007	3.8111	3.8215	3.8320	3.8425
124	3.8530	3.8636	3.8742	3.8848	3.8954	3.9060	3.9167	3.9274	3.9381	3.9488
125	3.9596	3.9704	3.9813	3.9921	4.0030	4.0139	4.0248	4.0357	4.0467	4.0577
126	4.0687	4.0797	4.0908	4.1019	4.1131	4.1242	4.1354	4.1466	4.1578	4.1690
127	4.1803	4.1916	4.2030	4.2143	4.2256	4.2370	4.2485	4.2599	4.2714	4.2829
128	4.2945	4.3061	4.3177	4.3293	4.3410	4.3527	4.3645	4.3762	4.3880	4.3998
129	4.4116	4.4235	4.4354	4.4473	4.4592	4.4711	4.4831	4.4951	4.5072	4.5192
130	4.5313	4.5434	4.5555	4.5677	4.5798	4.5921	4.6043	4.6166	4.6289	4.6412

PRESSURE OF AQUEOUS VAPOR OVER WATER.

ENGLISH MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
130°	4.531	4.543	4.556	4.568	4.580	4.592	4.604	4.617	4.629	4.641
131	4.654	4.666	4.678	4.691	4.703	4.716	4.728	4.741	4.754	4.766
132	4.779	4.792	4.804	4.817	4.830	4.843	4.855	4.868	4.881	4.894
133	4.907	4.920	4.933	4.946	4.959	4.972	4.985	4.998	5.012	5.025
134	5.038	5.051	5.065	5.078	5.091	5.105	5.118	5.132	5.145	5.158
135	5.172	5.186	5.199	5.213	5.226	5.240	5.254	5.268	5.281	5.295
136	5.309	5.323	5.337	5.351	5.365	5.379	5.392	5.407	5.421	5.435
137	5.449	5.463	5.477	5.492	5.506	5.520	5.535	5.549	5.563	5.578
138	5.592	5.607	5.621	5.636	5.650	5.665	5.680	5.694	5.709	5.724
139	5.739	5.754	5.768	5.783	5.798	5.813	5.828	5.843	5.858	5.873
140	5.889	5.904	5.919	5.934	5.949	5.965	5.980	5.995	6.011	6.026
141	6.041	6.057	6.072	6.088	6.104	6.119	6.135	6.151	6.166	6.182
142	6.198	6.214	6.229	6.245	6.261	6.277	6.293	6.309	6.325	6.341
143	6.358	6.374	6.390	6.406	6.422	6.439	6.455	6.472	6.488	6.504
144	6.521	6.537	6.554	6.571	6.587	6.604	6.621	6.637	6.654	6.671
145	6.688	6.705	6.722	6.739	6.756	6.773	6.790	6.807	6.824	6.841
146	6.858	6.876	6.893	6.910	6.928	6.945	6.962	6.980	6.997	7.015
147	7.032	7.050	7.068	7.085	7.103	7.121	7.139	7.156	7.174	7.192
148	7.210	7.228	7.246	7.264	7.282	7.300	7.319	7.337	7.355	7.374
149	7.392	7.410	7.429	7.447	7.466	7.484	7.503	7.521	7.540	7.559
150	7.577	7.596	7.615	7.634	7.653	7.672	7.691	7.710	7.729	7.748
151	7.767	7.786	7.805	7.824	7.844	7.863	7.882	7.902	7.921	7.941
152	7.960	7.980	8.000	8.019	8.039	8.059	8.078	8.098	8.118	8.138
153	8.158	8.178	8.198	8.218	8.238	8.258	8.278	8.298	8.319	8.339
154	8.360	8.380	8.400	8.421	8.441	8.462	8.482	8.503	8.524	8.545
155	8.565	8.586	8.607	8.628	8.649	8.670	8.691	8.712	8.733	8.754
156	8.776	8.797	8.818	8.839	8.861	8.882	8.904	8.925	8.947	8.968
157	8.990	9.012	9.034	9.055	9.077	9.099	9.121	9.143	9.165	9.187
158	9.209	9.231	9.253	9.276	9.298	9.320	9.342	9.365	9.387	9.410
159	9.432	9.455	9.478	9.500	9.523	9.546	9.569	9.592	9.615	9.638
160	9.661	9.684	9.707	9.730	9.753	9.776	9.799	9.823	9.846	9.870
161	9.893	9.916	9.940	9.964	9.987	10.011	10.035	10.059	10.082	10.106
162	10.130	10.154	10.178	10.203	10.227	10.251	10.275	10.299	10.324	10.348
163	10.373	10.397	10.422	10.446	10.471	10.495	10.520	10.545	10.570	10.595
164	10.620	10.645	10.670	10.695	10.720	10.745	10.770	10.795	10.821	10.846
165	10.872	10.897	10.922	10.948	10.974	10.999	11.025	11.051	11.077	11.102
166	11.128	11.154	11.180	11.206	11.232	11.258	11.284	11.311	11.337	11.363
167	11.390	11.417	11.444	11.470	11.497	11.523	11.550	11.577	11.604	11.631
168	11.658	11.685	11.712	11.739	11.766	11.793	11.821	11.848	11.875	11.903
169	11.930	11.957	11.985	12.013	12.040	12.068	12.096	12.124	12.152	12.180
170	12.208	12.236	12.264	12.292	12.320	12.349	12.377	12.406	12.434	12.463
171	12.491	12.520	12.548	12.577	12.606	12.635	12.664	12.693	12.722	12.751
172	12.780	12.809	12.838	12.868	12.897	12.927	12.956	12.986	13.015	13.045
173	13.074	13.104	13.134	13.164	13.194	13.224	13.254	13.284	13.314	13.344
174	13.374	13.405	13.435	13.465	13.496	13.527	13.557	13.588	13.619	13.649
175	13.680	13.711	13.742	13.773	13.804	13.835	13.867	13.898	13.929	13.961
176	13.992	14.024	14.055	14.087	14.118	14.150	14.182	14.214	14.246	14.278
177	14.310	14.342	14.374	14.406	14.438	14.471	14.503	14.536	14.568	14.601
178	14.633	14.666	14.699	14.731	14.764	14.797	14.830	14.864	14.897	14.930
179	14.963	14.996	15.030	15.063	15.097	15.130	15.164	15.197	15.231	15.265
180	15.299	15.333	15.367	15.401	15.435	15.469	15.504	15.538	15.572	15.607

PRESSURE OF AQUEOUS VAPOR OVER WATER.

ENGLISH MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
180°	15.299	15.333	15.367	15.401	15.435	15.469	15.504	15.538	15.572	15.607
181	15.641	15.676	15.710	15.745	15.780	15.815	15.850	15.885	15.920	15.955
182	15.990	16.025	16.060	16.096	16.131	16.167	16.202	16.238	16.274	16.309
183	16.345	16.381	16.417	16.453	16.489	16.525	16.561	16.598	16.634	16.670
184	16.707	16.743	16.780	16.817	16.853	16.890	16.927	16.964	17.001	17.038
185	17.075	17.112	17.150	17.187	17.224	17.262	17.300	17.337	17.375	17.413
186	17.450	17.488	17.526	17.564	17.602	17.641	17.679	17.717	17.756	17.794
187	17.832	17.871	17.910	17.948	17.987	18.026	18.065	18.104	18.143	18.182
188	18.221	18.261	18.300	18.340	18.379	18.419	18.458	18.498	18.538	18.578
189	18.618	18.658	18.698	18.738	18.778	18.818	18.859	18.899	18.940	18.980
190	19.021	19.062	19.102	19.143	19.184	19.225	19.266	19.308	19.349	19.390
191	19.431	19.473	19.514	19.556	19.598	19.639	19.681	19.723	19.765	19.807
192	19.849	19.892	19.934	19.976	20.019	20.061	20.104	20.146	20.189	20.232
193	20.275	20.318	20.361	20.404	20.447	20.490	20.533	20.577	20.620	20.664
194	20.707	20.751	20.795	20.839	20.883	20.927	20.971	21.015	21.059	21.103
195	21.148	21.192	21.237	21.282	21.326	21.371	21.416	21.461	21.506	21.551
196	21.597	21.642	21.687	21.733	21.778	21.824	21.870	21.915	21.961	22.007
197	22.053	22.099	22.145	22.192	22.238	22.284	22.331	22.377	22.424	22.471
198	22.517	22.564	22.611	22.658	22.706	22.753	22.800	22.847	22.895	22.942
199	22.990	23.038	23.085	23.133	23.181	23.229	23.277	23.325	23.374	23.422
200	23.470	23.519	23.568	23.616	23.665	23.714	23.763	23.812	23.861	23.910
201	23.959	24.009	24.058	24.108	24.157	24.207	24.257	24.307	24.357	24.407
202	24.457	24.507	24.557	24.608	24.658	24.709	24.759	24.810	24.861	24.912
203	24.963	25.014	25.065	25.116	25.168	25.219	25.271	25.322	25.374	25.426
204	25.478	25.530	25.582	25.634	25.686	25.738	25.791	25.843	25.896	25.948
205	26.001	26.054	26.107	26.160	26.213	26.266	26.319	26.373	26.426	26.480
206	26.534	26.587	26.641	26.695	26.749	26.803	26.857	26.912	26.966	27.021
207	27.075	27.130	27.184	27.239	27.294	27.349	27.404	27.460	27.515	27.570
208	27.626	27.681	27.737	27.793	27.848	27.904	27.960	28.016	28.073	28.129
209	28.185	28.242	28.298	28.355	28.412	28.469	28.526	28.583	28.640	28.697
210	28.754	28.812	28.869	28.927	28.985	29.042	29.100	29.158	29.216	29.275
211	29.333	29.391	29.450	29.508	29.567	29.626	29.685	29.744	29.803	29.862
212	29.921	29.981	30.040	30.100	30.159	30.219	30.279	30.339	30.399	30.459
213	30.519	30.580	30.640	30.701	30.761	30.822	30.883	30.944	31.005	31.066
214	31.127	31.189	31.250	31.311	31.373	31.435	31.497	31.559	31.621	31.683

PRESSURE OF AQUEOUS VAPOR OVER ICE.

METRIC MEASURES.

Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.	Temperature.	Vapor Pressure.
C.	mm.	C.	mm.	C.	mm.	C.	mm.	C.	mm.
−70°	0.0018	−60°	0.0078	−50.0°	0.0291	−45.0°	0.0537	−40.0°	0.0964
69	0.0021	59	0.0089	49.5	0.0308	44.5	0.0570	39.5	0.1020
68	0.0025	58	0.0102	49.0	0.0329	44.0	0.0605	39.0	0.1080
67	0.0028	57	0.0117	48.5	0.0350	43.5	0.0642	38.5	0.1143
66	0.0033	56	0.0134	48.0	0.0373	43.0	0.0680	38.0	0.1209
−65	0.0038	−55	0.0153	−47.5	0.0396	−42.5	0.0721	−37.5	0.1279
64	0.0044	54	0.0174	47.0	0.0421	42.0	0.0765	37.0	0.1352
63	0.0051	53	0.0198	46.5	0.0448	41.5	0.0811	36.5	0.1430
62	0.0059	52	0.0226	46.0	0.0476	41.0	0.0859	36.0	0.1511
61	0.0068	51	0.0256	45.5	0.0506	40.5	0.0910	35.5	0.1596

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−35°	0.1686	0.1668	0.1650	0.1632	0.1614	0.1596	0.1579	0.1562	0.1545	0.1528
34	0.1880	0.1860	0.1840	0.1820	0.1800	0.1781	0.1761	0.1742	0.1723	0.1705
33	0.2094	0.2072	0.2050	0.2028	0.2006	0.1984	0.1963	0.1942	0.1921	0.1901
32	0.2331	0.2306	0.2281	0.2257	0.2233	0.2209	0.2186	0.2163	0.2140	0.2117
31	0.2591	0.2564	0.2537	0.2510	0.2484	0.2458	0.2432	0.2406	0.2381	0.2355
−30	0.2878	0.2848	0.2818	0.2789	0.2760	0.2731	0.2703	0.2674	0.2646	0.2619
29	0.3194	0.3161	0.3128	0.3096	0.3064	0.3032	0.3001	0.2970	0.2939	0.2908
28	0.3541	0.3505	0.3469	0.3433	0.3398	0.3363	0.3329	0.3295	0.3261	0.3227
27	0.3923	0.3883	0.3843	0.3804	0.3766	0.3727	0.3689	0.3652	0.3615	0.3578
26	0.4341	0.4297	0.4254	0.4211	0.4169	0.4127	0.4085	0.4044	0.4003	0.3963
−25	0.4800	0.4752	0.4705	0.4658	0.4611	0.4565	0.4519	0.4474	0.4429	0.4385
24	0.5303	0.5251	0.5199	0.5147	0.5096	0.5046	0.4996	0.4946	0.4897	0.4848
23	0.5854	0.5796	0.5739	0.5683	0.5628	0.5572	0.5517	0.5463	0.5409	0.5356
22	0.6456	0.6393	0.6331	0.6270	0.6209	0.6148	0.6088	0.6029	0.5970	0.5912
21	0.7115	0.7046	0.6978	0.6911	0.6844	0.6778	0.6713	0.6648	0.6583	0.6519
−20	0.7834	0.7759	0.7685	0.7611	0.7538	0.7466	0.7395	0.7324	0.7254	0.7184
19	0.8618	0.8537	0.8456	0.8376	0.8296	0.8217	0.8139	0.8062	0.7985	0.7909
18	0.9474	0.9385	0.9297	0.9209	0.9123	0.9037	0.8952	0.8867	0.8784	0.8701
17	1.0406	1.0309	1.0213	1.0118	1.0024	0.9930	0.9837	0.9745	0.9654	0.9563
16	1.1421	1.1316	1.1211	1.1108	1.1005	1.0903	1.0802	1.0702	1.0602	1.0504
−15	1.2525	1.2411	1.2297	1.2184	1.2072	1.1962	1.1852	1.1743	1.1635	1.1527
14	1.3726	1.3601	1.3477	1.3355	1.3233	1.3113	1.2993	1.2875	1.2757	1.2641
13	1.5029	1.4894	1.4759	1.4626	1.4495	1.4364	1.4234	1.4105	1.3978	1.3851
12	1.6444	1.6297	1.6151	1.6007	1.5864	1.5722	1.5581	1.5441	1.5302	1.5165
11	1.7979	1.7820	1.7662	1.7506	1.7350	1.7196	1.7043	1.6892	1.6741	1.6592
−10	1.9643	1.9470	1.9299	1.9129	1.8961	1.8794	1.8628	1.8464	1.8301	1.8139
9	2.1445	2.1258	2.1073	2.0889	2.0707	2.0526	2.0347	2.0168	1.9992	1.9817
8	2.3395	2.3193	2.2993	2.2794	2.2596	2.2401	2.2206	2.2014	2.1823	2.1633
7	2.5505	2.5287	2.5070	2.4855	2.4642	2.4430	2.4220	2.4011	2.3804	2.3599
6	2.7785	2.7549	2.7315	2.7083	2.6852	2.6623	2.6396	2.6171	2.5947	2.5725
− 5	3.0248	2.9993	2.9740	2.9489	2.9240	2.8993	2.8747	2.8504	2.8262	2.8023
4	3.2907	3.2632	3.2359	3.2088	3.1819	3.1552	3.1287	3.1025	3.0764	3.0505
3	3.5775	3.5479	3.5184	3.4892	3.4602	3.4314	3.4028	3.3745	3.3463	3.3184
2	3.8868	3.8548	3.8230	3.7916	3.7603	3.7292	3.6985	3.6678	3.6375	3.6074
1	4.2199	4.1854	4.1513	4.1174	4.0837	4.0502	4.0171	3.9841	3.9515	3.9190
− 0	4.5802	4.5428	4.5057	4.4690	4.4325	4.3962	4.3604	4.3248	4.2896	4.2546

PRESSURE OF AQUEOUS VAPOR OVER WATER.

METRIC MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
0°	4.580	4.614	4.647	4.681	4.715	4.750	4.784	4.819	4.854	4.889
1	4.924	4.960	4.996	5.032	5.068	5.105	5.142	5.179	5.216	5.254
2	5.291	5.329	5.368	5.406	5.445	5.484	5.523	5.562	5.602	5.642
3	5.682	5.723	5.763	5.804	5.846	5.887	5.929	5.971	6.013	6.056
4	6.098	6.141	6.185	6.228	6.272	6.316	6.361	6.406	6.450	6.496
5	6.541	6.587	6.633	6.680	6.726	6.773	6.820	6.868	6.916	6.964
6	7.012	7.061	7.110	7.159	7.209	7.259	7.309	7.360	7.410	7.462
7	7.513	7.565	7.617	7.669	7.722	7.775	7.828	7.882	7.936	7.991
8	8.045	8.100	8.156	8.211	8.267	8.324	8.380	8.437	8.494	8.552
9	8.610	8.669	8.727	8.786	8.846	8.906	8.966	9.026	9.087	9.148
10	9.210	9.272	9.334	9.397	9.460	9.523	9.587	9.651	9.716	9.781
11	9.846	9.912	9.978	10.044	10.111	10.178	10.246	10.314	10.382	10.451
12	10.521	10.590	10.660	10.731	10.801	10.873	10.944	11.016	11.089	11.162
13	11.235	11.309	11.383	11.458	11.533	11.608	11.684	11.761	11.837	11.915
14	11.992	12.070	12.149	12.228	12.307	12.387	12.468	12.549	12.630	12.712
15	12.794	12.877	12.960	13.043	13.127	13.212	13.297	13.383	13.469	13.555
16	13.642	13.729	13.817	13.906	13.995	14.084	14.174	14.265	14.356	14.447
17	14.539	14.632	14.725	14.818	14.912	15.007	15.102	15.197	15.293	15.390
18	15.487	15.585	15.683	15.782	15.882	15.981	16.082	16.183	16.285	16.387
19	16.489	16.593	16.696	16.801	16.906	17.011	17.117	17.224	17.331	17.439
20	17.548	17.657	17.766	17.877	17.987	18.099	18.211	18.323	18.437	18.551
21	18.665	18.780	18.896	19.012	19.129	19.247	19.365	19.484	19.603	19.723
22	19.844	19.965	20.087	20.210	20.333	20.457	20.582	20.707	20.833	20.960
23	21.087	21.215	21.344	21.473	21.604	21.734	21.866	21.998	22.131	22.264
24	22.398	22.533	22.669	22.805	22.942	23.080	23.219	23.358	23.498	23.638
25	23.780	23.922	24.065	24.209	24.353	24.498	24.644	24.791	24.938	25.086
26	25.235	25.385	25.535	25.687	25.839	25.991	26.145	26.299	26.455	26.610
27	26.767	26.925	27.083	27.242	27.402	27.563	27.725	27.887	28.051	28.215
28	28.380	28.546	28.712	28.880	29.048	29.217	29.387	29.558	29.730	29.903
29	30.076	30.251	30.426	30.602	30.779	30.957	31.136	31.315	31.496	31.678
30	31.860	32.043	32.228	32.413	32.599	32.786	32.974	33.163	33.353	33.543
31	33.735	33.928	34.121	34.316	34.512	34.708	34.906	35.104	35.303	35.504
32	35.705	35.908	36.111	36.315	36.521	36.727	36.935	37.143	37.353	37.563
33	37.775	37.987	38.201	38.415	38.631	38.848	39.065	39.284	39.504	39.725
34	39.947	40.170	40.394	40.619	40.846	41.073	41.302	41.531	41.762	41.994
35	42.227	42.461	42.696	42.932	43.170	43.408	43.648	43.889	44.131	44.374
36	44.619	44.864	45.111	45.358	45.608	45.858	46.109	46.362	46.615	46.870
37	47.127	47.384	47.643	47.902	48.163	48.426	48.689	48.954	49.220	49.487
38	49.756	50.025	50.296	50.569	50.842	51.117	51.393	51.670	51.949	52.229
39	52.510	52.793	53.077	53.362	53.649	53.937	54.226	54.516	54.808	55.101
40	55.396	55.692	55.989	56.288	56.588	56.889	57.192	57.496	57.802	58.109
41	58.417	58.727	59.038	59.351	59.665	59.981	60.298	60.616	60.936	61.257
42	61.580	61.904	62.230	62.557	62.886	63.216	63.547	63.880	64.215	64.551
43	64.889	65.228	65.569	65.911	66.255	66.600	66.947	67.295	67.645	67.997
44	68.350	68.704	69.061	69.419	69.778	70.139	70.502	70.866	71.232	71.599
45	71.968	72.339	72.712	73.086	73.461	73.839	74.218	74.598	74.981	75.365
46	75.751	76.138	76.527	76.918	77.311	77.705	78.101	78.499	78.898	79.300
47	79.703	80.107	80.514	80.922	81.332	81.744	82.158	82.573	82.990	83.409
48	83.830	84.253	84.677	85.104	85.532	85.962	86.394	86.828	87.263	87.701
49	88.140	88.581	89.024	89.470	89.916	90.365	90.816	91.269	91.723	92.180
50	92.639	93.099	93.562	94.026	94.492	94.961	95.431	95.903	96.378	96.854

PRESSURE OF AQUEOUS VAPOR OVER WATER.

METRIC MEASURES.

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
50°	92.64	93.10	93.56	94.03	94.49	94.96	95.43	95.90	96.38	96.85
51	97.33	97.81	98.30	98.78	99.27	99.76	100.25	100.74	101.23	101.73
52	102.23	102.73	103.23	103.74	104.25	104.75	105.27	105.78	106.30	106.81
53	107.33	107.86	108.38	108.91	109.44	109.97	110.50	111.04	111.57	112.11
54	112.66	113.20	113.75	114.30	114.85	115.40	115.96	116.51	117.07	117.64
55	118.20	118.77	119.34	119.91	120.49	121.06	121.64	122.22	122.81	123.39
56	123.98	124.57	125.16	125.76	126.36	126.96	127.56	128.17	128.77	129.38
57	130.00	130.61	131.23	131.85	132.47	133.10	133.73	134.36	134.99	135.62
58	136.26	136.90	137.54	138.19	138.84	139.49	140.14	140.80	141.46	142.12
59	142.78	143.45	144.12	144.79	145.46	146.14	146.82	147.50	148.19	148.88
60	149.57	150.26	150.95	151.65	152.35	153.06	153.77	154.48	155.19	155.90
61	156.62	157.34	158.07	158.79	159.52	160.26	160.99	161.73	162.47	163.21
62	163.96	164.71	165.46	166.22	166.98	167.74	168.50	169.27	170.04	170.81
63	171.59	172.37	173.15	173.93	174.72	175.51	176.31	177.10	177.91	178.71
64	179.52	180.32	181.14	181.95	182.77	183.59	184.42	185.25	186.08	186.91
65	187.75	188.59	189.44	190.28	191.13	191.99	192.85	193.71	194.57	195.44
66	196.31	197.18	198.06	198.94	199.82	200.71	201.60	202.49	203.39	204.29
67	205.19	206.10	207.01	207.92	208.84	209.76	210.68	211.61	212.54	213.47
68	214.41	215.35	216.30	217.24	218.20	219.15	220.11	221.07	222.04	223.01
69	223.98	224.96	225.94	226.92	227.91	228.90	229.89	230.89	231.89	232.90
70	233.91	234.92	235.94	236.96	237.98	239.01	240.04	241.08	242.12	243.16
71	244.21	245.26	246.31	247.37	248.43	249.50	250.57	251.64	252.72	253.80
72	254.88	255.97	257.07	258.16	259.27	260.37	261.48	262.59	263.71	264.83
73	265.96	267.08	268.22	269.35	270.50	271.64	272.79	273.94	275.10	276.26
74	277.43	278.60	279.77	280.95	282.13	283.32	284.51	285.71	286.90	288.11
75	289.32	290.53	291.74	292.97	294.19	295.42	296.65	297.89	299.13	300.38
76	301.63	302.89	304.15	305.41	306.68	307.95	309.23	310.51	311.80	313.09
77	314.38	315.68	316.99	318.30	319.61	320.93	322.25	323.58	324.91	326.25
78	327.59	328.93	330.28	331.64	333.00	334.36	335.73	337.10	338.48	339.86
79	341.25	342.65	344.04	345.44	346.85	348.26	349.68	351.10	352.53	353.96
80	355.40	356.84	358.28	359.73	361.19	362.65	364.11	365.58	367.06	368.54
81	370.03	371.52	373.01	374.51	376.02	377.53	379.05	380.57	382.09	383.62
82	385.16	386.70	388.25	389.80	391.36	392.92	394.49	396.06	397.64	399.22
83	400.81	402.40	404.00	405.61	407.22	408.83	410.45	412.08	413.71	415.35
84	416.99	418.64	420.29	421.95	423.61	425.28	426.95	428.64	430.32	432.01
85	433.71	435.41	437.12	438.83	440.55	442.28	444.01	445.75	447.49	449.24
86	450.99	452.75	454.51	456.28	458.06	459.84	461.63	463.42	465.22	467.03
87	468.84	470.66	472.48	474.31	476.14	477.99	479.83	481.68	483.54	485.41
88	487.28	489.16	491.04	492.93	494.82	496.72	498.63	500.54	502.46	504.39
89	506.32	508.26	510.20	512.15	514.11	516.07	518.04	520.01	521.99	523.98
90	525.97	527.97	529.98	531.99	534.01	536.04	538.07	540.11	542.15	544.21
91	546.26	548.33	550.40	552.48	554.56	556.65	558.75	560.85	562.96	565.08
92	567.20	569.33	571.47	573.61	575.76	577.92	580.08	582.25	584.43	586.61
93	588.80	591.00	593.20	595.41	597.63	599.86	602.09	604.33	606.57	608.82
94	611.08	613.35	615.62	617.90	620.19	622.48	624.79	627.09	629.41	631.73
95	634.06	636.40	638.74	641.09	643.45	645.82	648.19	650.57	652.96	655.35
96	657.75	660.16	662.58	665.00	667.43	669.87	672.32	674.77	677.23	679.70
97	682.18	684.66	687.15	689.65	692.15	694.67	697.19	699.71	702.25	704.79
98	707.35	709.90	712.47	715.04	717.63	720.22	722.81	725.42	728.03	730.65
99	733.28	735.92	738.56	741.21	743.87	746.54	749.22	751.90	754.59	757.29
100	760.00	762.72	765.44	768.17	770.91	773.66	776.42	779.18	781.95	784.73

PRESSURE OF AQUEOUS VAPOR OVER WATER.

METRIC MEASURES.

Temperature.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
100°	760.0	787.5	815.9	845.0	875.1	906.0	937.8	970.5	1004.2	1038.8
110	1074.4	1111.0	1148.6	1187.2	1226.9	1267.7	1309.6	1352.6	1396.8	1442.1
120	1488.7	1536.4	1585.4	1635.7	1687.3	1740.2	1794.4	1850.0	1907.0	1965.4
130	2025.2	2086.5	2149.3	2213.7	2279.6	2347.0	2416.1	2486.8	2559.2	2633.2
140	2709.0	2786.5	2865.8	2947.0	3029.9	3114.7	3201.4	3290.1	3380.7	3473.3
150°	3567.9	3664.6	3763.3	3864.2	3967.2	4072.4	4179.8	4289.5	4401.5	4515.7
160	4632.4	4751.4	4872.8	4996.7	5123.1	5252.0	5383.4	5517.5	5654.2	5793.5
170	5935.6	6080.4	6228.0	6378.4	6531.7	6687.8	6846.9	7009.0	7174.0	7342.1
180	7513.3	7687.7	7865.2	8045.9	8229.8	8417.0	8607.6	8801.5	8998.9	9199.6
190°	9404	9612	9823	10038	10257	10479	10705	10935	11169	11407
200	11648	11894	12143	12397	12654	12916	13182	13452	13727	14006
210	14289	14577	14869	15165	15467	15772	16083	16398	16718	17043
220	17372	17707	18046	18391	18740	19095	19454	19819	20190	20565
230°	20946	21332	21724	22121	22524	22932	23347	23766	24192	24623
240	25061	25504	25953	26408	26870	27337	27811	28291	28778	29270
250	29770	30275	30787	31306	31832	32364	32903	33449	34002	34562
260	35128	35702	36283	36872	37467	38070	38680	39298	39923	40556
270	41197	41845	42501	43165	43836	44516	45204	45899	46603	47316
280°	48036	48765	49503	50248	51003	51766	52538	53318	54108	54906
290	55714	56530	57356	58191	59035	59888	60751	61624	62506	63398
300	64299	65211	66132	67063	68005	68956	69918	70890	71872	72865
310	73869	74883	75907	76943	77990	79047	80116	81195	82286	83389
320	84503	85628	86765	87913	89074	90246	91430	92626	93835	95056
330°	96289	97534	98793	100060	101350	102640	103950	105280	106610	107960
340	109320	110700	112090	113490	114910	116340	117780	119240	120720	122210
350	123710	125220	126760	128310	129870	131440	133030	134640	136270	137900
360	139560	141230	142920	144620	146340	148070	149820	151590	153380	155180
370	157000	158840	160690	162560	164450					

WEIGHT OF A CUBIC FOOT OF SATURATED VAPOR.

ENGLISH MEASURES.

Temperature.		Temperature.	.0	.5	Temperature.	.0	.2	.4	.6	.8
F.	Grains	F.	Grains	Grains	F.	Grains	Grains	Grains	Grains	Grains
−30°	0.095	+20°	1.244	1.273	+70°	8.066	8.117	8.170	8.223	8.276
29	0.100	21	1.301	1.332	71	8.329	8.383	8.437	8.491	8.546
28	0.106	22	1.362	1.393	72	8.600	8.656	8.711	8.766	8.823
27	0.112	23	1.425	1.457	73	8.879	8.936	8.992	9.050	9.107
26	0.119	24	1.490	1.524	74	9.165	9.223	9.281	9.341	9.400
−25	0.126	+25	1.558	1.593	+75	9.460	9.519	9.579	9.640	9.700
24	0.134	26	1.629	1.666	76	9.761	9.823	9.885	9.947	10.009
23	0.141	27	1.703	1.741	77	10.072	10.135	10.199	10.263	10.327
22	0.150	28	1.779	1.819	78	10.392	10.457	10.521	10.587	10.653
21	0.158	29	1.859	1.900	79	10.720	10.785	10.853	10.921	10.987
−20	0.167	+30	1.942	1.984	+80	11.056	11.124	11.193	11.262	11.331
19	0.176	31	2.028	2.072	81	11.401	11.471	11.542	11.613	11.685
18	0.187	32	2.118	2.159	82	11.756	11.828	11.900	11.974	12.047
17	0.197	33	2.200	2.242	83	12.121	12.195	12.269	12.344	12.419
16	0.208	34	2.286	2.330	84	12.494	12.570	12.646	12.723	12.800
−15	0.220	+35	2.375	2.420	+85	12.878	12.956	13.034	13.113	13.192
14	0.232	36	2.466	2.513	86	13.272	13.351	13.432	13.512	13.594
13	0.244	37	2.560	2.609	87	13.676	13.758	13.840	13.923	14.006
12	0.258	38	2.658	2.708	88	14.090	14.174	14.258	14.344	14.429
11	0.272	39	2.759	2.810	89	14.515	14.601	14.689	14.776	14.864
−10	0.286	+40	2.863	2.916	+90	14.951	15.040	15.129	15.219	15.309
9	0.302	41	2.970	3.026	91	15.400	15.490	15.581	15.673	15.766
8	0.318	42	3.082	3.138	92	15.858	15.951	16.045	16.139	16.234
7	0.335	43	3.196	3.254	93	16.328	16.423	16.520	16.616	16.713
6	0.353	44	3.315	3.374	94	16.810	16.909	17.007	17.106	17.205
− 5	0.371	+45	3.436	3.499	+95	17.305	17.406	17.506	17.607	17.709
4	0.391	46	3.563	3.627	96	17.812	17.914	18.018	18.121	18.226
3	0.411	47	3.693	3.759	97	18.330	18.436	18.542	18.648	18.755
2	0.433	48	3.828	3.895	98	18.863	18.971	19.079	19.188	19.298
− 1	0.455	49	3.965	4.036	99	19.407	19.518	19.629	19.741	19.853
± 0	0.479	+50	4.108	4.181	+100	19.966	20.079	20.193	20.307	20.422
+ 1	0.503	51	4.255	4.331	101	20.538	20.654	20.770	20.887	21.005
2	0.529	52	4.407	4.485	102	21.123	21.242	21.362	21.481	21.602
3	0.556	53	4.564	4.644	103	21.723	21.845	21.967	22.090	22.213
4	0.584	54	4.725	4.807	104	22.337	22.462	22.588	22.714	22.839
5	0.613	+55	4.891	4.976	+105	22.966	23.095	23.223	23.351	23.481
6	0.644	56	5.062	5.149	106	23.611	23.742	23.873	24.005	24.138
7	0.676	57	5.238	5.328	107	24.271	24.405	24.539	24.673	24.809
8	0.709	58	5.420	5.513	108	24.946	25.082	25.220	25.358	25.597
9	0.744	59	5.607	5.703	109	25.636	25.776	25.917	26.058	26.201
10	0.780	+60	5.800	5.899	+110	26.343	26.486	26.630	26.775	26.920
11	0.818	61	5.999	6.099	111	27.066	27.213	27.360	27.508	27.657
12	0.858	62	6.203	6.306	112	27.807	27.956	28.107	28.259	28.411
13	0.900	63	6.413	6.521	113	28.563	28.717	28.871	29.026	29.181
14	0.943	64	6.630	6.740	114	29.338	29.495	29.653	29.812	29.970
15	0.988	+65	6.852	6.966	+115	30.130	30.291	30.452	30.614	30.777
16	1.035	66	7.082	7.198	116	30.940	31.104	31.270	31.435	31.601
17	1.084	67	7.317	7.437	117	31.768	31.937	32.106	32.274	32.445
18	1.135	68	7.560	7.683	118	32.616	32.787	32.960	33.133	33.307
+19	1.189	+69	7.809	7.937	+119	33.482	33.657	33.834	34.010	34.189

TABLE 74.

WEIGHT OF A CUBIC METER OF SATURATED VAPOR.

METRIC MEASURES.

Temperature.		Temperature.	.0	.5	Temperature.	.0	.2	.4	.6	.8
C.	Grams.	C.	Grams.	Grams.	C.	Grams.	Grams.	Grams.	Grams.	Grams.
−29°	0.378	−17°	1.174	1.123	−5°	3.261	3.208	3.157	3.106	3.056
28	0.418	16	1.284	1.228	4	3.534	3.478	3.422	3.368	3.314
27	0.461	15	1.403	1.342	3	3.828	3.767	3.708	3.649	3.591
26	0.508	14	1.531	1.466	2	4.144	4.078	4.015	3.951	3.889
25	0.559	13	1.671	1.599	1	4.482	4.412	4.344	4.276	4.209
24	0.615	12	1.820	1.744	0	4.847	4.771	4.697	4.624	4.553
−23	0.677	−11	1.983	1.900	+0	4.847	4.914	4.982	5.051	5.121
22	0.743	10	2.158	2.069	1	5.192	5.264	5.336	5.409	5.483
21	0.816	9	2.347	2.251	2	5.559	5.634	5.711	5.789	5.868
20	0.894	8	2.551	2.447	3	5.947	6.028	6.110	6.192	6.275
19	0.980	7	2.770	2.658	4	6.360	6.445	6.532	6.619	6.708
18	1.073	6	3.006	2.886	5	6.797	6.888	6.979	7.072	7.166

Temperature.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
C.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
+6°	7.261	7.309	7.357	7.405	7.453	7.502	7.552	7.601	7.651	7.701
7	7.751	7.802	7.853	7.904	7.956	8.007	8.059	8.112	8.164	8.217
8	8.271	8.324	8.378	8.432	8.487	8.542	8.597	8.652	8.708	8.764
9	8.821	8.877	8.934	8.991	9.049	9.106	9.165	9.223	9.282	9.341
+10	9.401	9.461	9.521	9.582	9.643	9.704	9.765	9.827	9.889	9.952
11	10.015	10.078	10.142	10.205	10.270	10.334	10.400	10.465	10.530	10.597
12	10.664	10.730	10.797	10.865	10.932	11.001	11.069	11.138	11.208	11.278
13	11.348	11.418	11.489	11.561	11.632	11.704	11.777	11.850	11.922	11.997
14	12.070	12.144	12.219	12.295	12.370	12.446	12.523	12.600	12.677	12.754
+15	12.832	12.911	12.990	13.068	13.148	13.229	13.309	13.390	13.472	13.553
16	13.635	13.718	13.801	13.885	13.969	14.053	14.139	14.224	14.309	14.395
17	14.482	14.569	14.657	14.744	14.833	14.922	15.011	15.101	15.191	15.282
18	15.373	15.465	15.557	15.650	15.743	15.836	15.931	16.025	16.121	16.216
19	16.311	16.409	16.505	16.603	16.701	16.799	16.898	16.998	17.097	17.198
+20	17.300	17.401	17.503	17.606	17.708	17.812	17.917	18.021	18.126	18.232
21	18.338	18.445	18.553	18.660	18.768	18.878	18.987	19.097	19.207	19.319
22	19.430	19.542	19.655	19.769	19.882	19.996	20.112	20.227	20.343	20.461
23	20.578	20.695	20.814	20.933	21.053	21.173	21.295	21.416	21.538	21.660
24	21.783	21.907	22.032	22.157	22.282	22.409	22.536	22.663	22.791	22.920
+25	23.049	23.179	23.310	23.442	23.573	23.706	23.839	23.973	24.107	24.242
26	24.378	24.514	24.651	24.790	24.929	25.066	25.206	25.346	25.488	25.629
27	25.771	25.915	26.058	26.203	26.348	26.494	26.641	26.787	26.936	27.084
28	27.234	27.384	27.534	27.686	27.837	27.990	28.143	28.298	28.453	28.609
29	28.765	28.923	29.081	29.239	29.399	29.559	29.720	29.881	30.044	30.207
+30	30.371	30.535	30.701	30.867	31.034	31.202	31.371	31.540	31.710	31.880
31	32.052	32.225	32.398	32.572	32.747	32.923	33.100	33.277	33.454	33.633
32	33.812	33.993	34.175	34.356	34.540	34.723	34.909	35.094	35.280	35.467
33	35.656	35.844	36.034	36.224	36.416	36.609	36.801	36.995	37.190	37.386
34	37.583	37.780	37.979	38.178	38.378	38.579	38.782	38.984	39.187	39.393
+35	39.599	39.805	40.013	40.221	40.430	40.640	40.851	41.064	41.277	41.491
36	41.706	41.921	42.139	42.356	42.575	42.795	43.015	43.237	43.459	43.683
37	43.908	44.134	44.360	44.587	44.815	45.046	45.277	45.507	45.740	45.973
38	46.208	46.443	46.680	46.918	47.156	47.396	47.636	47.878	48.121	48.365
39	48.609	48.855	49.103	49.350	49.600	49.850	50.101	50.353	50.606	50.861
+40	51.117	51.373	51.631	51.890	52.150	52.410	52.673	52.936	53.200	53.466

HYGROMETRICAL TABLES.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$

Pressure of Saturated Aqueous Vapor, e.

Temperature.	0	1	2	3	4	5	6	7	8	9
F.	Inches.	Inches.	Inches.	Inches.	Inches	Inches.	Inches.	Inches.	Inches.	Inches.
−60°	.0010									
50	20	.0018	.0017	.0016	.0015	.0014	.0013	.0012	.0011	.0011
40	38	36	33	31	29	28	26	24	23	21
30	71	66	62	59	55	52	49	46	43	40
20	.0127	.0120	.0113	.0107	.0101	.0095	.0090	.0084	.0080	.0075

$$e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

$B = 30.0$ inches

t'	$t - t'$ .0	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
−20°	.0127	.0106	.0085	.0063	.0042	.0021				
19	135	113	92	71	49	28	.0007			
18	143	121	.0100	79	57	36	.0015			
17	151	130	108	87	66	44	23	.0002		
16	160	138	117	96	74	53	32	.0010		
15	169	148	126	.0105	84	62	41	19		
14	179	157	136	115	93	72	50	29	.0008	
13	189	168	146	125	.0103	82	61	39	.0018	
12	200	178	157	136	114	93	71	50	29	.0007
11	211	190	168	147	125	.0104	83	61	40	.0018
10	223	202	180	159	137	116	94	73	52	30
9	236	214	193	171	150	128	.0107	85	64	43
8	249	227	206	184	163	141	120	98	77	56
7	263	241	220	198	177	155	134	.0112	91	69
6	277	256	234	213	191	170	148	127	.0105	84
5	292	271	249	228	206	185	163	142	120	.0099
4	308	287	265	244	222	201	179	158	136	.0115
3	325	304	282	261	239	218	196	175	153	132
2	343	321	300	278	257	235	214	192	171	149
− 1	361	340	318	297	275	254	232	210	189	167
± 0	381	359	338	316	294	273	251	230	208	187
+ 1	401	380	358	337	315	293	272	250	229	207
2	423	401	379	358	336	315	293	271	250	228
3	445	423	402	380	359	337	315	294	272	250
4	468	447	425	404	382	360	339	317	295	274
5	493	471	450	428	407	385	363	342	320	298
6	519	497	476	454	432	411	389	367	346	324
7	546	524	503	481	459	438	416	394	373	351
8	574	552	531	509	487	466	444	422	401	379
9	604	582	560	539	517	495	474	452	430	408
10	.0635	.0613	.0591	.0569	.0548	.0526	.0504	.0483	.0461	.0439
−20 } +10 }	$\Delta e \times \Delta B$	+.0001	+.0001	+.0002	+.0003	+.0004	+.0004	+.0005	+.0006	+.0007

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.
ENGLISH MEASURES.

Values of $e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.0$ inches

t'	$t - t'$									
	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
−10°	.0009									
9	21									
8	34	.0013								
7	48	26	.0005							
6	62	41	.0019							
5	77	56	34	.0013						
4	93	72	50	29	.0007					
3	.0110	88	67	45	.0024	.0002				
2	127	.0106	84	63	41	.0020				
− 1	146	124	.0103	81	60	38	.0016			
± 0	165	144	122	.0100	79	57	36	.0014		
+ 1	185	164	142	121	99	78	56	34	.0013	
2	207	185	163	142	.0120	.0099	77	55	34	.0012
3	229	207	186	164	142	.0121	99	78	56	34
4	252	231	209	187	166	144	.0122	.0101	79	58
5	277	255	233	212	190	168	147	125	.0104	82
6	302	281	259	237	216	194	172	151	129	.0107
7	329	308	286	264	243	221	199	178	156	134
8	357	336	314	292	271	249	227	205	184	162
9	387	365	343	322	300	278	257	235	213	191
10	.0417	.0396	.0374	.0352	.0331	.0309	.0287	.0266	.0244	.0222
−10 } +10 } $\Delta e \times \Delta B$	+.0007	+.0008	+.0009	+.0009	+.0010	+.0011	+.0012	+.0012	+.0013	+.0014

t'	$t - t'$									
	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
3°	.0013									
4	36	.0014								
5	60	39	.0017							
6	86	64	42	.0021						
7	.0113	91	69	47	.0026	.0004				
8	140	.0119	97	75	54	32	.0010			
9	170	148	.0126	.0105	83	61	40	.0018		
10	.0200	.0179	.0157	.0135	.0114	.0092	.0070	.0048	.0027	.0005
+10 $\Delta e \times \Delta B$	+.0014	+.0015	+.0016	+.0017	+.0017	+.0018	+.0019	+.0020	+.0020	+.0021

TABLE 75.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.0$ inches

t'	$t - t'$ 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
10°	$\Delta e \times \Delta B$	+.0004	+.0007	+.0011	+.0014	+.0018	+.0022	+.0025	+.0029	+.0033
10°	0.063	0.053	0.042	0.031	0.020	0.009				
11	67	56	45	34	23	.012	0.002			
12	70	59	48	37	27	16	5			
13	74	63	52	41	30	19	8			
14	77	66	56	45	34	23	.012	0.001		
15	81	70	59	49	38	27	16	5		
16	85	74	63	53	42	31	20	9		
17	89	79	68	57	46	35	24	.013	0.002	
18	94	83	72	61	50	39	28	18	7	
19	.099	88	77	66	55	44	33	22	11	0.000
20	.103	92	81	71	60	49	38	27	16	.005
21	.108	97	86	76	65	54	43	32	21	.010
22	.114	.103	92	81	70	59	48	37	26	15
23	.119	.108	97	86	75	64	53	42	32	21
24	.125	.114	.103	92	81	70	59	48	37	26
25	.131	.120	.109	98	87	76	65	54	43	32
26	.137	.126	.115	.104	93	82	71	60	49	38
27	.143	.133	.122	.111	.100	89	78	67	56	45
28	.150	.139	.128	.117	.106	95	84	73	62	51
29	.157	.146	.135	.124	.113	.102	91	80	69	58
30	.165	.154	.143	.132	.121	.110	99	88	77	66
31	.172	.161	.150	.139	.128	.117	.106	95	84	73
32	.180	.169	.158	.147	.136	.125	.114	.103	92	81
33	.188	.177	.166	.155	.144	.133	.122	.111	.100	89
34	.195	.184	.173	.162	.151	.140	.129	.118	.107	96
35	.203	.192	.181	.170	.159	.148	.137	.126	.115	.104
36	.212	.201	.190	.179	.168	.157	.145	.134	.123	.112
37	.220	.209	.198	.187	.176	.165	.154	.143	.132	.121
38	.229	.218	.207	.196	.185	.174	.163	.152	.141	.130
39	.238	.227	.216	.205	.194	.183	.172	.161	.150	.139
40	.248	.237	.226	.215	.203	.192	.181	.170	.159	.148
41	.258	.246	.235	.224	.213	.202	.191	.180	.169	.158
42	.268	.257	.246	.234	.223	.212	.201	.190	.179	.168
43	.278	.267	.256	.245	.234	.223	.212	.201	.190	.178
44	.289	.278	.267	.256	.245	.234	.223	.211	.200	.189
45	.300	.289	.278	.267	.256	.245	.234	.223	.211	.200
46	.312	.301	.290	.279	.268	.256	.245	.234	.223	.212
47	.324	.313	.302	.291	.280	.268	.257	.246	.235	.224
48	.336	.325	.314	.303	.292	.281	.270	.259	.248	.236
49	.349	.338	.327	.316	.305	.294	.283	.271	.260	.249
50	.363	.351	.340	.329	.318	.307	.296	.285	.274	.262
51	.376	.365	.354	.343	.332	.321	.309	.298	.287	.276
52	.390	.379	.368	.357	.346	.335	.324	.312	.301	.290
53	.405	.394	.383	.372	.361	.349	.338	.327	.316	.305
54	.420	.409	.398	.387	.376	.364	.353	.342	.331	.320
55	.436	.425	.414	.402	.391	.380	.369	.358	.347	.335
56	.452	.441	.430	.419	.407	.396	.385	.374	.363	.352
57	.469	.458	.446	.435	.424	.413	.402	.390	.379	.368
58	.486	.475	.464	.452	.441	.430	.419	.408	.396	.385
59	.504	.493	.481	.470	.459	.448	.437	.425	.414	.403
60	0.522	0.511	0.500	0.488	0.477	0.466	0.455	0.444	0.432	0.421
60	$\Delta e \times \Delta B$	+.0004	+.0007	+.0011	+.0015	+.0019	+.0022	+.0026	+.0030	+.0034

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\, B\, (t - t') \left(1 + \frac{t' - 32}{1571} \right)$

$B = 30.00$

t'	$t - t'$									
	10	11	12	13	14	15	16	17	18	19
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
30° $\Delta e \times \Delta B$	+.0037	+.0040	+.0044	+.0048	+.0051	+.0055	+.0059	+.0062	+.0066	+.0070
22°	0.004									
23	.010									
24	15									
25	21	0.010								
26	27	16	0.005							
27	34	23	.012	0.001						
28	40	29	18	7						
29	47	36	25	.014	0.003					
30	55	44	33	22	.011	0.000				
31	62	51	40	29	18	.007				
32	70	59	48	37	26	.015	0.004			
33	78	67	55	44	33	22	11	0.000		
34	85	74	63	52	41	30	19	.008		
35	93	82	71	60	49	38	27	.016	0.005	
36	.101	90	79	68	57	46	35	24	.013	0.002
37	.110	99	88	77	66	55	43	32	21	.010
38	.119	.108	96	85	74	63	52	41	30	19
39	.128	.117	.105	94	83	72	61	50	39	28
40	.137	.126	.115	.104	93	82	71	60	49	37
41	.147	.136	.125	.114	.103	91	80	69	58	47
42	.157	.146	.135	.124	.113	.101	90	79	68	57
43	.167	.156	.145	.134	.123	.112	.101	90	79	68
44	.178	.167	.156	.145	.134	.123	.112	.100	89	78
45	.189	.178	.167	.156	.145	.134	.123	.112	.100	89
46	.201	.190	.179	.168	.156	.145	.134	.123	.112	.101
47	.213	.202	.191	.180	.168	.157	.146	.135	.124	.113
48	.225	.214	.203	.192	.181	.170	.159	.147	.136	.125
49	.238	.227	.216	.205	.193	.182	.171	.160	.149	.138
50	.251	.240	.229	.218	.207	.196	.184	.173	.162	.151
51	.265	.254	.243	.231	.220	.209	.198	.187	.176	.165
52	.279	.268	.257	.246	.234	.223	.212	.201	.190	.179
53	.294	.282	.271	.260	.249	.238	.227	.216	.204	.193
54	.309	.297	.286	.275	.264	.253	.242	.231	.219	.208
55	.324	.313	.302	.291	.280	.268	.257	.246	.235	.224
56	.340	.329	.318	.307	.296	.285	.273	.262	.251	.240
57	.357	.346	.334	.323	.312	.301	.290	.279	.267	.256
58	.374	.363	.352	.340	.329	.318	.307	.296	.284	.273
59	.392	.381	.369	.358	.347	.336	.325	.313	.302	.291
60	0.410	0.399	0.388	0.376	0.365	0.354	0.343	0.331	0.320	0.309
60 $\Delta e \times \Delta B$	+.0037	+.0041	+.0045	+.0049	+.0052	+.0056	+.0060	+.0064	+.0067	+.0071

TABLE 75.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\ B\ (t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.00$

t'	$t-t'$									
	20	21	22	23	24	25	26	27	28	29
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
40° $\Delta e \times \Delta B$	+.0074	+.0077	+.0081	+.0085	+.0089	+.0092	+.0096	+.0100	+.0103	+.0107
38°	0.008									
39	.017	0.006								
40	26	.015	0.004							
41	36	25	.014	0.003						
42	46	35	24	.013	0.002					
43	56	45	34	23	.012	0.001				
44	67	56	45	34	23	.012	0.001			
45	78	67	56	45	34	23	.012	0.001		
46	90	79	68	57	45	34	23	.012	0.001	
47	.102	91	79	68	57	46	35	24	13	0.002
48	.114	.103	92	81	70	58	47	36	25	.014
49	.127	.116	.104	93	82	71	60	49	38	27
50	.140	.129	.118	.106	95	84	73	62	51	40
51	.153	.142	.131	.120	.109	98	87	75	64	53
52	.167	.156	.145	.134	.123	.112	.101	89	78	67
53	.182	.171	.160	.149	.137	.126	.115	.104	93	82
54	.197	.186	.175	.164	.152	.141	.130	.119	.108	97
55	.212	.201	.190	.179	.168	.157	.145	.134	.123	.112
56	.229	.218	.206	.195	.184	.173	.162	.150	.139	.128
57	.245	.234	.223	.211	.200	.189	.178	.167	.156	.144
58	.262	.251	.240	.228	.217	.206	.195	.184	.173	.161
59	.280	.269	.257	.246	.235	.224	.213	.201	.190	.179
60	0.298	0.287	0.275	0.264	0.253	0.242	0.231	0.219	0.208	0.197
60 $\Delta e \times \Delta B$	+.0075	+.0078	+.0082	+.0086	+.0090	+.0093	+.0097	+.0101	+.0105	+.0108

t'	$t-t'$									
	30	31	32	33	34	35	36	37	38	39
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
50° $\Delta e \times \Delta B$	+.0111	+.0115	+.0119	+.0122	+.0126	+.0130	+.0134	+.0137	+.0141	+.0145
48°	0.003									
49	.015	.004								
50	29	.017	0.006							
51	42	31	.020	0.009						
52	56	45	34	.023	0.011	0.000				
53	70	59	48	37	26	.015	0.004			
54	85	74	63	52	41	30	.018	0.007		
55	.101	90	78	67	56	45	34	.023	0.011	0.000
56	.117	.106	95	83	72	61	50	39	28	.016
57	.133	.122	.111	.100	88	77	66	55	44	32
58	.150	.139	.128	.117	.105	94	83	72	61	49
59	.168	.157	.145	.134	.123	.112	.101	89	78	67
60	0.186	0.175	0.163	0.152	0.141	0.130	0.119	0.107	0.096	0.085
60 $\Delta e \times \Delta B$	+.0112	+.0116	+.0120	+.0123	+.0127	+.0131	+.0134	+.0138	+.0142	+.0146

t'	$t-t'$						
	40	41	42	43	44	45	46
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
56°	0.005						
57	.021	0.010					
58	38	27	0.016	0.005			
59	56	45	33	.022	0.011	0.000	
60	0.074	0.063	0.051	0.040	0.029	0.018	0.007
60 $\Delta e \times \Delta B$	+.0149	+.0153	+.0157	+.0161	+.0164	+.0168	+.0172

REDUCTION OF PSYCHROMETRIC OBSERVATION.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\, B\, (t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.00$

t'	$t-t'$										
	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
60°	$\Delta e \times \Delta B$	+.0004	+.0007	+.0011	+.0015	+.0019	+.0022	+.0026	+.0030	+.0034	+.0037
60°	0.522	0.511	0.500	0.488	0.477	0.466	0.455	0.444	0.432	0.421	0.410
61	.541	.530	.518	.507	.496	.485	.474	.462	.451	.440	.429
62	.560	.549	.538	.527	.516	.504	.493	.482	.471	.459	.448
63	.580	569	.558	.547	.536	.524	.513	.502	.491	.479	.468
64	.601	.590	.579	.568	.556	.545	.534	.523	.511	.500	.489
65	.623	.611	.600	.589	.578	.566	.555	.544	.533	.521	.510
66	.645	.633	.622	.611	.600	.588	.577	.566	.555	.543	.532
67	.667	.656	.645	.634	.622	.611	.600	.589	.577	.566	.555
68	.691	.680	.668	.657	.646	.635	.623	.612	.601	.590	.578
69	.715	.704	.692	.681	.670	.659	.647	.636	.625	.614	.602
70	.740	.729	.717	.706	.695	.684	.672	.661	.650	.638	.627
71	.766	.754	.743	.732	.720	.709	.698	.687	.675	.664	.653
72	.792	.781	.769	.758	.747	.735	.724	.713	.702	.690	.679
73	.819	.808	.797	.785	.774	.763	.751	.740	.729	.717	.706
74	.847	.836	.824	.813	.802	.791	.779	.768	.757	.745	.734
75	.876	.865	.853	.842	.831	.819	.808	.797	.786	.774	.763
76	.906	.894	.883	.872	.860	.849	.838	.826	.815	.804	.792
77	.936	.925	.914	.902	.891	.880	.868	.857	.846	.834	.823
78	.968	.956	.945	.934	.922	.911	.900	.888	.877	.866	.854
79	1.000	.989	.977	.966	.955	.943	.932	.921	.909	.898	.887
80	1.033	1.022	1.011	.999	.988	.977	.965	.954	.943	.931	.920
81	.068	.056	.045	1.034	1.022	1.011	.999	.988	.977	.965	.954
82	.103	.092	.080	.069	.057	.046	1.035	1.023	1.012	1.001	.989
83	.139	.128	.116	.105	.094	.082	.071	.060	.048	.037	1.026
84	.176	.165	.154	.142	.131	.120	.108	.097	.086	.074	.063
85	1.215	1.204	1.192	1.181	1.169	1.158	1.147	1.135	1.124	1.112	1.101
86	.254	.243	.232	.220	.209	.197	.186	.175	.163	.152	.140
87	.295	.284	.272	.261	.249	.238	.227	.215	.204	.192	.181
88	.336	.325	.314	.302	.291	.279	.268	.257	.245	.234	.222
89	.379	.368	.357	.345	.334	.322	.311	.300	.288	.277	.265
90	1.423	1.412	1.401	1.389	1.378	1.366	1.355	1.343	1.332	1.321	1.309
91	.469	.457	.446	.435	.423	.412	.400	.389	.377	.366	.355
92	.515	.504	.492	.481	.470	.458	.447	.435	.424	.412	.401
93	.563	.552	.540	.529	.517	.506	.494	.483	.471	.460	.449
94	.612	.601	.589	.578	.566	.555	.543	.532	.521	.509	.498
95	1.662	1.651	1.640	1.628	1.617	1.605	1.594	1.582	1.571	1.559	1.548
96	.714	.703	.691	.680	.668	.657	.646	.634	.623	.611	.600
97	.767	.756	.744	.733	.722	.710	.699	.687	.776	.664	.653
98	.822	.811	.799	.788	.776	.765	.753	.742	.730	.719	.707
99	.878	.867	.855	.844	.832	.821	.809	.798	.786	.775	.763
100	1.936	1.924	1.913	1.901	1.890	1.878	1.867	1.855	1.844	1.832	1.821
101	.994	.983	.972	.960	.949	.937	.926	.914	.903	.891	.880
102	2.055	2.043	2.032	2.020	2.009	.997	.986	.974	.963	.951	.940
103	.117	.106	.094	.083	.071	2.060	2.048	2.037	2.025	2.014	2.002
104	.181	.169	.158	.146	.135	.123	.112	.100	.089	.077	.066
105	2.246	2.235	2.223	2.212	2.200	2.189	2.177	2.166	2.154	2.143	2.131
106	.314	.302	.290	.279	.267	.256	.244	.233	.221	.210	.198
107	.382	.371	.359	.348	.336	.325	.313	.302	.290	.278	.267
108	.453	.441	.430	.418	.407	.395	.384	.372	.361	.349	.337
109	.525	.514	.502	.491	.479	.467	.456	.444	.433	.421	.410
110	2.599	2.588	2.576	2.565	2.553	2.542	2.530	2.519	2.507	2.495	2.484
110	$\Delta e \times \Delta B$	+.0004	+.0008	+.0012	+.015	+.0019	+.0023	+.0027	+.0031	+.0035	+.0039

TABLE 75.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.00$

t'	$t - t'$										
	0.0	11	12	13	14	15	16	17	18	19	20
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
60°	$\Delta e \times \Delta B$	+.0041	+.0045	+.0049	+.0052	+.0056	+.0060	+.0063	+.0067	+.0071	+.0075
60°	0.522	0.399	0.388	0.376	0.365	0.354	0.343	0.331	0.320	0.309	0.298
61	.541	0.418	.406	.395	.384	.373	.361	.350	.339	.328	.317
62	.560	.437	.426	.415	.403	.392	.381	.370	.358	.347	.336
63	.580	.457	.446	.435	.423	.412	.401	.390	.378	.367	.356
64	.601	.478	.466	.455	.444	.433	.422	.410	.399	.388	.377
65	.623	.499	.488	.476	.465	.454	.443	.431	.420	.409	.398
66	.645	.521	.510	.498	.487	.476	.465	.453	.442	.431	.420
67	.667	.544	.532	.521	.510	.499	.487	.476	.465	.454	.442
68	.691	.567	.556	.544	.533	.522	.511	.499	.488	.477	.466
69	.715	.591	.580	.568	.557	.546	.535	.523	.512	.501	.490
70	.740	.616	.605	.593	.582	.571	.559	.548	.537	.526	.514
71	.766	.641	.630	.619	.608	.596	.585	.574	.562	.551	.540
72	.792	.668	.656	.645	.634	.623	.611	.600	.589	.577	.566
73	.819	.695	.684	.672	.661	.650	.638	.627	.616	.604	.593
74	.847	.723	.711	.700	.689	.678	.666	.655	.644	.632	.621
75	.876	.752	.740	.729	.718	.706	.695	.684	.672	.661	.650
76	.906	.781	.770	.758	.747	.736	.725	.713	.702	.691	.679
77	.936	.812	.800	.789	.778	.766	.755	.744	.732	.721	.710
78	.968	.843	.832	.820	.809	.798	.786	.775	.764	.752	.741
79	1.000	.875	.864	.853	.841	.830	.819	.807	.796	.785	.773
80	1.033	.909	.897	.886	.875	.863	.852	.841	.829	.818	.806
81	.068	.943	.931	.920	.909	.897	.886	.875	.863	.852	.841
82	.103	.978	.967	.955	.944	.932	.921	.910	.898	.887	.876
83	.139	1.014	1.003	.991	.980	.969	.957	.946	.935	.923	.912
84	.176	.051	.040	1.029	1.017	1.006	.995	.983	.972	.960	.949
85	1.215	1.090	1.078	1.067	1.056	1.044	1.033	1.021	1.010	.999	.987
86	.254	.129	.118	.106	.095	.083	.072	.061	.049	1.038	1.027
87	.295	.170	.158	.147	.135	.124	.113	.101	.090	.078	.067
88	.336	.211	.200	.188	.177	.165	.154	.143	.131	.120	.108
89	.379	.254	.242	.231	.220	.208	.197	.185	.174	.163	.151
90	1.423	1.298	1.286	1.275	1.264	1.252	1.241	1.229	1.218	1.206	1.195
91	.469	.343	.332	.320	.309	.297	.286	.275	.263	.252	.240
92	.515	.390	.378	.367	.355	.344	.332	.321	.310	.298	.287
93	.563	.437	.426	.414	.403	.391	.380	.369	.357	.346	.334
94	.612	.486	.475	.463	.452	.440	.429	.418	.406	.395	.383
95	1.662	1.537	1.525	1.514	1.502	1.491	1.479	1.468	1.456	1.445	1.433
96	.714	.588	.577	.565	.554	.542	.531	.520	.508	.497	.485
97	.767	.641	.630	.618	.607	.595	.584	.572	.561	.550	.538
98	.822	.696	.684	.673	.661	.650	.638	.627	.615	.604	.593
99	.878	.752	.740	.729	.717	.706	.694	.683	.671	.660	.648
100	1.936	1.809	1.798	1.786	1.775	1.763	1.752	1.740	1.729	1.717	1.706
101	.994	.868	.857	.845	.834	.822	.811	.799	.788	.776	.765
102	2.055	.928	.917	.905	.894	.882	.871	.859	.848	.836	.825
103	.117	.991	.979	.968	.956	.944	.933	.921	.910	.898	.887
104	.181	2.054	2.043	2.031	2.020	2.008	.997	.985	.974	.962	.951
105	2.246	2.120	2.108	2.097	2.085	2.073	2.062	2.050	2.039	2.027	2.016
106	.314	.187	.175	.164	.152	.141	.129	.118	.106	.094	.083
107	.382	.255	.244	.232	.221	.209	.198	.186	.175	.163	.152
108	.453	.326	.314	.302	.291	.280	.268	.257	.245	.234	.222
109	.525	.398	.387	.375	.364	.352	.340	.329	.317	.306	.294
110	2.599	2.472	2.461	2.449	2.438	2.426	2.414	2.403	2.391	2.380	2.368
110	$\Delta e \times \Delta B$	+.0042	+.0046	+.0050	+.0054	+.0058	+.0062	+.0065	+.0069	+.0073	+.0077

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\,B\,(t-t')\left(1 + \frac{t'-32}{1571}\right)$

$B = 30.00$

t'	$t-t'$										
	0.0	21	22	23	24	25	26	27	28	29	30
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
60°	$\Delta e \times \Delta B$	+.0078	+.0082	+.0086	+.0090	+.0093	+.0097	+.0101	+.0105	+.0108	+.0112
60°	0.522	0.287	0.275	0.264	0.253	0.242	0.231	0.219	0.208	0.197	0.186
61	.541	0.305	.294	.283	.272	.261	.249	.238	.227	.216	.205
62	.560	.325	.314	.302	.291	.280	.269	.257	.246	.235	.224
63	.580	.345	.334	.322	.311	.300	.289	.277	.266	.255	.244
64	.601	.365	.354	.343	.332	.320	.309	.298	.287	.276	.264
65	.623	.387	.375	.364	.353	.342	.330	.319	.308	.297	.285
66	.645	.408	.397	.386	.375	.363	.352	.341	.330	.319	.307
67	.667	.431	.420	.409	.397	.386	.375	.364	.352	.341	.330
68	.691	.454	.443	.432	.421	.409	.398	.387	.376	.364	.353
69	.715	.478	.467	.456	.445	.433	.422	.411	.399	.388	.377
70	.740	.503	.492	.481	.469	.458	.447	.435	.424	.413	.402
71	.766	.529	.517	.506	.495	.483	.472	.461	.450	.438	.427
72	.792	.555	.544	.532	.521	.510	.498	.487	.476	.464	.453
73	.819	.582	.571	.559	.548	.537	.525	.514	.503	.491	.480
74	.847	.610	.598	.587	.576	.564	.553	.542	531	.519	.508
75	.876	.638	.627	.616	.605	.593	.582	.571	.559	.548	.537
76	.906	.668	.657	.645	.634	.623	.611	.600	.589	.577	.566
77	.936	.698	.687	.676	.664	.653	.642	.630	.619	.608	.596
78	.968	.730	.718	.707	.696	.684	.673	.662	.650	.639	.628
79	1.000	.762	.751	.739	.728	.717	.705	.694	.683	.671	.660
80	1.033	.795	.784	.772	.761	.750	.738	.727	.716	.704	.693
81	.068	.829	.818	.806	.795	.784	.772	.761	.750	.738	.727
82	.103	.864	.853	.842	.830	.819	.808	.796	.785	.773	.762
83	.139	.900	.889	.878	.866	.855	.844	.832	.821	.810	.798
84	.176	.938	.926	.915	.904	.892	.881	.869	.858	.847	.835
85	1.215	.976	.965	.953	.942	.930	.919	.908	.896	.885	.873
86	.254	1.015	1.004	.992	.981	.970	.958	.947	.935	.924	.913
87	.295	.056	.044	1.033	1.021	1.010	.999	.987	.976	.964	.953
88	.336	.097	.086	.074	.063	.051	1.040	1.029	1.017	1.006	.994
89	.379	.140	.128	.117	.106	.094	.083	.071	.060	.049	1.037
90	1.423	1.184	1.172	1.161	1.149	1.138	1.127	1.115	1.104	1.092	1.081
91	.469	.229	.217	.206	.195	.183	.172	.160	.149	.138	.126
92	.515	.275	.264	.252	.241	.230	.218	.207	.195	.184	.172
93	.563	.323	.311	.300	.288	.277	.266	.254	.243	.231	.220
94	.612	.372	.360	.349	.337	.326	.315	.303	.292	.280	.269
95	1.662	1.422	1.411	1.399	1.388	1.376	1.365	1.353	1.342	1.330	1.319
96	.714	.474	.462	.451	.439	.428	.416	.405	.393	.382	.371
97	.767	.527	.515	.504	.492	.481	.469	.458	.446	.435	.423
98	.822	.581	.570	.558	.547	.535	.524	.512	.501	.489	.478
99	.878	.637	.625	.614	.602	.591	.580	.568	.557	.545	.534
100	1.936	1.694	1.683	1.671	1.660	1.648	1.637	1.625	1.614	1.602	1.591
101	.994	.753	.742	.730	.719	.707	.696	.684	.673	.661	.650
102	2.055	.813	.802	.790	.779	.767	.756	.744	.733	.721	.710
103	.117	.875	.864	.852	.841	.829	.818	.806	.795	.783	.772
104	.181	.939	.928	.916	.905	.893	.882	.870	.858	.847	.835
105	2.246	2.004	1.993	1.981	1.970	1.958	1.947	1.935	1.924	1.912	1.901
106	.314	.071	2.060	2.048	2.037	2.025	2.014	2.002	.991	.979	.968
107	.382	.140	.129	.117	.105	.094	.082	.071	2.059	2.048	2.036
108	.453	.211	.199	.187	.176	.164	.153	.141	.130	.118	.107
109	.525	.283	.271	.260	.248	.236	.225	.213	.202	.190	.179
110	2.599	2.357	2.345	2.334	2.322	2.310	2.299	2.287	2.276	2.264	2.253
110	$\Delta e \times \Delta B$	+.0081	+.0085	+.0089	+.0092	+.0096	+.0100	+.0104	+.0108	+.0112	+.0116

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\ B\ (t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.00$

t'	$t-t'$										
	0.0	31	32	33	34	35	36	37	38	39	40
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
60°	$\Delta e \times \Delta B$	+.0116	+.0120	+.0123	+.0127	+.0131	+.0134	+.0138	+.0142	+.0146	+.0149
60°	0.522	0.175	0.163	0.152	0.141	0.130	0.119	0.107	0.096	0.085	0.074
61	.541	.193	.182	.171	.160	.148	.137	.126	.115	.104	.092
62	.560	.213	.201	.190	.179	.168	.156	.145	.134	.123	.112
63	.580	.232	.221	.210	.199	.188	.176	.165	.154	.143	.131
64	.601	.253	.242	.231	.219	.208	.197	.186	.174	.163	.152
65	.623	.274	.263	.252	.240	.229	.218	.207	.195	.184	.173
66	.645	.296	.285	.274	.262	.251	.240	.229	.217	.206	.195
67	.667	.318	.307	.296	.285	.273	.262	.251	.240	.228	.217
68	.691	.342	.330	.319	.308	.297	.285	.274	.263	.252	.240
69	.715	.366	.354	.343	.332	.321	.309	.298	.287	.275	.264
70	.740	.390	.379	.368	.357	.345	.334	.323	.311	.300	.289
71	.766	.416	.404	.393	.382	.371	.359	.348	.337	.325	.314
72	.792	.442	.431	.419	.408	.397	.385	.374	.363	.352	.340
73	.819	.469	.458	.446	.435	.424	.412	.401	.390	.379	.367
74	.847	.496	.485	.474	.463	.451	.440	.429	.418	.406	.395
75	.876	.525	.514	.503	.491	.480	.469	.457	.446	.435	.424
76	.906	.555	.543	.532	.521	.509	.498	.487	.476	.464	.453
77	.936	.585	.574	.562	.551	.540	.529	.517	.506	.495	.483
78	.968	.616	.605	.594	.582	.571	.560	.548	.537	.526	.514
79	1.000	.649	.637	.626	.615	.603	.592	.581	.569	.558	.547
80	1.033	.682	.670	.659	.648	.636	.625	.614	.602	.591	.580
81	.068	.716	.704	.693	.682	.670	.659	.648	.636	.625	.613
82	.103	.751	.739	.728	.717	.705	.694	.683	.671	.660	.648
83	.139	.787	.775	.764	.753	.741	.730	.719	.707	.696	.685
84	.176	.824	.813	.801	.790	.778	.767	.756	.744	.733	.722
85	1.215	.862	.851	.839	.828	.817	.805	.794	.782	.771	.760
86	.254	.901	.890	.878	.867	.856	.844	.833	.822	.810	.799
87	.295	.942	.930	.919	.907	.896	.885	.873	.862	.850	.839
88	.336	.983	.972	.960	.949	.937	.926	.915	.903	.892	.880
89	.379	1.026	1.014	1.003	.991	.980	.969	.957	.946	.934	.923
90	1.423	1.069	1.058	1.047	1.035	1.024	1.012	1.001	.990	.978	967
91	.469	.115	.103	.092	.080	.069	.058	.046	1.035	1.023	1.012
92	.515	.161	.150	.138	.127	.115	.104	.092	.081	.070	.058
93	.563	.208	.197	.186	.174	.163	.151	.140	.128	.117	.105
94	.612	.257	.246	.234	.223	.212	.200	.189	.177	.166	.154
95	1.662	1.308	1.296	1.285	1.273	1.262	1.250	1.239	1.227	1.216	1.204
96	.714	.359	.348	.336	.325	.313	.302	.290	.279	.267	.256
97	.767	.412	.401	.389	.378	.366	.355	.343	.332	.320	.309
98	.822	.466	.455	.443	.432	.420	.409	.398	.386	.375	.363
99	.878	.522	.511	.499	.488	.476	.465	.453	.442	.430	.419
100	1.936	1.579	1.568	1.556	1.545	1.533	1.522	1.510	1.499	1.488	1.476
101	.994	.638	.627	.615	.604	.592	.581	.569	.558	.546	.535
102	2.055	.698	.687	.675	.664	.652	.641	.629	.618	.606	.595
103	.117	.760	.749	.737	.726	.714	.703	.691	.680	.668	.657
104	.181	.824	.812	.801	.789	.778	.766	.755	.743	.732	.720
105	2.246	1.889	1.878	1.866	1.855	1.843	1.832	1.820	1.808	1.797	1.785
106	.314	.956	.945	.933	.922	.910	.898	.887	.875	.864	.852
107	.382	2.025	2.013	2.002	.990	.979	.967	.955	.944	.932	.921
108	.453	.095	.084	.072	2.060	2.049	2.037	2.026	2.014	2.003	.991
109	2.525	2.167	2.156	2.144	2.133	2.121	2.109	2.098	2.086	2.075	2.063
110	$\Delta e \times \Delta B$	+.0119	+.0123	+.0127	+.0131	+.0135	+.0139	+.0143	+.0146	+.0150	+.0154

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\,B\,(t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.00$

t'	$t - t'$										
	0.0	41	42	43	44	45	46	47	48	49	50
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
60°	$\Delta e \times \Delta B$	+.0153	+.0157	+.0161	+.0164	+.0168	+.0172	+.0176	+.0179	+.0183	+.0187
60°	0.522	0.063	0.051	0.040	0.029	0.018	0.007				
61	.541	.081	.070	.059	.048	.036	.025	0.014	0.003		
62	.560	.100	.089	.078	.067	.055	.044	.033	.022	0.011	
63	.580	.120	.109	.098	.087	.075	.064	.053	.042	.030	0.019
64	.601	.141	.129	.118	.107	.096	.085	.073	.062	.051	.040
65	.623	.162	.150	.139	.128	.117	.105	.094	.083	.072	.061
66	.645	.184	.172	.161	.150	.139	.127	.116	.105	.094	.082
67	.667	.206	.195	.183	.172	.161	.150	.138	.127	.116	.105
68	.691	.229	.218	.207	.195	.184	.173	.162	.150	.139	.128
69	.715	.253	.242	.230	.219	.208	.197	.185	.174	.163	.152
70	.740	.278	.266	.255	.244	.232	.221	.210	.199	.187	.176
71	.766	.303	.292	.280	.269	.258	.246	.235	.224	.213	.201
72	.792	.329	.318	.306	.295	.284	.273	.261	.250	.239	.227
73	.819	.356	.345	.333	.322	.311	.299	.288	.277	.266	.254
74	.847	.384	.372	.361	.350	.338	.327	.316	.304	.293	.282
75	.876	.412	.401	.390	.378	.367	.356	.344	.333	.322	.310
76	.906	.442	.430	.419	.408	.396	.385	.374	.362	.351	.340
77	.936	.472	.461	.449	.438	.427	.415	.404	.393	.381	.370
78	.968	.503	.492	.480	.469	.458	.446	.435	.424	.412	.401
79	1.000	.535	.524	.513	.501	.490	.478	.467	.456	.444	.433
80	1.033	.568	.557	.546	.534	.523	.511	.500	.489	.477	.466
81	.068	.602	.591	.579	.568	.557	.545	.534	.523	.511	.500
82	.103	.637	.626	.614	.603	.592	.580	.569	.558	.546	.535
83	.139	.673	.662	.650	.639	.628	.616	.605	.594	.582	.571
84	.176	.710	.699	.687	.676	.665	.653	.642	.631	.619	.608
85	1.215	.748	.737	.725	.714	.703	.691	.680	.669	.657	.646
86	.254	.787	.776	.765	.753	.742	.730	.719	.708	.696	.685
87	.295	.828	.816	.805	.793	.782	.771	.759	.748	.737	.725
88	.336	.869	.858	.846	.835	.823	.812	.801	.789	.778	.766
89	.379	.912	.900	.889	.877	.866	.855	.843	.832	.820	.809
90	1.423	.955	.944	.932	.921	.910	.898	.887	.875	.864	.853
91	.469	1.000	.989	.978	.966	.955	.943	.932	.920	.909	.898
92	.515	.047	1.035	1.024	1.012	1.001	.989	.978	.967	.955	.944
93	.563	.094	.083	.071	.060	.048	1.037	1.025	1.014	1.003	.991
94	.612	.143	.131	.120	.109	.097	.086	.074	.063	.051	1.040
95	1.662	1.193	1.182	1.170	1.159	1.147	1.136	1.124	1.113	1.101	1.090
96	.714	.244	.233	.222	.210	.199	.187	.176	.164	.153	.141
97	.767	.297	.286	.274	.263	.251	.240	.229	.217	.206	.194
98	.822	.352	.340	.329	.317	.306	.294	.283	.271	.260	.248
99	1.878	1.407	1.396	1.384	1.373	1.361	1.350	1.338	1.327	1.316	1.304
100	$\Delta e \times \Delta B$	+.0157	+.0161	+.0165	+.0168	+.0172	+.0176	+0.180	+.0184	+.0188	+.0191

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

ENGLISH MEASURES.

Values of $e = e' - 0.000367\, B\, (t - t')\left(1 + \frac{t' - 32}{1571}\right)$

$B = 30.00$

t'	$t - t'$										
	0.0	51	52	53	54	55	56	57	58	59	60
F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
70°	$\Delta e \times \Delta B$	+.0192	+.0195	+.0199	+.0203	+.0207	+.0210	+.0214	+.0218	+.0222	+.0226
62°	0.560										
63	.580	0.008									
64	.601	0.028	0.017	0.006							
65	.623	.049	.038	.027	0.016	0.004					
66	.645	.071	.060	.049	.037	.026	0.015	0.004			
67	.667	.093	.082	.071	.060	.048	.037	.026	0.015	0.003	
68	.691	.116	.105	.094	.083	.071	.060	.049	.038	.026	0.015
69	.715	.140	.129	.118	.106	.095	.084	.073	.061	.050	.039
70	.740	.165	.154	.142	.131	.120	.108	.097	.086	.075	.063
71	.766	.190	.179	.167	.156	.145	.134	.122	.111	.100	.089
72	.792	.216	.205	.194	.182	.171	.160	.148	.137	.126	.114
73	.819	.243	.232	.220	.209	.198	.186	.175	.164	.153	.141
74	.847	.271	.259	.248	.237	.225	.214	.203	.191	.180	.169
75	.876	.299	.288	.276	.265	.254	.243	.231	.220	.209	.197
76	.906	.328	.317	.306	.294	.283	.272	.260	.249	.238	.226
77	.936	.359	.347	.336	.325	.313	.302	.291	.279	.268	.257
78	.968	.390	.378	.367	.356	.344	.333	.322	.310	.299	.288
79	1.000	.422	.410	.399	.388	.376	.365	.354	.342	.331	.320
80	1.033	.455	.443	.432	.421	.409	.398	.387	.375	.364	.353
81	.068	.489	.477	.466	.455	.443	.432	.420	.409	.398	.386
82	.103	.524	.512	.501	.489	.478	.467	.455	.444	.433	.421
83	.139	.559	.548	.537	.525	.514	.503	.491	.480	.469	.457
84	.176	.596	.585	.574	.562	.551	.540	.528	.517	.505	.494
85	1.215	.634	.623	.612	.600	.589	.578	.566	.555	.543	.532
86	.254	.673	.662	.651	.639	.628	.617	.605	.594	.582	.571
87	.295	.714	.702	.691	.680	.668	.657	.645	.634	.623	.611
88	.336	.755	.744	.732	.721	.709	.698	.687	.675	.664	.652
89	1.379	0.798	0.786	0.775	0.763	0.752	0.740	0.729	0.718	0.706	0.695
90	$\Delta e \times \Delta B$	+.0194	+.0198	+.0202	+.0205	+.0209	+.0213	+.0217	+.0221	+.0225	+.0228

RELATIVE HUMIDITY.

TEMPERATURES FAHRENHEIT.

Air Temperature.	RELATIVE HUMIDITY, OR PERCENTAGE OF SATURATION.									
	10	20	30	40	50	60	70	80	90	100
F.	Vapor pressure (inches).									
−30°	0.0007	0.0014	0.0021	0.0028	0.0035	0.0042	0.0049	0.0056	0.0063	0.0071
29	.0007	.0015	.0022	.0030	.0037	.0045	.0052	.0060	.0067	.0075
28	.0008	.0016	.0024	.0032	.0040	.0048	.0056	.0064	.0072	.0080
27	.0008	.0017	.0025	.0034	.0042	.0051	.0059	.0068	.0076	.0084
26	.0009	.0018	.0027	.0036	.0045	.0054	.0063	.0072	.0081	.0090
−25	0.0010	0.0019	0.0029	0.0038	0.0048	0.0057	0.0067	0.0076	0.0086	0.0095
24	.0010	.0020	.0030	.0040	.0050	.0060	.0071	.0081	.0091	.0101
23	.0011	.0021	.0032	.0043	.0053	.0064	.0075	.0086	.0096	.0107
22	.0011	.0023	.0034	.0045	.0057	.0068	.0079	.0091	.0102	.0113
21	.0012	.0024	.0036	.0048	.0060	.0072	.0084	.0096	.0108	.0120
−20	0.0013	0.0025	0.0038	0.0051	0.0064	0.0076	0.0089	0.0102	0.0114	0.0127
19	.0013	.0027	.0040	.0054	.0067	.0081	.0094	.0108	.0121	.0135
18	.0014	.0029	.0043	.0057	.0071	.0086	.0100	.0114	.0128	.0143
17	.0015	.0030	.0045	.0060	.0076	.0091	.0106	.0121	.0136	.0151
16	.0016	.0032	.0048	.0064	.0080	.0096	.0112	.0128	.0144	.0160
−15	0.0017	0.0034	0.0051	0.0068	0.0084	0.0101	0.0118	0.0135	0.0152	0.0169
14	.0018	.0036	.0054	.0071	.0089	.0107	.0125	.0143	.0161	.0179
13	.0019	.0038	.0057	.0076	.0094	.0113	.0132	.0151	.0170	.0189
12	.0020	.0040	.0060	.0080	.0100	.0120	.0140	.0160	.0180	.0200
11	.0021	.0042	.0063	.0084	.0106	.0127	.0148	.0169	.0190	.0211
−10	0.0022	0.0045	0.0067	0.0089	0.0112	0.0134	0.0156	0.0178	0.0201	0.0223
9	.0024	.0047	.0071	.0094	.0118	.0141	.0165	.0188	.0212	.0236
8	.0025	.0050	.0075	.0099	.0124	.0149	.0174	.0199	.0224	.0249
7	.0026	.0053	.0079	.0105	.0131	.0158	.0184	.0210	.0236	.0263
6	.0028	.0055	.0083	.0111	.0139	.0166	.0194	.0222	.0249	.0277
− 5	0.0029	0.0058	0.0088	0.0117	0.0146	0.0175	0.0205	0.0234	0.0263	0.0292
4	.0031	.0062	.0093	.0123	.0154	.0185	.0216	.0247	.0278	.0308
3	.0033	.0065	.0098	.0130	.0163	.0195	.0228	.0260	.0293	.0325
2	.0034	.0069	.0103	.0137	.0171	.0206	.0240	.0274	.0309	.0343
1	.0036	.0072	.0108	.0145	.0181	.0217	.0253	.0289	.0325	.0361
±0	0.0038	0.0076	0.0114	0.0152	0.0190	0.0229	0.0267	0.0305	0.0343	0.0381
1	.0040	.0080	.0120	.0161	.0201	.0241	.0281	.0321	.0361	.0401
2	.0042	.0085	.0127	.0169	.0211	.0254	.0296	.0338	.0380	.0423
3	.0044	.0089	.0134	.0178	.0222	.0267	.0312	.0356	.0400	.0445
4	.0047	.0094	.0141	.0187	.0234	.0281	.0328	.0375	.0422	.0468
5	0.0049	0.0099	0.0148	0.0197	0.0247	0.0296	0.0345	0.0394	0.0444	0.0493
6	.0052	.0104	.0156	.0208	.0259	.0311	.0363	.0415	.0467	.0519
7	.0055	.0109	.0164	.0218	.0273	.0328	.0382	.0437	.0491	.0546
8	.0057	.0115	.0172	.0230	.0287	.0344	.0402	.0459	.0517	.0574
9	.0060	.0121	.0181	.0241	.0302	.0362	.0423	.0483	.0543	.0604
10	0.0063	0.0127	0.0190	0.0254	0.0317	0.0381	0.0444	0.0508	0.0571	0.0635
11	.0067	.0133	.0200	.0267	.0334	.0400	.0467	.0534	.0600	.0667
12	.0070	.0140	.0210	.0280	.0350	.0421	.0491	.0561	.0631	.0701
13	.0074	.0147	.0221	.0295	.0368	.0442	.0515	.0589	.0663	.0736
14	.0077	.0155	.0232	.0309	.0387	.0464	.0541	.0619	.0696	.0773
15	0.0081	0.0162	0.0244	0.0325	0.0406	0.0487	0.0568	0.0650	0.0731	0.0812
16	.0085	.0170	.0256	.0341	.0426	.0512	.0597	.0682	.0767	.0852
17	.0089	.0179	.0268	.0358	.0447	.0537	.0626	.0716	.0805	.0895
18	.0094	.0188	.0282	.0376	.0470	.0563	.0657	.0751	.0845	.0939
19	.0099	.0197	.0296	.0394	.0493	.0591	.0690	.0788	.0887	.0985
20	0.0103	0.0207	0.0310	0.0413	0.0517	0.0620	0.0723	0.0827	0.0930	0.1033

RELATIVE HUMIDITY.

TEMPERATURES FAHRENHEIT.

Air Temperature.	RELATIVE HUMIDITY, OR PERCENTAGE OF SATURATION.									
	10	20	30	40	50	60	70	80	90	100
F.	Vapor pressure (inches).									
20°	0.010	0.021	0.031	0.041	0.052	0.062	0.072	0.083	0.093	0.103
21	.011	.022	.033	.043	.054	.065	.076	.087	.098	.108
22	.011	.023	.034	.045	.057	.068	.080	.091	.102	.114
23	.012	.024	.036	.048	.060	.071	.083	.095	.107	.119
24	.012	.025	.037	.050	.062	.075	.087	.100	.112	.125
25	0.013	0.026	0.039	0.052	0.065	0.078	0.092	0.105	0.118	0.131
26	.014	.027	.041	.055	.068	.082	.096	.110	.123	.137
27	.014	.029	.043	.057	.072	.086	.100	.115	.129	.143
28	.015	.030	.045	.060	.075	.090	.105	.120	.135	.150
29	.016	.031	.047	.063	.079	.094	.110	.126	.142	.157
30	0.016	0.033	0.049	0.066	0.082	0.099	0.115	0.132	0.148	0.165
31	.017	.034	.052	.069	.086	.103	.121	.138	.155	.172
32	.018	.036	.054	.072	.090	.108	.126	.144	.162	.180
33	.019	.038	.056	.075	.094	.113	.131	.150	.169	.188
34	.020	.039	.059	.078	.098	.117	.137	.156	.176	.195
35	0.020	0.041	0.061	0.081	0.102	0.122	0.142	0.163	0.183	0.203
36	.021	.042	.064	.085	.106	.127	.148	.169	.191	.212
37	.022	.044	.066	.088	.110	.132	.154	.176	.198	.220
38	.023	.046	.069	.092	.115	.137	.160	.183	.206	.229
39	.024	.048	.071	.095	.119	.143	.167	.191	.214	.238
40	0.025	0.050	0.074	0.099	0.124	0.149	0.173	0.198	0.223	0.248
41	.026	.052	.077	.103	.129	.155	.180	.206	.232	.258
42	.027	.054	.080	.107	.134	.161	.187	.214	.241	.268
43	.028	.056	.083	.111	.139	.167	.195	.223	.250	.278
44	.029	.058	.087	.116	.145	.173	.202	.231	.260	.289
45	0.030	0.060	0.090	0.120	0.150	0.180	0.210	0.240	0.270	0.300
46	.031	.062	.094	.125	.156	.187	.218	.250	.281	.312
47	.032	.065	.097	.130	.162	.194	.227	.259	.292	.324
48	.034	.067	.101	.135	.168	.202	.236	.269	.303	.336
49	.035	.070	.105	.140	.175	.210	.245	.279	.314	.349
50	0.036	0.073	0.109	0.145	0.181	0.218	0.254	0.290	0.326	0.363
51	.038	.075	.113	.151	.188	.226	.263	.301	.339	.376
52	.039	.078	.117	.156	.195	.234	.273	.312	.351	.390
53	.041	.081	.122	.162	.203	.243	.284	.324	.365	.405
54	.042	.084	.126	.168	.210	.252	.294	.336	.378	.420
55	0.044	0.087	0.131	0.174	0.218	0.262	0.305	0.349	0.392	0.436
56	.045	.090	.136	.181	.226	.271	.316	.362	.407	.452
57	.047	.094	.141	.187	.234	.281	.328	.375	.422	.469
58	.049	.097	.146	.194	.243	.292	.340	.389	.437	.486
59	.050	.101	.151	.201	.252	.302	.353	.403	.453	.504
60	0.052	0.104	0.157	0.209	0.261	0.313	0.365	0.418	0.470	0.522
61	.054	.108	.162	.216	.270	.325	.379	.433	.487	.541
62	.056	.112	.168	.224	.280	.336	.392	.448	.504	.560
63	.058	.116	.174	.232	.290	.348	.406	.464	.522	.580
64	.060	.120	.180	.241	.301	.361	.421	.481	.541	.601
65	0.062	0.125	0.187	0.249	0.311	0.374	0.436	0.498	0.560	0.623
66	.064	.129	.193	.258	.322	.387	.451	.516	.580	.645
67	.067	.133	.200	.267	.334	.400	.467	.534	.601	.667
68	.069	.138	.207	.276	.345	.415	.484	.553	.622	.691
69	.072	.143	.214	.286	.358	.429	.500	.572	.644	.715
70	0.074	0.148	0.222	0.296	0.370	0.444	0.518	0.592	0.666	0.740

RELATIVE HUMIDITY.
TEMPERATURES FAHRENHEIT.

Air Temper-ature.	RELATIVE HUMIDITY, OR PERCENTAGE OF SATURATION.									
	10	20	30	40	50	60	70	80	90	100
F.	Vapor pressure (inches).									
70°	0.074	0.148	0.222	0.296	0.370	0.444	0.518	0.592	0.666	0.740
71	.077	.153	.230	.306	.383	.459	.536	.612	.689	.766
72	.079	.158	.238	.317	.396	.475	.554	.634	.713	.792
73	.082	.164	.246	.328	.410	.491	.573	.655	.737	.819
74	.085	.169	.254	.339	.424	.508	.593	.678	.762	.847
75	0.088	0.175	0.263	0.350	0.438	0.526	0.613	0.701	0.788	0.876
76	.091	.181	.272	.362	.453	.543	.634	.724	.815	.906
77	.094	.187	.281	.374	.468	.562	.655	.749	.843	.936
78	.097	.194	.290	.387	.484	.581	.677	.774	.871	.968
79	.100	.200	.300	.400	.500	.600	.700	.800	.900	1.000
80	0.103	0.207	0.310	0.413	0.517	0.620	0.723	0.827	0.930	1.033
81	.107	.214	.320	.427	.534	.641	.747	.854	.961	1.068
82	.110	.221	.331	.441	.551	.662	.772	.882	.993	1.103
83	.114	.228	.342	.456	.570	.684	.797	.911	1.025	1.139
84	.118	.235	.353	.471	.588	.706	.824	.941	1.059	1.176
85	0.121	0.243	0.364	0.486	0.607	0.729	0.850	0.972	1.093	1.215
86	.125	.251	.376	.502	.627	.753	.878	1.003	1.129	1.254
87	.129	.259	.388	.518	.647	.777	.906	1.036	1.165	1.295
88	.134	.267	.401	.535	.668	.802	.936	1.069	1.203	1.336
89	.138	.276	.414	.552	.690	.828	.966	1.104	1.241	1.379
90	0.142	0.285	0.427	0.569	0.712	0.854	0.996	1.139	1.281	1.423
91	.147	.294	.441	.588	.734	.881	1.028	1.175	1.322	1.469
92	.152	.303	.455	.606	.758	.909	1.061	1.212	1.364	1.515
93	.156	.313	.469	.625	.782	.938	1.094	1.250	1.407	1.563
94	.161	.322	.484	.645	.806	.967	1.128	1.290	1.451	1.612
95	0.166	0.332	0.499	0.665	0.831	0.998	1.164	1.330	1.496	1.662
96	.171	.343	.514	.686	.857	1.029	1.200	1.371	1.543	1.714
97	.177	.353	.530	.707	.884	1.060	1.237	1.414	1.591	1.767
98	.182	.364	.547	.729	.911	1.093	1.275	1.458	1.640	1.822
99	.188	.376	.563	.751	.939	1.127	1.315	1.502	1.690	1.878
100	0.194	0.387	0.581	0.774	0.968	1.161	1.355	1.548	1.742	1.936
101	.199	.399	.598	.798	.997	1.197	1.396	1.596	1.795	1.994
102	.206	.411	.616	.822	1.028	1.233	1.438	1.644	1.850	2.055
103	.212	.423	.635	.847	1.059	1.270	1.482	1.694	1.905	2.117
104	.218	.436	.654	.872	1.090	1.309	1.527	1.745	1.963	2.181
105	0.225	0.449	0.674	0.899	1.123	1.348	1.572	1.797	2.022	2.246
106	.231	.463	.694	.925	1.157	1.388	1.619	1.851	2.082	2.314
107	.238	.476	.715	.953	1.191	1.429	1.668	1.906	2.144	2.382
108	.245	.491	.736	.981	1.226	1.472	1.717	1.962	2.208	2.453
109	.253	.505	.758	1.010	1.263	1.515	1.768	2.020	2.273	2.525
110	0.260	0.520	0.780	1.040	1.300	1.560	1.820	2.080	2.339	2.599
111	.268	.535	.803	1.070	1.338	1.605	1.873	2.140	2.408	2.676
112	.275	.551	.826	1.101	1.377	1.652	1.927	2.203	2.478	2.754
113	.283	.567	.850	1.133	1.417	1.700	1.983	2.267	2.550	2.833
114	.292	.583	.875	1.166	1.458	1.749	2.041	2.332	2.624	2.915
115	0.300	0.600	0.900	1.200	1.500	1.800	2.100	2.399	2.699	2.999
116	.309	.617	.926	1.234	1.543	1.851	2.160	2.468	2.777	3.085
117	.317	.635	.952	1.269	1.587	1.904	2.221	2.539	2.856	3.173
118	.326	.653	.979	1.305	1.632	1.958	2.285	2.611	2.937	3.264
119	.336	.671	1.007	1.342	1.678	2.014	2.349	2.685	3.021	3.356
120	0.345	0.690	1.035	1.380	1.725	2.071	2.416	2.761	3.106	3.451

Table 77.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

METRIC MEASURES.

Values of $e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t')$

Temperature.	PRESSURE OF AQUEOUS VAPOR, *e*.									
	0	1	2	3	4	5	6	7	8	9
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−50°	0.029	0.026	0.023	0.020	0.017	0.015	0.013	0.012	0.010	0.009
40	0.096	0.086	0.076	0.068	0.060	0.054	0.048	0.042	0.037	0.033
30	0.288	0.259	0.233	0.209	0.188	0.169	0.151	0.135	0.121	0.108

$$e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t')$$

$$B = 760 \text{ mm.}$$

t'	*t* − *t'*										
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−30°	$\Delta e \times \Delta B$	+0.006	+0.013	+0.019	+0.025	+0.032	+0.038	+0.045	+0.051	+0.057	+0.064
−30°	0.288	0.239	0.191	0.143	0.094	0.046					
29	.319	.271	.222	.174	.125	.077	0.028				
28	.354	.306	.257	.208	.160	.111	.063	0.014			
27	.392	.344	.295	.246	.198	.149	.101	.052	0.003		
26	.434	.385	.337	.288	.239	.191	.142	.093	.045		
−25	0.480	0.431	0.383	0.334	0.285	0.236	0.188	0.139	0.090	0.042	
24	.530	.482	.433	.384	.335	.286	.238	.189	.140	.091	0.043
23	.585	.537	.488	.439	.390	.341	.292	.244	.195	.146	.097
22	.646	.597	.548	.499	.450	.401	.352	.303	.254	.206	.157
21	.712	.663	.614	.565	.516	.467	.418	.369	.320	.271	.222
−20	0.783	0.734	0.685	0.636	0.587	0.538	0.489	0.440	0.391	0.342	0.293
19	.862	.813	.764	.715	.666	.616	.567	.518	.469	.420	.371
18	.947	.898	.849	.800	.751	.702	.653	.604	.554	.505	.456
17	1.041	.991	.942	.893	.844	.795	.746	.696	.647	.598	.549
16	1.142	1.093	1.044	.994	.945	.896	.847	.797	.748	.699	.650
−15	1.252	1.203	1.154	1.105	1.055	1.006	0.957	0.907	0.858	0.809	0.760
14	1.373	1.323	1.274	1.225	1.175	1.126	1.076	1.027	.978	.928	.879
13	1.503	1.453	1.404	1.355	1.305	1.256	1.206	1.157	1.108	1.058	1.009
12	1.644	1.595	1.545	1.496	1.447	1.397	1.348	1.298	1.249	1.199	1.150
11	1.798	1.748	1.699	1.649	1.600	1.550	1.501	1.451	1.402	1.352	1.303
−10	1.964	1.915	1.865	1.816	1.766	1.716	1.667	1.617	1.568	1.518	1.468
9	2.144	2.095	2.045	1.996	1.946	1.896	1.847	1.797	1.747	1.698	1.648
8	2.340	2.290	2.240	2.190	2.141	2.091	2.041	1.992	1.942	1.892	1.843
7	2.550	2.501	2.451	2.401	2.351	2.302	2.252	2.202	2.152	2.103	2.053
6	2.778	2.729	2.679	2.629	2.579	2.529	2.480	2.430	2.380	2.330	2.280
−5	3.025	2.975	2.925	2.875	2.825	2.775	2.726	2.676	2.626	2.576	2.526
−5	$\Delta e \times \Delta B$	+0.007	+0.013	+0.020	+0.026	+0.033	+0.039	+0.046	+0.052	+0.059	+0.066

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

METRIC MEASURES.

Values of $e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t')$

$B = 760$ mm.

t'	$t - t'$										
	0.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−20°	$\Delta e \times \Delta B$	+0.071	+0.077	+0.084	+0.090	+0.097	+0.103	+0.110	+0.116	+0.123	+0.129
−25°	0.480										
24	.530										
23	.585	0.048									
22	.646	.108	0.059	0.010							
21	.712	.173	.124	.075	0.026						
−20	.783	.244	.195	.146	.097	0.048					
19	.862	.322	.273	.224	.175	.126	0.077	0.028			
18	.947	.407	.358	.309	.260	.211	.161	.112	0.063	0.014	
17	1.041	.500	.450	.401	.352	.303	.254	.205	.155	.106	0.057
16	1.142	.600	.551	.502	.453	.404	.354	.305	.256	.207	.157
−15	1.252	.710	.661	.612	.562	.513	.464	.414	.365	.316	.267
14	1.373	.830	.780	.731	.682	.632	.583	.534	.484	.435	.386
13	1.503	.959	.910	.861	.811	.762	.712	.663	.614	.564	.515
12	1.644	1.100	1.051	1.001	.952	.902	.853	.803	.754	.705	.655
11	1.798	1.253	1.204	1.154	1.105	1.055	1.005	.956	.906	.857	.807
−10	+1.964	1.419	1.369	1.320	1.270	1.221	1.171	1.121	1.072	1.022	.973
9	2.144	1.598	1.549	1.499	1.450	1.400	1.350	1.301	1.251	1.201	1.152
8	2.340	1.793	1.743	1.693	1.644	1.594	1.544	1.495	1.445	1.395	1.346
7	2.550	2.003	1.953	1.904	1.854	1.804	1.754	1.705	1.655	1.605	1.555
6	2.778	2.231	2.181	2.131	2.081	2.031	1.981	1.932	1.882	1.832	1.782
−5	3.025	2.476	2.426	2.376	2.327	2.277	2.227	2.177	2.127	2.077	2.027
−5	$\Delta e \times \Delta B$	+0.072	+0.079	+0.085	+0.092	+0.098	+0.105	+0.112	+0.118	+0.125	+0.131

t'	$t - t'$										
	0.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−15°	$\Delta e \times \Delta B$	+0.136	+0.143	+0.149	+0.156	+0.162	+0.169	+0.175	+0.182	+0.188	+0.195
−17°	1.041	0.008									
16	1.142	0.108	0.059	0.010							
−15	1.252	0.217	.168	.119	0.069	0.020					
14	1.373	.336	.287	.237	.188	.139	0.089	0.040			
13	1.503	.465	.416	.366	.317	.268	.218	.169	0.119	0.070	0.021
12	1.644	.606	.556	.507	.457	.408	.358	.309	.259	.210	.160
11	1.798	.758	.708	.659	.609	.560	.510	.461	.411	.362	.312
−10	1.964	.923	.873	.824	.774	.725	.675	.626	.576	.526	.477
9	2.144	1.102	1.052	1.003	.953	.903	.854	.804	.755	.705	.655
8	2.340	1.296	1.246	1.196	1.147	1.097	1.047	.998	.948	.898	.849
7	2.550	1.506	1.456	1.406	1.356	1.307	1.257	1.207	1.157	1.108	1.058
6	2.778	1.732	1.683	1.633	1.583	1.533	1.483	1.434	1.384	1.334	1.284
− 5	3.025	1.977	1.928	1.878	1.828	1.778	1.728	1.678	1.628	1.579	1.529
− 5	$\Delta e \times \Delta B$	+0.138	+0.144	+0.151	+0.157	+0.164	+0.171	+0.177	+0.184	+0.190	+0.197

TABLE 77.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

METRIC MEASURES.

Values of $e = e' - 0.000660\,B\,(t-t')\,(1 + 0.00115\,t')$

$B = 760$ mm.

t'	$t-t'$ 3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−10° $\Delta e \times \Delta B$	+0.202	+0.209	+0.215	+0.222	+0.228	+0.235	+0.241	+0.248	+0.254	+0.261
−12°	0.111	0.061	0.012							
11	.263	.213	.164	0.114	0.065	0.015				
−10	.427	.378	.328	.278	.229	.179	0.130	0.080	0.031	
9	.606	.556	.506	.457	.407	.357	.308	.258	.209	0.159
8	.799	.749	.699	.650	.600	.550	.501	.451	.401	.352
7	1.008	.958	909	.859	.809	.759	.710	.660	.610	.560
6	1.234	1.184	1.135	1.085	1.035	.985	.935	.886	.836	.786
−5	1.479	1.429	1.379	1.329	1.279	1.229	1.180	1.130	1.080	1.030
−5 $\Delta e \times \Delta B$	+0.203	+0.210	+0.217	+0.223	+0.230	+0.236	+0.243	+0.249	+0.256	+0.262

t'	$t-t'$ 4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−8° $\Delta e \times \Delta B$	+0.268	+0.275	+0.281	+0.288	+0.294	+0.301	+0.307	+0.314	+0.320	+0.327
−9°	0.109	0.060	0.010							
8	0.302	0.252	.202	0.153	0.103	0.053	0.004			
7	.510	.461	.411	.361	.311	.262	.212	0.162	0.112	0.063
6	.736	.686	.637	.587	.537	.487	.437	.387	.338	.288
−5	0.980	0.930	0.880	0.830	0.781	0.731	0.681	0.631	0.581	0.531
−5 $\Delta e \times \Delta B$	+0.269	+0.276	+0.282	+0.289	+0.295	+0.302	+0.308	+0.315	+0.322	+0.328

t'	$t-t'$ 5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−7°	0.013									
6	.238	0.188	0.138	0.089	0.039					
−5	0.481	0.431	0.382	0.332	0.282	0.232	0.182	0.132	0.082	0.033
−5 $\Delta e \times \Delta B$	+0.335	+0.341	+0.348	+0.354	+0.361	+0.367	+0.374	+0.381	+0.387	+0.394

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

METRIC MEASURES.

Values of $e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t')$

$B = 760$ mm.

t'	$t - t'$										
	0	1	2	3	4	5	6	7	8	9	10
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
−5°	$\Delta e \times \Delta B$	+0.07	+0.13	+0.20	+0.26	+0.33	+0.39	+0.46	+0.52	+0.59	+0.66
−5°	3.02	2.53	2.03	1.53	1.03	0.53	0.03				
4	3.29	2.79	2.29	1.79	1.29	0.79	0.29				
3	3.58	3.08	2.58	2.08	1.58	1.08	0.58	0.08			
2	3.89	3.39	2.89	2.39	1.89	1.38	0.88	0.38			
1	4.22	3.72	3.22	2.72	2.22	1.71	1.21	0.71	0.21		
±0	4.58	4.08	3.58	3.08	2.57	2.07	1.57	1.07	0.57	0.07	
+1	4.92	4.42	3.92	3.42	2.92	2.41	1.91	1.41	0.91	0.40	
2	5.29	4.79	4.29	3.78	3.28	2.78	2.27	1.77	1.27	0.77	0.26
3	5.68	5.18	4.68	4.17	3.67	3.17	2.66	2.16	1.66	1.15	0.65
4	6.10	5.59	5.09	4.59	4.08	3.58	3.07	2.57	2.07	1.56	1.06
5	6.54	6.03	5.53	5.03	4.52	4.02	3.51	3.01	2.51	2.00	1.50
6	7.01	6.51	6.00	5.50	4.99	4.49	3.98	3.48	2.97	2.47	1.96
7	7.51	7.01	6.50	6.00	5.49	4.98	4.48	3.97	3.47	2.96	2.46
8	8.05	7.54	7.03	6.53	6.02	5.51	5.01	4.50	4.00	3.49	2.98
9	8.61	8.10	7.60	7.09	6.58	6.08	5.57	5.06	4.56	4.05	3.54
10	9.21	8.70	8.20	7.69	7.18	6.67	6.17	5.66	5.15	4.64	4.14
11	9.85	9.34	8.83	8.32	7.81	7.31	6.80	6.29	5.78	5.27	4.77
12	10.52	10.01	9.50	9.00	8.49	7.98	7.47	6.96	6.45	5.94	5.44
13	11.24	10.73	10.22	9.71	9.20	8.69	8.18	7.67	7.16	6.65	6.14
14	11.99	11.48	10.97	10.46	9.95	9.44	8.93	8.42	7.91	7.41	6.90
15	12.79	12.28	11.77	11.26	10.75	10.24	9.73	9.22	8.71	8.20	7.69
16	13.64	13.13	12.62	12.11	11.60	11.09	10.58	10.07	9.56	9.04	8.53
17	14.54	14.03	13.52	13.00	12.49	11.98	11.47	10.96	10.45	9.94	9.42
18	15.49	14.98	14.46	13.95	13.44	12.93	12.42	11.90	11.39	10.88	10.37
19	16.49	15.98	15.46	14.95	14.44	13.93	13.41	12.90	12.39	11.88	11.36
20	17.55	17.03	16.52	16.01	15.50	14.98	14.47	13.96	13.44	12.93	12.42
21	18.66	18.15	17.64	17.12	16.61	16.10	15.58	15.07	14.56	14.04	13.53
22	19.84	19.33	18.82	18.30	17.79	17.27	16.76	16.24	15.73	15.22	14.70
23	21.09	20.57	20.06	19.54	19.03	18.51	18.00	17.48	16.97	16.45	15.94
24	22.40	21.88	21.37	20.85	20.34	19.82	19.31	18.79	18.27	17.76	17.24
25	23.78	23.26	22.75	22.23	21.72	21.20	20.68	20.17	19.65	19.14	18.62
26	25.24	24.72	24.20	23.69	23.17	22.65	22.14	21.62	21.10	20.59	20.07
27	26.77	26.25	25.73	25.22	24.70	24.18	23.66	23.15	22.63	22.11	21.60
28	28.38	27.86	27.34	26.83	26.31	25.79	25.27	24.76	24.24	23.72	23.20
29	30.08	29.56	29.04	28.52	28.00	27.48	26.97	26.45	25.93	25.41	24.89
30	31.86	31.34	30.82	30.30	29.78	29.27	28.75	28.23	27.71	27.19	26.67
31	33.74	33.22	32.70	32.18	31.66	31.14	30.62	30.10	29.58	29.06	28.54
32	35.70	35.18	34.66	34.14	33.62	33.10	32.58	32.06	31.54	31.02	30.50
33	37.78	37.25	36.73	36.21	35.69	35.17	34.65	34.13	33.61	33.09	32.57
34	39.95	39.43	38.90	38.38	37.86	37.34	36.82	36.30	35.78	35.26	34.73
35	42.23	41.71	41.18	40.66	40.14	39.62	39.10	38.57	38.05	37.53	37.01
36	44.62	44.10	43.57	43.05	42.53	42.01	41.48	40.96	40.44	39.92	39.40
37	47.13	46.60	46.08	45.56	45.04	44.51	43.99	43.47	42.94	42.42	41.90
38	49.76	49.23	48.71	48.19	47.66	47.14	46.61	46.09	45.57	45.04	44.52
39	52.51	51.99	51.46	50.94	50.41	49.89	49.37	48.84	48.32	47.79	47.27
40	55.40	54.87	54.35	53.82	53.30	52.77	52.25	51.72	51.20	50.67	50.15
41	58.42	57.89	57.37	56.84	56.32	55.79	55.27	54.74	54.21	53.69	53.16
42	61.58	61.05	60.53	60.00	59.48	58.95	58.43	57.90	57.37	56.85	56.32
43	64.89	64.36	63.84	63.31	62.78	62.26	61.73	61.20	60.68	60.15	59.62
44	68.35	67.82	67.30	66.77	66.24	65.72	65.19	64.66	64.13	63.61	63.08
45	71.97	71.44	70.91	70.39	69.86	69.33	68.80	68.28	67.75	67.22	66.69
45	$\Delta e \times \Delta B$	+0.07	+0.14	+0.21	+0.28	+0.35	+0.42	+0.49	+0.56	+0.62	+0.69

TABLE 77.

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

METRIC MEASURES.

Values of $e = e' - 0.000660\,B\,(t - t')\,(1 + 0.00115\,t')$

$B = 760$ mm.

t'	$t - t'$										
	0	11	12	13	14	15	16	17	18	19	20
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
+5°	$\Delta e \times \Delta B$	+0.73	+0.80	+0.86	+0.93	+1.00	+1.06	+1.13	+1.19	+1.26	+1.33
+3°	5.68	0.15									
4	6.10	0.56	0.05								
5	6.54	0.99	0.49								
6	7.01	1.46	0.95	0.45							
7	7.51	1.95	1.45	0.94	0.43						
8	8.05	2.48	1.97	1.46	0.96	0.45					
9	8.61	3.04	2.53	2.02	1.52	1.01	0.50				
10	9.21	3.63	3.12	2.61	2.11	1.60	1.09	0.58	0.08		
11	9.85	4.26	3.75	3.24	2.73	2.23	1.72	1.21	0.70	0.20	
12	10.52	4.93	4.42	3.91	3.40	2.89	2.38	1.88	1.37	0.86	0.35
13	11.24	5.63	5.13	4.62	4.11	3.60	3.09	2.58	2.07	1.56	1.05
14	11.99	6.39	5.88	5.37	4.86	4.35	3.84	3.33	2.82	2.31	1.80
15	12.79	7.18	6.67	6.16	5.65	5.14	4.63	4.12	3.61	3.10	2.59
16	13.64	8.02	7.51	7.00	6.49	5.98	5.47	4.96	4.45	3.94	3.43
17	14.54	8.91	8.40	7.89	7.38	6.87	6.36	5.85	5.33	4.82	4.31
18	15.49	9.86	9.34	8.83	8.32	7.81	7.30	6.78	6.27	5.76	5.25
19	16.49	10.85	10.34	9.83	9.31	8.80	8.29	7.78	7.26	6.75	6.24
20	17.55	11.90	11.39	10.88	10.36	9.85	9.34	8.82	8.31	7.80	7.29
21	18.66	13.01	12.50	11.99	11.47	10.96	10.45	9.93	9.42	8.90	8.39
22	19.84	14.19	13.67	13.16	12.64	12.13	11.62	11.10	10.59	10.07	9.56
23	21.09	15.42	14.91	14.39	13.88	13.36	12.85	12.33	11.82	11.30	10.79
24	22.40	16.73	16.21	15.70	15.18	14.67	14.15	13.64	13.12	12.60	12.09
25	23.78	18.10	17.59	17.07	16.56	16.04	15.52	15.01	14.49	13.98	13.46
26	25.24	19.55	19.04	18.52	18.00	17.49	16.97	16.45	15.94	15.42	14.90
27	26.77	21.08	20.56	20.04	19.53	19.01	18.49	17.98	17.46	16.94	16.42
28	28.38	22.68	22.17	21.65	21.13	20.61	20.10	19.58	19.06	18.54	18.02
29	30.08	24.37	23.86	23.34	22.82	22.30	21.78	21.26	20.75	20.23	19.71
30	31.86	26.15	25.63	25.11	24.60	24.08	23.56	23.04	22.52	22.00	21.48
31	33.74	28.02	27.50	26.98	26.46	25.94	25.42	24.90	24.38	23.86	23.34
32	35.70	29.98	29.46	28.94	28.42	27.90	27.38	26.86	26.34	25.82	25.30
33	37.78	32.05	31.53	31.01	30.49	29.97	29.44	28.92	28.40	27.88	27.36
34	39.95	34.21	33.69	33.17	32.65	32.13	31.61	31.09	30.57	30.04	29.52
35	42.23	36.49	35.97	35.44	34.92	34.40	33.88	33.36	32.83	32.31	31.79
36	44.62	38.87	38.35	37.83	37.31	36.78	36.26	35.74	35.22	34.69	34.17
37	47.13	41.37	40.85	40.33	39.81	39.28	38.76	38.24	37.71	37.19	36.67
38	49.76	44.00	43.47	42.95	42.43	41.90	41.38	40.86	40.33	39.81	39.29
39	52.51	46.74	46.22	45.70	45.17	44.65	44.12	43.60	43.08	42.55	42.03
40	55.40	49.62	49.10	48.58	48.05	47.53	47.00	46.48	45.95	45.43	44.90
41	58.42	52.64	52.11	51.59	51.06	50.54	50.01	49.49	48.96	48.44	47.91
42	61.58	55.80	55.27	54.74	54.22	53.69	53.17	52.64	52.12	51.59	51.06
43	64.89	59.10	58.57	58.05	57.52	56.99	56.47	55.94	55.41	54.89	54.36
44	68.35	62.55	62.03	61.50	60.97	60.45	59.92	59.39	58.86	58.34	57.81
45	71.97	66.16	65.64	65.11	64.58	64.05	63.53	63.00	62.47	61.94	61.42
45	$\Delta e \times \Delta B$	+0.76	+0.83	+0.90	+0.97	+1.04	+1.11	+1.18	+1.25	+1.32	+1.39

REDUCTION OF PSYCHROMETRIC OBSERVATIONS.

METRIC MEASURES.

Values of $e = e' - 0.000660\ B\ (t - t')\ (1 + 0.00115\ t')$

$B = 760$ mm.

t'	$t-t'$ 0	21	22	23	24	25	26	27	28	29	30
C.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
+15°	$\Delta e \times \Delta B$	+0.141	+0.148	+0.154	+0.161	+0.168	+0.175	+0.181	+0.188	+0.195	+0.201
13°	11.24	0.54	0.03								
14	11.99	1.29	0.78	0.27							
15	12.79	2.08	1.57	1.06	0.55	0.04					
+16	13.64	2.91	2.40	1.89	1.38	0.87	0.36				
17	14.54	3.80	3.29	2.78	2.27	1.75	1.24	0.73	0.22		
18	15.49	4.74	4.22	3.71	3.20	2.69	2.18	1.66	1.15	0.64	0.13
19	16.49	5.73	5.21	4.70	4.19	3.68	3.16	2.65	2.14	1.62	1.11
20	17.55	6.77	6.26	5.75	5.23	4.72	4.21	3.69	3.18	2.67	2.15
+21	18.66	7.88	7.36	6.85	6.34	5.82	5.31	4.79	4.28	3.77	3.25
22	19.84	9.04	8.53	8.02	7.50	6.99	6.47	5.96	5.44	4.93	4.42
23	21.09	10.27	9.76	9.25	8.73	8.22	7.70	7.19	6.67	6.16	5.64
24	22.40	11.57	11.06	10.54	10.03	9.51	9.00	8.48	7.97	7.45	6.93
25	23.78	12.94	12.43	11.91	11.40	10.88	10.36	9.85	9.33	8.82	8.30
+26	25.24	14.39	13.87	13.35	12.84	12.32	11.80	11.29	10.77	10.25	9.74
27	26.77	15.91	15.39	14.87	14.35	13.84	13.32	12.80	12.29	11.77	11.25
28	28.38	17.51	16.99	16.47	15.95	15.44	14.92	14.40	13.88	13.37	12.85
29	30.08	19.19	18.67	18.15	17.64	17.12	16.60	16.08	15.56	15.04	14.53
30	31.86	20.96	20.44	19.93	19.41	18.89	18.37	17.85	17.33	16.81	16.29
+31	33.74	22.83	22.31	21.79	21.27	20.75	20.23	19.71	19.19	18.67	18.15
32	35.70	24.78	24.26	23.74	23.22	22.70	22.18	21.66	21.14	20.62	20.10
33	37.78	26.84	26.32	25.80	25.28	24.76	24.24	23.72	23.20	22.68	22.16
34	39.95	29.00	28.48	27.96	27.44	26.92	26.40	25.87	25.35	24.83	24.31
35	42.23	31.27	30.75	30.23	29.70	29.18	28.66	28.14	27.62	27.10	26.57
+36	44.62	33.65	33.13	32.60	32.08	31.56	31.04	30.52	29.99	29.47	28.95
37	47.13	36.15	35.62	35.10	34.58	34.05	33.53	33.01	32.48	31.96	31.44
38	49.76	38.76	38.24	37.72	37.19	36.67	36.14	35.62	35.10	34.57	34.05
39	52.51	41.50	40.98	40.46	39.93	39.41	38.88	38.36	37.84	37.31	36.79
40	55.40	44.38	43.85	43.33	42.80	42.28	41.75	41.23	40.71	40.18	39.66
+40	$\Delta e \times \Delta B$	+0.145	+0.152	+0.159	+0.166	+0.173	+0.179	+0.186	+0.193	+0.200	+0.207

t'	$t-t'$	31	32	33	34	35	36	37	38	39	40
C.		mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
+20°	$\Delta e \times \Delta B$	+0.209	+0.216	+0.223	+0.230	+0.236	+0.243	+0.250	+0.257	+0.263	+0.270
19°		0.60	0.09								
20		1.64	1.13	0.61	0.10						
21		2.74	2.23	1.71	1.20	0.69	0.17				
22		3.90	3.39	2.87	2.36	1.84	1.33	0.82	0.30		
23		5.13	4.61	4.10	3.58	3.07	2.55	2.04	1.52	1.01	0.49
24		6.42	5.90	5.39	4.87	4.36	3.84	3.33	2.81	2.30	1.78
25		7.78	7.27	6.75	6.24	5.72	5.20	4.69	4.17	3.66	3.14
+26		9.22	8.70	8.19	7.67	7.15	6.64	6.12	5.60	5.09	4.57
27		10.73	10.22	9.70	9.18	8.67	8.15	7.63	7.11	6.60	6.08
28		12.33	11.81	11.29	10.78	10.26	9.74	9.22	8.71	8.19	7.67
29		14.01	13.49	12.97	12.45	11.93	11.42	10.90	10.38	9.86	9.34
30		15.77	15.26	14.74	14.22	13.70	13.18	12.66	12.14	11.62	11.10
+30	$\Delta e \times \Delta B$	+0.212	+0.218	+0.225	+0.232	+0.239	+0.246	+0.253	+0.259	+0.266	+0.273

RELATIVE HUMIDITY.
TEMPERATURE CENTIGRADE.

Air Temperature.	RELATIVE HUMIDITY, OR PERCENTAGE OF SATURATION.									
	10	20	30	40	50	60	70	80	90	100
C.	Vapor pressure (millimeters).									
−45°	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05
44	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.06
43	0.01	0.01	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07
42	0.01	0.02	0.02	0.03	0.04	0.05	0.05	0.06	0.07	0.08
41	0.01	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.09
−40	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
39	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11
38	0.01	0.02	0.04	0.05	0.06	0.07	0.08	0.10	0.11	0.12
37	0.01	0.03	0.04	0.05	0.07	0.08	0.09	0.11	0.12	0.14
36	0.02	0.03	0.05	0.06	0.08	0.09	0.11	0.12	0.14	0.15
−35	0.02	0.03	0.05	0.07	0.08	0.10	0.12	0.13	0.15	0.17
34	0.02	0.04	0.06	0.08	0.09	0.11	0.13	0.15	0.17	0.19
33	0.02	0.04	0.06	0.08	0.10	0.13	0.15	0.17	0.19	0.21
32	0.02	0.05	0.07	0.09	0.12	0.14	0.16	0.19	0.21	0.23
31	0.03	0.05	0.08	0.10	0.13	0.16	0.18	0.21	0.23	0.26
−30	0.03	0.06	0.09	0.12	0.14	0.17	0.20	0.23	0.26	0.29
29	0.03	0.06	0.10	0.13	0.16	0.19	0.22	0.26	0.29	0.32
28	0.04	0.07	0.11	0.14	0.18	0.21	0.25	0.28	0.32	0.35
27	0.04	0.08	0.12	0.16	0.20	0.24	0.27	0.31	0.35	0.39
26	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.35	0.39	0.43
−25	0.05	0.10	0.14	0.19	0.24	0.29	0.34	0.38	0.43	0.48
24	0.05	0.11	0.16	0.21	0.27	0.32	0.37	0.42	0.48	0.53
23	0.06	0.12	0.18	0.23	0.29	0.35	0.41	0.47	0.53	0.59
22	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52	0.58	0.65
21	0.07	0.14	0.21	0.28	0.36	0.43	0.50	0.57	0.64	0.71
−20	0.08	0.16	0.24	0.31	0.39	0.47	0.55	0.63	0.71	0.78
19	0.09	0.17	0.26	0.34	0.43	0.52	0.60	0.69	0.78	0.86
18	0.09	0.19	0.28	0.38	0.47	0.57	0.66	0.76	0.85	0.95
17	0.10	0.21	0.31	0.42	0.52	0.62	0.73	0.83	0.94	1.04
16	0.11	0.23	0.34	0.46	0.57	0.69	0.80	0.91	1.03	1.14
−15	0.13	0.25	0.38	0.50	0.63	0.75	0.88	1.00	1.13	1.25
14	0.14	0.27	0.41	0.55	0.69	0.82	0.96	1.10	1.24	1.37
13	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50
12	0.16	0.33	0.49	0.66	0.82	0.99	1.15	1.32	1.48	1.64
11	0.18	0.36	0.54	0.72	0.90	1.08	1.26	1.44	1.62	1.80
−10	0.20	0.39	0.59	0.79	0.98	1.18	1.38	1.57	1.77	1.96
9	0.21	0.43	0.64	0.86	1.07	1.29	1.50	1.72	1.93	2.14
8	0.23	0.47	0.70	0.94	1.17	1.40	1.64	1.87	2.11	2.34
7	0.26	0.51	0.77	1.02	1.28	1.53	1.79	2.04	2.30	2.55
6	0.28	0.56	0.83	1.11	1.39	1.67	1.94	2.22	2.50	2.78
−5	0.30	0.60	0.91	1.21	1.51	1.81	2.12	2.42	2.72	3.02
4	0.33	0.66	0.99	1.32	1.65	1.97	2.30	2.63	2.96	3.29
3	0.36	0.72	1.07	1.43	1.79	2.15	2.50	2.86	3.22	3.58
2	0.39	0.78	1.17	1.55	1.94	2.33	2.72	3.11	3.50	3.89
1	0.42	0.84	1.27	1.69	2.11	2.53	2.95	3.38	3.80	4.22
± 0	0.46	0.92	1.37	1.83	2.29	2.75	3.21	3.66	4.12	4.58
+ 1	0.49	0.98	1.48	1.97	2.46	2.95	3.45	3.94	4.43	4.92
2	0.53	1.06	1.59	2.12	2.65	3.17	3.70	4.23	4.76	5.29
3	0.57	1.14	1.70	2.27	2.84	3.41	3.98	4.55	5.11	5.68
4	0.61	1.22	1.83	2.44	3.05	3.66	4.27	4.88	5.49	6.10
+ 5	0.65	1.31	1.96	2.62	3.27	3.92	4.58	5.23	5.89	6.54

RELATIVE HUMIDITY.

TEMPERATURE CENTIGRADE.

Air Temper-ature.	RELATIVE HUMIDITY, OR PERCENTAGE OF SATURATION.									
	10	20	30	40	50	60	70	80	90	100
C.	Vapor pressure (millimeters).									
5°	0.7	1.3	2.0	2.6	3.3	3.9	4.6	5.2	5.9	6.5
6	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	7.0
7	0.8	1.5	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5
8	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0
9	0.9	1.7	2.6	3.4	4.3	5.2	6.0	6.9	7.7	8.6
10	0.9	1.8	2.8	3.7	4.6	5.5	6.4	7.4	8.3	9.2
11	1.0	2.0	3.0	3.9	4.9	5.9	6.9	7.9	8.9	9.8
12	1.1	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5
13	1.1	2.2	3.4	4.5	5.6	6.7	7.9	9.0	10.1	11.2
14	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0
15	1.3	2.6	3.8	5.1	6.4	7.7	9.0	10.2	11.5	12.8
16	1.4	2.7	4.1	5.5	6.8	8.2	9.5	10.9	12.3	13.6
17	1.5	2.9	4.4	5.8	7.3	8.7	10.2	11.6	13.1	14.5
18	1.5	3.1	4.6	6.2	7.7	9.3	10.8	12.4	13.9	15.5
19	1.6	3.3	4.9	6.6	8.2	9.9	11.5	13.2	14.8	16.5
20	1.8	3.5	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5
21	1.9	3.7	5.6	7.5	9.3	11.2	13.1	14.9	16.8	18.7
22	2.0	4.0	6.0	7.9	9.9	11.9	13.9	15.9	17.9	19.8
23	2.1	4.2	6.3	8.4	10.5	12.7	14.8	16.9	19.0	21.1
24	2.2	4.5	6.7	9.0	11.2	13.4	15.7	17.9	20.2	22.4
25	2.4	4.8	7.1	9.5	11.9	14.3	16.6	19.0	21.4	23.8
26	2.5	5.0	7.6	10.1	12.6	15.1	17.7	20.2	22.7	25.2
27	2.7	5.4	8.0	10.7	13.4	16.1	18.7	21.4	24.1	26.8
28	2.8	5.7	8.5	11.4	14.2	17.0	19.9	22.7	25.5	28.4
29	3.0	6.0	9.0	12.0	15.0	18.0	21.1	24.1	27.1	30.1
30	3.2	6.4	9.6	12.7	15.9	19.1	22.3	25.5	28.7	31.9
31	3.4	6.7	10.1	13.5	16.9	20.2	23.6	27.0	30.4	33.7
32	3.6	7.1	10.7	14.3	17.9	21.4	25.0	28.6	32.1	35.7
33	3.8	7.6	11.3	15.1	18.9	22.7	26.4	30.2	34.0	37.8
34	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	39.9
35	4.2	8.4	12.7	16.9	21.1	25.3	29.6	33.8	38.0	42.2
36	4.5	8.9	13.4	17.8	22.3	26.8	31.2	35.7	40.2	44.6
37	4.7	9.4	14.1	18.9	23.6	28.3	33.0	37.7	42.4	47.1
38	5.0	10.0	14.9	19.9	24.9	29.9	34.8	39.8	44.8	49.8
39	5.3	10.5	15.8	21.0	26.3	31.5	36.8	42.0	47.3	52.5
40	5.5	11.1	16.6	22.2	27.7	33.2	38.8	44.3	49.9	55.4
41	5.8	11.7	17.5	23.4	29.2	35.1	40.9	46.7	52.6	58.4
42	6.2	12.3	18.5	24.6	30.8	36.9	43.1	49.3	55.4	61.6
43	6.5	13.0	19.5	26.0	32.4	38.9	45.4	51.9	58.4	64.9
44	6.8	13.7	20.5	27.3	34.2	41.0	47.8	54.7	61.5	68.4
45	7.2	14.4	21.6	28.8	36.0	43.2	50.4	57.6	64.8	72.0
46	7.6	15.2	22.7	30.3	37.9	45.5	53.0	60.6	68.2	75.8
47	8.0	15.9	23.9	31.9	39.9	47.8	55.8	63.8	71.7	79.7
48	8.4	16.8	25.1	33.5	41.9	50.3	58.7	67.1	75.4	83.8
49	8.8	17.6	26.4	35.3	44.1	52.9	61.7	70.5	79.3	88.1
50	9.3	18.5	27.8	37.1	46.3	55.6	64.8	74.1	83.4	92.6
51	9.7	19.5	29.2	38.9	48.7	58.4	68.1	77.9	87.6	97.3
52	10.2	20.4	30.7	40.9	51.1	61.3	71.6	81.8	92.0	102.2
53	10.7	21.5	32.2	42.9	53.7	64.4	75.1	85.9	96.6	107.3
54	11.3	22.5	33.8	45.1	56.3	67.6	78.9	90.1	101.4	112.7
55	11.8	23.6	35.5	47.3	59.1	70.9	82.7	94.6	106.4	118.2

TABLE 79.

RATE OF DECREASE OF VAPOR PRESSURE WITH ALTITUDE FOR MOUNTAIN STATIONS.

(*According to the empirical formula of Dr. J. Hann.*)

$$\frac{e}{e_0} = 10^{-\frac{h}{6200}}$$

e, e_0 = Vapor pressures at an upper and a lower station respectively.
h = Difference of altitude in meters.

Difference of Altitude.		$\frac{e}{e_0}$.	Difference of Altitude.		$\frac{e}{e_0}$.	Difference of Altitude.		$\frac{e}{e_0}$.
Meters.	Feet.		Meters.	Feet.		Meters.	Feet.	
200	656	0.93	1800	5905	0.52	3400	11155	0.29
400	1312	.86	2000	6562	.48	3600	11811	.27
600	1968	.80	2200	7218	.45	3800	12467	.25
800	2625	.75	2400	7874	.42	4000	13123	.23
1000	3281	0.69	2600	8530	0.39	4500	14764	0.19
1200	3937	.64	2800	9186	.36	5000	16404	.16
1400	4593	.60	3000	9842	.33	5500	18045	.13
1600	5249	.56	3200	10499	.31	6000	19685	.11

TABLE 80.

DEPTH OF WATER CORRESPONDING TO THE WEIGHT OF A CYLINDRICAL SNOW CORE 2.655 INCHES IN DIAMETER.

(One-fifth pound equals 1 inch.)

Weight lbs.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
.0	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45
.1	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
.2	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45
.3	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95
.4	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45
.5	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85	2.90	2.95
.6	3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45
.7	3.50	3.55	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95
.8	4.00	4.05	4.10	4.15	4.20	4.25	4.30	4.35	4.40	4.45
.9	4.50	4.55	4.60	4.65	4.70	4.75	4.80	4.85	4.90	4.95
1.0	5.00	5.05	5.10	5.15	5.20	5.25	5.30	5.35	5.40	5.45
1.1	5.50	5.55	5.60	5.65	5.70	5.75	5.80	5.85	5.90	5.95
1.2	6.00	6.05	6.10	6.15	6.20	6.25	6.30	6.35	6.40	6.45
1.3	6.50	6.55	6.60	6.65	6.70	6.75	6.80	6.85	6.90	6.95
1.4	7.00	7.05	7.10	7.15	7.20	7.25	7.30	7.35	7.40	7.45
1.5	7.50	7.55	7.60	7.65	7.70	7.75	7.80	7.85	7.90	7.95
1.6	8.00	8.05	8.10	8.15	8.20	8.25	8.30	8.35	8.40	8.45
1.7	8.50	8.55	8.60	8.65	8.70	8.75	8.80	8.85	8.90	8.95
1.8	9.00	9.05	9.10	9.15	9.20	9.25	9.30	9.35	9.40	9.45
1.9	9.50	9.55	9.60	9.65	9.70	9.75	9.80	9.85	9.90	9.95
2.0	10.00	10.05	10.10	10.15	10.20	10.25	10.30	10.35	10.40	10.45
2.1	10.50	10.55	10.60	10.65	10.70	10.75	10.80	10.85	10.90	10.95
2.2	11.00	11.05	11.10	11.15	11.20	11.25	11.30	11.35	11.40	11.45
2.3	11.50	11.55	11.60	11.65	11.70	11.75	11.80	11.85	11.90	11.95
2.4	12.00	12.05	12.10	12.15	12.20	12.25	12.30	12.35	12.40	12.45
2.5	12.50	12.55	12.60	12.65	12.70	12.75	12.80	12.85	12.90	12.95
2.6	13.00	13.05	13.10	13.15	13.20	13.25	13.30	13.35	13.40	13.45
2.7	13.50	13.55	13.60	13.65	13.70	13.75	13.80	13.85	13.90	13.95
2.8	14.00	14.05	14.10	14.15	14.20	14.25	14.30	14.35	14.40	14.45
2.9	14.50	14.55	14.60	14.65	14.70	14.75	14.80	14.85	14.90	14.95

DEPTH OF WATER CORRESPONDING TO THE WEIGHT OF SNOW (OR RAIN) COLLECTED IN AN 8-INCH GAGE. (One pound equals 0.5507 inch.)

Weight Pounds.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
.0	.00	.01	.01	.02	.02	.03	.03	.04	.04	.05
.1	.06	.06	.07	.07	.08	.08	.09	.09	.10	.10
.2	.11	.12	.12	.13	.13	.14	.14	.15	.15	.16
.3	.17	.17	.18	.18	.19	.19	.20	.20	.21	.22
.4	.22	.23	.23	.24	.24	.25	.25	.26	.26	.27
.5	.28	.28	.29	.29	.30	.30	.31	.31	.32	.33
.6	.33	.34	.34	.35	.35	.36	.36	.37	.38	.38
.7	.39	.39	.40	.40	.41	.41	.42	.43	.43	.44
.8	.44	.45	.45	.46	.46	.47	.47	.48	.49	.49
.9	.50	.50	.51	.51	.52	.52	.53	.54	.54	.55

QUANTITY OF RAINFALL CORRESPONDING TO GIVEN DEPTHS.

Depth of rainfall, inches.	Cubic inches per acre.	Cubic feet per acre.	Gallons per acre.		Tons per acre (2000 pounds). (62° F.)
			United States or Queen Anne.	Imperial (British).	
0.01	62726.4	36.3	271.5	226	1.1
0.02	125453.	72.6	543.	452	2.3
0.03	188179.	108.9	815.	678	3.4
0.04	250905.	145.2	1086.	904	4.5
0.05	313632.	181.5	1358.	1130	5.6
0.06	376358.	217.8	1629.	1356	6.8
0.07	439084.	254.1	1900.	1582	7.9
0.08	501810.	290.4	2171.	1808	9.0
0.09	564536.	326.7	2442.	2034	10.1
0.10	627264.	363.0	2715.	2261	11.3
0.25	1568160.	907.5	6789.	5652	28.
0.50	3136320.	1815.	13577.	11303	56.
0.75	4704480.	2722.	20366.	16955	85.
1.00	6272640.	3630.	27154.	22607	113.
1.25	7840800.	4538.	33943.	28259	141.
1.50	9408960.	5445.	40371.	33911	170.
1.75	10977120.	6352.	47520.	39563	198.
2.00	12545280.	7260.	54309.	45214	226.
2.25	14113440.	8168.	61097.	50866	255.
2.50	15681600.	9075.	67866.	56517	283.
2.75	17249760.	9982.	74674.	62169	311.
3.00	18817920.	10890.	81463.	67821	339.
4.00	25090560.	14520.	108617.	90428	452.
5.00	31363200.	18150	135772.	113035	565.
6.00	37635840.	21780.	162926.	135642	678.

GEODETICAL TABLES.

VALUE OF GRAVITY ON THE EARTH AT SEA LEVEL.

$$g_\phi = 978.039\,(1 + 0.005294\,\sin^2\phi - 0.000007\,\sin^2 2\phi)$$
$$= 980.621\,(1 - 0.002640\,\cos 2\phi + 0.000007\,\cos^2 2\phi)$$

ϕ	g_ϕ	ϕ	g_ϕ	ϕ	g_ϕ	ϕ	g_ϕ	ϕ	g_ϕ
° ′	Dynes.	° ′	Dynes.	° ′	Dynes.	° ′	Dynes.	° ′	Dynes.
0 0	978.039	20 00	978.642	37 00	979.908	54 00	981.422	71 00	982.665
1 0	.041	20	.661	20	.937	20	.450	20	.684
2 0	.045	40	.681	40	.966	40	.479	40	.702
3 0	.053	21 00	.701	38 00	.995	55 00	.507	72 00	.720
4 0	.064	20	.721	20	980.024	20	.535	20	.738
		40	.742	40	.054	40	.564	40	.755
5 00	.078	22 00	.762	39 00	.083	56 00	.592	73 00	.772
20	.084	20	.783	20	.113	20	.620	20	.789
40	.089	40	.805	40	.142	40	.647	40	.805
6 00	.095	23 00	.826	40 00	.172	57 00	.675	74 00	.822
20	.102	20	.848	20	.201	20	.703	20	.837
40	.108	40	.870	40	.231	40	.730	40	.853
7 00	.115	24 00	.892	41 00	.261	58 00	.757	75 00	.868
20	.123	20	.914	20	.291	20	.784	20	.883
40	.131	40	.937	40	.321	40	.811	40	.898
8 00	.139	25 00	.960	42 00	.350	59 00	.838	76 00	.912
20	.147	20	.983	20	.380	20	.865	20	.926
40	.156	40	979.006	40	.410	40	.891	40	.940
9 00	.165	26 00	.030	43 00	.440	60 00	.917	77 00	.953
20	.174	20	.054	20	.471	20	.943	20	.966
40	.184	40	.077	40	.501	40	.969	40	.979
10 00	.194	27 00	.102	44 00	.531	61 00	.995	78 00	.992
20	.205	20	.126	20	.561	20	982.020	20	983.004
40	.215	40	.151	40	.591	40	.046	40	.016
11 00	.227	28 00	.175	45 00	.621	62 00	.071	79 00	.027
20	.238	20	.201	20	.651	20	.096	20	.039
40	.250	40	.226	40	.681	40	.121	40	.049
12 00	.262	29 00	.251	46 00	.711	63 00	.145	80 00	.060
20	.274	20	.277	20	.741	20	.169	20	.070
40	.287	40	.302	40	.772	40	.194	40	080
13 00	.300	30 00	.328	47 00	.802	64 00	.217	81 00	.090
20	.313	20	.354	20	.832	20	.241	20	.099
40	.327	40	.381	40	.862	40	.265	40	.108
14 00	.341	31 00	.407	48 00	.892	65 00	.288	82 00	.116
20	.355	20	.434	20	.922	20	.311	20	.124
40	.369	40	.460	40	.952	40	.334	40	.132
15 00	.384	32 00	.487	49 00	.981	66 00	.356	83 00	.140
20	.399	20	.515	20	981.011	20	.379	20	.147
40	.415	40	.542	40	.041	40	.401	40	.153
16 00	.430	33 00	.569	50 00	.071	67 00	.423	84 00	.160
20	.447	20	.597	20	.100	20	.445	20	.166
40	.463	40	.624	40	.130	40	.466	40	.172
17 00	.479	34 00	.652	51 00	.160	68 00	.487	85 00	.177
20	.496	20	.680	20	.189	20	.508	20	.182
40	.514	40	.708	40	.218	40	.528	40	.187
18 00	.531	35 00	.736	52 00	.248	69 00	.549		
20	.549	20	.765	20	.277	20	.569	86 00	.192
40	.567	40	.793	40	.306	40	.589	87 00	.203
19 00	.585	36 00	.822	53 00	.335	70 00	.608	88 00	.210
20	.604	20	.850	20	.364	20	.628	89 00	.215
40	978.623	40	979.879	40	981.393	40	982.647	90 00	983.217

RELATIVE ACCELERATION OF GRAVITY AT DIFFERENT LATITUDES.

Ratio of the acceleration of gravity at sea level for each 10′ of latitude, to its acceleration at latitude 45°.

$$\frac{g_\phi}{g_{45}} = 1 - 0.002640 \cos 2\phi + 0.000007 \cos^2 2\phi$$

Latitude. ϕ	0′	10′	20′	30′	40′	50′
0°	0.997367	0.997367	0.997367	0.997367	0.997368	0.997368
1	.997369	.997369	.997370	.997371	.997371	.997372
2	.997373	.997374	.997376	.997377	.997378	.997380
3	.997381	.997383	.997385	.997387	.997388	.997390
4	.997393	.997395	.997397	.997399	.997402	.997404
5	0.997407	0.997410	0.997412	0.997415	0.997418	0.997421
6	.997424	.997428	.997431	.997434	.997438	.997441
7	.997445	.997449	.997453	.997456	.997460	.997465
8	.997469	.997473	.997477	.997482	.997486	.997491
9	.997496	.997500	.997505	.997510	.997515	.997520
10	0.997525	0.997531	0.997536	0.997541	0.997547	0.997553
11	.997558	.997564	.997570	.997576	.997582	.997588
12	.997594	.997600	.997607	.997613	.997620	.997626
13	.997633	.997640	.997646	.997653	.997660	.997667
14	.997674	.997682	.997689	.997696	.997704	.997711
15	0.997719	0.997727	0.997734	0.997742	0.997750	0.997758
16	.997766	.997774	.997783	.997791	.997799	.997808
17	.997816	.997825	.997833	.997842	.997851	.997860
18	.997869	.997878	.997887	.997896	.997905	.997915
19	.997924	.997934	.997943	.997953	.997962	.997972
20	0.997982	0.997992	0.998002	0.998012	0.998022	0.998032
21	.998042	.998052	.998063	.998073	.998084	.998094
22	.998104	.998115	.998126	.998137	.998148	.998159
23	.998170	.998181	.998192	.998203	.998214	.998225
24	.998237	.998248	.998260	.998271	.998283	.998294
25	0.998306	0.998318	0.998330	0.998341	0.998353	0.998365
26	.998377	.998389	.998402	.998414	.998426	.998438
27	.998451	.998463	.998476	.998488	.998501	.998513
28	.998526	.998539	.998551	.998564	.998577	.998590
29	.998603	.998616	.998629	.998642	.998655	.998669
30	0.998682	0.998695	0.998708	0.998722	0.998735	0.998749
31	.998762	.998776	.998789	.998803	.998817	.998830
32	.998844	.998858	.998872	.998886	.998899	.998913
33	.998927	.998941	.998956	.998970	.998984	.998998
34	.999012	.999026	.999041	.999055	.999069	.999084
35	0.999098	0.999112	0.999127	0.999141	0.999156	0.999170
36	.999185	.999199	.999214	.999229	.999243	.999258
37	.999273	.999288	.999302	.999317	.999332	.999347
38	.999362	.999377	.999392	.999406	.999421	.999436
39	.999451	.999466	.999482	.999497	.999512	.999527
40	0.999542	0.999557	0.999572	0.999587	0.999602	0.999618
41	.999633	.999648	.999663	.999678	.999694	.999709
42	.999724	.999739	.999755	.999770	.999785	.999801
43	.999816	.999831	.999847	.999862	.999877	.999893
44	.999908	.999923	.999939	.999954	.999969	.999985
45	1.000000	1.000015	1.000031	1.000046	1.000061	1.000077

RELATIVE ACCELERATION OF GRAVITY AT DIFFERENT LATITUDES.

Ratio of the acceleration of gravity at sea level for each 10′ of latitude, to its acceleration at latitude 45°.

$$\frac{g_\phi}{g_{45}} = 1 - 0.002640 \cos 2\phi + 0.000007 \cos^2 2\phi$$

Latitude. ϕ	0′	10′	20′	30′	40′	50′
45	1.000000	1.000015	1.000031	1.000046	1.000061	1.000077
46	092	108	123	138	153	169
47	184	200	215	230	246	261
48	276	291	307	322	337	352
49	368	383	398	413	428	444
50	1.000459	1.000474	1.000489	1.000504	1.000519	1.000534
51	549	564	579	594	609	624
52	639	654	669	684	699	713
53	728	743	758	773	787	802
54	816	831	846	860	875	889
55	1.000904	1.000918	1.000933	1.000947	1.000961	1.000976
56	0990	1004	1018	1033	1047	1061
57	1075	1089	1103	1117	1131	1145
58	1159	1173	1186	1200	1214	1227
59	1241	1255	1268	1282	1295	1308
60	1.001322	1.001335	1.001348	1.001362	1.001375	1.001388
61	1401	1414	1427	1440	1453	1466
62	1478	1491	1504	1517	1529	1542
63	1554	1567	1579	1591	1604	1616
64	1628	1640	1652	1664	1676	1688
65	1.001700	1.001712	1.001723	1.001735	1.001747	1.001758
66	1770	1781	1792	1804	1815	1826
67	1837	1848	1859	1870	1881	1892
68	1903	1913	1924	1935	1945	1955
69	1966	1976	1986	1996	2007	2017
70	1.002026	1.002036	1.002046	1.002056	1.002066	1.002075
71	2085	2094	2104	2113	2122	2131
72	2140	2149	2158	2167	2176	2185
73	2194	2202	2211	2219	2227	2236
74	2244	2252	2260	2268	2276	2284
75	1.002292	1.002299	1.002307	1.002314	1.002322	1.002329
76	2336	2344	2351	2358	2365	2372
77	2378	2385	2392	2398	2405	2411
78	2418	2424	2430	2436	2442	2448
79	2454	2460	2465	2471	2476	2482
80	1.002487	1.002492	1.002497	1.002502	1.002507	1.002512
81	2517	2522	2527	2531	2536	2540
82	2544	2548	2553	2557	2561	2564
83	2568	2572	2576	2579	2582	2586
84	2589	2592	2595	2598	2601	2604
85	1.002607	1.002609	1.002612	1.002614	1.002617	1.002619
86	2621	2623	2625	2627	2629	2631
87	2632	2634	2636	2637	2638	2639
88	2641	2642	2643	2643	2644	2645
89	2645	2646	2646	2647	2647	2647
90	1.002647					

LENGTH OF ONE DEGREE OF THE MERIDIAN AT DIFFERENT LATITUDES.

Latitude.	Meters.	Statute Miles.	Geographic Miles. 1′ of the Eq.	Latitude.	Meters.	Statute Miles.	Geographic Miles. 1′ of the Eq.
0°	110 568.5	68.703	59.594	45°	111 132.1	69.054	59.898
1	110 568.8	68.704	59.594	46	111 151.9	69.067	59.908
2	110 569.8	68.705	59.595	47	111 171.6	69.079	59.919
3	110 571.5	68.706	59.596	48	111 191.3	69.091	59.929
4	110 573.9	68.707	59.597	49	111 210.9	69.103	59.940
5	110 577.0	68.709	59.598	50	111 230.5	69.115	59.951
6	110 580.7	68.711	59.600	51	111 249.9	69.127	59.961
7	110 585.1	68.714	59.603	52	111 269.2	69.139	59.972
8	110 590.2	68.717	59.606	53	111 288.3	69.151	59.982
9	110 595.9	68.721	59.609	54	111 307.3	69.163	59.992
10	110 602.3	68.725	59.612	55	111 326.0	69.175	60.002
11	110 609.3	68.729	59.616	56	111 344.5	69.186	60.012
12	110 617.0	68.734	59.620	57	111 362.7	69.198	60.022
13	110 625.3	68.739	59.625	58	111 380.7	69.209	60.032
14	110 634.2	68.745	59.629	59	111 398.4	69.220	60.041
15	110 643.7	68.751	59.634	60	111 415.7	69.230	60.051
16	110 653.8	68.757	59.640	61	111 432.7	69.241	60.060
17	110 664.5	68.763	59.646	62	111 449.4	69.251	60.069
18	110 675.7	68.770	59.652	63	111 465.7	69.261	60.077
19	110 687.5	68.778	59.658	64	111 481.5	69.271	60.086
20	110 699.9	68.786	59.665	65	111 497.0	69.281	60.094
21	110 712.8	68.794	59.672	66	111 512.0	69.290	60.102
22	110 726.2	68.802	59.679	67	111 526.5	69.299	60.110
23	110 740.1	68.810	59.686	68	111 540.5	69.308	60.118
24	110 754.4	68.819	59.694	69	111 554.1	69.316	60.125
25	110 769.2	68.829	59.702	70	111 567.1	69.324	60.132
26	110 784.5	68.838	59.710	71	111 579.7	69.332	60.139
27	110 800.2	68.848	59.719	72	111 591.6	69.340	60.145
28	110 816.3	68.858	59.727	73	111 603.0	69.347	60.151
29	110 832.8	68.868	59.736	74	111 613.9	69.354	60.157
30	110 849.7	68.879	59.745	75	111 624.1	69.360	60.163
31	110 866.9	68.889	59.755	76	111 633.8	69.366	60.168
32	110 884.4	68.900	59.764	77	111 642.8	69.372	60.173
33	110 902.3	68.911	59.774	78	111 651.2	69.377	60.177
34	110 920.4	68.923	59.784	79	111 659.0	69.382	60.182
35	110 938.8	68.934	59.794	80	111 666.2	69.386	60.186
36	110 957.4	68.946	59.804	81	111 672.6	69.390	60.189
37	110 976.3	68.957	59.814	82	111 678.5	69.394	60.192
38	110 995.3	68.969	59.824	83	111 683.6	69.397	60.195
39	111 014.5	68.981	59.834	84	111 688.1	69.400	60.197
40	111 033.9	68.993	59.845	85	111 691.9	69.402	60.199
41	111 053.4	69.005	59.855	86	111 695.0	69.404	60.201
42	111 073.0	69.017	59.866	87	111 697.4	69.405	60.202
43	111 092.6	69.029	59.876	88	111 699.2	69.407	60.203
44	111 112.4	69.042	59.887	89	111 700.2	69.407	60.204
45	111 132.1	69.054	59.898	90	111 700.6	69.407	60.204

LENGTH OF ONE DEGREE OF THE PARALLEL AT DIFFERENT LATITUDES.

Latitude.	Meters.	Statute Miles.	Geographic Miles. 1′ of the Eq.	Latitude.	Meters.	Statute Miles.	Geographic Miles. 1′ of the Eq.
0°	111 321.9	69.171	60.000	45°	78 850.0	48.995	42.498
1	111 305.2	69.162	59.991	46	77 466.5	48.135	41.753
2	111 254.6	69.130	59.964	47	76 059.2	47.261	40.994
3	111 170.4	69.078	59.918	48	74 628.5	46.372	40.223
4	111 052.6	69.005	59.855	49	73 174.9	45.469	39.440
5	110 901.2	68.911	59.773	50	71 698.9	44.552	38.644
6	110 716.2	68.796	59.673	51	70 200.8	43.621	37.837
7	110 497.7	68.660	59.556	52	68 681.1	42.676	37.018
8	110 245.8	68.503	59.420	53	67 140.3	41.719	36.187
9	109 960.5	68.326	59.266	54	65 578.8	40.749	35.346
10	109 641.9	68.128	59.095	55	63 997.1	39.766	34.493
11	109 290.1	67.909	58.905	56	62 395.7	38.771	33.630
12	108 905.2	67.670	58.697	57	60 775.1	37.764	32.757
13	108 487.3	67.411	58.472	58	59 135.7	36.745	31.873
14	108 036.6	67.131	58.229	59	57 478.1	35.715	30.979
15	107 553.1	66.830	57.969	60	55 802.8	34.674	30.076
16	107 037.0	66.510	57.690	61	54 110.2	33.622	29.164
17	106 488.5	66.169	57.395	62	52 400.9	32.560	28.243
18	105 907.7	65.808	57.082	63	50 675.4	31.488	27.313
19	105 294.7	65.427	56.751	64	48 934.3	30.406	26.374
20	104 649.8	65.026	56.404	65	47 178.0	29.315	25.428
21	103 973.2	64.606	56.039	66	45 407.1	28.215	24.473
22	103 265.0	64.166	55.657	67	43 622.2	27.106	23.511
23	102 525.4	63.706	55.259	68	41 823.8	25.988	22.542
24	101 754.6	63.227	54.843	69	40 012.4	24.862	21.566
25	100 953.0	62.729	54.411	70	38 188.6	23.729	20.583
26	100 120.6	62.212	53.963	71	36 353.0	22.589	19.593
27	99 257.8	61.676	53.498	72	34 506.2	21.441	18.598
28	98 364.8	61.121	53.016	73	32 648.6	20.287	17.597
29	97 441.9	60.548	52.519	74	30 780.9	19.126	16.590
30	96 489.3	59.956	52.006	75	28 903.6	17.960	15.578
31	95 507.3	59.345	51.476	76	27 017.4	16.788	14.562
32	94 496.2	58.717	50.931	77	25 122.8	15.611	13.541
33	93 456.3	58.071	50.371	78	23 220.4	14.428	12.515
34	92 387.9	57.407	49.795	79	21 310.8	13.242	11.486
35	91 291.3	56.726	49.204	80	19 394.6	12.051	10.453
36	90 166.8	56.027	48.598	81	17 472.4	10.857	9.417
37	89 014.8	55.311	47.977	82	15 544.7	9.659	8.378
38	87 835.6	54.578	47.341	83	13 612.2	8.458	7.337
39	86 629.6	53.829	46.691	84	11 675.5	7.255	6.293
40	85 397.0	53.063	46.027	85	9 735.1	6.049	5.247
41	84 138.4	52.281	45.349	86	7 791.7	4.841	4.200
42	82 854.0	51.483	44.656	87	5 845.9	3.632	3.151
43	81 544.2	50.669	43.950	88	3 898.3	2.422	2.101
44	80 209.4	49.840	43.231	89	1 949.4	1.211	1.051
45	78 850.0	48.995	42.498	90	0.0	0.000	0.000

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	Latitude North.								
	0°	5°	10°	15°	20°	25°	30°	35°	40°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−23° 27′	12 7	11 50	11 32	11 14	10 55	10 35	10 13	9 48	9 19
−23 20	12 7	11 50	11 32	11 14	10 56	10 36	10 14	9 49	9 20
−23 0	12 7	11 50	11 33	11 15	10 57	10 37	10 15	9 51	9 23
−22 40	12 7	11 50	11 33	11 16	10 58	10 38	10 17	9 53	9 26
−22 20	12 7	11 51	11 34	11 17	10 59	10 40	10 19	9 55	9 29
−22 0	12 7	11 51	11 34	11 18	11 0	10 41	10 20	9 58	9 31
−21 40	12 7	11 51	11 35	11 19	11 1	10 43	10 22	10 0	9 34
−21 20	12 7	11 52	11 35	11 19	11 2	10 44	10 24	10 2	9 37
−21 0	12 7	11 52	11 36	11 20	11 4	10 46	10 26	10 4	9 40
−20 40	12 7	11 52	11 37	11 21	11 5	10 47	10 28	10 6	9 42
−20 20	12 7	11 52	11 37	11 22	11 6	10 49	10 29	10 8	9 45
−20 0	12 7	11 53	11 38	11 23	11 7	10 50	10 31	10 11	9 47
−19 40	12 7	11 53	11 38	11 23	11 8	10 51	10 33	10 13	9 50
−19 20	12 7	11 53	11 39	11 24	11 9	10 53	10 35	10 15	9 53
−19 0	12 7	11 53	11 39	11 25	11 10	10 54	10 37	10 17	9 55
−18 40	12 7	11 54	11 40	11 26	11 11	10 55	10 38	10 19	9 58
−18 20	12 7	11 54	11 40	11 27	11 12	10 57	10 40	10 21	10 1
−18 0	12 7	11 54	11 41	11 28	11 13	10 58	10 42	10 23	10 3
−17 40	12 7	11 54	11 41	11 28	11 14	10 59	10 43	10 26	10 5
−17 20	12 7	11 55	11 42	11 29	11 15	11 1	10 45	10 28	10 8
−17 0	12 7	11 55	11 42	11 30	11 16	11 2	10 47	10 30	10 10
−16 40	12 7	11 55	11 43	11 31	11 17	11 4	10 49	10 32	10 13
−16 20	12 7	11 55	11 43	11 31	11 18	11 5	10 50	10 34	10 16
−16 0	12 7	11 56	11 44	11 32	11 19	11 6	10 52	10 36	10 18
−15 40	12 7	11 56	11 44	11 33	11 20	11 8	10 53	10 38	10 20
−15 20	12 7	11 56	11 45	11 34	11 21	11 9	10 55	10 40	10 23
−15 0	12 7	11 56	11 45	11 34	11 22	11 10	10 57	10 42	10 25
−14 40	12 7	11 57	11 46	11 35	11 23	11 11	10 59	10 44	10 28
−14 20	12 7	11 57	11 46	11 36	11 25	11 13	11 0	10 46	10 30
−14 0	12 7	11 57	11 47	11 37	11 26	11 14	11 2	10 48	10 32
−13 40	12 7	11 57	11 47	11 37	11 27	11 16	11 4	10 50	10 35
−13 20	12 7	11 58	11 48	11 38	11 28	11 17	11 5	10 52	10 37
−13 0	12 7	11 58	11 48	11 39	11 29	11 18	11 7	10 54	10 40
−12 40	12 7	11 58	11 49	11 40	11 30	11 19	11 8	10 56	10 42
−12 20	12 7	11 58	11 49	11 40	11 31	11 21	11 10	10 58	10 44
−12 0	12 7	11 58	11 50	11 41	11 32	11 22	11 11	11 0	10 47
−11 40	12 7	11 59	11 50	11 42	11 33	11 23	11 13	11 2	10 49
−11 20	12 7	11 59	11 51	11 43	11 34	11 25	11 15	11 4	10 52
−11 0	12 7	11 59	11 51	11 43	11 35	11 26	11 16	11 6	10 54
−10 40	12 7	11 59	11 52	11 44	11 36	11 27	11 18	11 8	10 56
−10 20	12 7	12 0	11 52	11 45	11 37	11 28	11 20	11 10	10 59
−10 0	12 7	12 0	11 53	11 46	11 38	11 30	11 21	11 12	11 1
−9 40	12 7	12 0	11 53	11 46	11 39	11 31	11 23	11 14	11 3
−9 20	12 7	12 0	11 54	11 47	11 40	11 32	11 24	11 16	11 5
−9 0	12 7	12 1	11 54	11 47	11 41	11 34	11 26	11 17	11 8
−8 40	12 7	12 1	11 55	11 48	11 42	11 35	11 28	11 19	11 10
−8 20	12 7	12 1	11 55	11 49	11 43	11 36	11 29	11 21	11 12
−8 0	12 7	12 1	11 56	11 50	11 44	11 37	11 31	11 23	11 14

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.									
	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−23° 27′	9 7	8 53	8 38	8 22	8 4	7 44	7 22	6 56	6 27	5 52
−23 20	9 8	8 54	8 39	8 23	8 5	7 45	7 24	6 58	6 29	5 54
−23 0	9 11	8 58	8 43	8 28	8 10	7 50	7 29	7 4	6 36	6 2
−22 40	9 14	9 1	8 46	8 31	8 14	7 55	7 34	7 10	6 43	6 9
−22 20	9 17	9 4	8 50	8 35	8 18	8 0	7 39	7 16	6 49	6 17
−22 0	9 20	9 7	8 53	8 38	8 22	8 4	7 44	7 22	6 55	6 25
−21 40	9 23	9 10	8 57	8 42	8 26	8 9	7 49	7 27	7 1	6 32
−21 20	9 26	9 13	9 1	8 46	8 30	8 13	7 54	7 32	7 8	6 38
−21 0	9 28	9 17	9 4	8 50	8 34	8 18	7 59	7 38	7 14	6 46
−20 40	9 31	9 20	9 7	8 53	8 38	8 22	8 4	7 43	7 20	6 52
−20 20	9 34	9 23	9 11	8 57	8 42	8 26	8 8	7 49	7 25	6 59
−20 0	9 37	9 26	9 14	9 1	8 46	8 31	8 13	7 54	7 31	7 5
−19 40	9 40	9 29	9 17	9 4	8 50	8 35	8 18	7 59	7 37	7 12
−19 20	9 43	9 32	9 20	9 7	8 54	8 39	8 23	8 4	7 43	7 18
−19 0	9 46	9 35	9 24	9 11	8 58	8 43	8 27	8 9	7 48	7 25
−18 40	9 48	9 38	9 27	9 15	9 2	8 47	8 32	8 14	7 54	7 31
−18 20	9 51	9 41	9 30	9 19	9 6	8 52	8 36	8 19	7 59	7 37
−18 0	9 54	9 44	9 34	9 22	9 10	8 56	8 41	8 24	8 5	7 43
−17 40	9 56	9 47	9 37	9 25	9 13	9 0	8 45	8 29	8 10	7 49
−17 20	9 59	9 50	9 40	9 29	9 17	9 4	8 50	8 34	8 15	7 55
−17 0	10 2	9 53	9 43	9 32	9 21	9 8	8 54	8 38	8 20	8 1
−16 40	10 5	9 56	9 46	9 35	9 25	9 12	8 58	8 43	8 26	8 6
−16 20	10 7	9 59	9 49	9 39	9 28	9 16	9 2	8 47	8 31	8 12
−16 0	10 10	10 1	9 52	9 43	9 32	9 20	9 7	8 52	8 36	8 17
−15 40	10 12	10 4	9 55	9 46	9 35	9 24	9 11	8 57	8 41	8 23
−15 20	10 15	10 7	9 58	9 49	9 39	9 28	9 15	9 2	8 46	8 29
−15 0	10 18	10 10	10 1	9 52	9 43	9 31	9 19	9 6	8 51	8 34
−14 40	10 20	10 13	10 4	9 56	9 46	9 35	9 23	9 11	8 56	8 40
−14 20	10 23	10 16	10 7	9 59	9 49	9 39	9 28	9 15	9 1	8 45
−14 0	10 26	10 19	10 10	10 2	9 53	9 43	9 32	9 19	9 6	8 50
−13 40	10 28	10 21	10 13	10 5	9 56	9 47	9 36	9 24	9 11	8 56
−13 20	10 31	10 24	10 16	10 8	10 0	9 50	9 40	9 28	9 16	9 1
−13 0	10 33	10 26	10 19	10 11	10 3	9 54	9 44	9 33	9 20	9 6
−12 40	10 36	10 29	10 22	10 15	10 7	9 58	9 48	9 37	9 25	9 11
−12 20	10 38	10 32	10 25	10 18	10 10	10 1	9 52	9 41	9 30	9 17
−12 0	10 41	10 35	10 28	10 21	10 13	10 5	9 56	9 46	9 35	9 22
−11 40	10 44	10 38	10 31	10 25	10 17	10 9	10 0	9 50	9 39	9 27
−11 20	10 46	10 40	10 34	10 28	10 20	10 13	10 4	9 55	9 44	9 32
−11 0	10 49	10 43	10 37	10 31	10 23	10 16	10 8	9 59	9 49	9 37
−10 40	10 51	10 46	10 40	10 34	10 27	10 19	10 12	10 3	9 53	9 42
−10 20	10 53	10 49	10 43	10 37	10 31	10 23	10 16	10 7	9 58	9 47
−10 0	10 56	10 51	10 46	10 40	10 34	10 27	10 19	10 11	10 3	9 52
− 9 40	10 59	10 54	10 49	10 43	10 37	10 31	10 23	10 16	10 7	9 57
− 9 20	11 1	10 56	10 52	10 46	10 40	10 34	10 27	10 20	10 11	10 2
− 9 0	11 3	10 59	10 55	10 49	10 44	10 37	10 31	10 24	10 16	10 7
− 8 40	11 6	11 2	10 57	10 52	10 47	10 41	10 34	10 28	10 20	10 11
− 8 20	11 8	11 4	11 0	10 55	10 50	10 44	10 38	10 32	10 25	10 16
− 8 0	11 10	11 7	11 3	10 58	10 53	10 48	10 42	10 36	10 29	10 21

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.								
	0°	5°	10°	15°	20°	25°	30°	35°	40°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−8° 0′	12 7	12 1	11 55	11 50	11 44	11 37	11 31	11 23	11 14
−7 40	12 7	12 1	11 56	11 50	11 45	11 38	11 32	11 25	11 17
−7 20	12 7	12 1	11 56	11 51	11 46	11 40	11 34	11 27	11 19
−7 0	12 7	12 2	11 57	11 52	11 47	11 41	11 35	11 29	11 22
−6 40	12 7	12 2	11 57	11 53	11 48	11 42	11 37	11 31	11 24
−6 20	12 7	12 2	11 58	11 53	11 49	11 43	11 38	11 32	11 26
−6 0	12 7	12 2	11 58	11 54	11 50	11 45	11 40	11 34	11 28
−5 40	12 7	12 3	11 59	11 55	11 51	11 46	11 41	11 36	11 31
−5 20	12 7	12 3	11 59	11 55	11 52	11 47	11 43	11 38	11 33
−5 0	12 7	12 3	12 0	11 56	11 53	11 49	11 44	11 40	11 35
−4 40	12 7	12 3	12 0	11 57	11 54	11 50	11 46	11 42	11 37
−4 20	12 7	12 4	12 1	11 58	11 55	11 51	11 47	11 44	11 40
−4 0	12 7	12 4	12 1	11 58	11 56	11 52	11 49	11 46	11 42
−3 40	12 7	12 4	12 2	11 59	11 57	11 53	11 51	11 47	11 44
−3 20	12 7	12 4	12 2	12 0	11 58	11 55	11 52	11 49	11 46
−3 0	12 7	12 5	12 3	12 1	11 58	11 56	11 54	11 51	11 49
−2 40	12 7	12 5	12 3	12 1	11 59	11 58	11 55	11 53	11 51
−2 20	12 7	12 5	12 4	12 2	12 0	11 59	11 57	11 55	11 53
−2 0	12 7	12 5	12 4	12 3	12 1	12 0	11 58	11 57	11 55
−1 40	12 7	12 5	12 4	12 4	12 2	12 1	12 0	11 59	11 58
−1 20	12 7	12 6	12 5	12 4	12 3	12 2	12 2	12 1	12 0
−1 0	12 7	12 6	12 5	12 5	12 4	12 4	12 3	12 2	12 2
−0 40	12 7	12 6	12 6	12 5	12 5	12 5	12 5	12 4	12 4
−0 20	12 7	12 6	12 6	12 6	12 6	12 6	12 6	12 6	12 7
0 0	12 7	12 7	12 7	12 7	12 7	12 7	12 8	12 8	12 9
+0 20	12 7	12 7	12 7	12 8	12 8	12 8	12 9	12 10	12 11
0 40	12 7	12 7	12 8	12 8	12 9	12 10	12 11	12 12	12 13
1 0	12 7	12 7	12 8	12 9	12 10	12 11	12 13	12 14	12 15
1 20	12 7	12 8	12 9	12 10	12 11	12 13	12 14	12 16	12 17
1 40	12 7	12 8	12 9	12 10	12 12	12 14	12 16	12 17	12 20
2 0	12 7	12 8	12 10	12 11	12 13	12 15	12 17	12 19	12 22
2 20	12 7	12 8	12 10	12 12	12 14	12 16	12 19	12 21	12 25
2 40	12 7	12 9	12 11	12 13	12 15	12 17	12 20	12 23	12 27
3 0	12 7	12 9	12 11	12 13	12 16	12 19	12 22	12 25	12 29
3 20	12 7	12 9	12 12	12 14	12 17	12 20	12 23	12 27	12 31
3 40	12 7	12 9	12 12	12 15	12 18	12 21	12 25	12 29	12 33
4 0	12 7	12 10	12 13	12 16	12 19	12 22	12 26	12 31	12 35
4 20	12 7	12 10	12 13	12 16	12 20	12 23	12 28	12 32	12 38
4 40	12 7	12 10	12 14	12 17	12 21	12 25	12 29	12 34	12 40
5 0	12 7	12 10	12 14	12 18	12 22	12 26	12 31	12 36	12 43
5 20	12 7	12 10	12 15	12 19	12 23	12 28	12 32	12 38	12 45
5 40	12 7	12 11	12 15	12 19	12 24	12 29	12 34	12 40	12 47
6 0	12 7	12 11	12 16	12 20	12 25	12 30	12 35	12 42	12 49
6 20	12 7	12 11	12 16	12 21	12 26	12 31	12 37	12 44	12 52
6 40	12 7	12 11	12 16	12 22	12 27	12 32	12 39	12 46	12 54
7 0	12 7	12 12	12 17	12 22	12 28	12 34	12 40	12 48	12 56
7 20	12 7	12 12	12 17	12 23	12 29	12 35	12 42	12 50	12 58
7 40	12 7	12 12	12 18	12 23	12 30	12 36	12 43	12 52	13 1
8 0	12 7	12 13	12 18	12 24	12 31	12 38	12 45	12 53	13 3

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.									
	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−8° 0′	11 11	11 7	11 3	11 58	10 53	10 48	10 43	10 36	10 30	10 21
−7 40	11 13	11 10	11 5	11 1	10 57	10 52	10 46	10 40	10 34	10 26
−7 20	11 16	11 12	11 8	11 4	11 0	10 55	10 50	10 44	10 38	10 31
−7 0	11 19	11 15	11 11	11 7	11 3	10 59	10 54	10 48	10 42	10 35
−6 40	11 21	11 17	11 14	11 10	11 7	11 2	10 58	10 52	10 47	10 40
−6 20	11 23	11 20	11 17	11 13	11 10	11 5	11 1	10 56	10 51	10 45
−6 0	11 26	11 23	11 20	11 16	11 13	11 9	11 5	11 0	10 55	10 50
−5 40	11 28	11 25	11 23	11 19	11 16	11 13	11 8	11 4	10 59	10 55
−5 20	11 31	11 28	11 25	11 22	11 19	11 16	11 13	11 8	11 4	10 59
−5 0	11 33	11 31	11 28	11 25	11 23	11 19	11 16	11 12	11 8	11 4
−4 40	11 35	11 33	11 31	11 28	11 26	11 23	11 20	11 16	11 13	11 8
−4 20	11 38	11 36	11 34	11 31	11 29	11 26	11 23	11 20	11 17	11 13
−4 0	11 40	11 38	11 37	11 34	11 32	11 30	11 27	11 24	11 21	11 18
−3 40	11 43	11 41	11 39	11 37	11 35	11 33	11 31	11 28	11 26	11 22
−3 20	11 45	11 43	11 42	11 40	11 38	11 37	11 35	11 32	11 30	11 27
−3 0	11 47	11 46	11 45	11 43	11 42	11 40	11 38	11 36	11 34	11 32
−2 40	11 50	11 49	11 47	11 46	11 45	11 44	11 42	11 40	11 38	11 37
−2 20	11 52	11 51	11 50	11 49	11 48	11 47	11 46	11 44	11 43	11 41
−2 0	11 55	11 54	11 53	11 52	11 52	11 50	11 49	11 48	11 47	11 46
−1 40	11 57	11 56	11 55	11 55	11 55	11 54	11 53	11 52	11 51	11 50
−1 20	11 59	11 59	11 58	11 58	11 58	11 57	11 57	11 56	11 56	11 55
−1 0	12 2	12 2	12 1	12 1	12 1	12 1	12 1	12 0	12 0	11 59
−0 40	12 4	12 4	12 4	12 4	12 4	12 4	12 4	12 4	12 4	12 4
−0 20	12 7	12 7	12 7	12 7	12 7	12 7	12 8	12 8	12 8	12 9
+0 0	12 9	12 9	12 10	12 10	12 10	12 11	12 11	12 12	12 13	12 13
0 20	12 11	12 12	12 13	12 13	12 14	12 14	12 15	12 16	12 17	12 18
0 40	12 14	12 14	12 15	12 16	12 17	12 17	12 19	12 20	12 21	12 23
1 0	12 16	12 17	12 18	12 19	12 20	12 21	12 22	12 24	12 25	12 27
1 20	12 19	12 20	12 20	12 22	12 23	12 25	12 26	12 28	12 29	12 32
1 40	12 21	12 22	12 23	12 25	12 26	12 28	12 30	12 32	12 34	12 37
2 0	12 23	12 25	12 26	12 28	12 29	12 31	12 34	12 36	12 38	12 41
2 20	12 26	12 28	12 29	12 31	12 32	12 35	12 37	12 40	12 43	12 46
2 40	12 28	12 30	12 32	12 34	12 36	12 38	12 41	12 44	12 47	12 50
3 0	12 31	12 32	12 35	12 37	12 39	12 41	12 44	12 48	12 51	12 55
3 20	12 33	12 35	12 37	12 40	12 42	12 45	12 48	12 52	12 55	13 0
3 40	12 35	12 38	12 40	12 43	12 46	12 49	12 52	12 56	13 0	13 4
4 0	12 38	12 40	12 43	12 46	12 49	12 52	12 56	13 0	13 4	13 9
4 20	12 40	12 43	12 46	12 49	12 52	12 55	12 59	13 4	13 8	13 14
4 40	12 43	12 46	12 49	12 52	12 55	12 59	13 3	13 8	13 13	13 19
5 0	12 45	12 48	12 51	12 55	12 58	13 2	13 7	13 12	13 17	13 23
5 20	12 47	12 51	12 54	12 58	13 2	13 6	13 11	13 16	13 22	13 28
5 40	12 50	12 53	12 57	13 1	13 5	13 10	13 14	13 20	13 26	13 33
6 0	12 53	12 56	12 59	13 4	13 8	13 13	13 18	13 24	13 31	13 38
6 20	12 55	12 59	13 2	13 7	13 11	13 16	13 22	13 28	13 35	13 43
6 40	12 58	13 1	13 5	13 10	13 14	13 20	13 26	13 32	13 39	13 47
7 0	13 0	13 4	13 8	13 13	13 18	13 23	13 29	13 36	13 44	13 52
7 20	13 2	13 7	13 11	13 16	13 21	13 27	13 33	13 40	13 48	13 57
7 40	13 5	13 9	13 14	13 19	13 25	13 31	13 37	13 44	13 53	14 2
8 0	13 7	13 12	13 17	13 22	13 28	13 34	13 41	13 48	13 57	14 7

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.								
	0°	5°	10°	15°	20°	25°	30°	35°	40°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
+8° 0′	12 7	12 13	12 18	12 24	12 31	12 38	12 45	12 53	13 3
8 20	12 7	12 13	12 19	12 25	12 32	12 39	12 47	12 55	13 5
8 40	12 7	12 13	12 19	12 26	12 33	12 40	12 48	12 57	13 8
9 0	12 7	12 13	12 20	12 26	12 34	12 41	12 50	12 59	13 10
9 20	12 7	12 13	12 20	12 27	12 35	12 43	12 52	13 1	13 13
9 40	12 7	12 14	12 21	12 28	12 36	12 44	12 53	13 3	13 14
10 0	12 7	12 14	12 21	12 29	12 37	12 45	12 55	13 5	13 17
10 20	12 7	12 14	12 22	12 29	12 38	12 47	12 56	13 7	13 19
10 40	12 7	12 14	12 22	12 30	12 39	12 48	12 58	13 9	13 22
11 0	12 7	12 15	12 23	12 31	12 40	12 49	12 59	13 11	13 24
11 20	12 7	12 15	12 23	12 32	12 41	12 50	13 1	13 13	13 26
11 40	12 7	12 15	12 24	12 32	12 42	12 52	13 2	13 15	13 29
12 0	12 7	12 15	12 24	12 33	12 43	12 53	13 4	13 17	13 31
12 20	12 7	12 16	12 25	12 34	12 44	12 55	13 6	13 19	13 34
12 40	12 7	12 16	12 25	12 35	12 45	12 56	13 8	13 21	13 36
13 0	12 7	12 16	12 26	12 35	12 46	12 57	13 9	13 23	13 38
13 20	12 7	12 16	12 26	12 36	12 47	12 58	13 11	13 25	13 41
13 40	12 7	12 17	12 27	12 37	12 48	13 0	13 13	13 27	13 43
14 0	12 7	12 17	12 27	12 38	12 49	13 1	13 14	13 29	13 46
14 20	12 7	12 17	12 28	12 39	12 50	13 2	13 16	13 31	13 48
14 40	12 7	12 17	12 28	12 40	12 51	13 4	13 17	13 33	13 51
15 0	12 7	12 18	12 29	12 40	12 52	13 5	13 19	13 35	13 53
15 20	12 7	12 18	12 29	12 41	12 53	13 7	13 21	13 37	13 56
15 40	12 7	12 18	12 30	12 41	12 54	13 8	13 23	13 39	13 58
16 0	12 7	12 19	12 30	12 42	12 55	13 9	13 25	13 41	14 1
16 20	12 7	12 19	12 31	12 43	12 56	13 11	13 26	13 43	14 3
16 40	12 7	12 19	12 31	12 44	12 58	13 12	13 28	13 45	14 6
17 0	12 7	12 19	12 32	12 45	12 59	13 13	13 29	13 47	14 8
17 20	12 7	12 20	12 32	12 46	13 0	13 15	13 31	13 50	14 11
17 40	12 7	12 20	12 33	12 46	13 1	13 16	13 33	13 52	14 14
18 0	12 7	12 20	12 33	12 47	13 2	13 17	13 35	13 54	14 16
18 20	12 7	12 20	12 34	12 48	13 3	13 19	13 37	13 56	14 19
18 40	12 7	12 21	12 34	12 49	13 4	13 20	13 38	13 58	14 22
19 0	12 7	12 21	12 35	12 50	13 5	13 22	13 40	14 0	14 24
19 20	12 7	12 21	12 35	12 51	13 6	13 23	13 42	14 2	14 26
19 40	12 7	12 22	12 36	12 52	13 7	13 25	13 44	14 5	14 29
20 0	12 7	12 22	12 36	12 52	13 8	13 26	13 46	14 7	14 32
20 20	12 7	12 22	12 37	12 53	13 10	13 28	13 47	14 10	14 35
20 40	12 7	12 22	12 37	12 54	13 11	13 29	13 49	14 12	14 37
21 0	12 7	12 23	12 38	12 55	13 12	13 31	13 51	14 14	14 40
21 20	12 7	12 23	12 39	12 56	13 13	13 32	13 53	14 16	14 43
21 40	12 7	12 23	12 39	12 56	13 14	13 34	13 55	14 19	14 46
22 0	12 7	12 24	12 40	12 57	13 16	13 35	13 56	14 21	14 49
22 20	12 7	12 24	12 41	12 58	13 17	13 37	13 58	14 23	14 52
22 40	12 7	12 24	12 41	12 59	13 18	13 38	14 0	14 25	14 54
23 0	12 7	12 25	12 42	13 0	13 19	13 40	14 2	14 28	14 57
23 20	12 7	12 25	12 42	13 1	13 20	13 41	14 4	14 30	15 0
23 27	12 7	12 25	12 43	13 1	13 20	13 41	14 5	14 31	15 1

DURATION OF SUNSHINE AT DIFFERENT LATITUDES

Declination of the Sun.	LATITUDE NORTH.									
	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
+8° 0′	13 7	13 12	13 17	13 22	13 28	13 34	13 41	13 49	13 58	14 7
8 20	13 10	13 14	13 20	13 25	13 31	13 38	13 45	13 53	14 2	14 12
8 40	13 12	13 17	13 23	13 28	13 34	13 41	13 49	13 57	14 6	14 17
9 0	13 15	13 20	13 25	13 31	13 38	13 45	13 53	14 1	14 11	14 22
9 20	13 17	13 23	13 28	13 34	13 41	13 49	13 56	14 5	14 15	14 26
9 40	13 20	13 25	13 31	13 38	13 44	13 52	14 0	14 10	14 20	14 31
10 0	13 22	13 28	13 34	13 41	13 48	13 56	14 4	14 14	14 25	14 36
10 20	13 25	13 31	13 37	13 44	13 51	13 59	14 8	14 18	14 29	14 41
10 40	13 28	13 34	13 40	13 47	13 55	14 3	14 12	14 22	14 34	14 47
11 0	13 30	13 36	13 43	13 50	13 58	14 7	14 16	14 27	14 38	14 52
11 20	13 32	13 39	13 46	13 53	14 1	14 10	14 20	14 31	14 43	14 57
11 40	13 35	13 41	13 49	13 56	14 5	14 14	14 24	14 35	14 48	15 2
12 0	13 38	13 44	13 52	14 0	14 8	14 18	14 28	14 40	14 53	15 8
12 20	13 40	13 47	13 55	14 3	14 12	14 22	14 32	14 44	14 58	15 13
12 40	13 43	13 50	13 58	14 6	14 16	14 25	14 37	14 49	15 2	15 18
13 0	13 46	13 53	14 1	14 10	14 19	14 29	14 41	14 53	15 7	15 23
13 20	13 48	13 56	14 4	14 13	14 22	14 33	14 45	14 58	15 13	15 29
13 40	13 50	13 58	14 7	14 16	14 26	14 37	14 49	15 2	15 17	15 35
14 0	13 53	14 1	14 10	14 19	14 29	14 41	14 53	15 7	15 22	15 40
14 20	13 56	14 4	14 13	14 23	14 33	14 45	14 57	15 11	15 28	15 46
14 40	13 59	14 7	14 16	14 26	14 37	14 49	15 2	15 16	15 33	15 51
15 0	14 1	14 10	14 19	14 29	14 40	14 52	15 6	15 21	15 38	15 57
15 20	14 4	14 13	14 22	14 33	14 44	14 56	15 10	15 26	15 43	16 2
15 40	14 7	14 16	14 26	14 36	14 48	15 0	15 14	15 30	15 48	16 8
16 0	14 10	14 19	14 29	14 40	14 52	15 4	15 19	15 35	15 53	16 14
16 20	14 12	14 22	14 32	14 43	14 55	15 8	15 23	15 40	15 59	16 20
16 40	14 15	14 25	14 35	14 46	14 59	15 13	15 28	15 45	16 4	16 26
17 0	14 17	14 28	14 38	14 50	15 3	15 17	15 32	15 50	16 10	16 32
17 20	14 20	14 31	14 41	14 53	15 7	15 21	15 37	15 55	16 15	16 38
17 40	14 23	14 34	14 45	14 57	15 10	15 25	15 41	16 0	16 20	16 45
18 0	14 26	14 37	14 48	15 1	15 14	15 29	15 46	16 5	16 26	16 51
18 20	14 29	14 40	14 52	15 4	15 18	15 34	15 50	16 10	16 32	16 58
18 40	14 32	14 43	14 55	15 8	15 22	15 38	15 55	16 15	16 38	17 4
19 0	14 35	14 46	14 58	15 11	15 26	15 42	16 0	16 20	16 44	17 11
19 20	14 37	14 49	15 1	15 15	15 30	15 46	16 5	16 25	16 50	17 17
19 40	14 40	14 52	15 5	15 19	15 34	15 51	16 10	16 31	16 56	17 24
20 0	14 43	14 55	15 8	15 22	15 38	15 55	16 15	16 37	17 2	17 31
20 20	14 46	14 58	15 11	15 26	15 42	16 0	16 20	16 42	17 8	17 38
20 40	14 49	15 2	15 15	15 30	15 46	16 4	16 25	16 47	17 14	17 46
21 0	14 52	15 5	15 19	15 34	15 50	16 9	16 30	16 53	17 20	17 53
21 20	14 55	15 8	15 22	15 38	15 55	16 13	16 35	16 59	17 27	18 1
21 40	14 58	15 11	15 26	15 42	15 59	16 18	16 40	17 5	17 34	18 8
22 0	15 1	15 14	15 29	15 46	16 3	16 23	16 45	17 11	17 40	18 16
22 20	15 4	15 18	15 33	15 49	16 7	16 28	16 50	17 17	17 47	18 24
22 40	15 7	15 22	15 37	15 53	16 12	16 32	16 56	17 23	17 54	18 32
23 0	15 10	15 25	15 40	15 57	16 16	16 37	17 1	17 29	18 1	18 41
23 20	15 13	15 28	15 44	16 1	16 21	16 42	17 7	17 35	18 8	18 49
23 27	15 14	15 29	15 46	16 3	16 23	16 44	17 9	17 37	18 11	18 52

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.										
	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−23° 27′	5 52	5 31	5 8	4 42	4 11	3 34	2 46	1 29			
−23 20	5 55	5 34	5 12	4 46	4 16	3 40	2 53	1 41			
−23 0	6 2	5 43	5 21	4 56	4 28	3 53	3 11	2 11			
−22 40	6 10	5 51	5 30	5 6	4 39	4 7	3 27	2 35	0 59		
−22 20	6 17	5 59	5 39	5 16	4 50	4 20	3 43	2 56	1 43		
−22 0	6 25	6 7	5 47	5 25	5 1	4 32	3 58	3 14	2 13		
−21 40	6 32	6 14	5 56	5 34	5 11	4 43	4 11	3 31	2 38	1 1	
−21 20	6 39	6 22	6 4	5 43	5 20	4 55	4 24	3 47	2 59	1 45	
−21 0	6 46	6 29	6 12	5 52	5 30	5 5	4 36	4 1	3 18	2 16	
−20 40	6 52	6 37	6 20	6 1	5 40	5 16	4 48	4 16	3 35	2 41	1 2
−20 20	6 59	6 44	6 27	6 9	5 49	5 26	4 59	4 29	3 51	3 2	1 47
−20 0	7 5	6 51	6 34	6 17	5 58	5 35	5 10	4 41	4 6	3 22	2 19
−19 40	7 12	6 58	6 42	6 25	6 6	5 45	5 21	4 53	4 20	3 39	2 44
−19 20	7 18	7 4	6 49	6 33	6 14	5 54	5 31	5 5	4 34	3 55	3 6
−19 0	7 25	7 11	6 56	6 41	6 23	6 3	5 41	5 16	4 47	4 11	3 26
−18 40	7 31	7 17	7 4	6 48	6 31	6 12	5 51	5 26	4 59	4 25	3 44
−18 20	7 37	7 24	7 10	6 55	6 39	6 20	6 1	5 37	5 11	4 39	4 1
−18 0	7 43	7 31	7 17	7 3	6 47	6 29	6 10	5 47	5 22	4 52	4 16
−17 40	7 49	7 37	7 24	7 10	6 55	6 38	6 19	5 57	5 33	5 5	4 31
−17 20	7 55	7 43	7 31	7 17	7 2	6 46	6 28	6 7	5 43	5 17	4 45
−17 0	8 1	7 49	7 37	7 24	7 9	6 53	6 36	6 16	5 54	5 28	4 58
−16 40	8 6	7 55	7 44	7 31	7 17	7 1	6 44	6 26	6 4	5 40	5 11
−16 20	8 12	8 1	7 50	7 38	7 24	7 9	6 52	6 35	6 14	5 51	5 23
−16 0	8 17	8 7	7 56	7 44	7 31	7 17	7 1	6 44	6 24	6 2	5 35
−15 40	8 23	8 13	8 2	7 51	7 38	7 25	7 9	6 52	6 34	6 12	5 47
−15 20	8 29	8 19	8 8	7 58	7 45	7 32	7 17	7 1	6 43	6 22	5 59
−15 0	8 34	8 25	8 15	8 4	7 52	7 39	7 25	7 9	6 52	6 32	6 10
−14 40	8 40	8 31	8 21	8 10	7 59	7 46	7 32	7 17	7 1	6 42	6 20
−14 20	8 45	8 36	8 27	8 17	8 5	7 53	7 40	7 26	7 10	6 51	6 31
−14 0	8 50	8 42	8 33	8 23	8 12	8 1	7 47	7 34	7 18	7 1	6 41
−13 40	8 56	8 47	8 38	8 29	8 19	8 7	7 55	7 41	7 26	7 10	6 51
−13 20	9 1	8 53	8 44	8 35	8 25	8 14	8 2	7 49	7 35	7 19	7 1
−13 0	9 6	8 58	8 50	8 41	8 32	8 21	8 10	7 57	7 43	7 28	7 10
−12 40	9 11	9 4	8 56	8 47	8 38	8 28	8 17	8 5	7 51	7 37	7 20
−12 20	9 17	9 10	9 2	8 53	8 44	8 34	8 24	8 12	7 59	7 45	7 29
−12 0	9 22	9 15	9 7	8 59	8 50	8 41	8 31	8 20	8 7	7 53	7 38
−11 40	9 27	9 20	9 13	9 5	8 56	8 47	8 38	8 27	8 15	8 2	7 47
−11 20	9 32	9 25	9 19	9 11	9 3	8 54	8 44	8 34	8 23	8 10	7 56
−11 0	9 37	9 31	9 24	9 17	9 9	9 0	8 51	8 41	8 31	8 18	8 5
−10 40	9 42	9 36	9 29	9 22	9 15	9 7	8 58	8 49	8 38	8 26	8 14
−10 20	9 47	9 41	9 35	9 28	9 21	9 13	9 5	8 56	8 46	8 34	8 22
−10 0	9 52	9 46	9 40	9 34	9 27	9 19	9 11	9 3	8 53	8 42	8 31
− 9 40	9 57	9 51	9 46	9 40	9 33	9 26	9 18	9 10	9 0	8 50	8 39
− 9 20	10 2	9 56	9 51	9 45	9 39	9 32	9 25	9 16	9 8	8 58	8 47
− 9 0	10 7	10 2	9 56	9 50	9 44	9 38	9 31	9 23	9 15	9 5	8 55
− 8 40	10 11	10 7	10 2	9 56	9 50	9 44	9 37	9 30	9 22	9 13	9 3
− 8 20	10 16	10 12	10 7	10 2	9 56	9 50	9 44	9 37	9 29	9 21	9 11
− 8 0	10 21	10 17	10 12	10 7	10 2	9 56	9 50	9 43	9 36	9 28	9 19

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.									
	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−23° 27′										
−23 20										
−23 0										
−22 40										
−22 20										
−22 0										
−21 40										
−21 20										
−21 0										
−20 40										
−20 20										
−20 0										
−19 40	1 3									
−19 20	1 50									
−19 0	2 22									
−18 40	2 47	1 5								
−18 20	3 10	1 52								
−18 0	3 30	2 25								
−17 40	3 49	2 52	1 6							
−17 20	4 6	3 14	1 55							
−17 0	4 22	3 35	2 29							
−16 40	4 37	3 54	2 56	1 8						
−16 20	4 52	4 12	3 20	1 58						
−16 0	5 6	4 28	3 41	2 32						
−15 40	5 19	4 44	4 1	3 1	1 10					
−15 20	5 32	4 59	4 19	3 25	2 2					
−15 0	5 44	5 13	4 36	3 47	2 37					
−14 40	5 56	5 27	4 52	4 7	3 6	1 13				
−14 20	6 8	5 40	5 7	4 26	3 31	2 5				
−14 0	6 19	5 52	5 21	4 43	3 54	2 42				
−13 40	6 29	6 5	5 35	5 0	4 14	3 12	1 15			
−13 20	6 40	6 17	5 49	5 16	4 34	3 38	2 10			
−13 0	6 51	6 29	6 2	5 31	4 52	4 2	2 48			
−12 40	6 1	6 40	6 15	5 45	5 9	4 23	3 19	1 18		
−12 20	7 11	6 50	6 27	5 59	5 25	4 43	3 46	2 15		
−12 0	7 21	7 1	6 39	6 13	5 41	5 2	4 10	2 55		
−11 40	7 31	7 12	6 51	6 26	5 56	5 19	4 32	3 27	1 21	
−11 20	7 40	7 23	7 3	6 38	6 11	5 38	4 53	3 55	2 20	
−11 0	7 50	7 33	7 14	6 51	6 25	5 54	5 13	4 20	3 2	
−10 40	7 59	7 43	7 25	7 3	6 34	6 9	5 31	4 43	3 35	1 25
−10 20	8 8	7 53	7 35	7 15	6 52	6 23	5 49	5 5	4 5	2 27
−10 0	8 17	8 3	7 46	7 27	7 4	6 38	6 6	5 25	4 31	3 10
− 9 40	8 26	8 13	7 56	7 38	7 17	6 52	6 22	5 44	4 56	3 46
− 9 20	8 35	8 22	8 7	7 50	7 29	7 6	6 38	6 3	5 19	4 17
− 9 0	8 44	8 31	8 17	8 1	7 41	7 20	6 53	6 21	5 40	4 44
− 8 40	8 53	8 41	8 27	8 11	7 53	7 33	7 8	6 38	6 0	5 10
− 8 20	9 1	8 50	8 37	8 22	8 5	7 46	7 22	6 55	6 19	5 34
− 8 0	9 10	8 59	8 47	8 33	8 17	7 59	7 36	7 11	6 38	5 56

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.										
	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−8° 0′	10 21	10 17	10 12	10 7	10 2	9 56	9 50	9 43	9 36	9 28	9 19
−7 40	10 26	10 22	10 17	10 13	10 8	10 2	9 56	9 50	9 43	9 35	9 27
−7 20	10 31	10 27	10 23	10 18	10 13	10 8	10 3	9 57	9 50	9 43	9 35
−7 0	10 35	10 32	10 28	10 23	10 19	10 14	10 9	10 4	9 57	9 50	9 43
−6 40	10 40	10 37	10 33	10 29	10 25	10 20	10 15	10 10	10 4	9 57	9 51
−6 20	10 45	10 42	10 38	10 34	10 31	10 26	10 22	10 16	10 11	10 5	9 58
−6 0	10 50	10 47	10 43	10 40	10 36	10 32	10 28	10 23	10 18	10 12	10 6
−5 40	10 55	10 52	10 49	10 45	10 41	10 38	10 34	10 29	10 25	10 19	10 14
−5 20	10 59	10 56	10 54	10 50	10 47	10 44	10 40	10 36	10 31	10 26	10 21
−5 0	11 4	11 1	10 59	10 56	10 53	10 50	10 46	10 42	10 38	10 34	10 29
−4 40	11 8	11 6	11 4	11 1	10 58	10 55	10 52	10 49	10 45	10 41	10 36
−4 20	11 13	11 11	11 9	11 7	11 4	11 1	10 58	10 55	10 52	10 48	10 44
−4 0	11 18	11 16	11 14	11 12	11 10	11 7	11 4	11 1	10 58	10 55	10 51
−3 40	11 22	11 21	11 19	11 17	11 15	11 13	11 10	11 8	11 5	11 2	10 59
−3 20	11 27	11 26	11 24	11 22	11 20	11 19	11 16	11 14	11 11	11 9	11 6
−3 0	11 32	11 31	11 29	11 28	11 26	11 24	11 22	11 20	11 18	11 16	11 13
−2 40	11 37	11 35	11 34	11 33	11 31	11 30	11 28	11 27	11 25	11 23	11 21
−2 20	11 41	11 40	11 39	11 38	11 37	11 36	11 34	11 33	11 32	11 30	11 28
−2 0	11 46	11 45	11 44	11 43	11 43	11 41	11 40	11 40	11 38	11 37	11 35
−1 40	11 50	11 50	11 49	11 49	11 48	11 47	11 46	11 46	11 45	11 44	11 43
−1 20	11 55	11 55	11 54	11 54	11 53	11 53	11 52	11 52	11 52	11 51	11 50
−1 0	11 59	11 59	11 59	11 59	11 59	11 59	11 58	11 58	11 58	11 58	11 58
−0 40	12 4	12 4	12 4	12 4	12 4	12 4	12 4	12 4	12 5	12 5	12 5
−0 20	12 9	12 9	12 9	12 10	12 10	12 10	12 10	12 11	12 11	12 12	12 12
0 0	12 13	12 14	12 14	12 15	12 15	12 16	12 16	12 17	12 18	12 19	12 19
+0 20	12 18	12 19	12 19	12 20	12 20	12 22	12 22	12 23	12 25	12 26	12 27
0 40	12 22	12 23	12 24	12 25	12 26	12 27	12 28	12 29	12 31	12 33	12 34
1 0	12 27	12 28	12 29	12 31	12 32	12 33	12 34	12 36	12 38	12 40	12 41
1 20	12 32	12 33	12 34	12 36	12 37	12 39	12 40	12 42	12 44	12 47	12 49
1 40	12 37	12 38	12 39	12 41	12 43	12 44	12 46	12 49	12 51	12 54	12 56
2 0	12 41	12 43	12 44	12 46	12 48	12 50	12 52	12 55	12 58	13 1	13 4
2 20	12 46	12 47	12 49	12 52	12 53	12 56	12 59	13 1	13 4	13 8	13 11
2 40	12 50	12 52	12 54	12 57	12 59	13 2	13 5	13 7	13 11	13 15	13 19
3 0	12 55	12 57	12 59	13 2	13 5	13 8	13 11	13 14	13 17	13 22	13 26
3 20	13 0	13 2	13 5	13 7	13 10	13 13	13 17	13 20	13 24	13 29	13 34
3 40	13 4	13 7	13 10	13 13	13 16	13 19	13 23	13 27	13 31	13 36	13 41
4 0	13 9	13 12	13 15	13 18	13 22	13 25	13 29	13 33	13 38	13 43	13 49
4 20	13 14	13 17	13 20	13 23	13 27	13 31	13 35	13 40	13 45	13 50	13 56
4 40	13 19	13 22	13 25	13 29	13 32	13 37	13 41	13 46	13 52	13 58	14 4
5 0	13 23	13 27	13 30	13 34	13 38	13 43	13 47	13 53	13 58	14 5	14 11
5 20	13 28	13 32	13 35	13 40	13 44	13 49	13 54	13 59	14 5	14 12	14 19
5 40	13 33	13 37	13 41	13 45	13 50	13 55	14 0	14 6	14 12	14 19	14 27
6 0	13 38	13 42	13 46	13 50	13 55	14 1	14 6	14 13	14 19	14 26	14 35
6 20	13 43	13 47	13 51	13 56	14 1	14 7	14 12	14 19	14 26	14 34	14 43
6 40	13 47	13 52	13 56	14 1	14 7	14 13	14 18	14 26	14 33	14 42	14 51
7 0	13 52	13 57	14 1	14 7	14 12	14 19	14 25	14 32	14 40	14 49	14 59
7 20	13 57	14 2	14 7	14 13	14 18	14 25	14 31	14 39	14 48	14 57	15 7
7 40	14 2	14 7	14 12	14 18	14 24	14 31	14 38	14 46	14 55	15 4	15 15
8 0	14 7	14 12	14 17	14 23	14 30	14 37	14 45	14 52	15 2	15 12	15 23

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.									
	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
−8° 0′	9 10	8 59	8 47	8 33	8 17	7 58	7 37	7 10	6 38	5 56
−7 40	9 18	9 08	8 56	8 43	8 28	8 11	7 50	7 26	6 56	6 18
−7 20	9 26	9 17	9 6	8 53	8 39	8 23	8 4	7 41	7 14	6 38
−7 0	9 35	9 26	9 16	9 3	8 50	8 35	8 17	7 56	7 31	6 58
−6 40	9 43	9 34	9 25	9 14	9 1	8 47	8 30	8 11	7 47	7 17
−6 20	9 51	9 43	9 34	9 24	9 12	8 59	8 43	8 25	8 3	7 36
−6 0	9 59	9 52	9 43	9 34	9 23	9 11	8 56	8 39	8 19	7 54
−5 40	10 7	10 1	9 53	9 44	9 34	9 22	9 9	8 53	8 34	8 11
−5 20	10 15	10 9	10 2	9 53	9 44	9 34	9 22	9 7	8 50	8 28
−5 0	10 23	10 17	10 11	10 3	9 55	9 45	9 34	9 20	9 5	8 46
−4 40	10 31	10 26	10 20	10 13	10 5	9 56	9 46	9 34	9 19	9 2
−4 20	10 39	10 34	10 29	10 22	10 15	10 7	9 58	9 47	9 34	9 18
−4 0	10 47	10 43	10 38	10 32	10 26	10 18	10 10	10 0	9 49	9 34
−3 40	10 55	10 51	10 46	10 41	10 36	10 29	10 22	10 13	10 3	9 50
−3 20	11 3	10 59	10 55	10 51	10 46	10 40	10 34	10 26	10 17	10 6
−3 0	11 11	11 8	11 4	11 0	10 56	10 51	10 45	10 39	10 31	10 22
−2 40	11 19	11 16	11 13	11 10	11 6	11 2	10 57	10 52	10 45	10 37
−2 20	11 26	11 24	11 22	11 19	11 16	11 13	11 8	11 4	10 59	10 52
−2 0	11 34	11 32	11 31	11 28	11 26	11 23	11 20	11 17	11 13	11 8
−1 40	11 42	11 41	11 39	11 38	11 36	11 34	11 32	11 29	11 26	11 23
−1 20	11 49	11 49	11 48	11 47	11 46	11 45	11 43	11 42	11 40	11 38
−1 0	11 57	11 57	11 56	11 56	11 56	11 55	11 55	11 55	11 54	11 53
−0 40	12 5	12 5	12 5	12 5	12 6	12 6	12 7	12 7	12 8	12 8
−0 20	12 13	12 13	12 14	12 15	12 16	12 17	12 18	12 20	12 21	12 23
0 0	12 20	12 22	12 22	12 24	12 26	12 28	12 29	12 32	12 35	12 38
+0 20	12 28	12 30	12 31	12 34	12 36	12 38	12 41	12 44	12 49	12 53
0 40	12 36	12 38	12 40	12 43	12 46	12 49	12 53	12 57	13 2	13 9
1 0	12 44	12 46	12 49	12 52	12 56	13 0	13 5	13 10	13 16	13 24
1 20	12 52	12 55	12 58	13 2	13 6	13 11	13 16	13 23	13 30	13 40
1 40	12 59	13 3	13 7	13 11	13 16	13 22	13 28	13 36	13 44	13 55
2 0	13 7	13 11	13 16	13 20	13 26	13 32	13 40	13 49	13 59	14 11
2 20	13 15	13 19	13 25	13 30	13 36	13 43	13 52	14 1	14 13	14 27
2 40	13 23	13 28	13 33	13 40	13 46	13 54	14 4	14 14	14 28	14 43
3 0	13 31	13 36	13 42	13 49	13 57	14 5	14 16	14 28	14 42	14 59
3 20	13 39	13 44	13 51	13 59	14 7	14 17	14 28	14 41	14 56	15 16
3 40	13 47	13 53	14 1	14 8	14 17	14 28	14 40	14 55	15 11	15 33
4 0	13 55	14 2	14 10	14 18	14 28	14 40	14 53	15 8	15 27	15 50
4 20	14 3	14 10	14 19	14 28	14 38	14 51	15 5	15 22	15 43	16 7
4 40	14 11	14 19	14 28	14 38	14 49	15 2	15 18	15 36	15 58	16 25
5 0	14 19	14 28	14 37	14 48	15 0	15 14	15 31	15 50	16 14	16 44
5 20	14 27	14 37	14 46	14 58	15 11	15 26	15 44	16 5	16 31	17 3
5 40	14 35	14 45	14 56	15 8	15 22	15 38	15 57	16 20	16 47	17 22
6 0	14 44	14 54	15 5	15 19	15 33	15 50	16 11	16 35	17 5	17 43
6 20	14 52	15 3	15 15	15 29	15 44	16 3	16 25	16 51	17 23	18 5
6 40	15 1	15 12	15 25	15 40	15 56	16 16	16 39	17 7	17 41	18 27
7 0	15 10	15 22	15 35	15 50	16 8	16 29	16 53	17 23	18 1	18 50
7 20	15 18	12 31	15 45	16 1	16 20	16 42	17 8	17 40	18 21	19 16
7 40	15 27	15 40	15 55	16 12	16 32	16 55	17 23	17 58	18 42	19 44
8 0	15 35	15 50	16 5	16 23	16 44	17 9	17 39	18 16	19 5	20 15

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH.										
	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
+ 8° 0′	14 7	14 12	14 17	14 23	14 30	14 37	14 45	14 53	15 2	15 12	15 23
8 20	14 12	14 17	14 23	14 29	14 36	14 43	14 52	15 0	15 10	15 20	15 32
8 40	14 17	14 22	14 28	14 35	14 42	14 50	14 58	15 7	15 17	15 28	15 40
9 0	14 22	14 27	14 34	14 41	14 48	14 56	15 5	15 14	15 25	15 36	15 49
9 20	14 27	14 32	14 39	14 46	14 54	15 2	15 11	15 21	15 32	15 44	15 57
9 40	14 32	14 38	14 45	14 52	15 0	15 9	15 18	15 28	15 40	15 52	16 6
10 0	14 37	14 43	14 50	14 58	15 6	15 15	15 25	15 35	15 47	16 0	16 15
10 20	14 42	14 49	14 56	15 4	15 13	15 22	15 32	15 43	15 55	16 8	16 24
10 40	14 47	14 54	15 2	15 10	15 19	15 28	15 39	15 50	16 3	16 17	16 33
11 0	14 52	14 59	15 7	15 16	15 25	15 35	15 46	15 58	16 11	16 26	16 42
11 20	14 57	15 5	15 13	15 22	15 31	15 41	15 53	16 5	16 19	16 34	16 52
11 40	15 2	15 10	15 19	15 28	15 38	15 48	16 0	16 13	16 27	16 43	17 1
12 0	15 8	15 16	15 25	15 34	15 44	15 55	16 7	16 21	16 35	16 52	17 11
12 20	15 13	15 21	15 31	15 40	15 50	16 2	16 15	16 29	16 44	17 1	17 21
12 40	15 18	15 27	15 36	15 46	15 57	16 9	16 22	16 37	16 53	17 11	17 31
13 0	15 23	15 33	15 42	15 53	16 4	16 16	16 30	16 45	17 2	17 20	17 41
13 20	15 29	15 39	15 48	15 59	16 11	16 23	16 37	16 53	17 10	17 30	17 52
13 40	15 35	15 44	15 55	16 5	16 17	16 31	16 45	17 1	17 19	17 40	18 3
14 0	15 40	15 50	16 1	16 12	16 24	16 38	16 53	17 10	17 29	17 50	18 14
14 20	15 46	15 56	16 7	16 19	16 31	16 46	17 1	17 19	17 38	18 0	18 26
14 40	15 51	16 2	16 13	16 25	16 38	16 53	17 9	17 28	17 48	18 11	18 38
15 0	15 57	16 8	16 19	16 32	16 46	17 1	17 17	17 37	17 58	18 22	18 50
15 20	16 2	16 14	16 26	16 39	16 53	17 9	17 26	17 46	18 8	18 33	19 3
15 40	16 8	16 20	16 32	16 46	17 1	17 17	17 35	17 55	18 18	18 45	19 16
16 0	16 14	16 26	16 39	16 53	17 8	17 25	17 44	18 5	18 29	18 57	19 30
16 20	16 20	16 32	16 46	17 0	17 16	17 33	17 53	18 15	18 40	19 10	19 45
16 40	16 26	16 39	16 52	17 7	17 23	17 41	18 2	18 25	18 51	19 23	20 1
17 0	16 32	16 45	16 59	17 14	17 31	17 50	18 11	18 35	19 3	19 36	20 17
17 20	16 38	16 52	17 6	17 22	17 39	17 59	18 21	18 46	19 15	19 50	20 35
17 40	16 45	16 58	17 13	17 29	17 47	18 8	18 31	18 57	19 28	20 6	20 55
18 0	16 51	17 5	17 20	17 37	17 56	18 17	18 41	19 8	19 41	20 22	21 17
18 20	16 58	17 12	17 28	17 45	18 5	18 26	18 52	19 20	19 55	20 40	21 42
18 40	17 4	17 19	17 35	17 53	18 14	18 36	19 3	19 33	20 10	20 59	22 13
19 0	17 11	17 26	17 43	18 2	18 23	18 46	19 14	19 46	20 26	21 20	22 58
19 20	17 17	17 33	17 51	18 10	18 32	18 56	19 25	20 0	20 44	21 45	
19 40	17 24	17 41	17 59	18 19	18 41	19 7	19 37	20 14	21 3	22 16	
20 0	17 31	17 48	18 7	18 28	18 51	19 19	19 50	20 30	21 23	22 59	
20 20	17 38	17 56	18 15	18 37	19 1	19 30	20 4	20 47	24 47		
20 40	17 45	18 4	18 23	18 46	19 12	19 42	20 19	21 5	22 17		
21 0	17 52	18 11	18 32	18 56	19 23	19 25	20 34	21 26	23 1		
21 20	18 0	18 20	18 41	19 6	19 34	20 8	20 50	21 50			
21 40	18 8	18 28	18 50	19 16	19 46	20 22	21 8	22 19			
22 0	18 16	18 37	19 0	19 27	19 58	20 37	21 29	23 2			
22 20	18 24	18 46	19 10	19 38	20 11	20 53	21 52				
22 40	18 32	18 55	19 20	19 50	20 25	21 11	22 21				
23 0	18 41	19 4	19 31	20 2	20 40	21 31	23 3				
23 20	18 49	19 13	19 41	20 14	20 56	21 54					
23 27	18 52	19 17	19 46	20 19	21 2	22 3					

Table 87.

DURATION OF SUNSHINE AT DIFFERENT LATITUDES.

Declination of the Sun.	LATITUDE NORTH. 71°	72°	73°	74°	75°
	h. m.	h. m.	h. m.	h. m.	h. m.
+ 8° 0′	15 35	15 50	16 5	16 23	16 44
8 20	15 44	15 59	16 16	16 35	16 57
8 40	15 53	16 9	16 26	16 46	17 10
9 0	16 3	16 19	16 37	16 58	17 23
9 20	16 12	16 29	16 48	17 10	17 37
9 40	16 22	16 39	16 59	17 23	17 51
10 0	16 31	16 50	17 11	17 35	18 5
10 20	16 41	17 0	17 22	17 49	18 20
10 40	16 50	17 11	17 34	18 2	18 36
11 0	17 1	17 22	17 47	18 16	18 52
11 20	17 11	17 34	17 59	18 31	19 9
11 40	17 22	17 45	18 13	18 46	19 27
12 0	17 32	17 57	18 26	19 1	19 46
12 20	17 43	18 9	18 40	19 18	20 7
12 40	17 55	18 22	18 55	19 35	20 29
13 0	18 6	18 35	19 11	19 54	20 55
13 20	18 18	18 49	19 26	20 14	21 23
13 40	18 30	19 2	19 43	20 35	21 59
14 0	18 43	19 17	20 1	21 0	22 50
14 20	18 56	19 33	20 20	21 28	
14 40	19 10	19 49	20 41	22 2	
15 0	19 24	20 7	21 5	22 52	
15 20	19 40	20 26	21 32		
15 40	19 55	20 46	22 5		
16 0	20 13	21 10	22 54		
16 20	20 31	21 36			
16 40	20 51	22 8			
17 0	21 13	22 56			
17 20	21 39				
17 40	22 11				

Declination of the Sun.	76°	77°	78°	79°	80°
+ 8° 0′	17 9	17 39	18 16	19 5	20 15
8 20	17 23	17 55	18 35	19 29	20 50
8 40	17 38	18 12	18 56	19 56	21 33
9 0	17 53	18 30	19 17	20 25	22 35
9 20	18 8	18 48	19 41	20 59	
9 40	18 25	19 8	20 6	21 40	
10 0	18 41	19 28	20 31	22 39	
10 20	18 59	19 50	21 6		
10 40	19 18	20 15	21 46		
11 0	19 38	20 41	22 43		
11 20	19 59	21 13			
11 40	20 23	21 50			
12 0	20 49	22 46			
12 20	21 19				
12 40	21 55				

Table 88.

DECLINATION OF THE SUN FOR THE YEAR 1899.

Day of Month.	*Jan.*	*Feb.*	*Mar.*
1	—23° 0′	—17° 4′	— 7° 33′
4	—22 44	16 12	6 24
7	22 22	15 16	5 14
10	21 57	14 19	4 4
13	21 28	13 19	2 53
16	20 55	12 18	1 42
19	20 19	11 14	— 0 31
21	19 53	10 31	+ 0 16
24	19 11	9 25	1 27
27	18 26	8 18	2 38
30	17 38	....	3 48

Day of Month.	*Apr.*	*May.*	*June.*
1	+ 4° 34′	+15° 6′	+22° 4′
4	5 43	15 59	22 27
7	6 51	16 50	22 46
10	7 58	17 38	23 1
13	9 4	18 24	23 13
16	10 9	19 7	23 22
19	11 12	19 47	23 26
21	11 53	20 12	23 27
24	12 53	20 47	23 25
27	13 51	21 19	23 20
30	14 48	21 47	23 11

Day of Month.	*July.*	*Aug.*	*Sept.*
1	+23° 7′	+18° 1′	+ 8° 17′
4	22 53	17 15	7 11
7	22 36	16 26	6 4
10	22 15	15 34	4 56
13	21 50	14 40	3 47
16	21 22	13 44	2 38
19	20 51	12 46	1 28
21	20 29	12 7	+ 0 42
24	19 52	11 6	— 0 29
27	19 13	10 4	1 39
30	18 31	9 0	2 49

Day of Month.	*Oct.*	*Nov.*	*Dec.*
1	— 3° 12′	—14° 27′	—21° 50′
4	4 22	15 24	22 16
7	5 31	16 18	22 38
10	6 40	17 10	22 56
13	7 48	18 0	23 10
16	8 55	18 46	23 20
19	10 0	19 29	23 26
21	10 43	19 56	23 27
24	11 47	20 35	23 26
27	12 48	21 9	23 20
30	13 49	21 40	23 10

DURATION OF ASTRONOMICAL TWILIGHT.

(Interval between sunrise or sunset and the time when the true position of the sun's center is 18° below the horizon.)

Date.	North Latitude.														
	0°	10°	20°	25°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Jan. 1	1 14	1 15	1 18	1 21	1 26	1 28	1 29	1 31	1 34	1 37	1 41	1 45	1 49	1 53	1 59
11	1 14	1 14	1 18	1 21	1 25	1 27	1 29	1 31	1 33	1 36	1 39	1 43	1 47	1 52	1 57
21	1 13	1 13	1 17	1 20	1 23	1 25	1 28	1 30	1 32	1 34	1 38	1 41	1 45	1 49	1 54
Feb. 1	1 12	1 12	1 15	1 18	1 22	1 24	1 26	1 28	1 30	1 33	1 36	1 39	1 43	1 47	1 52
11	1 11	1 12	1 14	1 17	1 21	1 23	1 25	1 27	1 29	1 32	1 34	1 37	1 41	1 45	1 49
21	1 10	1 11	1 13	1 16	1 20	1 22	1 24	1 26	1 28	1 31	1 33	1 36	1 40	1 44	1 48
Mar. 1	1 10	1 11	1 13	1 16	1 20	1 21	1 23	1 25	1 28	1 30	1 33	1 36	1 39	1 43	1 48
11	1 09	1 10	1 13	1 16	1 19	1 21	1 23	1 25	1 28	1 30	1 33	1 36	1 39	1 43	1 48
21	1 09	1 10	1 13	1 16	1 20	1 22	1 24	1 26	1 29	1 31	1 34	1 37	1 41	1 45	1 50
Apr. 1	1 09	1 11	1 14	1 17	1 21	1 23	1 25	1 27	1 30	1 33	1 36	1 40	1 44	1 49	1 54
11	1 10	1 11	1 15	1 18	1 22	1 24	1 27	1 30	1 33	1 36	1 39	1 43	1 48	1 54	2 00
21	1 11	1 12	1 16	1 20	1 24	1 27	1 29	1 32	1 36	1 39	1 43	1 48	1 54	2 01	2 08
May 1	1 12	1 13	1 18	1 22	1 27	1 30	1 33	1 36	1 39	1 43	1 48	1 54	2 01	2 10	2 20
11	1 13	1 14	1 19	1 24	1 30	1 33	1 36	1 40	1 43	1 48	1 54	2 01	2 10	2 20	2 35
21	1 13	1 15	1 21	1 26	1 32	1 36	1 39	1 43	1 48	1 54	2 01	2 10	2 20	2 35	2 58
June 1	1 14	1 16	1 23	1 28	1 35	1 38	1 41	1 46	1 52	1 59	2 07	2 18	2 31	2 54	
11	1 15	1 17	1 24	1 29	1 36	1 40	1 44	1 49	1 55	2 02	2 12	2 23	2 40	3 11	
21	1 15	1 18	1 24	1 29	1 37	1 41	1 45	1 50	1 56	2 03	2 13	2 25	2 44	3 19	
July 1	1 15	1 17	1 24	1 29	1 36	1 40	1 44	1 49	1 55	2 02	2 12	2 23	2 40	3 10	
11	1 14	1 16	1 23	1 28	1 35	1 38	1 41	1 46	1 52	1 59	2 07	2 18	2 31	2 54	
21	1 13	1 15	1 21	1 26	1 32	1 36	1 39	1 43	1 48	1 54	2 01	2 10	2 21	2 36	3 00
Aug. 1	1 13	1 14	1 19	1 24	1 30	1 33	1 36	1 40	1 44	1 48	1 54	2 02	2 10	2 20	2 35
11	1 12	1 13	1 18	1 22	1 27	1 30	1 33	1 36	1 39	1 43	1 48	1 54	2 01	2 10	2 20
21	1 11	1 12	1 16	1 20	1 24	1 27	1 30	1 33	1 36	1 39	1 43	1 48	1 54	2 01	2 09
Sept. 1	1 10	1 11	1 14	1 18	1 22	1 24	1 27	1 30	1 33	1 36	1 39	1 43	1 48	1 53	2 00
11	1 09	1 11	1 13	1 17	1 21	1 23	1 25	1 27	1 30	1 33	1 36	1 39	1 44	1 49	1 54
21	1 09	1 10	1 13	1 16	1 20	1 22	1 24	1 26	1 29	1 31	1 34	1 37	1 41	1 45	1 50
Oct. 1	1 09	1 10	1 13	1 16	1 19	1 21	1 23	1 25	1 28	1 30	1 33	1 36	1 39	1 43	1 48
11	1 10	1 11	1 13	1 16	1 19	1 21	1 23	1 25	1 28	1 30	1 33	1 36	1 39	1 43	1 48
21	1 10	1 11	1 13	1 16	1 20	1 22	1 24	1 26	1 28	1 31	1 33	1 36	1 40	1 44	1 48
Nov. 1	1 11	1 12	1 14	1 17	1 21	1 23	1 25	1 27	1 29	1 32	1 34	1 38	1 41	1 46	1 49
11	1 12	1 12	1 16	1 18	1 22	1 24	1 26	1 28	1 30	1 33	1 36	1 40	1 43	1 47	1 52
21	1 13	1 13	1 17	1 20	1 24	1 26	1 28	1 30	1 32	1 35	1 38	1 42	1 46	1 49	1 55
Dec. 1	1 14	1 14	1 18	1 21	1 25	1 27	1 29	1 31	1 33	1 36	1 40	1 44	1 47	1 52	1 57
11	1 14	1 15	1 18	1 22	1 26	1 28	1 30	1 32	1 34	1 37	1 41	1 45	1 49	1 53	1 59
21	1 15	1 16	1 19	1 22	1 26	1 28	1 30	1 32	1 35	1 38	1 41	1 45	1 49	1 54	1 59

DURATION OF CIVIL TWILIGHT.

(Interval between sunrise or sunset and the time when the true position of the sun's center is 6° below the horizon.)

[Minutes.]

Date.	NORTH LATITUDE.														
	0°	10°	20°	25°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°
Jan. 1	22	22	24	25	27	27	28	28	29	30	32	33	34	36	39
11	22	22	24	25	26	27	28	28	29	30	31	32	33	35	38
21	22	22	23	24	26	26	27	27	28	29	30	32	33	34	37
Feb. 1	22	22	23	24	25	26	27	27	27	28	29	31	32	34	35
11	22	22	22	23	25	26	26	27	27	28	29	30	31	33	34
21	21	22	22	23	24	25	25	26	27	28	28	29	30	32	33
Mar. 1	21	22	22	23	24	24	25	26	27	28	28	29	30	31	33
11	21	21	22	23	24	24	25	26	26	27	27	29	30	31	32
21	21	21	22	23	24	24	25	26	26	27	27	28	30	31	33
Apr. 1	21	21	22	23	24	25	25	26	27	28	28	29	30	32	33
11	21	22	22	23	24	25	26	26	27	28	28	29	31	32	34
21	22	22	22	23	25	25	26	27	28	28	29	30	32	34	35
May 1	22	22	23	24	25	26	27	28	28	29	30	32	33	35	36
11	22	22	23	24	26	27	28	29	29	30	31	33	35	36	39
21	22	22	24	25	27	28	28	29	30	31	33	35	36	38	41
June 1	22	22	24	25	27	28	28	29	31	32	34	36	37	40	43
11	22	23	24	26	28	28	29	30	31	33	34	36	38	41	44
21	22	23	25	26	28	29	29	30	31	33	34	36	38	42	44
July 1	22	23	24	26	28	28	29	30	31	33	34	36	38	41	44
11	22	22	24	25	27	28	28	29	31	32	34	36	37	40	43
21	22	22	24	25	27	28	28	29	30	31	33	35	36	38	41
Aug. 1	22	22	23	24	26	27	28	29	29	30	31	33	35	36	39
11	22	22	23	24	25	26	27	28	28	29	30	32	33	35	36
21	22	22	22	23	25	25	26	28	28	28	29	30	32	34	35
Sept. 1	21	22	22	23	24	25	26	26	27	28	28	29	31	32	34
11	21	21	22	23	24	25	25	26	27	28	28	29	30	31	33
21	21	21	22	23	24	24	25	26	26	27	27	29	30	31	32
Oct. 1	21	21	22	23	24	24	25	26	26	27	27	29	30	31	32
11	21	22	22	23	24	24	25	26	27	28	28	29	30	31	33
21	21	22	22	23	24	25	25	26	27	28	28	29	30	32	33
Nov. 1	22	22	22	23	25	25	26	27	28	28	29	30	31	33	34
11	22	22	23	24	25	26	27	28	28	29	30	31	32	33	35
21	22	22	23	24	26	26	27	28	28	29	30	32	33	34	37
Dec. 1	22	22	24	25	26	27	28	28	29	30	31	33	34	35	38
11	22	22	24	25	27	27	28	28	29	30	32	33	34	36	39
21	22	23	24	25	27	27	28	28	29	31	32	33	34	37	39

TABLE 91.

RELATIVE INTENSITY OF SOLAR RADIATION.

Mean intensity J for 24 hours of solar radiation on a horizontal surface at the top of the atmosphere and the solar constant A, in terms of the mean solar constant A_0.

Date.	Longitude of the Sun.	Relative Mean Vertical Intensity $\left(\frac{J}{A_0}\right)$. Latitude North.										$\frac{A}{A_0}$.
		0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	
Jan. 1	0°.99	0.303	0.265	0.220	0.169	0.117	0.066	0.018				1.0335
16	15.78	.307	.271	.229	.180	.129	.078	.028				1.0324
Feb. 1	31.54	.312	.282	.244	.200	.150	.100	.048	0.006			1.0288
15	45.34	.317	.293	.261	.223	.177	.118	.075	.027			1.0235
Mar. 1	59.14	.320	.303	.279	.245	.204	.158	.108	.056	0.013		1.0173
16	73.93	.321	.313	.296	.270	.236	.195	.148	.097	.057		1.0096
Apr. 1	89.70	.317	.319	.312	.295	.269	.235	.195	.148	.101	0.082	1.0009
16	104.49	.311	.321	.323	.315	.297	.271	.238	.201	.175	.177	0.9923
May 1	119.29	.303	.318	.330	.329	.320	.302	.278	.253	.255	.259	0.9841
16	134.05	.294	.318	.333	.339	.337	.327	.312	.298	.317	.322	0.9772
June 1	149.82	.287	.315	.334	.345	.349	.345	.337	.344	.360	.366	0.9714
16	164.60	.283	.313	.334	.348	.354	.353	.348	.361	.378	.384	0.9679
July 1	179.39	.283	.312	.333	.347	.352	.351	.345	.356	.373	.379	0.9666
16	194.13	.287	.314	.332	.342	.345	.340	.329	.331	.347	.352	0.9674
Aug. 1	209.94	.294	.316	.330	.334	.330	.318	.300	.282	.295	.300	0.9709
16	224.73	.303	.318	.325	.322	.310	.291	.264	.234	.227	.231	0.9760
Sept. 1	240.50	.310	.318	.316	.305	.285	.256	.220	.180	.139	.140	0.9828
16	255.29	.315	.315	.305	.284	.256	.220	.178	.130	.107	.043	0.9909
Oct. 1	270.07	.317	.308	.289	.261	.225	.183	.135	.084	.065		0.9995
16	284.86	.316	.298	.271	.236	.194	.147	.097	.047	.015		1.0080
Nov. 1	300.63	.312	.286	.251	.211	.164	.114	.063	.018			1.0164
16	315.42	.308	.276	.235	.190	.140	.089	.040				1.0235
Dec. 1	330.19	.304	.267	.224	.175	.124	.072	.024				1.0288
16	344.98	.302	.263	.218	.167	.115	.064	.016				1.0323
Year.....		0.305	0.301	0.289	0.268	0.241	0.209	0.173	0.144	0.133	0.126	

TABLE 92.

RELATIVE AMOUNTS OF SOLAR RADIATION RECEIVED ON A HORIZONTAL SURFACE DURING THE YEAR AT DIFFERENT LATITUDES.

Latitude. (North.)	Atmospheric transmission coefficient.				
	1.0	0.9	0.8	0.7	0.6
Equator.	439	374	316	262	213
10°	433	368	310	257	209
20°	416	350	293	242	195
30°	386	322	266	213	171
40°	347	284	231	185	144
50°	301	239	190	149	114
60°	249	191	148	113	84
70°	207	152	113	83	60
80°	192	134	94	64	43
90°	181	125	85	56	35

TABLE 93.

AIR MASS, M, CORRESPONDING TO DIFFERENT ZENITH DISTANCES OF THE SUN.

Sun's zenith distance.	Sun's zenith distance.									
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
	Air mass.									
0	1.00									
10	1.02					1.04				
20	1.06	1.07	1.08	1.09	1.09	1.10	1.11	1.12	1.13	1.14
30	1.15	1.17	1.18	1.19	1.20	1.22	1.24	1.25	1.27	1.28
40	1.30	1.32	1.34	1.37	1.39	1.41	1.44	1.46	1.49	1.52
50	1.55	1.59	1.62	1.66	1.70	1.74	1.78	1.83	1.88	1.94
60	2.00	2.06	2.12	2.20	2.27	2.36	2.45	2.55	2.65	2.77
70	2.90	3.05	3.21	3.39	3.59	3.82	4.08	4.37	4.72	5.12
80	5.60	6.18	6.88	7.77	8.90	10.39	12.44	15.36	19.79	26.96

TABLE 94.

RELATIVE ILLUMINATION INTENSITIES.

Source of illumination.	Intensity.	Ratio to zenithal full moon.
	Foot-candles.	
Zenithal sun	9600.0	465000.0
Sky at sunset	33.00	1650.0
Sky at end of civil twilight	0.40	20.0
Zenithal full moon	0.02	1.0
Quarter moon	0.002	0.1
Starlight	0.00008	0.004

MISCELLANEOUS TABLES.

TABLE 95.

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Temperature term: $\delta_t = \frac{0.00129305}{1 + 0.0020389\,(t - 32°)}$. Fahrenheit temperatures.

1 cubic centimeter of dry air at the temperature 32°F. and pressure 760 mm., under the standard value of gravity, weighs 0.00129305 gram.

Temperature.	δ_t	Log δ_t	Temperature.	δ_t	Log δ_t	Temperature.	δ_t	Log δ_t
F.	0.00	— 10	F.	0.00	— 10	F.	0.00	— 10
−45°	15339	7.18579	30°	12983	7.11339	75°	11888	7.07512
−40	15155	.18056	31	12957	.11250	76	11866	.07430
−35	14977	.17541	32	12931	.11162	77	11844	.07349
−30	14802	.17031	33	12904	.11073	78	11822	.07268
−25	14631	.16527	34	12878	.10985	79	11800	.07187
	0.00			0.00			0.00	
−20	14464	7.16029	35	12852	7.10897	80	11778	7.07107
−18	14398	.15831	36	12826	.10809	81	11756	.07026
−16	14333	.15634	37	12800	.10721	82	11734	.06946
−14	14269	.15439	38	12774	.10633	83	11713	.06865
−12	14205	.15244	39	12749	.10546	84	11691	.06785
	0.00			0.00			0.00	
−10	14142	7.15050	40	12723	7.10459	85	11670	7.06705
− 8	14079	.14856	41	12698	.10372	86	11648	.06625
− 6	14017	.14664	42	12672	.10285	87	11627	.06546
− 4	13955	.14472	43	12647	.10198	88	11605	.06466
− 2	13894	.14282	44	12622	.10112	89	11584	.06387
	0.00			0.00			0.00	
+ 0	13833	7.14092	45	12597	7.10025	90	11563	7.06307
1	13803	.13997	46	12572	.09939	91	11542	.06228
2	13773	.13903	47	12547	.09853	92	11521	.06149
3	13743	.13808	48	12522	.09767	93	11500	.06070
4	13713	.13714	49	12497	.09682	94	11479	.05992
	0.00			0.00			0.00	
5	13684	7.13621	50	12473	7.09596	95	11458	7.05913
6	13654	.13527	51	12448	.09511	96	11438	.05835
7	13625	.13434	52	12424	.09426	97	11418	.05757
8	13596	.13340	53	12400	.09341	98	11397	.05678
9	13567	.13247	54	12375	.09256	99	11376	.05600
	0.00			0.00			0.00	
10	13538	7.13155	55	12351	7.09171	100	11356	7.05523
11	13509	.13062	56	12327	.09087	101	11336	.05445
12	13480	.12970	57	12303	.09002	102	11315	.05367
13	13452	.12877	58	12280	.08918	103	11295	.05290
14	13423	.12785	59	12256	.08834	104	11275	.05213
	0.00			0.00			0.00	
15	13395	7.12694	60	12232	7.08750	105	11255	7.05136
16	13367	.12602	61	12209	.08667	106	11235	.05058
17	13338	.12510	62	12185	.08583	107	11215	.04982
18	13310	.12419	63	12162	.08500	108	11196	.04905
19	13282	.12328	64	12138	.08416	109	11176	.04828
	0.00			0.00			0.00	
20	13255	7.12237	65	12115	7.08334	110	11156	7.04752
21	13227	.12147	66	12092	.08251	112	11117	.04599
22	13200	.12056	67	12069	.08168	114	11078	.04447
23	13172	.11966	68	12046	.08085	116	11040	.04296
24	13145	.11876	69	12023	.08003	118	11001	.04145
	0.00			0.00			0.00	
25	13118	7.11786	70	12001	7.07921	120	10963	7.03994
26	13091	.11696	71	11978	.07839	125	10870	.03621
27	13064	.11606	72	11956	.07757	130	10776	.03248
28	13037	.11517	73	11933	.07675	135	10686	.02883
29	13010	.11428	74	11910	.07593	140	10597	.02518

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Humidity term: Values of 0378 *e*. Auxiliary to Table 97.

e = Vapor pressure in inches. (See Tables 69 and 70.)

Temperature by normal hydrogen thermometer.

Dew-Point.	*e* Vapor Pressure. (Ice.)	0.378 *e*	Dew-Point.	Vapor Pressure. (*)	0.378 *e*	Dew-Point.	Vapor Pressure. (Water.)	0.378 *e*	Dew-Point.	Vapor Pressure. (Water.)	0.378 *e*
F.	Inch.	Inch.	F.	Inch.	Inch.	F.	Inch.	Inch.	F.	Inches.	Inches.
−60°	0.0010	0.000	− 10°	0.0223	0.008	40°	0.2477	0.094	90°	1.423	0.538
59	.0011	.000	9	.0236	.009	41	.2575	.097	91	1.469	.555
58	.0011	.000	8	.0249	.009	42	.2677	.101	92	1.515	.573
57	.0012	.000	7	.0263	.010	43	.2782	.106	93	1.563	.591
56	.0013	.000	6	.0277	.010	44	.2891	.109	94	1.612	.609
−55	0.0014	0.001	5	0.0292	0.011	45	0.3003	0.114	95	1.662	0.628
54	.0015	.001	4	.0308	.012	46	.3120	.118	96	1.714	.648
53	.0016	.001	3	.0325	.012	47	.3240	.122	97	1.767	.668
52	.0017	.001	2	.0343	.013	48	.3365	.127	98	1.822	.689
51	.0018	.001	− 1	.0361	.014	49	.3493	.132	99	1.878	.710
−50	0.0020	0.001	± 0	0.0381	0.014	50	0.3626	0.137	100	1.936	0.732
49	.0021	.001	+ 1	.0401	.015	51	.3763	.142	101	1.994	.754
48	.0023	.001	2	.0423	.016	52	.3905	.147	102	2.055	.777
47	.0024	.001	3	.0445	.017	53	.4052	.153	103	2.117	.800
46	.0026	.001	4	.0468	.018	54	.4203	.159	104	2.181	.824
−45	0.0028	0.001	+ 5	0.0493	0.019	55	0.4359	0.165	105	2.246	0.849
44	.0029	.001	6	.0519	.020	56	.4521	.171	106	2.314	.875
43	.0031	.001	7	.0546	.021	57	.4687	.177	107	2.382	.900
42	.0033	.001	8	.0574	.022	58	.4859	.184	108	2.453	.927
41	.0036	.001	9	.0604	.023	59	.5037	.190	109	2.525	.954
−40	0.0038	0.001	+ 10	0.0635	0.024	60	0.5220	0.197	110	2.599	0.982
39	.0040	.002	11	.0667	.025	61	.5409	.204	111	2.676	1.012
38	.0043	.002	12	.0701	.027	62	.5604	.212	112	2.754	1.041
37	.0046	.002	13	.0736	.028	63	.5805	.219	113	2.833	1.071
36	.0049	.002	14	.0773	.029	64	.6013	.227	114	2.915	1.102
−35	0.0052	0.002	+15	0.0812	0.031	65	0.6226	0.235	115	2.999	1.134
34	.0055	.002	16	.0852	.032	66	.6447	.244	116	3.085	1.166
33	.0059	.002	17	.0895	.034	67	.6674	.252	117	3.173	1.199
32	.0062	.002	18	.0939	.035	68	.6909	.261	118	3.264	1.234
31	.0066	.003	19	.0985	.037	69	.7150	.270	119	3.356	1.269
−30	0.0070	0.003	+20	0.1033	0.039	70	0.7399	0.280	120	3.451	1.304
29	.0075	.003	21	.1084	.041	71	.7655	.289	121	3.548	1.341
28	.0080	.003	22	.1136	.043	72	.7919	.299	122	3.647	1.379
27	.0084	.003	23	.1191	.045	73	.8191	.310	123	3.749	1.417
26	.0090	.003	24	.1248	.047	74	.8471	.320	124	3.853	1.456
−25	0.0095	0.004	+25	0.1308	0.049	75	0.8760	0.331	125	3.960	1.497
24	.0101	.004	26	.1370	.052	76	.9056	.343	126	4.069	1.538
23	.0107	.004	27	.1435	.054	77	.9362	.354	127	4.180	1.580
22	.0113	.004	28	.1502	.057	78	.9677	.366	128	4.294	1.623
21	.0120	.005	29	.1573	.059	79	1.0001	.378	129	4.412	1.668
−20	0.0127	0.005	+30	0.1646	0.062	80	1.0334	0.391	130	4.531	1.713
19	.0135	.005	31	.1723	.065	81	1.0676	.404	131	4.654	1.759
18	.0143	.005	32	.1803	.068	82	1.1029	.417	132	4.779	1.806
17	.0151	.006	33	.1877	.071	83	1.1392	.431	133	4.907	1.855
16	.0160	.006	34	.1954	.074	84	1.1765	.445	134	5.038	1.904
−15	0.0169	0.006	+35	0.2034	0.077	85	1.2149	0.459	135	5.172	1.955
14	.0179	.007	36	.2117	.080	86	1.2543	.474	136	5.309	2.007
13	.0189	.007	37	.2202	.083	87	1.2949	.489	137	5.449	2.060
12	.0200	.008	38	.2291	.087	88	1.3365	.505	138	5.592	2.114
11	.0211	.008	39	.2382	.090	89	1.3794	.521	139	5.739	2.169
10	0.0223	0.008	40	0.2477	0.094	90	1.4234	0.538	140	5.889	2.226

* Values for temperatures less than 32° F. refer to vapor over ice.

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Humidity and pressure terms combined: $\frac{\delta}{\delta_0} = \frac{h}{29.921} = \frac{B - 0.378e}{29.921}$.

B = Barometric pressure in inches; e = Vapor pressure in inches.

h.	h/29.921.	Log h/29.921.	h.	h/29.291.	Log h/29.921.	h.	h/29.921.	Log h/29.921.
Inch's.		— 10	Inches.		— 10	Inches.		— 10
10.0	0.3342	9.52402	**15.0**	0.5013	9.70012	**20.0**	0.6684	9.82505
10.1	.3376	.52835	15.1	.5047	.70300	20.1	.6718	.82722
10.2	.3409	.53262	15.2	.5080	.70587	20.2	.6751	.82938
10.3	.3442	.53686	15.3	.5113	.70871	20.3	.6784	.83152
10.4	.3476	.54106	15.4	.5147	.71154	20.4	.6818	.83365
10.5	0.3509	9.54521	**15.5**	0.5180	9.71435	**20.5**	0.6851	9.83578
10.6	.3543	.54933	15.6	.5214	.71715	20.6	.6885	.83789
10.7	.3576	.55341	15.7	.5247	.71992	20.7	.6918	.83999
10.8	.3609	.55745	15.8	.5281	.72268	20.8	.6952	.84209
10.9	.3643	.56145	15.9	.5314	.72542	20.9	.6985	.84417
11.0	0.3676	9.56542	**16.0**	0.5347	9.72814	**21.0**	0.7018	9.84624
11.1	.3710	.56935	16.1	.5381	.73085	21.1	.7052	.84831
11.2	.3743	.57324	16.2	.5414	.73354	21.2	.7085	.85036
11.3	.3777	.57710	16.3	.5448	.73621	21.3	.7119	.85240
11.4	.3810	.58093	16.4	.5481	.73887	21.4	.7152	.85444
11.5	0.3843	9.58472	**16.5**	0.5515	9.74151	**21.5**	0.7186	9.85646
11.6	.3877	.58848	16.6	.5548	.74413	21.6	.7219	.85848
11.7	.3910	.59221	16.7	.5581	.74674	21.7	.7252	.86048
11.8	.3944	.59591	16.8	.5615	.74933	21.8	.7286	.86248
11.9	.3977	.59957	16.9	.5648	.75191	21.9	.7319	.86447
12.0	0.4011	9.60321	**17.0**	0.5682	9.75447	**22.0**	0.7353	9.86645
12.1	.4044	.60681	17.1	.5715	.75702	22.1	.7386	.86842
12.2	.4077	.61038	17.2	.5748	.75955	22.2	.7420	.87038
12.3	.4111	.61393	17.3	.5782	.76207	22.3	.7453	.87233
12.4	.4144	.61745	17.4	.5815	.76457	22.4	.7486	.87427
12.5	0.4178	9.62093	**17.5**	0.5849	9.76706	**22.5**	0.7520	9.87621
12.6	.4211	.62439	17.6	.5882	.76954	22.6	.7553	.87813
12.7	.4244	.62782	17.7	.5916	.77200	22.7	.7587	.88005
12.8	.4278	.63123	17.8	.5949	.77444	22.8	.7620	.88196
12.9	.4311	.63461	17.9	.5982	.77687	22.9	.7653	.88386
13.0	0.4345	9.63797	**18.0**	0.6016	9.77930	**23.0**	0.7687	9.88575
13.1	.4378	.64130	18.1	.6049	.78170	23.1	.7720	.88764
13.2	.4412	.64460	18.2	.6083	.78410	23.2	.7754	.88951
13.3	.4445	.64788	18.3	.6116	.78648	23.3	.7787	.89138
13.4	.4478	.65113	18.4	.6149	.78884	23.4	.7821	.89324
13.5	0.4512	9.65436	**18.5**	0.6183	9.79120	**23.5**	0.7854	9.89509
13.6	.4545	.65756	18.6	.6216	.79354	23.6	.7887	.89693
13.7	.4579	.66074	18.7	.6250	.79587	23.7	.7921	.89877
13.8	.4612	.66390	18.8	.6283	.79818	23.8	.7954	.90060
13.9	.4646	.66704	18.9	.6317	.80049	23.9	.7988	.90242
14.0	0.4679	9.67015	**19.0**	0.6350	9.80278	**24.0**	0.8021	9.90424
14.1	.4712	.67324	19.1	.6383	.80506	24.1	.8054	.90604
14.2	.4746	.67631	19.2	.6417	.80733	24.2	.8088	.90784
14.3	.4779	.67936	19.3	.6450	.80958	24.3	.8121	.90963
14.4	.4813	.68239	19.4	.6484	.81183	24.4	.8155	.91141
14.5	0.4846	9.68539	**19.5**	0.6517	9.81406	**24.5**	0.8188	9.91319
14.6	.4879	.68837	19.6	.6551	.81628	24.6	.8222	.91496
14.7	.4913	.69134	19.7	.6584	.81849	24.7	.8255	.91672
14.8	.4946	.69429	19.8	.6617	.82069	24.8	.8289	.91848
14.9	.4980	.69721	19.9	.6651	.82288	24.9	.8322	.92022

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Humidity and pressure terms combined: $\frac{\delta}{\delta_0} = \frac{h}{29.921} = \frac{B - 0.378e}{29.921}$.

B = Barometric pressure in inches; e = Vapor pressure in inches.

h.	h/29.921	Log h/29.921	h.	h/29.921	Log h/29.921	h.	h/29.921	Log h/29.921
Inches.		− 10	Inches.		− 10	Inches.		− 10
25.00	0.8355	9.92196	**27.25**	0.9107	9.95939	**29.50**	0.9859	9.99385
25.05	.8372	.92283	27.30	.9124	.96019	29.55	.9876	.99458
25.10	.8389	.92370	27.35	.9141	.96098	29.60	.9893	.99532
25.15	.8405	.92456	27.40	.9157	.96177	29.65	.9909	.99605
25.20	.8422	.92542	27.45	.9174	.96256	29.70	.9926	.99678
25.25	0.8439	9.92628	**27.50**	0.9191	9.96336	**29.75**	0.9943	9.99751
25.30	.8456	.92714	27.55	.9208	.96414	29.80	.9960	.99824
25.35	.8472	.92800	27.60	.9224	.96493	29.85	.9976	.99897
25.40	.8489	.92886	27.65	.9241	.96572	29.90	.9993	.99970
25.45	.8506	.92971	27.70	.9258	.96650	29.95	1.0010	0.00042
25.50	0.8522	9.93056	**27.75**	0.9274	9.96728	**30.00**	1.0026	0.00115
25.55	.8539	.93141	27.80	.9291	.96807	30.05	1.0043	.00187
25.60	.8556	.93226	27.85	.9308	.96885	30.10	1.0060	.00259
25.65	.8573	.93311	27.90	.9325	.96963	30.15	1.0076	.00331
25.70	.8589	.93396	27.95	.9341	.97040	30.20	1.0093	.00403
25.75	0.8606	9.93480	**28.00**	0.9358	9.97118	**30.25**	1.0110	0.00475
25.80	.8623	.93564	28.05	.9375	.97195	30.30	1.0127	.00547
25.85	.8639	.93648	28.10	.9391	.97273	30.35	1.0143	.00618
25.90	.8656	.93732	28.15	.9408	.97350	30.40	1.0160	.00690
25.95	.8673	.93816	28.20	.9425	.97427	30.45	1.0177	.00761
26.00	0.8690	9.93900	**28.25**	0.9441	9.97504	**30.50**	1.0193	0.00832
26.05	.8706	.93983	28.30	.9458	.97581	30.55	1.0210	.00903
26.10	.8723	.94066	28.35	.9475	.97657	30.60	1.0227	.00975
26.15	.8740	.94149	28.40	.9492	.97734	30.65	1.0244	.01045
26.20	.8756	.94233	28.45	.9508	.97810	30.70	1.0260	.01116
26.25	0.8773	9.94315	**28.50**	0.9525	9.97887	**30.75**	1.0277	0.01187
26.30	.8790	.94398	28.55	.9542	.97963	30.80	1.0294	.01257
26.35	.8806	.94480	28.60	.9558	.98039	30.85	1.0310	.01328
26.40	.8823	.94563	28.65	.9575	.98115	30.90	1.0327	.01398
26.45	.8840	.94645	28.70	.9592	.98191	30.95	1.0344	.01468
26.50	0.8857	9.94727	**28.75**	0.9609	9.98266	**31.00**	1.0361	0.01539
26.55	.8873	.94809	28.80	.9625	.98342	31.05	1.0377	.01608
26.60	.8890	.94891	28.85	.9642	.98417	31.10	1.0394	.01678
26.65	.8907	.94972	28.90	.9659	.98492	31.15	1.0411	.01748
26.70	.8924	.95054	28.95	.9675	.98567	31.20	1.0427	.01818
26.75	0.8940	9.95135	**29.00**	0.9692	9.98642	**31.25**	1.0444	0.01887
26.80	.8957	.95216	29.05	.9709	.98717	31.30	1.0461	.01957
26.85	.8974	.95297	29.10	.9726	.98792	31.35	1.0478	.02026
26.90	.8990	.95378	29.15	.9742	.98866	31.40	1.0494	.02095
26.95	.9007	.95458	29.20	.9759	.98941	31.45	1.0511	.02164
27.00	0.9024	9.95539	**29.25**	0.9776	9.99015	**31.50**	1.0528	0.02233
27.05	.9040	.95619	29.30	.9792	.99089	31.55	1.0544	.02302
27.10	.9057	.95699	29.35	.9809	.99163	31.60	1.0561	.02371
27.15	.9074	.95779	29.40	.9826	.99237	31.65	1.0578	.02439
27.20	.9091	.95859	29.45	.9843	.99311	31.70	1.0594	.02508

TABLE 98.

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Temperature term: $\delta_{t,\,760} = \dfrac{0.00129305}{1 + 0.003670\,t}$. Centigrade temperature.

1 cubic centimeter of dry air at the temperature 0° C. and pressure 760 mm., under the standard value of gravity, weighs 0.00129305 gram.

t.	$\delta_{t,\,760}$	Log $\delta_{t,\,760}$	t.	$\delta_{t,\,760}$	Log $\delta_{t,\,760}$	t.	$\delta_{t,\,760}$	Log $\delta_{t,\,760}$
C.	0.00	— 10	C.	0.00	— 10	C.	0.00	— 10
−34°	14774	7.16950	**− 4°.5**	13148	7.11885	**18°.0**	12129	7.08383
−33	14712	.16768	− 4.0	13123	.11804	18.5	12108	8309
−32	14651	.16587	− 3.5	13099	.11723	19.0	12088	8234
−31	14590	.16407	− 3.0	13074	.11642	19.5	12067	8160
	0.00			0.00			0.00	
−30	14530	7.16227	**− 2.5**	13050	7.11562	**20.0**	12046	7.08085
−29	14471	.16049	− 2.0	13026	.11481	20.5	12026	8011
−28	14412	.15871	− 1.5	13002	.11401	21.0	12005	7937
−27	14353	.15693	− 1.0	12978	.11321	21.5	11985	7863
−26	14295	.15517	− 0.5	12954	.11241	22.0	11965	7789
	0.00			0.00			0.00	
−25	14237	7.15341	**0.0**	12931	7.11162	**22.5**	11944	7.07716
−24	14179	.15166	+ 0.5	12907	.11082	23.0	11924	7642
−23	14123	.14991	1.0	12884	.11006	23.5	11904	7569
−22	14066	.14818	1.5	12860	.10923	24.0	11884	7496
−21	14010	.14645	2.0	12836	.10844	24.5	11864	7422
	0.00			0.00			0.00	
−20.0	13955	7.14472	**2.5**	12813	7.10765	**25.0**	11844	7.07349
−19.5	13927	.14386	3.0	12790	.10686	25.5	11824	7276
−19.0	13900	.14301	3.5	12766	.10607	26.0	11804	7204
−18.5	13872	.14215	4.0	12744	.10529	26.5	11784	7131
−18.0	13845	.14130	4.5	12720	.10450	27.0	11765	7058
	0.00			0.00			0.00	
−17.5	13818	7.14044	**5.0**	12698	7.10372	**27.5**	11745	7.06986
−17.0	13791	.13959	5.5	12675	.10294	28.0	11726	6913
−16.5	13764	.13874	6.0	12652	.10216	28.5	11706	6841
−16.0	13737	.13790	6.5	12629	.10138	29.0	11687	6769
−15.5	13710	.13705	7.0	12607	.10069	29.5	11667	6697
	0.00			0.00			0.00	
−15.0	13684	7.13621	**7.5**	12584	7.09982	**30.0**	11648	7.06625
−14.5	13657	.13536	8.0	12562	9905	30.5	11629	6554
−14.0	13631	.13452	8.5	12539	9828	31.0	11610	6482
−13.5	13604	.13368	9.0	12517	9750	31.5	11591	6411
−13.0	13578	.13285	9.5	12495	9673	32.0	11572	6340
	0.00			0.00			0.00	
−12.5	13552	7.13201	**10.0**	12473	7.09596	**32.5**	11553	7.06268
−12.0	13526	.13117	10.5	12451	9519	33.0	11534	6197
−11.5	13500	.13034	11.0	12429	9443	33.5	11515	6126
−11.0	13473	.12951	11.5	12407	9366	34.0	11496	6055
−10.5	13449	.12868	12.0	12385	9290	34.5	11477	5984
	0.00			0.00			0.00	
−10.0	13423	7.12785	**12.5**	12363	7.09214	**35.0**	11459	7.05913
− 9.5	13398	.12703	13.0	12342	9137	35.5	11440	5843
− 9.0	13372	.12620	13.5	12320	9061	36.0	11421	5772
− 8.5	13347	.12538	14.0	12299	8986	36.5	11403	5702
− 8.0	13322	.12456	14.5	12277	8910	37.0	11385	5632
	0.00			0.00			0.00	
− 7.5	13297	7.12374	**15.0**	12256	7.08834	**37.5**	11366	7.05562
− 7.0	13271	.12292	15.5	12235	8759	38.0	11348	5492
− 6.5	13246	.12210	16.0	12213	8683	38.5	11330	5422
− 6.0	13222	.12128	16.5	12192	8608	39.0	11311	5352
− 5.5	13197	.12047	17.0	12171	8533	39.5	11293	5282
	0.00			0.00			0.00	
− 5.0	13172	7.11966	**17.5**	12150	7.08458	**40.0**	11275	7.05213

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Temperature term. (*Continued.*)

t.	$\delta_{t, 760}$	Log $\delta_{t, 760}$	t.	$\delta_{t, 760}$	Log $\delta_{t, 760}$	t.	$\delta_{t, 760}$	Log $\delta_{t, 760}$
C.	0.00	−10	C.	0.00	−10	C.	0.00	−10
40°	11275	7.05213	50°	10926	7.03845	60°	10597	7.02518
41	11239	.05074	51	10892	.03710	61	10565	.02388
42	11204	.04936	52	10858	.03576	62	10534	.02258
43	11168	.04798	53	10825	.03443	63	10502	.02128
44	11133	.04660	54	10792	.03309	64	10471	.01999
	0.00			0.00			0.00	
45	11098	7.04523	55	10759	7.03177	65	10440	7.01870
46	11063	.04387	56	10726	.03044	66	10409	.01742
47	11028	.04251	57	10694	.02912	67	10379	.01614
48	10994	.04115	58	10661	.02780	68	10348	.01486
49	10960	.03980	59	10629	.02649	69	10318	.01358

TABLE 99.

Humidity term: Values of 0.378 *e*. Auxiliary to Table 100.
e = Vapor pressure in mm. (See Tables 71 and 72.)

Dew-point.	*e* Vapor Pressure (Ice).	0.378 *e*	Dew-point.	*e* Vapor Pressure (Water).	0.378 *e*	Dew-point.	*e* Vapor Pressure (Water).	0.378 *e*
C.	mm.	mm.	C.	mm.	mm.	C.	mm.	mm.
−50	0.029	0.01	0°	4.580	1.73	30°	31.860	12.04
−45	0.054	0.02	1	4.924	1.86	31	33.735	12.75
−40	0.096	0.04	2	5.291	2.00	32	35.705	13.50
−35	0.169	0.06	3	5.682	2.15	33	37.775	14.28
−30	0.288	0.11	4	6.098	2.31	34	39.947	15.10
−25	0.480	0.18	5	6.541	2.47	35	42.227	15.96
24	0.530	0.20	6	7.012	2.66	36	44.619	16.87
23	0.585	0.22	7	7.513	2.84	37	47.127	17.81
22	0.646	0.24	8	8.045	3.04	38	49.756	18.81
21	0.712	0.27	9	8.610	3.25	39	52.510	19.85
−20	0.783	0.30	10	9.210	3.48	40	55.396	20.94
19	0.862	0.33	11	9.846	3.72	41	58.417	22.08
18	0.947	0.36	12	10.521	3.98	42	61.580	23.28
17	1.041	0.39	13	11.235	4.25	43	64.889	24.53
16	1.142	0.43	14	11.992	4.53	44	68.350	25.84
−15	1.252	0.47	15	12.794	4.84	45	71.968	27.20
14	1.373	0.52	16	13.642	5.16	46	75.751	28.63
13	1.503	0.57	17	14.539	5.50	47	79.703	30.13
12	1.644	0.62	18	15.487	5.85	48	83.830	31.69
11	1.798	0.68	19	16.489	6.23	49	88.140	33.32
−10	1.964	0.74	20	17.548	6.63	50	92.64	35.02
9	2.144	0.81	21	18.665	7.06	51	97.33	36.79
8	2.340	0.88	22	19.844	7.50	52	102.23	38.64
7	2.550	0.96	23	21.087	7.97	53	107.33	40.57
6	2.778	1.05	24	22.398	8.47	54	112.66	42.59
−5	3.025	1.14	25	23.780	8.99	55	118.20	44.68
4	3.291	1.24	26	25.235	9.54	56	123.98	46.86
3	3.578	1.35	27	26.767	10.12	57	130.00	49.14
2	3.887	1.47	28	28.380	10.73	58	136.26	51.51
1	4.220	1.60	29	30.076	11.37	59	142.78	53.97
0	4.580	1.73	30	31.860	12.04	60	149.57	56.54

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Humidity and pressure terms combined : $\frac{\delta}{\delta_0} = \frac{h}{760} = \frac{B - 0.378e}{760}$.

B = Barometric pressure in mm. ; e = Vapor pressure in mm.

h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.	h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.	h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.
mm.		− 10	mm.		− 10	mm.		− 10
300	0.3947	9.59631	**400**	0.5263	9.72125	**450**	0.5921	9.77240
302	.3974	.59919	401	.5276	.72233	451	.5934	.77336
304	.4000	.60206	402	.5289	.72341	452	.5947	.77432
306	.4026	.60491	403	.5303	.72449	453	.5961	.77528
308	.4053	.60774	404	.5316	.72557	454	.5974	.77624
310	0.4079	9.61055	**405**	0.5329	9.72664	**455**	0.5987	9.77720
312	.4105	.61334	406	.5342	.72771	456	.6000	.77815
314	.4132	.61612	407	.5355	.72878	457	.6013	.77910
316	.4158	.61887	408	.5369	.72985	458	.6026	.78005
318	.4184	.62161	409	.5382	.73091	459	.6040	.78100
320	0.4211	9.62434	**410**	0.5395	9.73197	**460**	0.6053	9.78194
322	.4237	.62704	411	.5408	.73303	461	.6066	.78289
324	.4263	.62973	412	.5421	.73408	462	.6079	.78383
326	.4289	.63240	413	.5434	.73514	463	.6092	.78477
328	.4316	.63506	414	.5447	.73619	464	.6105	.78570
330	0.4342	9.63770	**415**	0.5461	9.73723	**465**	0.6118	9.78664
332	.4368	.64032	416	.5474	.73828	466	.6132	.78757
334	.4395	.64293	417	.5487	.73932	467	.6145	.78850
336	.4421	.64552	418	.5500	.74036	468	.6158	.78943
338	.4447	.64810	419	.5513	.74140	469	.6171	.79036
340	0.4474	9.65066	**420**	0.5526	9.74244	**470**	0.6184	9.79128
342	.4500	.65321	421	.5540	.74347	471	.6197	.79221
344	.4526	.65574	422	.5553	.74450	472	.6210	.79313
346	.4553	.65826	423	.5566	.74553	473	.6224	.79405
348	.4579	.66076	424	.5579	.74655	474	.6237	.79496
350	0.4605	9.66325	**425**	0.5592	9.74758	**475**	0.6250	9.79588
352	.4632	.66573	426	.5605	.74860	476	.6263	.79679
354	.4658	.66819	427	.5618	.74961	477	.6276	.79770
356	.4684	.67064	428	.5632	.75063	478	.6289	.79861
358	.4711	.67307	429	.5645	.75164	479	.6303	.79952
360	0.4737	9.67549	**430**	0.5658	9.75265	**480**	0.6316	9.80043
362	.4763	.67790	431	.5671	.75366	481	.6329	.80133
364	.4789	.68029	432	.5684	.75467	482	.6342	.80223
366	.4816	.68267	433	.5697	.75567	483	.6355	.80313
368	.4842	.68503	434	.5711	.75668	484	.6368	.80403
370	0.4868	9.68739	**435**	0.5724	9.75768	**485**	0.6382	9.80493
372	.4895	.68973	436	.5737	.75867	486	.6395	.80582
374	.4921	.69206	437	.5750	.75967	487	.6408	.80672
376	.4947	.69437	438	.5763	.76066	488	.6421	.80761
378	.4974	.69668	439	.5776	.76165	489	.6434	.80850
380	0.5000	9.69897	**440**	0.5790	9.76264	**490**	0.6447	9.80938
382	.5026	.70125	441	.5803	.76362	491	.6461	.81027
384	.5053	.70352	442	.5816	.76461	492	.6474	.81115
386	.5079	.70577	443	.5829	.76559	493	.6487	.81203
388	.5105	.70802	444	.5842	.76657	494	.6500	.81291
390	0.5132	9.71025	**445**	0.5855	9.76755	**495**	0.6513	9.81379
392	.5158	.71247	446	.5868	.76852	496	.6526	.81467
394	.5184	.71468	447	.5882	.76949	497	.6540	.81556
396	.5211	.71688	448	.5895	.77046	498	.6553	.81642
398	.5237	.71907	449	.5908	.77143	499	.6566	.81729

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Humidity and pressure terms combined : $\frac{\delta}{\delta_0} = \frac{h}{760} = \frac{B - 0.378e}{760}$.

B = Barometric pressure in mm. ; e = Vapor pressure in mm.

h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.	h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.	h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.
mm.		− 10	mm.		− 10	mm.		− 10
500	0.6579	9.81816	**550**	0.7237	9.85955	**600**	0.7895	9.89734
501	.6592	.81902	551	.7250	.86034	601	.7908	.89806
502	.6605	.81989	552	.7263	.86112	602	.7921	.89878
503	.6618	.82075	553	.7276	.86191	603	.7934	.89950
504	.6632	.82162	554	.7290	.86270	604	.7947	.90022
505	0.6645	9.82248	**555**	0.7303	9.86348	**605**	0.7961	9.90094
506	.6658	.82334	556	.7316	.86426	606	.7974	.90166
507	.6671	.82419	557	.7329	.86504	607	.7987	.90238
508	.6684	.82505	558	.7342	.86582	608	.8000	.90309
509	.6697	.82590	559	.7355	.86660	609	.8013	.90380
510	0.6711	9.82676	**560**	0.7368	9.86737	**610**	0.8026	9.90452
511	.6724	.82761	561	.7382	.86815	611	.8040	.90523
512	.6737	.82846	562	.7395	.86892	612	.8053	.90594
513	.6750	.82930	563	.7408	.86969	613	.8066	.90665
514	.6763	.83015	564	.7421	.87046	614	.8079	.90735
515	0.6776	9.83099	**565**	0.7434	9.87123	**615**	0.8092	9.90806
516	.6789	.83184	566	.7447	.87200	616	.8105	.90877
517	.6803	.83268	567	.7461	.87277	617	.8118	.90947
518	.6816	.83352	568	.7474	.87353	618	.8132	.91017
519	.6829	.83435	569	.7487	.87430	619	.8145	.91088
520	0.6842	9.83519	**570**	0.7500	9.87506	**620**	0.8158	9.91158
521	.6855	.83602	571	.7513	.87582	621	.8171	.91228
522	.6869	.83686	572	.7526	.87658	622	.8184	.91298
523	.6882	.83769	573	.7540	.87734	623	.8197	.91367
524	.6895	.83852	574	.7553	.87810	624	.8211	.91437
525	0.6908	9.83934	**575**	0.7566	9.87885	**625**	0.8224	9.91507
526	.6921	.84017	576	.7579	.87961	626	.8237	.91576
527	.6934	.84100	577	.7592	.88036	627	.8250	.91645
528	.6947	.84182	578	.7605	.88111	628	.8263	.91715
529	.6961	.84264	579	.7618	.88186	629	.8276	.91784
530	0.6974	9.84346	**580**	0.7632	9.88261	**630**	0.8289	9.91853
531	.6987	.84428	581	.7645	.88336	631	.8303	.91922
532	.7000	.84510	582	.7658	.88411	632	.8316	.91990
533	.7013	.84591	583	.7671	.88486	633	.8329	.92059
534	.7026	.84673	584	.7684	.88560	634	.8342	.92128
535	0.7040	9.84754	**585**	0.7697	9.88634	**635**	0.8355	9.92196
536	.7053	.84835	586	.7711	.88708	636	.8368	.92264
537	.7066	.84916	587	.7724	.88782	637	.8382	.92332
538	.7079	.84997	588	.7737	.88856	638	.8395	.92401
539	.7092	.85078	589	.7750	.88930	639	.8408	.92469
540	0.7105	9.85158	**590**	0.7763	9.89004	**640**	0.8421	9.92537
541	.7118	.85238	591	.7776	.89077	641	.8434	.92604
542	.7132	.85318	592	.7789	.89151	642	.8447	.92672
543	.7145	.85399	593	.7803	.89224	643	.8461	.92740
544	.7158	.85478	594	.7816	.89297	644	.8474	.92807
545	0.7171	9.85558	**595**	0.7829	9.89370	**645**	0.8487	9.92875
546	.7184	.85638	596	.7842	.89443	646	.8500	.92942
547	.7197	.85717	597	.7855	.89516	647	.8513	.93009
548	.7211	.85797	598	.7868	.89589	648	.8526	.93076
549	.7224	.85876	599	.7882	.89662	649	.8539	.93143

TABLE 100.

WEIGHT IN GRAMS OF ONE CUBIC CENTIMETER OF AIR.

Humidity and pressure terms combined : $\frac{\delta}{\delta_0} = \frac{h}{760} = \frac{B - 0.378e}{760}$.

B = Barometric pressure in mm. ; e = Vapor pressure in mm.

h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.	h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.	h.	$\frac{h}{760}$.	Log $\frac{h}{760}$.
mm.		— 10	mm.		— 10	mm.		— 10
650	0.8553	9.93210	**700**	0.9211	9.96428	**750**	0.9868	9.99425
651	.8566	.93277	701	.9224	.96490	751	.9882	.99483
652	.8579	.93341	702	.9237	.96552	752	.9895	.99540
653	.8592	.93410	703	.9250	.96614	753	.9908	.99598
654	.8605	.93476	704	.9263	.96676	754	.9921	.99656
655	0.8618	9.93543	**705**	0.9276	9.96738	**755**	0.9934	9.99713
656	.8632	.93609	706	.9289	.96799	756	.9947	.99771
657	.8645	.93675	707	.9303	.96860	757	.9961	.99828
658	.8658	.93741	708	.9316	.96922	758	.9974	.99886
659	.8671	.93807	709	.9329	.96983	759	.9987	.99943
660	0.8684	9.93873	**710**	0.9342	9.97044	**760**	1.0000	0.00000
661	.8697	.93939	711	.9355	.97106	761	.0013	.00057
662	.8711	.94004	712	.9368	.97167	762	.0026	.00114
663	.8724	.94070	713	.9382	.97228	763	.0039	.00171
664	.8737	.94135	714	.9395	.97288	764	.0053	.00228
665	0.8750	9.94201	**715**	0.9408	9.97349	**765**	1.0066	0.00285
666	.8763	.94266	716	.9421	.97410	766	.0079	.00342
667	.8776	.94331	717	.9434	.97470	767	.0092	.00398
668	.8790	.94396	718	.9447	.97531	768	.0105	.00455
669	.8803	.94461	719	.9461	.97592	769	.0118	.00511
670	0.8816	9.94526	**720**	0.9474	9.97652	**770**	1.0132	0.00568
671	.8829	.94591	721	.9487	.97712	771	.0145	.00624
672	.8842	.94656	722	.9500	.97772	772	.0158	.00680
673	.8855	.94720	723	.9513	.97832	773	.0171	.00736
674	.8869	.94785	724	.9526	.97892	774	.0184	.00793
675	0.8882	9.94849	**725**	0.9539	9.97952	**775**	1.0197	0.00849
676	.8895	.94913	726	.9553	.98012	776	.0211	.00905
677	.8908	.94978	727	.9566	.98072	777	.0224	.00961
678	.8921	.95042	728	.9579	.98132	778	.0237	.01017
679	.8934	.95106	729	.9592	.98191	779	.0250	.01072
680	0.8947	9.95170	**730**	0.9605	9.98250	**780**	1.0263	0.01128
681	.8960	.95233	731	.9618	.98310	781	.0276	.01184
682	.8974	.95297	732	.9632	.98370	782	.0289	.01239
683	.8987	.95361	733	.9645	.98429	783	.0303	.01295
684	.9000	.95424	734	.9658	.98488	784	.0316	.01350
685	0.9013	9.95488	**735**	0.9671	9.98547	**785**	1.0329	0.01406
686	.9026	.95551	736	.9684	.98606	786	.0342	.01461
687	.9039	.95614	737	.9697	.98665	787	.0355	.01516
688	.9053	.95677	738	.9711	.98724	788	.0368	.01571
689	.9066	.95740	739	.9724	.98783	789	.0382	.01626
690	0.9079	9.95804	**740**	0.9737	9.98842	**790**	1.0395	0.01681
691	.9092	.95866	741	.9750	.98900	791	.0408	.01736
692	.9105	.95929	742	.9763	.98959	792	.0421	.01791
693	.9118	.95992	743	.9776	.99018	793	.0434	.01846
694	.9132	.96054	744	.9789	.99076	794	.0447	.01901
695	0.9145	9.96117	**745**	0.9803	9.99134	**795**	1.0461	0.01955
696	.9158	.96180	746	.9816	.99192	796	.0474	.02010
697	.9171	.96242	747	.9829	.99251	797	.0487	.02064
698	.9184	.96304	748	.9842	.99309	798	.0500	.02119
699	.9197	.96366	749	.9855	.99367	799	.0513	.02173

ATMOSPHERIC WATER-VAPOR LINES IN THE VISIBLE SPECTRUM.

Wave lengths in Ångströms.	Number of lines.	Intensity.
5292.3–5296.0	4?	00
5861.8–5870.0	7	00
5870.864		1
5871.3–5876.0	8	00
5876.338		1
5876.6–5879.4	4	00
5879.820		1
5879.945		1
5880.7–5881.0	2	0
5881.147		1
5881.320		0
5882.084		1
5882.2–5883.2	3	0
5884.120		5
5884.4–5885.8	3	00
5886.193		5
5886.560		1
5886.6–5886.9	2	0
5887.445		5
5887.880		3
5888.056		00
5888.920		2
5889.303		00
5889.855		3
5890.100		2
5890.4–5890.9	2	00
5891.398		1
5891.720		0
5891.878		4
5892.608		3
5893.268		0
5893.725		1
5894.6–5896.6	5	0
5896.710		1
5897.047		2
5897.3–5898.2	4	00
5898.378		4
5898.6–5899.0	2	00
5899.215		2
5899.752		00
5900.135		2
5900.260		4
5900.6–5901.5	3	00
5901.682		6
5902.238		000
5902.363		1
5903.035		000
5903.748		1
5903.9–5907.7	13	00
5908.070		1
5908.425		1
5909.213		3
5909.668		00
5910.398		1
5910.5–5910.9	3	00
5910.987		2
5911.1–5912.9	7	00
5913.212		3
5914.430		6
5915.146		1
5915.650		1
5915.840		1
5916.0–5918.2	6	00
5918.635		4
5919.175		000
5919.276		5
5919.860		7
5920.395		00
5920.776		1
5921.3–5922.6	3	0
5922.735		2
5922.9–5923.4	2	0
5923.865		1
5924.040		2
5924.490		4
5924.975		000
5925.220		2
5926.835		000
5928.510		2
5929.0–5931.2	5	00
5932.306		5
5932.998		2
5933.2–5940.2	14	000
5940.640		1
5941.091		00
5941.290		5
5941.470		000
5941.845		2
5942.500		000
5942.635		1
5942.789		3
5944.530		1
5944.945		1
5945.4–5945.5	2	00
5945.865		1
5946.223		3
5946.864		000
5947.062		1
5947.283		2
5947.6–5949.2	4	000
5949.390		2
5949.8–5954.6	11	00
5955.170		1
5956.0–5956.6	4	000
5958.098		1
5958.460		1
5961.6–5966.6	5	00
5966.885		1
5967.540		00
5968.058		2
5968.280		000
5968.495		2
5969.2–5970.9	3	00
5971.557		1
5975.330		1
5976.694		00
5977.252		1
5977.6–6479.7	73	000

TABLE 101.

ATMOSPHERIC WATER-VAPOR LINES IN THE VISIBLE SPECTRUM.

Wave lengths in Ångströms.	Number of lines.	Intensity.
6480.285		1
6480.4–6483.3	4	0000
6483.468		1
6483.6–6490.9	11	000
6491.015		1
6493.1–6493.5	2	00
6494.725		1
6496.082		2
6497.8–6514.5	7	00
6514.956		2
6516.080		000
6516.750		1
6516.855		2
6517.3–6519.4	3	00
6519.682		1
6522.1–6523.9	4	0000
6524.080		1
6526.0–6530.8	2	000
6532.595		1
6534.172		2
6534.8–6542.6	3	000
6544.140		2
6546.0–6547.9	2	00
6548.855		1
6552.865		1
6554.025		00 ?
6556.308		1
6557.4–6558.4	2	0
6560.800		1 ?
6563.7–6569.0	4	00
6572.330		1
6575.085		1
6580.4–6929.6	11	000
6934.075		2
6937.957		2
6938.520		1
6939.875		2
6940.436		2
6941.260		000
6941.475		1
6942.402		2
6942.630		1
6944.060		3
6947.782		5
6947.863		00
6949.240		1
6949.310		1
6951.010		1
6953.828		1
6954.0–6955.9	2	00
6956.660 }		4
6956.746 }		1
6959.704		3
6961.515		4
6964.812		1
6971.135		0
6977.715		3
6981.722		1
6985.220		0
6986.833		3
6988.125		0
6989.237		3
6990.632		1
6993.776		2
6994.360		1
6998.978		0
6999.223		2
7004.575		0
7004.995		2
7005.3–7010.1	2	0
7011.590		2
7016.330		1
7016.675		3
7023.770		2
7027.213		0
7027.740		2

TABLE 102.

ATMOSPHERIC WATER-VAPOR BANDS IN THE INFRA-RED SPECTRUM.

Name of band.	Wave-lengths.	Transmission coefficient a.
	μ	
α	0.718	0.91
	0.814	0.92
	0.896	0.90
ρ	0.933	0.63
σ	0.945	0.69
τ	0.974	0.91
Φ_1	1.119	0.54
Φ_2	1.134	0.60
	1.172	0.92
In Ψ	1.331	0.74
In Ψ	1.451	0.36
Ψ_1	1.469	0.55

The infra-red bands may perhaps be composed of numerous fine lines which the bolographic apparatus does not separately distinguish.

Wide bands of very great atmospheric water-vapor absorption are found in the infra-red spectrum as follows :

Name.	Wave lengths.	Absorption at Washington.
	μ μ	
$\rho\sigma\tau$	0.926–0.978	0.3 to 0.5
Φ	1.095–1.165	0.5 to 0.8
Ψ	1.319–1.498	0.7 to 1.0
Ω	1.762–1.977	0.9 to 1.0
X	2.520–2.845	1.0 { Partly CO_2 }

See Vol. I, *Annals Astrophysical Observatory*, Smithsonian Institution.

TRANSMISSION PERCENTAGES OF RADIATION THROUGH MOIST AIR.

Range of Wave-lengths.		PRECIPITABLE WATER IN CENTIMETERS.												
μ	μ	.001	.003	.006	.01	.03	.06	.10	.25	.50	1.0	2.0	6.0	10.0
0.75 to	1.0				*100*	99	99	98	97	95	93	90	83	*78*
1.0	1.25				*99*	99	98	97	95	92	89	85	74	*69*
1.25	1.5				*96*	*92*	*84*	*80*	*66*	57	51	44	31	*28*
1.5	2.0				*98*	*97*	*94*	*88*	*79*	73	70	66	60	*57*
* 2.	3.	*96*	*92*	*87*	*84*	*77*	*70*	*64*						
3.	4.	*95*	*88*	*84*	*78*	*72*	*66*	*63*						
* 4.	5.	*92*	*83*	*76*	*71*	*65*	*60*	*53*						
5.	6.	95	82	75	68	56	51	47	35					
6.	7.	*85*	54	50	31	24	8	4	3	*2*	0	0	0	0
7.	8.	*94*	84	76	68	57	46	35	16	*10*	*2*	0	0	0
8.	9.	100	100	100	99	98	96	94	*65*					
† 9.	10.	100	100	100	100	100	100	100	100	100	100	100		
†10.	11.	100	100	100	100	100	100	100	100	100	100	100		
11.	12.	100	100	100	100	100	99	98	96	95	*93*			
12.	13.	100	100	100	100	99	99	97	*86*	*82*				
*13.	14.	100	100	100	99	97	94	90	*80*	*60*				
*14.	15.			*96*	*93*	*80*	*75*	*50*	*15*	*0*	*0*	*0*	*0*	*0*
*15.	16.					*70*	*55*	*40*	*0*	*0*	*0*	*0*	*0*	*0*
16.	17.						*50*	*20*	*0*	0	0	0	0	0
17.	18.						*25*	*10*	*0*	0	0	0	0	0
18.		0	0	0	0	0	0	0	0	0	0	0	0	0

* These places require multiplication by the following factors to allow for losses in CO_2 gas. Under average sea-level outdoor conditions the CO_2 (partial pressure = 0.0003 atmos.) amounts to about 0.6 grams per cu.m. Paschen gives 3 times as much for indoor conditions.
2μ to 3μ, for 2 grams in m^2 path (95); for 140 grams in m^2 path (93);
4 " 5 , " " " " " " (93); " " " " " " (70); more CO_2 no further effect;
13 " 14 , slight allowance to be made;
14 " 15 , 80 grams in m^2 path reduces energy to zero;
15 " 16 , " " " " " " " " " " .
† These places require multiplication by 0.90 and 0.70 respectively for one air mass and 0.85 and 0.65 for two air masses to allow for ozone absorption when the radiation comes from a celestial body.

F. Paschen gives (*Annalen d. Physik. u. Chemie*, 51, p. 14, 1894) the absorption of the radiation from a blackened strip at 500° C. by a layer 33 centimeters thick of water vapor at 100° *C.* and atmospheric pressure as follows:

	μ μ	μ μ	μ μ
Wave length............	2.20–3.10	5.33–7.67	7.67–10 (?)
Percentage absorption...	80	94	94–13

The following table, due to Rubens and Aschkinass (*Annalen d. Physik u. Chemie*, 64, p. 598, 1898), gives the absorption of radiation from a zircon burner by a layer 75 centimeters thick of water vapor saturated at 100° *C.* This amount of vapor is about equivalent to a layer of water 0.45 millimeter thick or to 1.5% of the water in a total vertical atmospheric column whose dew-point at sea-level is 10° *C.* The region of spectrum examined includes most of the region of terrestrial radiation.

	μ	μ	μ μ	μ	μ	μ	μ
Wave length..........	7.0	8.0	9.0–12.0	12.4	12.8	13.4	14.0
Percentage absorption...	75	40	6	20	13	28	22
	μ	μ	μ	μ	μ	μ	μ
Wave length..........	14.3	15.0	15.7	16.0	17.5	18.3	20.0
Percentage absorption...	43	35	65	52	88	80	100

INTERNATIONAL METEOROLOGICAL SYMBOLS.

The International Meteorological Symbols were adopted at the Vienna meteorological congress of 1873. A few additions and modifications have been made at subsequent international meteorological meetings. The forms of these symbols are more or less flexible. Those shown in the accompanying table are the forms which have generally been used in the United States, and with two exceptions ("wet fog" and "zodiacal light") are identical with those used by the Prussian Meteorological Institute and given in the German editions of the International Meteorological Codex. The principal variants found in the meteorological publications of the different countries are given in the *Monthly Weather Review* (Wash., D.C.), May, 1916, p. 268.

Exponents. — An exponent added to a symbol indicates the degree of intensity, ranging from ° weak (light, etc.) to ² strong (heavy, etc.). Thus, ●°, light rain; ●², heavy rain. German and French observers use the exponent ¹ to denote medium intensity, in accordance with the German and French versions of the report of the Vienna congress, and the German editions of the Codex. The English version of the above-mentioned report and the English edition of the Codex provide for the use of only two exponents, ° and ²; hence in English-speaking countries the omission of the exponent indicates medium intensity.

Time of occurrence. — When hours of occurrence are added to symbols, the abbreviation *a* is used for a.m., and *p* for p.m. Thus, ● 10a – 4p denotes "rain from 10 a.m. to 4 p.m." 12*a* = noon; 12*p* = midnight. The abbreviation *n* means "during night." Stations taking tri-daily observations may use *a* to mean between the first and second observation; *p*, between the second and third; and *n*, between the third and the first.

For further information concerning the International Symbols and other meteorological symbols, see "Meteorological Symbols," by C. Fitzhugh Talman, *Monthly Weather Review* (Wash., D.C.), May, 1916, pp. 265–274.

INTERNATIONAL METEOROLOGICAL SYMBOLS.

Symbol.	Meaning.	Remarks.
◍	Rain.	
✳	Snow.	
⛈	Thunderstorm.	Thunder and lightning.
T	Thunder.	Without lightning.
≮	Lightning.	Without thunder; "heat-lightning."
▲	Hail.*	
△	Graupel.	Sometimes called "soft hail." French, *grésil.* Resembles little snow-pellets.
≡	Fog.	
≣	Ground fog.	Not exceeding the height of a man.
≡:	Wet fog.	One which wets exposed surfaces.
⊔	Hoarfrost.	
⌓	Dew.	
V	Rime.	A rough frost deposit from fog.
∾	Glaze; Glazed frost.†	Ice coating due to rain, "ice-storm." In America often called "sleet."
✢	Driving snow.	Ger., *Schneegestöber;* Fr., *bourrasque de neige.*
⟵	Ice-crystals.	Ice-needles sometimes seen floating or slowly falling in the air in clear, cold weather.
⊠	Snow on ground.	Ground near station more than half covered.
⸺ш	Gale.	Wind of force 8–12, Beaufort scale. (Rept. Int. Met'l Comm., Berlin, 1910, English ed., p. 17.) Formerly used for "strong wind." A 3-barbed arrow is introduced in the 2d German ed. of the Int. Met'l Codex to denote "strong wind," but no authority is cited. According to the Observer's Handbook of the British Met'l Office "the number of barbs on the arrow may conveniently be made to represent the strongest wind force noted," but there is no international sanction for such variants.
⊙	Sunshine.	In German edition of Int. Met'l Codex, but has never been definitely recognized by the international organization. (See Rept. Int. Met'l Comm., Southport, 1903, Engl. ed., p. 19 and 101.) Widely used in German and Austrian publications.
⊕	Solar halo.	
⦶	Solar corona.	
⊽	Lunar halo.	
Ѡ	Lunar corona.	
∩	Rainbow.	
⌓	Aurora.	
⩙	Zodiacal light.	
∞	Haze.	Due to fine dust, or to the disturbance of atmospheric transparency by air-currents of different densities ("optical turbidity"), and not to water-drops. In practice, this is often difficult to distinguish from light fog (≡°), or "mist" of British observers. Prussian and Austrian observers underscore this symbol (∞̲) to denote a definitely *smoky* atmosphere ("Moorrauch").

* True hail, which occurs chiefly with summer thunderstorms, should be distinguished from the snowy pellets, like miniature snowballs, known as *graupel,* or *soft hail* (△): also from the small particles of clear ice, called *sleet* by the U.S. Weather Bureau, for which there is no international symbol. On the history of the word *sleet* see *Monthly Weather Review,* May, 1916, pp. 281–286.

† *Glaze* is the official term in the United States; *glazed frost* in Great Britain.

INTERNATIONAL CLOUD CLASSIFICATION.

The International Conference of Meteorologists held at Munich in 1891 recommended the following classification of clouds, elaborated by Messrs. Abercromby and Hildebrandsson:

a. Detached clouds with rounded upper outlines (most frequent in dry weather).
b. Clouds of great horizontal extent suggesting a layer or sheet (wet weather).

A. **Upper Clouds,** average altitude 9000^m.

a. 1. *Cirrus.*
b. 2. *Cirro-stratus.*

B. **Intermediate Clouds,** between 3000^m and 7000^m.

a. { 3. *Cirro-cumulus.*
  { 4. *Alto-cumulus.*
b. 5. *Alto-stratus.*

C. **Lower Clouds,** below 2000^m.

a. 6. *Strato-cumulus.*
b. 7. *Nimbus.*

D. **Clouds of diurnal ascending currents.**

a. 8. *Cumulus;* top 1800^m; base 1400^m.
b. 9. *Cumulo-nimbus;* top 3000^m to 8000^m; base 1400^m.

E. **High Fogs,** under 1000^m.

10. *Stratus.*

DEFINITIONS AND DESCRIPTIONS OF CLOUD FORMS.

1. **Cirrus (Ci.).** — *Detached clouds of delicate and fibrous appearance, often showing a feather-like structure, generally of a whitish color.* Cirrus clouds take the most varied shapes, such as isolated tufts, thin filaments on a blue sky, threads spreading out in the form of feathers, curved filaments ending in tufts, sometimes called *Cirrus uncinus*, etc.; they are sometimes arranged in parallel belts which cross a portion of the sky in a great circle, and by an effect of perspective appear to converge towards a point on the horizon, or, if sufficiently extended, towards the opposite point also. (Ci.-St. and Ci.-Cu., etc., are also sometimes arranged in similar bands.)

2. **Cirro-stratus (Ci.-St.).** — *A thin, whitish sheet of clouds* sometimes covering the sky completely and giving it only a milky appearance (it is then called *Cirro-nebula*), at other times presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the Sun and Moon.

3. **Cirro-cumulus (Ci.-Cu.). Mackerel sky.** — *Small globular masses or white flakes without shadows, or showing very slight shadows, arranged in groups and often in lines.*

4. **Alto-stratus (A.-St.).** — *A thick sheet of a gray or bluish color,* sometimes forming a compact mass of dark gray color and fibrous structure. At other times the sheet is thin, resembling thick Ci.-St., and through it the Sun or the Moon may be seen dimly gleaming as through ground glass. This form exhibits all changes peculiar to Ci.-St., but from measurements its average altitude is found to be about one half that of Ci.-St.

5. **Alto-cumulus (A.-Cu.).** — *Largish globular masses, white or grayish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused.* The detached masses are generally larger and more compact (resembling St.-Cu.) at the center of the group, but the thickness of the layer varies. At times the masses spread themselves out and assume the appearance of small waves or thin slightly curved plates. At the margin they form into finer flakes (resembling Ci.-Cu.). They often spread themselves out in lines in one or two directions.

6. **Strato-cumulus (St.-Cu.).** — *Large globular masses or rolls of dark clouds often covering the whole sky, especially in winter.* Generally St.-Cu. presents the appearance of a gray layer irregularly broken up into masses of which the edge is often formed of smaller masses, often of wavy appearance resembling A.-Cu. Sometimes this cloud-form presents the characteristic appearance of great rolls arranged in parallel lines and pressed close up against one another. In their centers these rolls are of a dark color. Blue sky may be seen through the intervening spaces which are of a much lighter color. (Roll-cumulus in England, Wulst-cumulus in Germany.) St.-Cu. clouds may be distinguished from Nb. by their globular or rolled appearance, and by the fact that they are not generally associated with rain.

7. **Nimbus (Nb.), Rain Clouds.** — *A thick layer of dark clouds, without shape and with ragged edges,* from which *steady* rain or snow usually falls. Through the openings in these clouds an upper layer of Ci.-St. or A.-St. may be seen almost invariably. If a layer of Nb.

separates up in a strong wind into shreds, or if small loose clouds are visible floating underneath a large Nb., the cloud may be described as *Fracto-nimbus* (Fr.-Nb.) (" Scud " of sailors).

8. **Cumulus (Cu.), Wool pack Clouds.** — *Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal.* These clouds appear to be formed by a diurnal ascensional movement which is almost always noticeable. When the cloud is opposite the Sun, the surfaces facing the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, as is usually the case, these clouds throw deep shadows; when, on the contrary, the clouds are on the same side of the observer as the Sun, they appear dark with bright edges.

True cumulus has well defined upper and lower limits, but in strong winds a broken cloud resembling Cumulus is often seen in which the detached portions undergo continual change. This form may be distinguished by the name *Fracto-cumulus* (Fr.-Cu.).

9. **Cumulo-nimbus (Cu.-Nb.), The Thunder-Cloud; Shower-Cloud.** — *Heavy masses of cloud rising in the form of mountains, turrets or anvils, generally surmounted by a sheet or screen of fibrous appearance (false Cirrus) and having at its base a mass of cloud similar to nimbus.* From the base local showers of rain or snow (occasionally of hail or soft hail) usually fall. Sometimes the upper edges assume the compact form of cumulus, and form massive peaks round which delicate " false Cirrus " floats. At other times the edges themselves separate into a fringe of filaments similar to Cirrus clouds. This last form is particularly common in spring showers.

The front of thunder-clouds of wide extent frequently presents the form of a large arc spread over a portion of a uniformly brighter sky.

10. **Stratus (St.).** — *A uniform layer of cloud resembling a fog but not resting on the ground.* When this sheet is broken up into irregular shreds in a wind, or by the summits of mountains, it may be distinguished by the name *Fracto-stratus* (Fr.-St.).

During summer all low clouds tend to assume forms resembling Cumulus, and may be described accordingly as *Stratus cumuliformis*, *Nimbus cumuliformis*, etc.

The term *Mammato-cumulus* is applied to a cloud having a mammillated lower surface, occurring especially in connection with severe local storms.

The ovoid form, with sharp edges, assumed by certain clouds, particularly during the occurrence of sirocco, mistral or foehn, is indicated by the adjective *lenticularis*, e.g., *Cumulus lenticularis* (*Cu. lent.*), *Stratus lenticularis* (*St. lent.*). Such clouds frequently show iridescence.

For pictures of typical cloud forms see "International Cloud Atlas," 2d ed., Paris, 1910; also U.S. Weather Bureau, "Classification of Clouds for the Guidance of Observers," Washington, D.C., 1911, and Gt. Britain, Meteorological Office, "Observer's Handbook," London (annual).

BEAUFORT WEATHER NOTATION.

Especially intended for the use of mariners, but sometimes used at land stations. The original notation was devised in 1805 by Admiral Sir F. Beaufort; it has since been slightly altered and amplified by British and American meteorologists. The following symbols are used by the marine observers of the U.S. Weather Bureau: —

Upper Atmosphere:
- *b.* — Blue sky.
- *c.* — Cloudy sky.
- *o.* — Overcast sky.

Lower Atmosphere:
- *v.* — Visibility (exceptionally clear).
- *z.* — Haze.
- *m.* — Mist.
- *f.* — Fog.

Precipitation:
- *d.* — Drizzling.
- *p.* — Passing showers.
- *r.* — Rain.
- *s.* — Snow.
- *h.* — Hail.

Electric phenomena:
- *l.* — Lightning.
- *t.* — Thunder.

Wind:
- *q.* Squally.

The British Meteorological Office also uses the following: —

- *e.* — Wet air without rain.
- *g.* — Gloom.
- *u.* — Ugly or threatening appearance of the weather.
- *w.* — Dew.

"The letters *b*, *c*, *o* are intended to refer only to the amount of cloud visible, and not to its density, form or other quality. They have gradually come to be regarded as corresponding to the following cloud amounts in the scale 0–10: b = 0 to 3; bc or cb = 4 to 6; c = 7 or 8; o = 9 or 10." — Marine Observer's Handbook, Lond., 1915, p. 82.

U.S. Weather Bureau Observers use a line (light or heavy) under the symbol, British observers a dot or two dots, to indicate great intensity. Thus, U.S., $\underline{r}$ heavy rain, $\underline{\underline{r}}$, very heavy rain. British, $\underset{\cdot}{r}$, heavy rain; $\underset{:}{r}$, very heavy rain.

LIST OF METEOROLOGICAL STATIONS.

NOTE.—Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

NORTH AMERICA.	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
GREENLAND.						
*Angmagsalik	65°	37′ N.	37°	34′ W.	104	32
*Godthaab	64	11	51	44	30	9
Ivigtut	61	12	48	10	16	5
*Jacobshavn	69	13	51	2	41	13
*North Star Bay	76	30	68	55	2	0.6
*Upernivik	72	47	56	7	44	19
ICELAND.						
*Berufjord	64	40 N.	14	19 W.	59	18
*Grimsey (Akureyri)	66	33	17	58	22	7
*Stykkisholm	65	5	22	46	37	11
*Vestmanno	63	26	20	15	23	8
FÄRO ISLANDS.						
*Thorshavn	62	3 N.	6	45 W.	30	26
ALASKA.						
*Dutch Harbor	53	55 N.	166	32 W.	13	4
*Eagle	64	46	141	12	835	255
Juneau	58	18	134	24	80	24
*Nome	64	30	165	24	23	7
*Sitka	57	4	135	20	63	19
*Tanana	65	10	152	6	220	67
*Valdez	61	7	146	16	23	7
CANADA AND NEWFOUNDLAND.						
Banff	51	10 N.	115	34 W.	4521	1378
*Barkerville	53	2	121	35	4180	1274
*Belle Isle	51	55	55	20	436	133
*Berens River	52	18	97	23	709	216
*Calgary	51	2	114	2	3389	1033
*Carcross	60	11	134	34	2172	662
*Davis Inlet	55	50	60	50		?
*Dawson	64	4	139	20	1053	321
Father Point	48	31	68	19	20	6
*Fort Chipewyan	58	42	111	10	715	218
*Fort Hope	51	32	87	48		?
*Fort Resolution	61	00	113	00	787	240
*Fort Simpson	61	52	120	43	423	129
Fredericton	45	57	66	36	164	50
Halifax	44	39	63	36	88	29
*Hay River	60	51	115	20	525	161
*Hebron (Labrador)	58	12	62	21	49	16
*Kamloops	50	41	120	29	1243	379
Kingston	44	13	76	29	285	87
*Macleod	49	44	113	24	3130	954
*Minnedosa	50	15	99	50	1699	518
Montreal	45	30	73	35	187	57
*Moose Factory	51	16	80	56	30	9
*Nain	56	33	61	41	13	4
Parry Sound	45	19	80	00	635	193
*Point Riche	50	42	57	25	36	11
Port Arthur	48	27	89	12	643	196
*Prince Albert	53	10	106	00	1430	436
*Prince Rupert	54	18	130	18	171	52

Table 107.

LIST OF METEOROLOGICAL STATIONS.

Note.—Stations with asterisk appear in the 'Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

CANADA. (*Continued.*)	Latitude.	Longitude from Greenwich.	Height. Feet.	Height. m.
*Qu'Appelle	50° 30′ N.	103° 47′ W.	2116	645
Quebec	46 48	71 13	296	90
*Sable Island	43 57	60 6	26	8
*St. John, N.B.	45 17	66 4	119	36
*St. Johns, Newfoundland	47 34	52 42	125	38
*S.W. Point, Anticosti	49 24	63 35	30	9
Sydney	46 10	60 10	48	11
*Toronto	43 40	79 24	379	116
*Victoria	48 24	123 19	230	70
*Winnipeg	49 53	97 7	760	232
Woodstock	43 8	80 47	980	299
*York Factory	57 00	92 28	36	11
UNITED STATES.				
*Abilene	32 23 N.	99 40 W.	1738	530
Albany	42 39	73 45	97	30
Alpena	45 5	83 30	609	186
Amarillo	35 13	101 50	3676	1120
Asheville	35 36	82 32	2255	687
Atlanta	33 45	84 23	1174	358
Atlantic City	39 22	74 25	52	16
Augusta	33 28	81 54	180	55
Baltimore	39 17	76 37	123	37
Binghamton	42 6	75 55	871	265
*Bismarck	46 47	100 38	1674	510
Block Island	41 10	71 36	26	8
Blue Hill	42 12	71 6	640	195
Boise	43 37	116 13	2739	835
Boston	42 21	71 4	125	38
Buffalo	42 53	78 53	767	234
Cairo	37 0	89 10	356	108
Cape Henry	36 56	76 0	18	5
*Charleston	32 47	79 56	48	15
Charlotte	35 13	80 51	779	237
Chattanooga	35 4	85 14	762	232
*Cheyenne	41 8	104 48	6088	1855
*Chicago	41 53	87 37	823	251
Cincinnati	39 6	84 30	628	191
Cleveland	41 30	81 42	762	232
Columbia, Mo	38 57	92 20	784	239
Columbia, S.C	34 0	81 3	351	107
Columbus	39 58	83 0	824	251
Concord	43 12	71 32	288	88
Corpus Christi	27 49	97 25	20	6
Davenport	41 30	90 38	606	185
*Denver	39 45	105 0	5291	1613
Des Moines	41 35	93 37	861	262
Detroit	42 20	83 3	730	222
Dodge City	37 45	100 0	2509	765
Drexel	41 20	96 16	1299	396
Dubuque	42 30	90 44	698	213
*Duluth	46 47	92 6	1133	345
Eastport	44 54	66 59	76	23
Elkins	38 53	79 49	1947	593
El Paso	31 47	106 30	3762	1147
Erie	42 7	80 5	714	217

LIST OF METEOROLOGICAL STATIONS.

NOTE. — Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

UNITED STATES. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
Escanaba	45°	48′ N.	87°	5′ W.	612	187
Eureka	40	48	124	11	62	19
Evansville	37	58	87	33	431	131
Fort Smith	35	22	94	24	457	139
Fort Worth	32	43	97	15	670	204
Fresno	36	43	119	49	330	101
*Galveston	29	18	94	50	54	16
Grand Haven	43	5	86	13	632	193
Grand Junction	39	4	108	34	4602	1403
Green Bay	44	31	88	0	617	188
Harrisburg	40	16	76	52	374	114
Hartford	41	46	72	40	159	48
Havre	48	34	109	40	2505	764
*Helena	46	34	112	4	4110	1253
Houghton	47	7	88	34	668	204
Houston	29	47	95	24	138	42
Huron	44	21	98	14	1306	398
Indianapolis	39	46	86	10	822	251
Ithaca	42	27	76	29	836	255
Jacksonville	30	20	81	39	43	13
Kalispell	48	10	114	25	2973	906
Kansas City	39	5	94	37	963	293
*Key West	24	33	81	48	22	7
Knoxville	35	56	83	58	996	304
La Crosse	43	49	91	15	714	218
Lander	42	50	108	45	5372	1637
Lansing	42	44	84	26	878	268
Lewiston	46	25	117	2	757	231
Lexington	38	2	84	33	989	301
Lincoln	40	49	96	45	1189	362
Little Rock	34	45	92	16	357	109
Los Angeles	34	3	118	15	338	103
Louisville	38	15	85	45	525	160
Lynchburg	37	25	79	9	681	207
Macon	32	50	83	38	370	113
Madison	43	5	89	23	974	297
Marquette	46	34	87	24	734	224
Memphis	35	9	90	3	399	122
Meridian	32	21	88	40	375	114
Milwaukee	43	2	87	54	681	207
Minneapolis	44	59	93	18	918	280
*Mobile	30	41	88	2	57	17
Montgomery	32	23	86	18	223	68
Moorhead	46	52	96	44	940	287
Mount Tamalpais	37	56	122	35	2375	724
Mount Weather	39	4	77	53	1725	526
Nantucket	41	17	70	6	12	4
*Nashville	36	10	86	47	546	166
New Haven	41	18	72	56	106	32
*New Orleans	29	57	90	4	53	16
*New York	40	43	74	0	314	111
Norfolk	36	51	76	17	91	28
North Head	46	16	124	4	211	64
*North Platte	41	08	100	45	2821	860
Northfield	44	10	72	41	876	267
Oklahoma City	35	26	97	33	1214	370
Omaha	41	16	95	56	1105	337

LIST OF METEOROLOGICAL STATIONS.

NOTE.—Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

UNITED STATES. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height. Feet.	Height. m.
Oswego	43°	29′ N.	76°	35′ W.	335	102
Parkersburg	39	16	81	36	638	194
Pensacola	30	25	87	13	56	17
Philadelphia	39	57	75	9	117	36
Phœnix	33	28	112	0	1108	338
Pike's Peak	38	50	105	2	14134	4308
Pittsburgh	40	32	80	2	842	257
Pocatello	42	52	112	29	4477	1365
Port Huron	43	0	82	26	638	194
Portland, Me	43	39	70	15	103	31
*Portland, Oreg	45	32	122	41	153	47
Providence	41	50	71	25	160	49
Pueblo	38	18	104	36	4685	1428
Raleigh	35	45	78	37	376	115
Richmond	37	32	77	27	144	44
Rochester	43	8	77	42	523	159
Roseburg	43	13	123	20	510	155
Sacramento	38	35	121	30	69	21
*St. Louis	38	38	90	12	568	173
St. Paul	44	58	93	3	837	255
Salt Lake City	40	46	111	54	4360	1329
San Antonio	29	27	98	28	693	211
*San Diego	32	43	117	10	87	26
Sandusky	41	25	82	40	629	192
*San Francisco	37	48	122	26	155	47
*Santa Fé	35	41	105	57	7013	2138
Sault Ste. Marie	46	30	84	21	614	187
Savannah	32	5	81	5	65	20
Scranton	41	24	75	42	805	245
Seattle	47	38	122	20	125	38
Shreveport	32	30	93	40	249	76
Spokane	47	40	117	25	1929	588
Springfield, Ill	39	48	89	39	636	194
Springfield, Mo	37	12	93	18	1324	403
Syracuse	43	2	76	10	597	182
Tacoma	47	16	122	23	213	65
Tampa	27	57	82	27	35	11
Tatoosh Island	48	23	124	44	86	26
Taylor	30	35	97	20	583	178
Toledo	41	40	83	34	628	191
Topeka	39	3	95	41	987	301
Valentine	42	50	100	32	2598	792
Vicksburg	32	22	90	53	247	75
*Washington	38	54	77	3	112	34
Wichita	37	41	97	20	1358	414
Williston	48	9	103	35	1878	572
Wilmington	34	14	77	57	78	24
Wytheville	36	56	81	5	2304	702
Yankton	42	54	97	28	1233	376
MEXICO, CENTRAL AMERICA AND WEST INDIES.						
*Barbados (Windward Islands)	13	8 N.	59	36 W.	180	55
Basseterre (St. Kitts)	17	18	62	43	29	9
*Belize (Brit. Honduras)	17	29	88	12	6	2
*Bermuda (Fort Prospect)	32	17	64	46	151	46

LIST OF METEOROLOGICAL STATIONS.

Note. — Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

MEXICO, CENTRAL AMERICA AND WEST INDIES. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
Bridgetown (Barbados)	13°	4′ N.	59°	37′ W.	30	9
Camp Jacob (Guadeloupe)	16	00	62	2	1650	503
Cienfuegos (Cuba) Montserrat	22	11	80	33	52	16
Colon (Panama)	9	23	79	53	36	11
*Culebra (Panama)	9	10	79	40	404	123
Fort de France (Martinique)	14	36	61	5	13	4
Grand Turk (Turks Is.)	21	21	71	7	11	3
*Grenada (Richmond Hill)	12	3	61	45	508	155
Guanajuato (Mexico)	21	00	101	15	6640	2024
Guatemala	14	37	90	31	4888	1490
*Havana (Cuba)	23	9	82	21	74	23
*Jamaica (Negril Point)	18	15	78	23	33	10
Kingston (Jamaica)	17	58	76	48	24	7
*Leon (Mexico)	21	7	101	41	5899	1799
Mazatlan (Mexico)	23	11	106	25	25	8
*Mexico (Mexico)	19	26	99	8	7480	2280
*Morelia (Mexico)	19	14	100	7	6342	1933
*Nassau (Bahamas)	25	5	77	21	26	8
*Oaxaca (Mexico)	17	4	96	44	5128	1563
*Port au Prince (Haiti)	18	34	72	22	118	37
Port of Spain (Trinidad)	10	35	61	30	40	12
Puebla (Mexico)	19	2	98	11	7116	2169
Puerto Principe (Cuba)	21	23	77	56	352	107
Roseau (Dominica)	15	17	61	23	25	8
*St. Croix (Christiansted)	17	45	64	42	23	7
St. Thomas (Virgin Is.)	18	20	64	55	24	7
*Salina Cruz (Mexico)	16	12	95	16	184	56
Saltillo (Mexico)	25	25	100	56	5399	1645
San Domingo (San Domingo)	18	28	69	53	65	20
San José (Costa Rica)	9	56	34	8	3724	1135
San Juan (Porto Rico)	18	29	66	07	82	25
San Luis Potosi (Mexico)	22	5	100	59	6200	1890
*San Salvador (Central America)	13	44	89	9	2155	657
Santiago de Cuba (Cuba)	19	55	75	50	82	25
Tacubaya (Mexico)	19	24	99	12	7621	2323
Vera Cruz (Mexico)	19	12	96	8	23	7
Willemstad (Curaçao)	12	6	68	56	75	23
*Zacatecas (Mexico)	22	47	102	35	8015	2610
*Zapotlan (Mexico)	19	38	103	37	5016	1529
SOUTH AMERICA.						
Andalgalá (Argentina)	27	30 S.	66	26 W.	3517	1072
Aracajú (Brazil)	10	55	37	4	14	4
*Arequipa (Peru)	16	22	71	33	8041	2451
Asuncion (Paraguay)	25	32	57	48	312	95
*Bahía Blanca (Argentina)	38	45	62	15	82	25
Bello Horizonte (Brazil)	19	54	43	30	2812	857
Bogotá (Colombia)	4	35 N.	74	14	8579	2615
*Buenos Aires (Argentina)	34	36 S.	58	22	72	22
Caldera (Chile)	27	3	70	53	98	30
*Caracas (Venezuela)	10	31 N.	66	56	3419	1042
Catamarca (Argentina)	28	27 S.	65	47	1673	510
*Cayenne (French Guiana)	4	56 N.	52	21	20	6
Ceres (Argentina)	29	55 S.	61	58	285	87
Chaco (Paraguay)	23	23	58	25	361	110
Concordia (Argentina)	31	23	58	2	79	24

LIST OF METEOROLOGICAL STATIONS.

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SOUTH AMERICA. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height. Feet.	Height. m.
Coquimbo (Chile)	29°	56′ S.	71°	21′ W.	82	25
*Córdoba (Argentina)	31	25	64	12	1388	423
Corrientes (Argentina)	27	27	58	49	177	54
*Curityba (Brazil)	25	26	49	16	2979	908
*Cuyaba (Brazil)	15	36	56	00	771	235
El Misti (Peru)						
Summit Station	16	16	71	30	19200	5852
Mt. Blanc station	16	16	71	30	15700	4785
*El Peru (Venezuela)	7	30 N.	62	00	?984	?300
*Fernando Noronha (Brazil)	3	51 S.	32	25	312	95
*Georgetown (Brit. Guiana)	6	50 N.	58	12	6	2
*Goya (Argentina)	29	9 S.	59	15	210	64
Iquique (Chile)	20	12	70	11	33	10
Isla Chañaral (Chile)	29	1	71	37	157	48
*Islota de los Evangelistas (Chile)	52	24	75	6	180	55
Juan Fernandez (Chile)	33	37	78	50	33	10
La Plata (Argentina)	34	9	57	9	60	18
Lima (Peru)	16	4	77	3	520	158
*Manaos (Brazil)	3	8	59	59	105	32
*Montevideo (Uruguay)	34	54	56	12	96	29
*Paramaribo (Dutch Guiana)	5	49 N.	55	9	13	4
Paraná (Argentina)	41	43 S.	60	31	256	78
*Porto Alegre (Brazil)	30	2	51	13	85	26
Potosi (Bolivia)	19	38	65	25	13287	4050
*Puerto de Antofagasta (Chile)	23	39	70	25	16	5
*Puerto de Arica (Chile)	18	28	70	20	33	10
*Puerto de Punta Arenas (Chile)	53	10	70	54	13	4
*Punta Angeles (Chile)	33	1	71	38	131	40
Punta Carranza (Chile)	35	36	72	38	98	30
*Punta Corona (Chile)	41	51	73	50	82	25
*Punta Dungeness (Chile)	52	24	68	25	16	5
*Punta Galera (Chile)	40	1	73	44	131	40
*Punta Tortuga (Chile)	29	56	71	21	82	25
Quito (Ecuador)	0	14	78	32	9337	2846
*Rio de Janeiro (Brazil)	22	54	43	10	197	61
*Rio Grande do Sul (Brazil)	32	2	52	6	7	2
Rosario (Paraguay)	32	55	60	38	85	26
San Juan (Argentina)	31	32	68	42	2168	664
*Santiago (Chile)	33	27	70	42	1706	520
*São Paulo (Brazil) Observatorio	23	34	46	38	2690	820
*Sucre (Bolivia)	19	3	67	17	9331	2844
Torre do Recife (Pernambuco, Brazil)	8	4	34	53	97	30
Valparaiso (Chile)	33	1	71	38	131	40
Villa Colon (Uruguay) Observatorio Prado	34	51	56	19	95	29
EUROPE.						
NORWAY AND SWEDEN.						
*Bergen (Norway)	60	24 N.	5	19 E.	144	44
*Bodö (Norway)	67	17	14	24	67	21
Carlshamn (Sweden)	56	10	14	52	39	12
Christiania (Norway)	59	55	10	43	82	25
*Christiansund (Norway)	63	7	7	45	59	18

LIST OF METEOROLOGICAL STATIONS.

NOTE.—Stations with asterisk appear in the "Réseau Mondial" in the British Meteorological Office for 1912. (London, 1917.)

NORWAY AND SWEDEN. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height. Feet.	Height. m.
Dovre (Norway)	62°	5′ N.	9°	7′ E.	2113	644
Florö (Norway)	61	36	5	2	26	7
*Gjesvaer (Norway)	71	6	25	22	20	6
*Haparanda (Sweden)	65	50	24	9	30	9
Härnösand (Sweden)	62	37	17	57	66	20
*Mehavn (Norway)	71	1	27	47	20	6
Skudenes (Norway)	59	9	5	16	12	4
Stockholm (Sweden)	59	21	18	4	144	44
*Trondhjem (Norway)	63	26	10	25	131	40
*Upsala (Sweden)	59	51	17	38	79	24
*Vardö (Norway)	70	22	31	8	33	10
RUSSIA.						
(WITH SIBERIA AND FINLAND.)						
Akhtuba	48	18° N.	46	9 E.	16	5
*Akmolinsk	51	12	71	23	?1138	?347
*Arkhangelsk	64	33	40	32	22	7
Askhabad	37	57	58	23	741	226
*Astrakhan	46	21	48	2	−46	−14
*Barnaoul	53	20	83	47	558	170
Batoum	41	40	41	38	10	3
Belagatchskoe Zimovie	51	00	80	18	1043	318
*Berezov	63	56	65	4	131	40
*Blagovyeshchensk	50	15	127	38	?525	?160
*Blagovyeshchensk Priisk	58	10	114	17	?1608	?490
Bogoslovsk	59	45	60	1	636	194
Choucha	39	46	46	45	4487	1368
Dorpat	58	22	26	43	243	74
Derkoulskoe verderie	49	3	39	48	499	152
*Doudinka	69	7	87	00	?66	?20
*Ekaterinburg	56	50	60	38	948	289
Elatma	54	58	41	45	459	140
Elisavetgrad	48	31	32	17	403	123
*Eniseisk	58	27	92	11	276	84
*Fort Alexandrovsk	44	31	50	16	79	24
Golooustnoe	52	1	105	27	1529	466
Goudaour	42	28	44	28	7231	2204
*Helsingfors	60	10	24	57	38	12
*Iakoutsk	62	1	129	43	354	?108
*Irgiz	48	37	61	16	367	112
*Irkutsk	52	16	104	19	1532	467
*Jurjev	58	23	26	43	246	75
Kamenaïa Steppe	51	3	40	42	623	190
Kansk	56	12	95	39	715	218
Kargopol	61	30	38	57	420	128
Kars	40	37	43	5	5731	1747
Kazalinsk	45	46	62	7	230	70
*Kazan	55	47	49	8	262	80
Kem	64	57	34	39	41	13
Kerki	37	50	65	13	804	245
*Kharkov (University)	50	00	36	14	459	140
*Kiev	50	27	30	30	600	183
*Kirensk	57	47	108	7	886	270
*Kola	68	53	33	1	22	7
*Krasnovodsk	40	00	52	59	−49	−15

LIST OF METEOROLOGICAL STATIONS.

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RUSSIA. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
*Kuopio	62°	54′ N.	27°	40′ E.	328	100
Kursk	51	45	36	12	774	236
*Lenkoran	38	46	48	52	−62	−19
Libava	56	31	21	1	16	5
Lubny (Gymnasium)	50	1	33	22	541	165
Lugansk	48	35	39	20	148	45
Magaratch	44	32	34	13	262	80
*Malye Karmakouly	72	23	52	43	48	15
Mariupolskoe verderie	47	39	37	30	919	280
Mezen	65	50	44	16	53	16
*Minousinsk	53	43	91	41	837	?255
*Moscow	55	45	37	34	512	156
*Narynskoe	41	26	76	2	?6611	?2015
*Nertchinsk	51	59	116	35	1588	484
Nertchinski Zavod	51	19	119	37	2041	622
Nijni Novgorod	56	20	44	00	518	158
*Nikolaevsk-sur-Amour	53	8	140	45	69	21
Nikolaief	46	58	31	58	64	20
Nikolsk	59	32	45	27	508	156
Novaia Alexandria	51	25	21	57	482	147
*Novorossiisk	44	40	37	49	121	37
*Obdorsk	66	31	66	35	86	24
*Odessa (University)	46	29	30	46	213	65
*Okhotsk	59	21	143	17	20	6
*Olekminsk	60	22	120	26	?663	?202
*Omsk	54	58	73	23	289	88
Orel	52	58	36	4	600	183
*Orenburg	51	45	55	6	374	114
*Oust-Maïskoe	60	25	134	29	?328	?100
*Oust-Tsylma	65	27	52	10	?82	?25
*Paikanskii Sklad	50	11	130	7	?551	?168
Pamirski Post	38	11	74	2	?11942	?3640
Pavlovsk	59	41	30	29	130	40
Pensa	53	11	45	1	706	215
*Perm	58	1	56	15	535	163
Pernov	58	23	24	30	32	10
*Petrograd	59	56	30	16	16	5
*Petropavlosk	52	53	158	47	285	87
*Petrozavodsk	61	47	34	23	128	39
Pinsk	52	7	26	6	466	142
Ploti	47	57	29	10	468	143
Polibino	53	44	52	56	355	108
Povenets	62	51	34	49	141	43
Rostov on Don	47	13	39	43	161	49
Rykovskoe	50	47	142	55	410	125
Saguny	50	36	39	43	685	209
Samarkand	39	39	66	57	2369	722
Sarapul	56	28	53	49	397	121
*Saratov	51	32	46	3	197	60
Smolensk	54	47	32	4	791	241
Sodankylä	67	25	26	36	590	180
*Sourgout	61	15	73	24	?131	?40
Stavropol	45	3	41	59	1909	582
*Tachkent	41	20	69	18	1568	478
*Tchita	52	2	113	30	2211	674

LIST OF METEOROLOGICAL STATIONS.

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RUSSIA. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height. Feet.	Height. m.
Termez	37°	12′ N.	67°	15′ E.	1017	310
*Tiflis	41	43	44	48	1342	409
Tiumen	57	10	65	32	292	89
*Tobolsk	58	12	68	14	354	108
*Tomsk	56	30	84	58	400	122
Totaikoi	44	54	34	11	994	303
*Touroukhanst	65	55	87	38	?131	?40
Troitskosavsk	50	22	106	27	2520	768
*Troitsko-Petcherskoe	62	42	56	13	404	?123
Tulun	54	33	100	22	1617	493
*Tygan Ourkan	54	5	124	46	?1214	?370
Ufa	54	43	55	56	571	174
Uman	48	45	30	13	709	216
Uralsk	51	12	51	22	124	38
Uspenskaia	56	38	39	12	783	239
Valaam	61	23	30	57	122	37
Varshava (Warsaw) (University)	52	15	21	1	394	120
Vasilevitchi	52	16	29	48	440	134
Velikiia Louki	56	21	30	31	341	104
*Velsk	61	5	42	7	?285	?87
Verkhniaia Michikha	51	30	105	58	4199	1280
*Verkhoïansk	67	33	133	24	328	100
*Vernyï	43	16	76	53	2566	782
Vïatka	58	36	49	41	607	185
Vilno	54	41	25	18	486	148
*Vladivostok	43	7	131	54	88	27
Vlotslavsk	52	40	19	4	213	65
Vologda	59	14	39	53	407	124
Vycknii Volotchok	57	35	34	34	548	167
Zlatoust	55	10	59	41	1502	458
FRANCE.						
Bagnères-de-Bigorre	43	4 N.	0	9 E.	1795	547
Besançon (Observatoire)	47	15	5	59	1020	311
Bordeaux	44	50	0	31 W.	243	74
Brest	48	23	4	30	200	61
Chamonix	45	55	7	2 E.	3406	1038
Cherbourg	49	39	1	38 W.	43	13
Dunkerque	51	2	2	22 E.	23	7
Langres	47	52	5	20	1529	466
Lyon (Saint-Genis-Laval)	45	41	4	47	981	299
*Marseilles	43	18	5	23	246	75
Mont Blanc (Grands Mulets)	45	52	6	51	9908	3020
Mont Blanc (Chamonix)	45	55	6	51	3405	1038
Mont Blanc (Les Bosses)					14301	4359
Mont Blanc (Sommet)	45	59	6	51	15781	4810
Mont Ventoux	44	10	5	16	6234	1900
Montpellier	43	37	3	53	118	36
*Nantes	47	15	1	34 W.	135	41
Nice (Observatoire)	43	43	7	18 E.	1115	340
Paris (Central Meteo. Bureau)	48	52	2	18	108	33
*Paris (Parc Saint Maur)	48	49	2	29	164	50
Paris (Eiffel)	48	52	2	18	1027	313
Paris (Montsouris)	48	49	2	20	253	77
Perpignan	42	42	2	53	102	31

LIST OF METEOROLOGICAL STATIONS.

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FRANCE. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height. Feet.	Height. m.
Pic du Midi de Bigorre	42°	56′ N.	0°	8′ E.	9380	2859
Puy de Dome (Plain)	45	46	3	5	1309	399
Puy de Dome (Summit)	45	46	2	57	4813	1467
Sainte-Honorine-du-Fay	49	5	0	30 W.	387	118
Toulouse	43	37	1	27 E.	636	194
GERMANY.						
Aachen (Prussia)	50	47 N.	6	6 E.	672	205
Ansbach (Bavaria)	49	18	10	33	1437	438
Altenberg (Saxony)	50	46	13	46	2481	756
Augsburg (Bavaria)	48	22	10	54	1640	500
Bad Elster (Saxony)	50	17	12	15	1644	501
Bamberg (Bavaria)	49	53	10	53	943	288
Bautzen (Saxony)	51	11	14	26	669	204
Bayreuth (Bavaria)	49	57	11	34	1190	363
Berlin (Prussia)	52	30	13	25	125	38
Borkum (Prussia)	53	35	6	40	26	8
Bremen	53	5	8	48	52	16
Breslau (Prussia)	51	7	17	2	482	147
Brocken (Prussia)	51	47	10	37	3766	1148
Bromberg (Prussia)	53	8	18	0	177	54
Chemnitz (Saxony)	50	50	12	55	1092	333
Dresden (Saxony)	51	3	13	44	361	110
Erfurt (Prussia)	50	58	11	4	718	219
Freiberg (Saxony)	50	55	13	21	1336	407
Friedrichshafen (Württemberg)	47	39	37	55	1338	408
Grosser Belchen (Alsace)	47	53	7	6	4573	1394
*Hamburg	53	33	9	59	85	26
Helgoland (North Sea)	54	10	7	51	144	44
Höchenschwand (Baden)	47	44	8	10	3296	1005
Hohenheim (Württemberg)	48	43	9	14	1319	402
Hohenspeissenberg (Bavaria)	47	48	11	1	3261	994
Kahl a. M. (Bavaria)	50	4	9	1	374	114
Kaiserlautern (Bavaria)	49	27	7	46	794	242
Karlsruhe (Baden)	49	1	8	25	416	127
Keitum (Prussia)	54	54	8	22	26	8
Kiel (Prussia)	54	20	10	9	155	47
Königsberg (Prussia)	54	43	20	30	33	10
Landshut (Bavaria)	48	32	12	10	1305	398
Leipzig (Saxony)	51	20	12	23	391	119
Ludwigshafen (Bavaria)	49	29	8	26	329	100
Magdeburg (Prussia)	52	8	11	38	177	54
Memel (Prussia)	55	43	21	7	33	10
München (Bavaria)	48	9	11	34	1726	526
Münster (Westfalen)	51	58	7	37	210	64
Neufahrwasser (Prussia)	54	24	18	40	15	5
Nürnberg (Bavaria)	49	27	11	3	1014	309
Passau (Bavaria)	48	34	13	28	1015	309
Posen (Prussia)	52	25	16	56	216	66
*Potsdam observatory (Prussia)	52	23	13	4	279	85
Regensburg (Bavaria)	49	1	12	7	1161	354
Reitzenhain (Saxony)	50	34	13	14	2551	778
Rügenwaldermünde (Prussia)	54	26	16	23	10	3
Schneeberg (Saxony)	50	36	12	38	1452	443
Schneekoppe (Prussia)	50	44	15	44	5282	1610

LIST OF METEOROLOGICAL STATIONS.

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GERMANY. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height. Feet.	m.
Strassburg (Alsace)	48°	35′ N.	7°	46′ E.	471	144
Stuttgart (Württemberg)	48	47	9	11	883	269
Swinemünde (Prussia)	53	56	14	16	33	10
Villingen (Baden)	48	4	8	27	2342	714
Wiesbaden (Prussia)	50	5	8	14	374	114
Wilhelmshaven (Oldenburg)	53	32	8	9	28	8
Würzburg (Bavaria)	49	48	9	56	588	179
Wustrow (Mecklenburg)	54	21	12	24	23	7
Zittau (Saxony)	51	54	14	49	827	252
HOLLAND.						
Amsterdam	52	23 N.	4	55 E.	9	2
*De Bilt	52	6	5	11	45	3
Groningen	53	13	6	33	29	9
Helder	52	58	4	45	18	6
Maastricht	50	51	5	41	167	61
Rotterdam	51	54	4	29	66	4
Vlissingen	51	26	3	34	26	8
BELGIUM.						
Arlon	49	40 N.	5	48 E.	1450	442
Bruxelles	50	51	4	22	131	40
Furnes	51	4	2	40	20	6
Liége	50	37	5	34	246	75
Maeseyck	51	6	5	48	115	35
Ostende	51	14	2	55	23	7
*Uccle	50	48	4	22	328	100
BRITISH ISLES.						
*Aberdeen	57	10 N.	2	6 W.	88	27
Armagh	54	21	6	39	200	61
Ben Nevis	56	48	5	00	4405	1343
Bidston (Liverpool)	53	24	3	4	188	57
Deerness, Orkney Is	58	56	2	45	164	50
Falmouth	50	9	5	4	167	51
Fort William	56	49	5	7	39	12
Glasgow	55	53	4	18	180	55
*Greenwich	51	28	0	00	157	48
Holyhead (Harbour office)	53	18	4	39	57	17
Kew	51	28	0	19	18	6
*Lerwick	60	9	1	8	59	18
London (Westminster)	51	30	0	8	76	23
Malin Head	55	23	7	24	208	63
Oxford	51	46	1	16	208	63
Scilly Islands, St. Mary's	49	56	6	18	131	40
Shields North	55	0	1	27	96	29
Southport	53	39	2	59	37	11
Stonyhurst College	53	51	2	28	375	114
Stornoway	58	11	6	22	51	16
Sumburgh head	59	51	1	17	112	34
*Valencia	51	56	10	15	46	14
Yarmouth	52	37	1	43 E.	17	5

LIST OF METEOROLOGICAL STATIONS.

NOTE. — Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

	Latitude.	Longitude from Greenwich.	Height.	
			Feet.	m.
SPAIN AND PORTUGAL.				
Barcelona (Spain)	41° 23′ N.	2° 10′ E.	138	42
Cadiz (Spain)	36 31	6 18 W.	46	14
Coimbra (Portugal)	40 12	8 25	459	140
*Horta (Portugal)	38 32	28 38	98	30
*Las Palmas (Canary Is.)	28 1	15 26	30	9
*Lisbon (Portugal)	38 43	9 9	312	95
*Madeira (Funchal)	32 37	16 54	82	25
*Madrid (Spain)	40 24	3 41	2149	655
Oña (Spain)	42 44	3 25	1903	580
Oporto (Portugal)	41 8	8 36	328	100
Oviedo (Spain)	43 23	5 48	801	244
*Palma (Spain)	39 33	2 42 E.	?	?
*Ponta Delgada (Azores)	37 44	25 40 W.	56	17
*Puerto de Orotava (Canary Is.)	28 25	16 32	?328	?100
San Fernando (Spain)	36 28	0 25	92	28
Sierra da Estrêlla (Portugal)	40 25	7 35	4547	1386
Teneriffe (Canary Is.)	28 25	16 30	454	138
Tortosa (Spain) Observatorio del Ebro	40 49	0 29 E.	167	51
Valencia (Spain)	39 28	0 22 W.	23	7
ITALY.				
Alessandria	44 54 N.	8 37 E.	321	98
Asti	44 54	8 13	465	142
Avellino	40 56	14 45	1871	570
Belluno	46 8	12 14	1325	404
Benevento	41 7	14 48	558	170
Bergamo	45 42	9 41	1267	386
Bologna	44 30	11 21	279	85
Caserta	41 3	13 82	250	76
Castellaneta	40 38	16 56	780	238
*Catania (Sicily)	37 30	15 3	213	65
Conegliano	45 53	12 19	279	85
Cremona	45 8	10 3	222	68
Desenzano	45 28	10 32	344	105
Elena	41 12	13 35	147	45
Fermo	43 10	13 43	919	280
Ferrara	44 51	11 37	131	40
Florence	43 46	11 15	238	73
Foggia	41 27	15 31	287	87
Forli	44 13	12 2	163	50
Genoa	44 25	8 55	177	54
Ischia	40 44	13 54	106	32
Lecce	40 22	18 12	236	72
Leghorn	43 33	10 18	78	24
Messina	38 12	15 33	197	60
Milan (Brera)	45 28	9 11	482	147
Modena	44 54	12 29	167	51
Moncalieri	45 0	7 41	848	258
Naples	40 52	14 16	489	149
Padua	45 24	11 53	103	31
Palermo	38 6	13 22	234	71
Pavia	45 11	9 10	268	82
Perugia	43 7	12 23	1706	520
Piacenza	45 3	9 40	235	72
Pisa	43 44	10 24	30	9

LIST OF METEOROLOGICAL STATIONS.

[N]OTE. — Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

ITALY. (*Continued.*)	Latitude		Longitude from Greenwich		Height. Feet.	m.
Pistoia	43°	55′ N.	10°	95′ E.	282	86
Prato	43	53	11	6	246	75
Reggio, Calabria	38	8	15	39	48	15
Riposto	37	41	15	12	46	14
Roca di Papa	41	46	12	43	2493	760
*Rome, Collegio Romano	41	54	12	29	207	63
Rovigo	45	3	11	47	69	21
Salo	45	36	10	29	328	100
Sassari	40	44	8	34	735	224
Sestola	44	15	10	46	3585	1092
Siena	43	19	11	20	1143	348
Syracuse (Sicily)	37	3	15	15	76	23
Teramo	42	40	13	43	945	288
Turin	45	4	7	41	907	276
Venice	45	26	12	20	70	21
SWITZERLAND.						
Alstätten	47	23 N.	9	33 E.	1476	450
Altdorf	46	53	8	39	1493	455
Basel	47	33	7	35	909	277
Bern	46	57	7	26	1877	572
Castasegna	46	20	9	31	2297	700
Chaumont	47	1	6	59	3698	1127
Davos Platz	46	48	9	49	5118	1561
Geneva	46	12	6	9	1329	405
Lugano	46	0	8	57	902	275
Neuchâtel	47	0	6	57	1601	488
Pilatus-Kulm	46	59	8	16	6781	2067
Rigi-Kulm	47	3	8	30	5863	1787
Säntis	47	15	9	20	8202	2500
Sils-Maria	46	26	9	46	5951	1814
St. Bernhard	45	52	7	11	8123	2476
*Zürich	47	23	8	33	1687	493
AUSTRIA-HUNGARY.						
Arco	45	55 N.	10	53 E.	298	91
Aussig a.d. Elbe	50	40	14	2	528	161
Bielitz	49	49	19	3	1125	343
Bruck a.d. Mur	47	25	15	17	1591	485
Brünn	49	11	16	33	679	207
Bucheben	47	8	12	58	3947	1203
*Budapest	47	30	19	2	369	112
Dobogókö	47	44	18	54	2290	698
Döllach	46	58	12	54	3359	1024
Görz	45	57	13	37	308	94
Graz	47	4	15	28	1211	369
Gries b. Bozen	46	30	11	20	932	284
Gyertyó-Szt. Miklos	46	43	25	36	2670	814
Herény	47	16	16	36	744	227
Innsbruck	47	16	11	24	1903	580
Klagenfurt I	46	37	14	18	1476	450
Krakau	50	4	19	57	722	220
Kremsmünster	48	4	14	8	1260	384
Lesina	43	10	16	26	62	19
Lussinpiccolo	44	32	14	28	10	3

TABLE 107.

LIST OF METEOROLOGICAL STATIONS.

NOTE. — Stations with asterisk appear in the " Réseau Mondial " of the British Meteorological Office for 1912. (London, 1917.)

AUSTRIA-HUNGARY. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
Marburg	46°	34′ N.	15°	39′ E.	886	270
Mariabrunn	48	12	16	14	751	229
Nagyszeben	45	47	24	19	1358	415
Obir (Berghaus)	46	30	14	29	6716	2044
Obir (Hannwarte)	46	30	14	29	7021	2140
Ó-Gyalla	47	52	18	12	394	120
Osielec	49	41	19	47	1378	420
Pécs	46	6	18	14	499	152
Pelagosa	42	23	16	16	302	92
Prag (Petřinwarte)	50	5	14	24	1066	325
Prag (Sternwarte)	50	5	14	25	646	197
Prerau	49	27	17	27	696	212
Rothholz	47	23	11	48	1758	536
Schmittenhöhe	47	20	12	44	6456	1968
Sonnblick	47	3	12	57	10190	3106
St. Katharein a. d. Lamming	47	28	15	10	2083	635
St. Pölten	48	12	15	37	899	274
Tarnopol	49	33	25	36	1063	324
Tragöss	47	31	15	5	2510	765
Turkeve	47	7	20	45	288	88
Ungvár	46	36	22	18	433	132
Weiswasser	50	30	14	48	964	294
*Vienna (Hohe Warte)	48	15	16	22	666	203
Wiener Neustadt	47	49	16	15	869	265
Zágrab	45	49	15	58	531	162
Zell am See	47	19	12	48	2503	763
Zsombolya	45	47	20	43	269	82
BALKAN PENINSULA AND ASIATIC TURKEY.						
*Athens (Greece)	37	58 N.	23	43 E.	351	107
*Baghdad (Asiatic Turkey)	33	21	44	28	128	39
*Beirut (Asiatic Turkey)	33	54	35	28	108	33
Belgrad (Servia)	44	48	20	27	453	138
Bouïouk-Dere (Asiatic Turkey)	41	10	29	3	384	117
*Bucharest (Roumania)	44	25	26	6	269	82
*Busrah (Asiatic Turkey)	30	31	47	53	26	8
Constantinople (European Turkey)	41	2	28	58	246	75
El-Athroun (Palestine)	31	50	34	60	656	200
Jerusalem (Palestine)	31	48	35	11	2447	746
Kazanlyk (Bulgaria)	42	37	25	24	1220	372
Le Krey (Asiatic Turkey)	33	49	35	40	3330	1015
Mamouret-ul-Aziz (Asiatic Turkey)	38	30	39	22	?3281	?1000
Monastir (Serbia)	41	1	19	3	2024	617
Saloniki (Greece)	40	39	23	7	6	2
Sarona (Palestine)	32	5	34	47	66	20
Scutari (Albania)	42	3	19	30	30	9
Sinaia (Roumania)	45	30	25	34	2821	860
Sinope (Asiatic Turkey)	42	1	35	19	?59	?18
Sivas (Asiatic Turkey)	39	43	34	50	4331	1320
Sofia (Bulgaria)	42	42	23	20	1804	550
Smyrna (Asiatic Turkey)	38	26	24	49	6	2
Sulina (Roumania)	45	9	29	40	6	2

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	Latitude.	Longitude from Greenwich.	Height.	
			Feet.	m.
MEDITERRANEAN.				
Canea (Crete)	35° 30′ N.	24° 00′ E.	105	32
*Gibraltar	36 6	5 21 W.	52	16
Kyrenia (Cyprus)	35 21	33 19 E.	52	16
Mahon (Minorca)	39 53	4 18	141	43
*Malta	35 54	14 31	194	59
*Nicosia (Cyprus)	35 12	33 24	72	22
ASIA.				
INDIA (WITH NEIGHBORING COUNTRIES).				
*Aden (Arabia)	12 45 N.	45 3 E.	94	29
Agra	27 10	78 5	555	169
Ajmer	26 27	74 44	1632	497
Akola	20 42	77 4	930	283
*Akyab (Burma)	20 11	92 56	20	6
*Allahabad	25 25	81 51	298	91
Amini Divi (Lakkadives)	11 6	72 45	13	4
Bangalore	12 58	77 37	2982	909
Batticaloa (Ceylon)	7 43	81 44	26	8
Belgaum	15 52	74 34	2524	769
Bellary	15 9	76 57	1455	443
Berhampore	19 18	84 51	67	20
*Bombay	18 54	72 49	37	11
Burdwan	23 16	87 54	102	31
*Bushire (Persia)	28 59	50 53	14	4
*Calcutta	22 36	88 23	20	6
*Cherrapunji	25 15	91 42	4308	1313
Chittagong	22 21	91 53	87	26
Cochin	9 58	76 17	10	3
*Colombo (Ceylon)	6 54	79 53	23	7
*Cothin	10 00	76 21	10	3
Cuttack	20 48	85 54	80	24
Dacca	23 43	90 26	35	11
Darjeeling	27 3	88 18	6960	2121
Deesa	24 14	72 13	474	144
*Dehra Dun	30 20	78 00	2234	681
Dhurbi	26 2	90 2	115	35
Diamond Island (Burma)	15 52	94 19	41	12
Durbhunga	26 10	86 00	166	51
Enzeli (Persia)	37 30	49 28	69	21
False Point	20 20	86 46	20	6
Galle (Ceylon)	6 1	80 14	48	15
*Gauhati	26 8	91 41	194	59
Hambantota (Ceylon)	6 7	81 7	40	12
Hazaribagh	23 59	85 25	2014	614
Hoshangabad	22 46	77 45	1004	305
*Hyderabad	25 24	68 18	95	29
Jacobabad	28 24	68 18	186	57
Jaffna (Ceylon)	9 40	79 56	9	3
*Jaipur	26 56	75 52	1431	436
*Jask (Persia)	25 44	57 47	13	4
Jubbulpore	23 10	79 59	1337	408
*Kandy (Ceylon)	7 18	80 40	1654	504
Karwar	14 48	74 11	44	13
Katmandu	27 42	85 12	4388	1337

LIST OF METEOROLOGICAL STATIONS.

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INDIA. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
Khandwa	21°	50′ N.	76°	23′ E.	1037	316
*Kodaikanal Observatory	10	13	77	28	7688	2343
*Kurrachee	24	53	66	57	13	4
*Lahore	31	34	74	20	732	223
*Leh	34	10	77	42	11503	3506
Lucknow	26	55	80	59	369	112
Ludhiana	30	55	75	54	806	246
*Madras	13	4	80	14	22	7
Malacca (Straits Settlements)	2	12	102	14	23	7
Meerut	29	1	77	45	738	225
Mercara	12	26	75	47	3721	1134
Mergui	12	27	98	35	96	29
*Meshed (Persia)	36	16	59	35	3105	946
Mooltan	30	12	71	31	420	128
Mount Abu	24	36	72	45	3945	1202
Murree	33	55	73	27	6333	1930
*Mysore	12	18	76	40	2520	768
*Nagpur	21	8	79	5	1017	310
Nuwara Eliya (Ceylon)	6	46	80	47	6240	1902
Nowgong	25	3	79	30	757	231
Patna	20	42	83	10	179	54
*Penang (Straits Settlements)	5	34	100	20	16	5
Periyakulam Observatory	10	9	77	32	944	288
Peshawar	34	2	71	37	1110	338
Poona	18	31	73	55	1992	607
*Port Blair (Andaman Is.)	11	40	92	40	59	18
Province Wellesley (Straits Settlements	5	21	100	25	57	17
*Quetta (Baluchistan)	30	11	67	3	5502	1677
Raipur	21	15	81	41	970	296
*Rangoon	16	46	95	48	20	6
Ranikhet	29	40	79	33	6069	1850
Ratnagiri	17	8	73	19	110	34
Roorkee	29	52	77	53	887	270
Salem	11	39	78	12	940	286
Saugor Island	21	40	88	10	6	2
Secunderabad	17	27	78	33	1787	545
*Seychelles	4	37 S.	55	27	16	5
*Shillong	25	33 N.	91	48	4921	1500
Sholapur	17	40	75	56	1585	483
Sibsagar	26	59	94	41	333	101
Silchar	24	50	92	51	89	27
*Simla	31	7	77	8	7224	2204
*Singapore (Straits Settlements)	1	17	103	51	6	2
Sutna	24	34	80	55	1040	317
Trichinopoli	10	50	78	46	272	83
Trincomalee (Ceylon)	8	33	81	15	12	4
Vizagapatam	17	42	83	20	30	9
*Waltair	17	45	83	16	30	9
Wellington	11	22	76	50	6200	1890
CHINA AND INDO-CHINA.						
Cap-Saint Jacques (Indo-China)	10	20 N.	107	5 E.	607	185
*Hang Kow (China)	30	35	114	17	121	37
Hanoi (Indo-China)	21	2	105	50	43	13
Harbin (China)	45	43	126	28	502	153

LIST OF METEOROLOGICAL STATIONS.

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	Latitude.		Longitude from Greenwich.		Height.	
CHINA AND INDO-CHINA. (*Continued.*)					Feet.	m.
*Hong Kong (China)	22°	18′ N.	114°	10′ E.	108	33
Kashgar (China)	39	25	76	7	3999	1219
Lang-biam (Indo-China)	12	2	108	20	4606	1404
*Moncay (China)	21	31	107	51	33	10
*Mukden (China)	41	48	123	23	144	44
*Nha-Trang (Indo-China)	12	16	109	12	23	7
Pekin (China)	39	57	116	28	125	38
*Phu Lien (China)	20	48	106	37	380	116
Pnom-Penh (Indo-China)	11	35	104	56	26	8
Pulo-Condor (Indo-China)	8	16	106	35	21	6
*Saigon (Indo-China)	10	46	106	42	36	11
*Shanghai (China) Zi-Ka-Wei	31	12	121	26	23	7
*Tiensin (China)	39	10	117	10	16	5
Tsingtau (Kiao-chau)	36	4	120	19	259	79
Urga (China)	47	55	106	50	?4447	?1325
JAPAN AND KOREA.						
*Chemulpo (Korea)	37	29 N.	126	32 E.	223	68
Fusan (Korea)	35	7	129	5	49	15
Hakodate	41	46	140	44	10	3
Hirosima	34	23	132	27	10	3
Hukuoka	33	35	130	25	20	6
*Joshin (Korea)	40	40	129	11	13	4
*Kioto	35	1	135	46	161	49
Kobe	34	41	135	11	191	58
Kumamoto	32	49	130	42	129	39
Matsuyama	33	50	132	45	106	32
*Miyako	39	38	141	59	98	30
*Nagasaki	32	44	129	52	436	133
*Naha	26	13	127	41	34	10
Nagoya	35	10	136	55	50	15
*Nemuro	43	20	145	35	87	27
*Ochiai	47	20	142	44	50	15
Osaka	34	39	135	31	20	6
Sapporo	43	4	141	21	55	17
Tadotsu	34	17	133	46	16	5
*Taihoku	25	2	121	31	30	9
*Tokio	35	41	139	45	70	21
Tokushima	34	6	134	37	13	4
Tsukubasan	36	13	140	6	2854	870
PHILIPPINES AND HAWAIIAN ISLANDS.						
Aparri (Luzon)	18	22 N.	121	38 E.	16	5
Altimonan (Luzon)	14	00	121	55	13	4
Baguio (Benguet)	16	25	120	36	4961	1512
*Bolinao (Luzon)	16	24	119	53	33	10
Cebu (Cebu)	10	18	123	54	30	9
Dagupan (Luzon)	16	3	120	20	10	3
*Honolulu (Hawaii)	21	19	157	52 W.	39	12
Iloilo (Panay)	10	42	122	34 E.	20	6
Legaspi (Luzon)	13	9	123	45	20	6
*Manila (Luzon)	14	35	120	59	46	14
Midway Island	28	13	177	22 W.	19	6
*Ormoc (Leyte)	11	00	124	36 E.	20	6

LIST OF METEOROLOGICAL STATIONS.

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PHILIPPINES AND HAWAIIAN ISLANDS. (*Continued.*)	Latitude.			Longitude from Greenwich.			Height. Feet.	m.
*Surigao (Mindanao)	9°	48′	N.	125°	29′	E.	20	6
*Tagbilaran (Bohol)	9	38		123	51		85	26
*Vigan (Luzon)	17	34		120	23		49	15
EAST INDIES.								
*Ambon	3	42	S.	128	10	E.	13	4
*Batavia (Java)	6	11		106	50		26	8
*Christmas Island	10	25		105	43		20	6
*Cocos Keeling Island	12	5		96	54		16	5
*Daru (New Guinea)	9	4		143	13		26	8
*Kajoemas (Java)	7	56		114	9		3117	950
*Koepang	10	10		123	34		10	3
*Kota Radja (Sumatra)	5	32	N.	95	20		23	7
*Medan (Sumatra)	3	35		98	41		79	24
*Padang (Sumatra)	0	56	S.	100	22		23	7
*Passeroean (Java)	7	38		112	55		16	5
*Pontianak (Borneo)	0	1		109	20		10	3
*Port Moresby (New Guinea)	9	29		147	9		128	39
Samarai	10	37		150	40		20	6
*Sandakan (Borneo)	5	49	N.	118	12		?	?
AUSTRALASIA.								
*Adelaide (South Australia)	34	56	S.	138	35	E.	141	43
Albany (West Australia)	35	2		117	50		41	12
*Alice Springs (South Australia)	23	38		133	37		1926	587
*Auckland (New Zealand)	36	50		174	50		125	38
*Boulia (Queensland)	22	55		139	38		479	146
*Bourke (New South Wales)	30	13		145	58		360	110
*Brisbane (Queensland)	27	28		153	2		137	42
Burketown (Queensland)	17	45		139	33		27	8
Camooweal (Queensland)	19	57		138	17		758	231
*Christchurch (New Zealand)	43	32		172	38		27	8
Cooktown (Queensland)	15	28		145	17		17	5
*Coolgardie (Western Australia)	30	57		121	10		1388	423
*Daly Waters (Northern Territory)	16	16		133	23		699	213
*Danger Point (New South Wales)	34	37		19	18		66	20
*Derby (Western Australia)	17	18		123	40		53	16
*Dunedin (New Zealand)	45	52		170	31		295	90
*Eucla (Western Australia)	31	45		128	58		15	5
*Georgetown (Queensland)	18	23		143	33		990	302
*Hall's Creek (Western Australia)	18	13		127	46		1224	373
*Hobart (Tasmania)	42	53		147	20		160	49
*Katanning (Western Australia)	33	42		117	35		1017	310
*Launceston (Tasmania)	41	27		147	10		30	9
*Laverton (Western Australia)	28	40		122	23		1463	466
Mackay (Queensland)	21	9		149	13		36	118
*Mein (Queensland)	13	13		142	57		400	122
*Melbourne (Victoria)	37	50		144	59		115	35
*Mitchell (Queensland)	26	32		147	52		1110	337
*Nullagine (Western Australia)	21	53		120	5		1270	386
*Onslow (Western Australia)	21	43		114	57		13	4
*Peak Hill (Western Australia)	25	38		118	47		1929	588
*Perth (Western Australia)	31	57		115	51		197	60
*Port Darwin (Northern Territory)	12	28		130	51		98	30
Richmond (Queensland)	20	44		143	10		697	212

LIST OF METEOROLOGICAL STATIONS.

NOTE. — Stations with asterisk appear in the "Réseau Mondial" of the British Meteorological Office for 1912. (London, 1917.)

AUSTRALASIA. (Continued.)	Latitude.			Longitude from Greenwich.			Height. Feet.	m.
*Rockhampton (Queensland)	23°	24′	S.	150°	30′	E.	37	11
Sandy Cape (Queensland)	24	41		153	16		330	100
*Streaky Bay (South Australia)	32	48		134	13		43	13
*Sydney (New South Wales)	33	52		151	12		146	44
Thargomindah (Queensland)	27	58		143	43		402	122
Thursday Island (Queensland)	10	34		142	12		17	5
Townsville Pilot Station (Queensland)	19	14		146	51		73	22
*Wellington (New Zealand)	41	16		174	46		6	2
*William Creek (South Australia)	28	55		136	21		249	76
Windorah (Queensland)	25	26		142	36		390	119
OCEANIA.								
*Apia (Samoa)	13	48	S.	171	46	W.	16	5
*Alofi (Niue Is.)	19	2		169	55		121	37
*Chatham Island	43	52		170	42		190	58
*Fanning Island	3	55	N.	159	23		13	4
Gomen (New Caledonia)	20	21	S.	164	10	E.	?	?
*Guam (Ladrones Is.)	13	20	N.	144	35		12	4
*Lord Howe Island	31	32	S.	159	4		?	?
*Malden Island	3	59		155	00	W.	26	8
*Mataveri (Easter Is.)	27	10		109	26		98	30
*Norfolk Island	29	4		167	58	E.	?	?
*Noumea (New Caledonia)	22	16		166	27		30	9
*Ocean Island	0	52		169	36		92	28
*Rarotonga (Cook Is.)	21	12		159	47	W.	?	?
*Rendova (Solomon Is.)	8	24		157	19	E.	?	?
*Suva (Fiji)	18	8		178	26		13	4
*Tahiti (Low Arch.)	15	47		148	14	W.	154	47
*Tulagi (Solomon Is.)	9	5		160	8	E.	6	2
*Uyelang	9	42	N.	161	2		33	10
*Yap	9	29		138	8		105	32
AFRICA.								
*Accra (Brit. Guinea)	5	35	N.	0	6	W.	59	18
Addis-Abeba (Abyssinia)	9	1		38	43	E.	7874	2400
*Alexandria (Egypt)	31	9		29	54		105	32
*Algiers (Algeria)	36	47		3	4		125	38
*Aswan (Egypt)	24	2		32	53		328	100
*Bathurst (Gambia)	13	24		16	36	W.	16	5
Bengazi (Tripoli)	32	7		20	2	E.	30	9
Bizerte (Tunis)	37	17		9	50		30	9
Bulawayo (South Rhodesia)	20	10	S.	28	40		4469	1362
Cairo (Egypt) Abassia Observatory	30	4	N.	31	17		108	33
*Cairo (Egypt) Helwan	29	52		31	20		380	116
*Cape Coast Castle (Brit. Guinea)	5	5		1	13	W.	?	?
Cape Spartel (Morocco)	35	47		5	55		191	58
*Cape Town (Cape Colony)	33	56	S.	18	29	E.	30	9
*Casablanca (Morocco)	33	37	N.	7	35	W.	56	17
Ceres (Cape Colony)	33	22	S.	19	20	E.	1493	455
*Conakry (Fr. Guinea)	9	31	N.	13	43	W.	52	16
Constantine (Algeria)	36	22		6	37	E.	2165	660
*Dakhla Oasis (Egypt)	25	30		29	00		426	130
*Dar-es-Salaam (Tanganyika Territory)	6	49	S.	39	18		26	8
*Durban (Natal)	29	51		31	00		262	80

LIST OF METEOROLOGICAL STATIONS.

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AFRICA. (*Continued.*)	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
*East London (Cape Colony)	33°	2′ S.	27°	55′ E.	33	10
El-Djem (Algeria)	35	21 N.	10	38	541	165
*El Obeid (Brit. Sudan)	13	11	30	14	1919	585
*Entebbe (Brit. East Africa)	0	5	32	29	3862	1177
Fort Napier (Natal)	29	36 S.	30	23	2200	671
Fort National (Algeria)	36	38 N.	3	72	3051	930
Geryville (Algeria)	33	41	1	00	4281	1305
Grahamstown (Cape Colony)	33	18 S.	26	32	1800	540
*Gwelo (South Rhodesia)	19	27	29	49	4646	1416
*Harrar (Abyssinia)	9	42 N.	42	30	6089	1856
*Heidelberg (Transvaal)	34	5 S.	20	58	5056	1541
*Insalah (Sahara)	27	17 N.	2	27	1083	330
Ismailia (Egypt)	30	36	32	16	30	9
*Johannesburg (Transvaal)	26	11 S.	28	4	6148	1874
*Kadugli (Brit. Sudan)	11	2 N.	29	45	1650	503
*Kafia Kingi (Brit. Sudan)	9	22	24	18	1955	596
*Katagum (Nigeria)	12	17	10	22	102	31
Kenilworth (Kimberley)	28	42 S.	24	27	3950	1204
*Khartoum (Egypt)	15	37 N.	32	33	1309	390
*Kimberley (Cape Colony)	28	43 S.	24	46	4042	1232
*Kontagora (Nigeria)	10	24 N.	5	24	1312	400
Laghouat (Algeria)	33	48	2	53	2559	780
*Lagos (Nigeria)	6	22	3	28	26	8
*Lamu (Brit. East Africa)	2	16 S.	40	54	10	3
*Libreville (Fr. Congo)	0	23 N.	9	26	115	35
*Loango (Fr. Congo)	4	38 S.	11	50	?164	?50
*Lorenzo Marques (Port. East Africa)	25	58	32	36	194	59
*McCarthy Is. (Gambia)	13	42 N.	14	46 W.	13	4
*Maiduguri (Port. East Africa)	11	48	13	12 E.	1214	370
*Mauritius (Royal Alfred Observatory)	20	6 S.	57	33	177	54
Mayumba (Fr. Congo)	3	23	10	31	200	61
Mojunga (Madagascar)	15	45	46	19	134	41
Mozambique (East Africa)	15	00	40	44	13	6
*Nairobi (Brit. East Africa)	1	18	36	59	5446	1660
*Nandi (Brit. East Africa)	0	2 N.	35	5	6594	2010
Oran (Algeria)	35	42	0	39 W.	174	53
Ouargla (Algeria)	31	55	4	70 E.	407	124
Port Elizabeth (Cape Colony)	33	58 S.	25	37	181	55
Port Saïd (Egypt)	31	16 N.	32	19	14	4
Porto Novo (Dahomey)	6	28 N.	2	40	65	20
*Pretoria (Transvaal)	25	45 S.	28	11	5170	1576
Queenstown (Cape Colony)	31	54	26	52	3500	1067
St. Denis (Réunion)	20	51	55	30	102	31
*St. Helena	15	57	5	40 W.	2073	632
St. Louis (Senegal)	16	1 N.	16	31	6	2
St. Paul de Loanda (Angolo)	8	47 S.	13	13 E.	194	59
*St. Vincent (C. Verde Is.)	16	54 N.	25	4 W.	36	11
*Sainte-Croix-des-Eshiras (Fr. Congo)	1	44 S.	10	21 E.	640	195
*Salisbury (Rhodesia)	17	49	31	3	4878	1487
*San Tiago (C. Verde Is.)	14	54 N.	23	31 W.	112	34
*Ségou (Fr. West Africa)	13	34	6	17	?892	?272
*Sierra Leone (Sierra Leone)	8	30	13	9	223	68
*Sokoto (Nigeria)	13	2	5	14 E.	1161	354
*Suez (Egypt)	29	57	32	32	10	3
*Tamatave (Madagascar)	18	9 S.	49	26	13	4
*Tananarivo (Madagascar)	18	55	47	43	4593	1400

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	Latitude.		Longitude from Greenwich.		Height.	
					Feet.	m.
AFRICA. (*Continued.*)						
Tangier (Morocco)	35°	47′ N.	5°	49′ W.	246	75
*Timbuctoo (Fr. West Africa)	16	43	2	52	820	250
*Tunis (Tunis)	36	48	10	10 E.	141	43
Upper Sheikh (East Africa)	9	56	45	11	4593	1400
Vivi (Congo)	5	40 S.	13	49	364	111
*Wadi Halfa (Egypt)	21	55 N.	31	20	420	128
*Wau (Brit. Sudan)	7	42	28	3	1444	440
*Windhoek (South-West Africa)	22	34 S.	17	5	5463	1665
*Yola (Nigeria)	9	12 N.	12	30	850	259
*Zanzibar (Brit. East Africa)	6	10 S.	39	11	73	22
*Zomba (Nyasaland Prot.)	15	23	35	18	2949	899
*Zungeru (Nigeria)	9	48 N.	6	10	426	130
ARCTIC AND ANTARCTIC. (*See also* GREENLAND, ICELAND, RUSSIA, etc.)						
Bossekop	69	57 N.	23	15 E.	?	?
*Cape Evans (McMurdo Sound)	77	38 S.	166	24	59	18
*Cape Pembroke	51	41	57	42 W.	69	21
Dicksonhavn	73	30 N.	81	00 E.	?	?
Fort Rae	62	39	115	44 W.	?	?
*Framheim	78	38 S.	163	37	36	11
Jan Mayen	70	59 N.	8	28	?	?
Kingua-Fjord (Cumberland Sound)	66	36	67	9	?	?
Lady Franklin Bay	81	44	64	45	?	?
Novaya Zemlya	72	30	52	45 E.	?	?
Orange Bay	55	31 S.	70	25 W.	?	?
Point Barrow	71	23 N.	156	40	?	?
Sagastyr	73	23	124	5 E.	?	?
*Spitsbergen						
Advent Bay	78	2	15	6	590	180
Green Harbour	78	2	14	14	36	10
*South Georgia	54	14 S.	36	33 W.	13	4
*South Orkneys	60	44	44	39	23	1

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
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THE MOSSES COLLECTED BY THE SMITHSONIAN AFRICAN EXPEDITION 1909-10

(WITH TWO PLATES)

BY
H. N. DIXON, M. A., F. L. S.

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THE MOSSES COLLECTED BY THE SMITHSONIAN AFRICAN EXPEDITION, 1909-10

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(With Two Plates)

The mosses collected by Dr. Edgar A. Mearns, during the Smithsonian African Expedition, consisted of eighty-three numbers, of which naturally several were duplicates, the actual number of species represented being forty-eight. As would be expected in the tropical region of Africa, the bulk of them were at high altitudes, only seven numbers being below 2,000 meters, five of these at 1,350 meters, the remaining two at 1,950 meters. Of the rest the largest proportion (between 65 and 70) came from the "giant heath zone" of Mt. Kenia, at about 3,630 meters, five from 4,200 meters, above that zone, and three or four from the "bamboo zone," at about 3,000 meters. Only eight species were in fruit.

A considerable number of the mosses are identical with species already decribed from Kilimanjaro, Ruwenzori, and Kenia itself; quite an appreciable proportion, however, are of especial interest either as being hitherto unknown, or—and these are perhaps the most interesting—as belonging to species already known, but from a very widely distant geographical area.

A connection between the mosses of the higher zones of the equatorial mountains of Africa and those of the palæarctic region of Europe and North America has been recognized for some time. Mitten,[1] in describing the mosses collected on Kilimanjaro by Bishop Hannington and by H. H. Johnston, refers specimens to the northern species, *Bryum roseum, B. alpinum,* and *Thuidium tamariscinum* (in addition to two or three almost cosmopolitan species); of these the two former at least occur also in temperate South Africa.

C. Müller, who has described the greater number of the species collected on Kilimanjaro, fully recognizes the close relationship between the genera of mosses of the higher zones of that mountain and those of the European alpine regions, but his theory of phytogeography does not admit an actual identity of species between two so widely separated areas, except—and that very rarely—in a few admittedly cosmopolitan types. In the conspectus he has given of

[1] Journn. Linn. Soc. Bot. **27**: 298.

the mosses of Kilimanjaro, therefore (4),[1] the relationship between these regions is masked by the creation of new species in the case of several mosses which nearly all bryologists would refer to corresponding palæarctic species. Thus, as Brotherus has pointed out, *Funaria kilimanscharica* C. M. is only one of the forms of *F. hygrometrica* Sibth.; *Polytrichum pungens* C. M. is to be referred to *P. commune* L.; *P. nano-globulus* C. M. to *P. piliferum* Schreb.; *Mnium kilimandscharicum* C. M. is *M. rostratum* Schrad.; and *Grimmia calyculata* C. M. is *G. ovata* Web. & Mohr. The greater number of these species, however, are more or less cosmopolitan, and their occurrence in Central Africa does not imply any special connection between the flora of that area and that of the palæarctic region, except in the case of *Grimmia ovata,* which is, otherwise, almost confined to that region, but reaches as far south as Ceylon in the Asiatic, and Guatemala in the American continent. *Bryum alpinum* Huds., which also occurs on Kilimanjaro, has a similar range, but somewhat more restricted; it also is found in South Africa (*B. afro-alpinum* Rehm. is certainly, and *B. Wilmsii* C. M. in all probability, the same thing).

Brotherus has also recorded *Campylopus polytrichoides* De Not. from the volcano region (1), but this is a warm-temperate zone species, its range being west and south Europe, Madeira, the East African Islands, and Brazil. He records also *Tetraplodon bryoides* Lindb. from Ruwenzori (1) between 3,000 and 4,000 meters, and this is of special interest, as its known range was almost confined to the alpine-arctic zone of Europe, Asia, and North America, except for an isolated station in New Guinea; *Pohlia elongata* Hedw., of nearly the same but slightly less alpine distribution; *Pogonatum aloides* (Hedw.) P. Beauv., with a somewhat similar range to *Grimmia ovata,* from 2,900 meters on Ruwenzori; *Hylocomium proliferum* (L.) Lindb., from 3,600 meters on Karisimbi in the volcano region, known from Europe, Asia, and North America, the Azores and Canaries, Algeria, and Tunis; and its var. *alpinum* Schlieph., from 3,800 meters on Ruwenzori, previously known only from the higher Alps of Europe; *Oxyrrhynchium rusciforme* (Neck.) Warnst., a native of temperate Europe and Asia, North America, the Canaries, and Algeria.

It will be seen that the presence of these species in the alpine zones of the equatorial mountains of Africa scarcely marks a definite connection with the palæarctic region, except in the case of *Tetraplodon*

[1] See Bibliography at end of present paper.

bryoides, Hylocomium proliferum var. *alpinum,* and perhaps *Grimmia ovata* and *Pohlia elongata;* the remaining species having too wide a range for their presence here to establish such a connection, though they would lend support to it were it well established.

It is therefore of the highest interest to find this connection immensely strengthened by certain of the species in this collection, which have hitherto not been known from the African continent. It will be well to give these in tabulated form together with their distribution as hitherto known.

Species	Distribution
Blindia acuta (Huds.) Bry. Eur.	Alpine and arctic Europe and North America; Caucasus; Central Asia.
Aulacomnium turgidum Schwaegr.	Higher Alps of Europe; Arctic regions; mountains of North America and Japan.
Neckera complanata (L.) Huebn.	Temperate regions of Europe and western Asia, and eastern North America.
Calliergon sarmentosum var. *subflavum* Ferg.	(Of type) Alpine-arctic regions of Europe, Asia, and North America; Fuegia; South Georgia; Alps of New Zealand.

Moreover, the plant described below as *Hygroamblystegium procerum* sp. nov. is extremely near to and possibly should be considered a subspecies of *H. filicinum,* the range of which is northern and alpine Europe, Asia, and North America, and New Zealand; and *Calliergon Keniae* sp. nov. belongs to a genus the representatives of which are exclusively confined to the arctic and cold-temperate regions, and almost entirely to those of the northern hemisphere.

The above listed species are so distinctively plants of a comparatively limited area of the alpine-arctic districts of the palæarctic region, that (taken with the two or three species referred to above) they can hardly be explained, I think, without postulating a bridge, at some time or other, between the two areas.

Engler (8) has discussed at some length the problem of the presence of representatives—either identical or as racial forms—of arctic-alpine plants at high elevations on the mountains of Central Africa, citing especially certain grasses and flowering plants (*e. g., Luzula spicata, Anthoxanthum odoratum, Koeleria cristata, Subularia aquatica*). His general conclusion is in favor of what may be termed a fortuitous transport, rather than a definite migration. He holds that there has been no continuous continental connection at any time, such as would provide the conditions necessary for a migration of plants of the colder European regions across northern or northeastern Africa to the mountains of Abyssinia and thence to the Central African ranges; but that there may have been a pluvial epoch (I suppose in interglacial or postglacial times) when the zones suitable to these plants were much more nearly approximated than now; *i. e.,* the alpine-arctic European plants would have descended to much lower levels and reached a much more southerly limit in Europe than now, while at the same time the conditions in North Africa would be such that similar and therefore favorable climatic conditions would occur at much lower altitudes than at present, and that the seeds of the plants in question (most of them being small-seeded plants) were transported either by strong northerly winds or by the agency of birds, or both.

I cannot quite think this theory fully adequate to explain the *data* of this question of distribution, especially in view of the additional facts evinced by the mosses dealt with in the present case. If the occurrence of these alpine-arctic seed-plants is due to what I have termed fortuitous transport, *i. e.,* there was no general migration in a southerly direction, but owing to the fact that similar conditions prevailed simultaneously in southerly Europe and the highlands of north-eastern Africa, at no very great distance away, aided by a pluvial epoch, extending over the regions concerned, seeds of these plants happening to be transported found a congenial resting place, thence retreating farther south to higher altitudes as warmer and more xerophytic conditions ensued—if this is the full explanation, it appears to me that we might ask why did not the corresponding interchange from south to north occur at the same time? Why do we not find in the present European alpine-arctic flora isolated instances of Central African genera, transported at the same time from there to here? One does not see why there should not have been *southerly* wind-currents adequate for transport equally with *northerly* ones; indeed, anything like a continuous or prevailing northerly wind would seem to presuppose a counter-current, possibly at somewhat higher levels, from a southerly direction. And if the means of transport was, or was aided by, migratory birds, they should in their return journeys have been equal carriers of a certain number of representatives of the African flora to the European lands.

On general grounds, therefore, I should have thought that Engler's solution of the problem in some measure failed to satisfy the conditions, inasmuch as it would seem to give all the requirements necessary for a counter-exchange of southerly plants to Europe, which does not appear to have taken place. And I venture to think that this view is considerably strengthened by the mosses of the present collection. To begin with, it may be postulated with practical certainty that the species I have noted above were not transmitted in the spore state, but in the gametophytic stage. For of the four species newly recorded as common to both regions, *Calliergon sarmentosum* and *Aulacomnium turgidum* are dioicous and extremely rare fruiters in the palæarctic region, while *Neckera complanata* also is dioicous and infrequent in fruit, though not so rare as the above two. For *Aulacomnium turgidum* Limpricht (2) cites only three fruiting localities in Central Europe, Hagen states that it is only found sterile in northern Norway, and the same is the case in Great Britain, while in North America the fruit is described as "rare," and I have seen no localities given. *Calliergon sarmentosum* is also, except in the most northerly arctic regions, extremely rare in fruit.

And these four species do not exhaust the contribution of the present collection to the common flora. For of the new species described, *Hygroamblystegium procerum,* while striking and distinct in habit, is structurally identical with the palæarctic *H. filicinum* and would without doubt, I think, if it had been found within the recognized range of that species, have been described as a variety or subspecies at most. And *Calliergon Keniae,* while scarcely, I think, to be placed under *C. sarmentosum,* is undoubtedly nearest to and a derivative from either that plant or *C. stramineum* (Dicks.); and the small genus to which these belong is one of the most markedly alpine-arctic types, reaching the southern part of the north temperate zone only under extreme alpine conditions, with a similar but still more restricted distribution in the southern hemisphere, and having no representative in the African flora. And again, *Philonotis speirophylla* sp. nov., while a clearly marked species, is undoubtedly near to and almost certainly a derivative from the northern, alpine-arctic *P. seriata* Mitt. These three related species are also dioicous, fruiting extremely rarely, *H. filicinum* indeed probably never fruiting in any form such as is at all likely to have given off the plant in question.

Here again, therefore, we are confronted with the problem as to why, under the theory of a fortuitous transport, north to south, from like conditions to like, a counter-exchange from south to north should not have occurred, and we do not find isolated species of African alpine genera among the alpine mosses of Europe; while in addition the further question arises as to why, postulating aerial transport by wind or by bird carriers, and failing a land connection, should just those species have been chosen out which, being sterile plants, present special difficulties to such modes of transport, when so many fertile species must have been present, the spores of which would have been transmitted infinitely more readily?

And it may be again pointed out that most of the mosses involved are markedly species of the colder, more boreal conditions of the palæarctic region. Now if we have to postulate a very discontinuous area at the migratory period, so that the transported plants had to pass over numerous and considerable gaps of lower, warmer, and drier land before reaching a suitable " pied-à-terre," it seems reasonable to suppose that the species that would survive would be rather those of the lower and more southerly type, those in fact more capable of enduring subxerophytic conditions, whereas it would be difficult to select—short of actual aquatic species—any more pronouncedly hygrophytic mosses than most of those in question, while *Tetraplodon bryoides* and *Hylocomium proliferum* var. *alpinum* though less distinctly hygrophytic are exclusively alpine, and the former at least would be quite unable to resist anything like xerophytic conditions. True, it might be argued that species of a less pronounced hygrophytic nature may have been transported under such conditions and may have been since crowded out, by the returning African flora, from the lower altitudes of the African mountains as the present climatic conditions supervened; but to maintain this contention would (since it implies the transport of a large number of plants by fortuitous means) be still more to strengthen my position that we should all the more expect under these circumstances to see the remains in Europe of a counter-exchange of species from south to north.

I cannot help concluding, therefore, that a more continuous land area under colder and more hygrophytic conditions than Engler admits is postulated by the known facts, and that the practically total absence of any counter-exchange from Africa to Europe presupposes something much more definite in the way of a southerly *migration* than has hitherto been recognized, difficult as it may be to trace the land connection that would have provided the necessary bridge of transit.

It is possible that the working out of the flowering plants of the expedition may throw further light on this problem of geographical distribution; but it is one in which to an unusual extent the lower plants such as the Bryineae may be expected to prove the best witnesses, and it is much to be hoped that further exploration will be carried on in the higher altitudes of the Central African ranges, and especially among the cryptogamic flora of those altitudes, for it is there that the data necessary for the solution of the problem will most likely be found.

The following species are described here for the first time: *Sphagnum Keniae, Hymenostylium crassinervium, Leptodontiopsis elata, Rhacomitrium defoliatum, Bryum plano-marginatum, Philonotis speirophylla, Breutelia stricticaulis, Polytrichum Keniae, Hygroamblystegium procerum, Calliergon Keniae, Isopterygium sericifolium, Rhynchostegiella Keniae.* The types of these are in the United States National Herbarium, duplicate types being in my own collection.

My thanks are due to Dr. Brotherus and to Mons. Thériot for assistance in the identification of certain of the species, and to the authorities of the British Museum and Kew collections for the opportunity of comparing specimens in these herbaria.

In the following list I have followed the order of Brotherus (Engler & Prantl, Pflanzenfamilien, Musci).

To save repetition I have used the following terms for the two collecting localities which occur most frequently:

"Loc. 3,630 meters." Western slopes of Mt. Kenia, along the trail from West Kenia Forest Station to summit, at about 3,630 meters, in the "giant heath zone," Sept. 21-27, 1909.

"Loc. 4,200 meters." Western upper slopes of Mt. Kenia, above the "giant heath zone," along the trail from West Kenia Forest Station to summit, at about 4,200 meters elevation, Sept. 25-27, 1909.

It may be possible to gain some idea of the prevailing species on Mt. Kenia from the number of gatherings made of some of them. Judged in this way the most frequent mosses would be: *Campylopus stramineus* (Mitt.) Jaeg., 13 gatherings; *Tortula Cavalli* Negri, 9 gatherings; *Bartramia ruwenzorensis* Broth., 5 gatherings; *Grimmia ovata* Web. & Mohr, 5 gatherings. None of the others are represented by more than three gatherings each.

SPHAGNACEAE

SPHAGNUM KENIAE Dixon, sp. nov.

(Plate 1, fig. 1)

§ Subsecunda. Caules breviusculi, ut videtur laxe caespitosi, flavovirides, infra pallide fuscescentes, habitu *S. mollusci* Bruch. Rami *perbreves,* raro 1 cm. longi, plerumque multo minus, *obtusi,* dense conferti.

Folia caulina *2 mm. longa,* late ovato-oblonga, apice in mucronem brevissimum latum convoluta, explicata tamen late rotundata obtusa dentibus nonnullis parvis coronata, limbo *angusto, 2-3-seriato, apud basin parum dilatato* circumdata. Cellulae hyalinae superiores (usque ad 2/3 folii longitudinem) fibrosae, raro bipartitae. Pori *magni,* dorsales *numerosissimi, ventrales paucissimi vel nulli.*

Folia ramea *minima,* circa 1 mm. longa, lenissime secunda, ovata, *brevissime obtusiuscule acuta,* apice 3-4-denticulata, limbo *perangusto,* 1-2-seriato, *denticulato.* Pori dorsales numerosi, ventrales perpauci. Cellulae chlorophyllosae peranguste ellipticae seu trapezoideae, *ventrales, superficie liberi,* cellulae hyalinae dorso perconvexae, prominentes.

Hab.: Loc. 3,630 meters, Nos. 1560 (type), 1561, 1563.

The very slender habit, resembling that of *S. molluscum,* the short branching, and the position of the chlorophyllose cells, on the ventral surface of the leaf, separate this species from most or all of the African species of the *Subsecunda* section. It appears to be nearest to *S. gracilescens* Hampe from southern Brazil; it is in fact very close to that species, which has the chlorophyllose cells in the same position, the short branches, etc. The coloring is quite different, however, the branching there is laxer, as is also the foliation, and the stem leaves are rather smaller, viz., 1-1.5 mm., according to Warnstorf. In view of the widely separated geographical areas these differences must be held sufficient to keep the two apart.

Sphagnum Davidii Warnst., from Ruwenzori, is a much more robust plant, with longer branches, chlorophyllose cells central, smaller stem leaves, more acute branch leaves, etc. *S. ruwenzorense* Negri differs in the same direction, and is larger in all its parts.

SPHAGNUM PAPPEANUM C. M.

Loc. 3,630 meters, No. 1562.

SPHAGNUM RUGEGENSE Warnst. var. GRACILESCENS Warnst.

Hab.: Bamboo zone, western slopes of Mt. Kenia, along the trail from West Kenia Forest Station to summit, at about 3,000 meters, No. 1727.

I have not seen the original plant (collected by Mildbraed on the Deutsch Zentral-Afrika Expedition, in the Rugege-Wald, in mountain bogs at 1,900 meters); but I have compared the present material with Warnstorf's description and figure in the Sphagnaceae (6), with which it agrees in habit and in every particular except in one minor point regarding the pores. These are remarkable among the section *Cuspidata,* being very numerous on both surfaces, especially the dorsal, where they are arranged in chain form along the commissures as in many of the *Subsecunda,* but are much larger; on the ventral surface they are also numerous, but somewhat less so, and are smaller, while here and there occur very minute pores in the angle of the cell or on its face. Warnstorf describes the pores of the ventral surface as "beringt," those of the dorsal surface as "schwach beringten," while in the present plant the dorsal ones are decidedly more strongly ringed than those on the ventral surface. In every other particular the plant agrees exactly with the var. *gracilescens* as described.

ANDREAEACEAE

ANDREAEA KILIMANDSCHARICA Par.

Andreaea striata C. M., not *A. striata* Mitt.

Loc. 3,630 meters, Nos. 1584, 1588. No. 1588 is in fruit, and the few capsules show a rather remarkable peculiarity. It will be recollected that Hooker f. and Wilson divided Andreaea into two subgenera, separating *A. Wilsoni* (as Acroschisma) from all the remaining species (Eu-Andreaea), on the ground of the capsule, which, instead of splitting to the base or nearly so into four to six valves, splits only about one-fourth the length, the lower part of the capsule remaining entire, shortly cylindric. Wilson placed also in Acroschisma another species, *A. densifolia* Mitt., from the Himalayas, but Brotherus includes it in Eu-Andreaea. According to Roth,[1] Mitten's specimens show a capsule narrowly elliptic to almost cylindric and split into valves from the middle or from two-thirds its length upwards, so that it remains a question as to which subgenus should claim it. The Mt. Kenia plant (No. 1588) shows a few capsules quite normal, one or two entire to about the middle, and one or two entire to about two-thirds the length, only the upper one-fourth or one-third split into valves (cf. *pl. 1, fig. 5, a, a'*). The species, it can hardly be doubted, is a Eu-Andreaea, and the peculiarity of the capsule form an abnormality; it is possible that this may be the case with *A. densifolia* Mitt. The three species, it may be remarked, are not in other respects nearly related to one another.

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[1] Die aussereuropäischen Laubmoose, Band 1, p. 21.

DICRANACEAE

DISTICHIUM KILIMANDJARICUM C. M.

Loc. 3,630 meters, No. 1547. I have no doubt that this is C. Müller's species, of which I have not seen specimens. The only slight discrepancy is that C. Müller describes the subula as papillose near the apex, while in this the greater part of the fine filiform subula is roughened; finely and regularly tuberculate would perhaps describe it best. The stems are exceedingly delicate and slender, the leaves distant, with a very long filiform subula which is very flexuose and curled when dry.

BLINDIA ACUTA (Huds.) Bry. eur., forma PROLIXA

Loc. 3,630 meters, No. 1593b. Accompanying *Rhacomitrium defoliatum* sp. nov., and *Calliergon sarmentosum* var. *subflavum.* It is a very elongate, sterile form, with distant, long and narrow leaves having long subulate points, but I cannot find any structural difference from our northern species; it has somewhat the habit of certain of the forms of the var. *trichodes,* but the leaves do not narrow so abruptly from the base to the subula as in that.

New to Africa. Distribution: Northern and alpine Europe; Caucasus; Central Asia; boreal parts of North America.

CAMPYLOPUS STRAMINEUS (Mitt.) Jaeg.

Campylopus substramineus Broth. Wissensch. Ergebn. der Deutsch. Zentral-Afrika Exped., 1907-8, Bd. II, Botanik, 139. 1914.
Campylopus sericeus Negri, Annali di Bot. **7**: 162. 1908.

Loc. 3,630 meters, Nos. 1359, 1544, 1548, 1549, 1553, 1558, 1565, 1577, 1578, 1594, 1598. Loc. 4,200 meters, Nos. 1655, 1659.

Evidently one of the common mosses in and above the "giant heath zone," and extremely variable in height, density, and length of leaf, while apparently always retaining a certain general habit and the straw to golden color from which it derives its name. Brotherus (1) describes *C. substramineus* sp. nov. as "praecedenti [*i. e., C. stramineus*] valde affinis, sed foliis duplo vel triplo longioribus diversa." In going through the above numbers I recognized at once that some of them must come under this plant, the long, silky leaves giving a very different appearance to the plant; but it soon became evident that it was going to be very difficult to draw the line between the two, in fact a regular gradation occurred from plants with leaves only about 3-4 mm. long to others where they are 7 mm. long at least; the longer leaf being usually, but by no means always, correlated with a taller, laxer habit of growth. Moreover, one single gathering (No. 1594) showed forms ranging from the shortest-leaved state to one with very long if not quite the longest leaves.

It occurred to me to examine Mitten's type from the Cameroons, collected by Mann, at Kew, and to my surprise I found both these forms represented there. Mann's specimens are on three sheets, two of them the short-leaved form, the third consisting of two fine fruiting tufts with silky, elongate leaves up to 7 mm. at least. As the fruiting plant, this last would probably have to be considered the type. In any case it is clear that there is no room for a new species, nor do I think any of the forms sufficiently marked or constant to be given varietal rank.

From the description I am strongly inclined to think that *C. sericeus* Negri, from Ruwenzori, is the long-leaved form of this species (the locality is very close to that where *C. substramineus* Broth. was collected), and this in spite of the fact that the author describes it as exhibiting stereids in the dorsal band of the nerve. Brotherus, quite rightly I believe, places *C. stramineus* in the section Pseudocampylopus, the nerve generally, and in the lower part no doubt constantly, showing a median row of guide cells and a dorsal row of subequal moderately lax cells, but no stereids. On cutting sections of the upper part of the leaves, however, I have found here and there a small number of decided stereid cells, intermixed with the dorsal, and I am therefore of the opinion that their presence in *C. sericeus* Negri does not entirely preclude its identity with *C. stramineus*.

CAMPYLOPUS PROCERUS (C. M.) Par.

Hab.: Bamboo zone, western slopes of Mt. Kenia, along the trail from West Kenia Forest Station to summit, at about 3,000 meters elevation, No. 1729. A slightly denser form with leaves a little closer than the original from Kilimanjaro, with which, however, it agrees otherwise.

CAMPYLOPUS JOANNIS-MEYERI (C. M.) Par.

Loc. 4,200 meters, No. 1658. I have not been able to see an original specimen, but from the description I have no doubt that this is the same as the plant from Kilimanjaro. It is in one respect a remarkable species: the nerve section betrays no sign of stereids; it consists of a ventral row of very large empty cells, a row of much smaller guide cells, and a single row of subequal and very similar dorsal cells; the cells of both these layers become somewhat substereid in the upper part of the leaf, but there is no stereid band. The species must therefore be placed in section Pseudocampylopus; it is the only *hair-pointed* species at present known there.

POTTIACEAE

HYMENOSTYLIUM CRASSINERVIUM Broth. & Dixon, sp. nov.

(Plate 1, fig. 2)

Stirps pro genere robusta, caespites densiusculos elatos usque ad 5 cm. altos, olivaceos, intra flavescentes formans, caulibus submollibus flexuosis interdum ramulosis interrupte foliosis, hic illic *propagulis rhizoideis substrictis simplicibus elongatis robustis* (ad 1 cm. longis 70-80 μ latis) rubris, nunc laevibus nunc papillosis parce vestitis. Caulis sectione sine fasciculo centrali, reti interno laxiusculo tenerrimo, externo e cellulis 2-3 seriebus stereideis vel substereideis rufo-fuscis composito.

Folia 1.5-2 mm. longa, madida *squarrosa vel recurva,* sicca leniter crispata, e basi paullo latiore *perbrevi* anguste ligulata, breviter nec anguste acuminata, acuta, concavo-carinata, marginibus vel omnino planis vel uno latere ad infimam basin brevissime angustissime recurvo, superne saepe valde *irregulariter minute sinuosis,* nullo modo denticulatis. Costa valida, basin versus ad 75 μ lata, in summo apice evanescens, dorso laevis vel hic illic minute scaberula, fuscescens. Cellulae superiores *subquadratae, pellucidae,* foliis junioribus chlorophyllosae, 8-11 μ latae, tenerrime papillosae, parietibus firmis, vix incrassatis, basilares breviter rectangulares (2-4 $\times$ 1), pellucidae, parietibus firmis.

Cetera nulla.

Forma robusta. Omnino robustior, ubique sordide olivacea, inferne haud flavescens.

Hab.: Vicinity of Thika, alt. about 1,350 meters, September 6 and 7, 1909, Nos. 1143 (type), 1144.

I submitted this plant, being uncertain of its position, to Dr. Brotherus, who kindly wrote that in his judgment the stem and leaf-sections indicated a Hymenostylium (rather than a Trichostomum).

No. 1144 consists entirely of the robust form, which is perhaps worthy of a varietal name; it is larger in all its parts, with the stems darker rather than paler below, the leaves larger, denser, and the whole plant more rigid. The leaves and stems vary, however, in density or otherwise of arrangement; both forms also occur in No. 1143, where there are a few somewhat intermediate stems, so that it is perhaps not more than an incidental form; the leaf structure presents no difference.

The irregularity of the leaf margin, while not very conspicuous and not always present, is of an unusual nature, consisting sometimes of slight sinuosities or indentations, sometimes of slight protuberances, quite without system, as if the leaf had been badly cut out with scissors; it is not due in any way to erosion.

LEPTODONTIUM PUMILUM (C. M.) Broth.

Loc. 4,200 meters, No. 1660. A small plant, with rather close, appressed foliage when dry, which agrees well with C. Müller's description. There is a peculiarity about the basal areolation, however, which the author does not mention, but which may well have escaped attention. The basal juxta-costal cells are rather widely rectangular, and pellucid, extending to about half the width of the lamina; the marginal row consists also of pellucid, short, quadrate cells; and between this and the juxta-costal ones there lies a band of narrower, linear-rectangular, bright golden-yellow cells (cf. *pl. 1, fig. 6*).

LEPTODONTIUM JOANNIS-MEYERI C. M.

Loc. 3,630 meters, No. 1546. I have not been able to see a specimen of the original, from Kilimanjaro, but I have no doubt this is C. Müller's plant. From the leaf structure it appears to me probable that the fruiting characters when known may show this to be a Leptodontiopsis.

LEPTODONTIOPSIS ELATA Dixon, sp. nov.

(Plate 1, fig. 3)

L. fragilifoliae Broth. affinis, sed *multo elatior,* 10-12 cm. alta, foliis *haud vel minime fragilibus,* plerumque ad summam apicem *integris,* rarissime denticulatis, siccis flexuoso-crispatis *haud appressis,* flavo-aurantiacis. Fructus caret.

Hab.: Loc. 3,630 meters, No. 1557.

A fine species, clearly—though sterile—allied to Brotherus' plant from Karisimbi in the volcano region and from Ruwenzori, but differing sufficiently, I think, in the characters italicized to be kept distinct. Brotherus figures his species as having the extreme apex of the leaf crowned with a few subpellucid denticulations; these occur occasionally, but very rarely, in the present plant, where the leaf usually ends in a quite entire, fine, subpellucid point. The basal cells are—as in *L. fragilifolia*—linear, highly incrassate, and with the walls porose.

TORTULA ERUBESCENS (C. M.) Broth. in Engl. & Prantl, Pflanzenfam. 1[3]: 434. 1902

Barbula erubescens C. M. Nuov. Giorn. Bot. Ital. **4**: 14. 1872.
Barbula Hildebrandti C. M. Linnaea **40**: 294. 1876.
Barbula Leikipiae C. M. Flora **73**: 480. 1890.
Barbula meruensis C. M. Flora *loc. cit.*
Barbula exesa C. M. Hedwigia **38**: 103. 1899.
Barbula oranica C. M. Hedwigia *loc. cit.*

Loc. 3,630 meters, No. 1583. This species is marked by the extreme fragility of the lamina of the leaf, which is carried to such an extreme that the whole of the leaves on a stem will frequently have almost disappeared with the exception of the midrib, and it is often difficult to find a leaf intact or even nearly so. The plants in the above synonymy were described as separate species, chiefly on the ground of their geographical position. One or two characters noted by C. Müller as apparently constituting distinctions are quite valueless. These are: A certain diversity in the size of the upper cells, the direction of the leaves when moist, whether erect-patent or somewhat recurved; the outline of the leaf, the degree of recurving of the margin, and the smoothness or roughness of the nerve at the back near the apex. Nearly all these characters show an equal degree of variation, within the limits of a single species, in allied European species of Syntrichia, and I should have been inclined to doubt, *a priori,* their validity. Apart from this, I have examined specimens of most of them, including the originals of *B. erubescens* and *B. Hildebrandti,* specimens of *B. meruensis* determined by Brotherus, and South African plants corresponding no doubt to one or both of the two species cited last in the synonymy. In all of these I find the above characters eminently variable. *B. Hildebrandti,* for example, has on the same specimen, and sometimes on the same stem, leaves varying from erect-patent to patent and slightly recurved, the apex broadly rounded or only subobtuse, the nerve rough at the back above or quite smooth. Similar variations occur in the other characters mentioned above, in some at least of these plants, and I have no question at all that they all belong to one rather remarkable and not on the whole very variable type. The nerve is excurrent in a very short red mucro, which may be either stout and obtuse or tipped with a very short, fine, paler point or apiculus.

TORTULA CAVALLI Negri, Annal. di Bot. 7: 164. 1908

Loc. 3,630 meters, Nos. 1358 (c. fr.), 1542 (c. fr.), 1572 (c. fr.), 1545 (c. fr.), 1566 (c. fr.), 1579, 1596, 1597. Loc. 4,200 meters, No. 1656 (c. fr.).

Negri's description and figure, though drawn from sterile plants, leave no doubt in my mind that this is the same species. Brotherus has already recorded the fruiting plant from Ruwenzori (1). Nos. 1579, 1596, and 1597 are, I believe, the male plant, though I have not been able actually to find antheridia, owing perhaps to the season at which they were gathered. These agree exactly with Negri's description, and are very marked by the erect, almost appressed leaves when moist, these usually very concave and therefore appearing pointed, and with the nerve only very shortly excurrent, so as to form a scarcely cuspidate point. They are, however, rather broadly oblong-spatulate when flattened out, and though leaves occur as narrow as that figured by Negri (5a), *table 1, fig. 8,* I should not consider this the most typical form.

The fruiting plant, however, presents some differences. It is usually more luxuriant, with larger leaves, more flexuose and twisted when dry, many of them, especially the conal ones, bearing a rather long, smoothish, hyaline hair-point. The seta is rather short for the size of the plant, about 1 cm. long, twisted strongly in the negative direction;[1] the capsule is about 3 mm. long without, 4.5 mm. with the lid, usually rather elliptic-cylindric than quite cylindric, and often slightly curved; the peristome tube appears to be about half the length of the whole. The perichaetial leaves are well differentiated, very long, gradually tapering to a long, colored arista, the whole reaching frequently to one-third the height of the seta.

The more robust plants reach a height of 10 cm., but the plants are often very short, dense, and compact. They sometimes occur on charred wood.

GRIMMIACEAE

GRIMMIA OVATA Web. & Mohr

Grimmia calyculata C. M. Flora **73**: 484. 1890.

Loc. 3,630 meters, Nos. 1552, 1582, 1585, 1586, 1589; all c. fr. Somewhat varying in size and in length of capsule and lid. *Grimmia calyculata* C. M. is without doubt founded on one of the smaller forms of this.[2]

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[1] I use the term "*positive*" for a spiral that twists in the direction in which the hands of a watch move, *negative* for the reverse direction.

[2] C. Müller describes *Grimmia calyculata* n. sp. twice over, in Flora, 1888, p. 414, and again, Flora, 1890, p. 484. It is by no means clear whether he intends to describe two species or whether they are actually identical; in any case the second is *G. ovata* Web. & Mohr.

RHACOMITRIUM DEFOLIATUM Dixon, sp. nov.

(Plate 1, fig. 4)

Stirps *praelonga, prolixa,* caulibus 15 cm. aequantibus vel superantibus, *iter iterumque divisis, rigidiusculis, saepe a basi usque fere ad apicem denudatis,* vel costis foliorum vetustorum solum praeditis. Folia perrigida, *sicca madidaque horride erecto-patentia, plerumque rufo-aurantiaca,* 2.5-3 mm. longa, e basi brevi ovata lanceolata, sensim acutata, apice subacuta vel subobtusa, mutica, valde carinato-concava, uno margine leniter recurvo; costa *valida,* apud basin 70-95 μ lata, plano-convexa, sectione (in medio folio) tres cellularum series exhibens, quarum ventrales circa quattuor magnae, mediae paucae (3-4) atque dorsales numerosae multo minores. Cellulae folii basilares perangustae, *alares bene evolutae, magnae, subpellucidae,* superiores *subquadratae, isodiametricae,* omnes sinuosae, 4-5 seriebus marginalibus ab apice usque fere ad basin *bistratosae, limbum bene notatum incrassatum* instruentes. Cetera nulla.

Hab.: Loc. 3,630 meters, Nos. 1593 (type), 1339. Evidently more or less submerged, or subject to aquatic action, probably in mountain torrent or waterfall.

A very distinct species, allied perhaps to *R. protensum* A. Br., but very distinct in the color, smaller leaves, thickened margins, well-developed auricles, etc. *Rhacomitrium alare* (Broth.) Par. differs entirely in the texture, weak nerve, elongate upper cells, etc.

The leaf margin often appears papillose, through the erosion of the outermost cell walls.

RHACOMITRIUM ALARE (Broth.) Par.

Loc. 3,630 meters, No. 1555, c. fr. The fruiting plant has not, I believe, been recorded. The sporophytic characters are of some interest, the two innermost perichaetial leaves being wide, very obtuse, and convolute, so as to form a tubular sheath around the base of the seta; the seta is yellow (brown when old), 1 cm. long; capsule elliptic-cylindric, castaneous when old. Peristome not seen.

The leaf apex varies greatly, being nearly always obtuse and quite hairless, while other leaves on the same stem will be acute with a short piliform hyaline point.

RHACOMITRIUM DURUM (C. M.) Par.

Loc. 3,630 meters, No. 1556, c. fr. This species also, I believe, has not been recorded hitherto in fruit. It was originally described from the Cameroons, but is recorded by Brotherus (1) from Central

Africa, in the volcano region at heights of 3,200 meters and 4,000 meters. The sporophytic characters are identical with those of *R. alare,* including the unusual character of the perichaetial leaves. In fact the plants are extremely closely allied to one another, though the long hyaline points of the present species give it a very different appearance. The difference between the two is practically that—and only that—which exists between the European *R. heterostichum* (Hedw.) Brid. and *R. affine* (Schleich.) Lindb.

ORTHOTRICHACEAE

AMPHIDIUM CYATHICARPUM (Mont.) Broth.

Zygodon kilimandscharicus C. M. Flora **73:** 482. 1890.

Loc. 3,630 meters, No. 1580c. In very low, soft, dense tufts with *Isopterygium sericifolium* sp. nov., etc. I have found ♂ flowers aggregated towards the apex of the short stems, but have not seen ♀ flowers or fruit. C. Müller in describing his *Z. kilimandscharicus* writes "An *Oncophorus* (*Rhabdoweisia*) *cyathicarpus* Mitt. in Journ. Linn. Soc. 1886?" There is no doubt at all that the identification is correct, and equally there is none that Mitten is correct in referring the African plant to the species described by Montagne from Chile, which is distributed throughout a great part of the South Temperate zone and the mountainous parts of the subtropical zone. C. Müller does not suggest any difference in his specimens from these unless it be the leaves denticulate throughout their length; but this character is no more marked in the African than in the South American plant, while the same rather remarkable variability in this character appears in both. The leaves may be absolutely entire from base to apex; they may be—on the same tuft or even sometimes on the same stem—slightly sinuate-denticulate either at apex or for a greater or less part of their length; or they may be minutely and distantly but quite sharply and distinctly denticulate from apex to just above the basal part. All these forms of toothing—or its absence—may occur even on the leaves from a single stem. *Zygodon kilimandscharicus* must certainly fall into the synonymy of *Amphidium cyathicarpum.*

SPLACHNACEAE

TETRAPLODON BRYOIDES (Zoeg.) Lindb.

Tetraplodon mnioides (Sw.) Bry. eur.

Loc. 3,630 meters, No. 1587, c. fr. In short, extremely dense tufts, with numerous capsules, which are only slightly exserted above the leaves of the tuft. The leaves are highly concave, and I should be inclined to refer it to var. *cavifolius* Berggr. (7). It is the form recorded by Brotherus (1) from similar altitudes on Ruwenzori.

BRYACEAE

POHLIA AFRO-CRUDA (C. M.) Broth.

Loc. 3,630 meters, No. 1580b. In small quantity among *Isopterygium sericifolium* sp. nov. Its near resemblance to the northern *P. cruda* (L.) quite justifies the name, but it appears to be well distinct; the leaves are distant, and the apex is usually half-twisted. It is a beautiful plant, highly glossy, and often very deep red in color.

POHLIA sp.

Loc. 3,630 meters, No. 1568b, c. fr. With *Bartramia ruvenzorensis* Broth. A few plants with immature and over-ripe capsules occurred mixed up with the Bartramia, but in too small quantity to permit of identification. It is just possible that it may be the fertile plant of *P. afro-cruda,* but I doubt it, as the leaves are much smaller, less glossy, less sharply toothed, less narrowed at base, and more densely arranged. It is a paroicous species, with the perichaetial leaves all small, short, erect, shortly pointed, faintly nerved, and subentire.

BRYUM (PSEUDOTRIQUETRA) PLANO-MARGINATUM Dixon, sp. nov.

Habitu formarum laxiorum *B. ventricosi* Dicks.; caules circa 5-6 cm. alti, infra radiculosi. Folia *sat laxe disposita, costa et alis valde decurrentibus,* siccitate contracta subtorta, ovato-lanceolata, acuta, apice subdenticulata; areolatio *B. ventricosi,* cellulis ad marginem seriebus pluribus linearibus subincrassatis, limbum perdistinctum per totam longitudinem instruentibus; costa basi purpurea, sat valida, *percurrens vel brevissime excurrens;* folia vix concava, *marginibus planis.* Cetera ignota.

Hab.: Vicinity of Thika, British East Africa, alt. about 1,350 meters, Sept. 6 and 7, 1909, No. 1146.

If it were not for the plane margin (very rarely a leaf shows the *slightest* recurving on one side at the extreme base) this might be referred to *B. ventricosum* Dicks. or to *B. bimum* Schreb., but the character appears to be quite sufficient to separate it. *B. minutirete* C. M. is described as with leaves obtusely rounded at apex, entire, with nerve vanishing below apex. It may conceivably, however, be only a form or state of this plant.

RHODOBRYUM SPATHULOSIFOLIUM (C. M.) Broth.

Loc. 3,630 meters, No. 1400, c. fr. From camp on Mt. Kenia (2,550 meters) at lower border of bamboo zone, westward to the Kasorongai River (1,950 meters), Oct. 17-19, 1909, No. 1885, c. fr.

AULACOMNIACEAE

AULACOMNIUM TURGIDUM (Wahl.) Schwaegr. var. PAPILLOSUM Dixon, var. nov.

Lumen cujusque cellulae superioris papilla magna centrali praeditum.

Loc. 3,630 meters, Nos. 1592 (type), 1595. The papillae vary a good deal, being sometimes wanting (especially in No. 1595), or existing as low mamillae only, but on most stems they are well developed. In other respects the plant is normal *A. turgidum.* In No. 1595, however, the stems show a very great variability in robustness, sometimes being exceedingly slender. This species is new to the African continent.

BARTRAMIACEAE

BARTRAMIA RUVENZORENSIS Broth.

Loc. 3,630 meters, Nos. 1568, 1574, 1581, 1590; all c. fr.

Brotherus in describing this species says that the nerve is distinct from the lamina to the leaf apex; I find it very ill defined above, however. Also, he describes the capsule as erect, but in the " Musci " he places the species under the heading "Kaps. geneigt." This appears to me the more accurate view, as the capsules are generally at least very slightly oblique.

Negri (5a) has some pertinent notes on this species. The original plant described was a bright green (*caespites viridissimi*); but, as Negri points out, the color may be yellowish. Both colors occur in this collection. He also arrives at the same conclusion as the above with regard to the inclination of the capsule.

PHILONOTIS SPEIROPHYLLA Dixon, sp. nov.

(Plate 2, fig. 7)

P. seriatae Mitt. affinis, sed gracilior, foliis *fere e basi ad apicem sensim attenuatis, nec infra ovatis, minus concavis, haud plicatis* anguste acuminatis, costa paullo minus valida, breviter tantum excurrente, dorso *laeviuscula,* marginibus *omnino planis,* per totam longitudinem tenuiter denticulatis. Fructus ignotus.

Hab.: Vicinity of Thika, British East Africa, alt. about 1,350 meters, Sept. 6-7, 1909, No. 1139.

Certainly near *P. seriata;* but the leaves gradually tapering from a somewhat hastate base, and therefore triangular in outline, scarcely concave, not plicate, the margins quite plane and closely and finely denticulate, with single, not geminate teeth, and the nerve only lightly and distantly roughened at back, are good distinguishing characters.

BREUTELIA SUBGNAPHALEA (C. M.) var. DENSIRAMEA Negri

Loc. 3,630 meters, Nos. 1571, 1576. A fine variety, with the branching very regularly and closely pinnate. The stems are sometimes densely tomentose above, but more often are quite free from tomentum.

Breutelia subgnaphalea is exceedingly near to *B. diffracta* Mitt., from West Africa. Vegetatively, indeed, I can find no difference. The fruit of *B. diffracta,* however, has an erect or only flexuose seta of above a centimeter in length, whereas that of *B. subgnaphalea* is described as short and recurved; the only capsule I have seen is on so short a seta that it is entirely concealed by the capsule, in the Kew specimen. C. Müller does not describe the peristome, and I am not aware whether it is present, or absent as in *B. diffracta.*

BREUTELIA AURONITENS Negri

Loc. 3,630 meters, Nos. 1543, 1567. A very beautiful plant, with tall, robust, densely foliate stems 15 to 20 cm. in length, of a bright golden yellow. No. 1567 is the ♂ plant, and has the leaves abruptly reflexed, whereas the normal form has them widely patent only. No. 1543 is in two forms, one having the reflexed leaves as in 1567, though not certainly a ♂ plant. This gives the stems a very different appearance, and I supposed at first that two species were involved, but it is clearly only a dimorphic form of the plant. Is the deflexion of the leaves by any chance a secondary sexual (♂) character? The same variation occurs, according to Brotherus, in *B. Stuhlmanni* Broth. This fact suggests the doubt whether the two species are actually distinct. Both were found first on Ruwenzori; they are similar in most characters, but differ in that *B. Stuhlmanni* has the stems tomentose above, a less robust habit, and a rather shorter leaf-base; but in view of the variation as to tomentum in *B. subgnaphalea* described above, and taking into account the rather remarkable dimorphism of leaf-direction occurring in both plants, there appears to be some ground for suspicion as to whether they are actually distinct.

BREUTELIA STRICTICAULIS Dixon, sp. nov.

(Plate 2, fig. 8)

Habitu *B. subgnaphaleae* (C. M.) sed *caulibus plerumque perstrictis,* subsimplicibus vel breviter distanter parce ramosis, 15 cm. altis vel ultra, stramineis, infra fuscis, hic illic usque ad apicem tomentosis. Folia 4-5 mm. longa, e basi brevi pluriplicata erecta *raptim deflexa,* hinc sensim attenuata, *breviuscule acute acuminata, siccitate* parum contracta, leniter plicata. Costa sat angusta, in cuspidem rigidiusculam subflexuosam dentatam excurrens. Folii *margines omnino plani,* inferne denticulati, superne *dentibus tenuibus angustissimis argute ciliolati.* Cellulae basilares angustissime lineares, laeves, *marginales haud vel vix latiores,* superiores lineares, unaquaque papilla alta in angulo inferiore instructa, *marginales 2-3 seriebus omnino laeves,* limbum paullo pellucidiorem instruentes.

Bracteae perigoniales internae obtusae vel subobtusae, evanidinerviae, basi pulchre aurantiacae.

Cetera ignota.

Hab.: Loc. 3,630 meters, No. 1541.

In many respects like *B. subgnaphalea* (C. M.), but more rigid and with certain structural differences of some importance. The leaves in that species taper very gradually to a very acute apex, with a longer, more flexuose filiform point, formed by the excurrent nerve; here they narrow rather rapidly and shortly, with a shorter, more rigid point. The upper denticulation in that is much finer with short, scarcely at all ciliolate teeth, and the border of smooth cells is almost or quite wanting. (Cf. *pl. 2, figs. 8c, 9c.*)

POLYTRICHACEAE

POLYTRICHUM KENIAE Dixon, sp. nov.

(Plate 2, fig. 10)

Robustum; caules ad 25 cm. alti vel ultra, infra cum foliis squamiformibus castaneis appressis subobtusis mucronatis teretes, nullo modo radiculosi, superne dense foliosi; folia madida patentia, sicca magis erecta, *rigidiuscula,* interdum appressa, inde frondem subteretem sistentia, *1-1.5 cm. longa,* e basi nitidiuscula aurantiaca vaginante decurrente *praelonga 1/3 folii longitudinem aequante vel superante,* in laminam lanceolatam sensim acuminatam producta, apice dorso-spinoso, marginibus (parte basilari excepta) *argute, spinose, sat distanter grosse dentatis.* Cellulae superiores valde incrassatae, subquadratae, lumine 7-12 μ lato, inferiores lineares, angustissimae, parietibus valde tenuibus. Lamellae 30-40, apice integro nec crenulato, e cellularum seriebus 5-6 quarum *apicalis* (sectione) *multo major, ovata, subconica, papillosa.* Cetera nulla.

Hab.: Loc. 3,630 meters, Nos. 1564 (type), 1550.

In the absence of fruit the exact position of this fine species must remain dubious, but the character of the apical cell of the lamellae removes it far from *P. commune,* of which it has somewhat the habit, but with much denser, more rigid leaves. The rather distant, spinose teeth of the leaf margin, quite without the small intermediate teeth found in some species, are also a marked character. The leaf base is remarkably long.

No. 1550 has shorter, more densely foliate stems. No. 1564 is associated with Sphagnum, and is probably a paludal plant.

HEDWIGIACEAE

RHACOCARPUS HUMBOLDTII (Hook.) Lindb.

Loc. 3,630 meters, Nos. 1540, 1551, 1559. Gathered in quantity, and in large, dense masses. It is evidently one of the dominant mosses of the district.

LEUCODONTACEAE

ANTITRICHIA KILIMANDSCHARICA Broth.

Loc. 3,630 meters, No. 1569. Among grass.

PTEROGONIUM ORNITHOPODIOIDES (Huds.) Lindb.

Loc. 3,630 meters, No. 1575. A robust dendroid form, with the branches nearly all attenuated to an extremely long decurved filiform flagellum, which is itself frequently branched near the tip. This gives the plant a very individual appearance, but structurally it agrees quite well with the normal form.

NECKERACEAE

PILOTRICHELLA PROFUSICAULIS (C. M.) Par.

Loc. 3,630 meters, No. 1307. Original specimens, in Herb. Bescherelle, at the British Museum, leg. Meyer, agree quite well; the apical points of the leaves vary somewhat considerably in length, and are usually longer in No. 1307 than in Meyer's specimens, but are quite equalled by some of these, and there is no constancy as to the character in individual plants. The yellowish, golden, or ruddy color, and the rather stout, obtuse branches are notable features of this species.

PAPILLARIA AFRICANA (C. M.) Jaeg.

Vicinity of Lake Naivasha, British East Africa, from lake level (1,860 meters) to 1,950 meters elevation, July 17-Aug. 15, 1909, No. 934.

NECKERA COMPLANATA (L.) Huebn. var. MAXIMA Dixon, var. nov.

Caules praelongi, ad 15 cm., molles.

Hab.: Bamboo zone, western slopes of Mt. Kenia, along the trail from West Kenia Forest Station to summit, at about 3,000 meters alt., No. 1728.

Except in the very elongate stems I find no difference from the European plant. It is known from the Canaries and Algeria, but is new to Central Africa.

PINNATELLA ENGLERI Broth.

Vicinity of Thika, British East Africa, alt. about 1,350 meters, No. 1145.

THAMNIUM HILDEBRANDTII (C. M.) Besch.

Vicinity of Lake Naivasha, British East Africa, from lake-level (1,860 meters) to 1,950 meters elevation, No. 877. Vicinity of Thika, alt. about 1,350 meters, No. 1141.

HYPNACEAE

HYGROAMBLYSTEGIUM PROCERUM Dixon, sp. nov.

(Plate 2, fig. 11)

Perrobustum; caules 20 cm. longi et ultra, inferne plus minusve denudati, *haud radiculosi,* superne *conferte regulariter eleganter pinnati, ramis subaequalibus pro more robustis, 1-1.25 cm. longis, frondem pectinatam ad 2 cm. latam* pulchre aurantiacam vel olivaceam sistentibus. Paraphyllia numerosa. Folia *H. filicini,* caulina magna, 1.5 mm. longa, deltoideo-ovata, ramea angustiora, ovato-lanceolata, omnia *tenerrime indistincte denticulata vel subintegra;* costa valida, percurrens vel plerumque in cuspidem robustam excurrens. Dioicum videtur. Fructus caret.

Hab.: Vicinity of Thika, British East Africa, alt. about 1,350 meters, Sept. 6 and 7, 1909, No. 1140. Probably growing on wet rocks in or near a stream. A few stems were found mixed with No. 1139 (*Philonotis speirophylla*).

This fine plant may be considered a subspecies of *H. filicinum* (L.) Loeske; structurally it is indeed almost identical, but I have seen no form of that species at all approaching this in size, or in the very regular, elegantly pectinate, robust branching; the stems also are quite free from radicles.

CALLIERGON KENIAE Dixon, sp. nov.

(Plate 2, fig. 12)

Gracile, *stramineum* vel *rufo-flavidum;* caules circa 5-6 cm. alti, haud cuspidati, *molles*, flexuosi, subsimplices, interdum valde tenelli. Folia sat laxe disposita, erecta, *nitida, parva,* 1.5-2 mm. longa, late ovato-oblonga, perconcava, *apice subcucullato, plerumque breviter late apiculato,* marginibus planis integerrimis. Costa *angusta,* ad basin usque ad 50 μ saepius circa 35-40 μ lata, longe infra apicem, saepe quidem apud 2/3 folii longitudinem desinens. Cellulae superiores *breviuscule lineares* subflexuosae, circa 150-200 μ longae, 5-6 μ latae, supra sensim abbreviatae, apud apicem multo breviores latioresque; basin versus laxiores saepe pulchre aurantiacae, rectangulares, ad angulos perlaxae, tenuiores, subvesiculosae, alas decurrentes majusculas formantes. Cetera ignota. Dioicum videtur.

Hab.: Loc. 3,630 meters, No. 1592b. With *Aulacomnium turgidum* var. *papillosum.*

The affinity of this species is no doubt with *C. stramineum,* of which it has the weak nerve and the areolation, but it differs in the color and habit, and the leaf apex, and is a more slender plant altogether. It is a much more delicate plant with smaller leaves than the following, which has branched stems, much more crowded, somewhat spreading, scarcely glossy leaves, a stouter nerve, and much more incrassate cells.

CALLIERGON SARMENTOSUM (Wahl.) Kindb. var. SUBFLAVUM Ferg.

Loc. 3,630 meters, No. 1339b. A few stems mixed with *Rhacomitrium defoliatum.* It agrees exactly with the Scotch plant, named as above by Ferguson, but is probably only a slight form or state of a pale color, having a weaker habit and more spreading leaves.

STEREODON CUPRESSIFORMIS (L.) Brid.

Loc. 3,630 meters, Nos. 1554, 1570.

No. 1554 is a rather robust form, apparently growing more or less prostrate on the ground, and with something the habit of var. *ericetorum* Bry. eur., but browner and more rigid.

No. 1570 is a very marked form, and worthy of a varietal name, but I hesitate to describe it as new from a doubt whether it be not

S. Hoehnelii (C. M.). The description of that plant (which I have not been able to see) seems to agree fairly well with this, but C. Müller describes the leaves as *very narrow,* which does not apply here. I do not feel justified therefore in referring No. 1570 to *S. Hoehnelii*—which I have no doubt is but a variety of *S. cupressiformis;* on the other hand I have a shrewd suspicion that it is really C. Müller's plant. It is a very soft, prolix form, pale dull green with very long flexuose stems having very few distant irregular branches, slender, but not extremely so, and particularly marked in having the leaves not at all falcate, but straight, suberect or slightly spreading, and generally homomallous. It might perhaps be placed under var. *resupinatus* (Wils.) Schimp., but I have not seen any form of that variety at all approaching this in habit.

ISOPTERYGIUM SERICIFOLIUM Dixon, sp. nov.

(Plate 2, fig. 14)

Autoicum. Dense caespitosum; caules valde intricati, irregulariter ramosi, pergraciles, condensati, *caespites depressos sericeos* instruentes. Rami inaequales, 1-2 cm. longi, *complanati,* parcissime ramulosi, cum foliis vix ultra 1 mm. lati, saepe subflagelliformes, *pallide straminei, valde sericei, nitidi, molles.* Folia 1 mm. longa, concava, e basi parum angustiore oblongo-lanceolata, superne *cito in acumen tenue subfiliforme flexuosum breviusculum* attenuata; marginibus planis *integerrimis.* Costa *gemella,* cruribus brevibus sed plerumque bene notatis, inaequalibus, angustissimis. Areolatio densissima, e cellulis *angustissime linearibus,* valde prosenchymaticis, *infra parum latioribus* instructa, alaribus *nullis.*

Flores masculi et feminei immaturi, apud ramorum basin siti. Cetera ignota.

Hab.: Loc. 3,630 meters, No. 1580.

Belonging to the group of which the nearest continental African allies are *Isopterygium plumigerum* (C. M.) Broth. and *I. conangium* (C. M.) Broth.; but it is quite distinct from these. *Isopterygium plumigerum* is not unlike it in aspect, but has quite different foliation, the leaves being more distichous and widely spreading, while here they point forward in a marked degree, their axis making only a small angle with the stem, while the apex is still more incurved. Most of the other allied species have the leaves also more or less markedly denticulate. *Isopterygium subleptoblastum* C. M. resembles it in leaf form and areolation, but is of a green color, and the leaves are nerveless.

PLEUROPUS SERICEUS (Hornsch.) Broth.

Loc. 3,630 meters, No. 1591. In small quantity, sterile.

BRACHYTHECIUM IMPLICATUM (Hornsch.) Jaeg.

Loc. 3,630 meters, No. 1599. On twigs, etc.

RHYNCHOSTEGIELLA KENIAE Dixon, sp. nov.

(Plate 2, fig. 13)

Caules valde intricati, elongati, mollissimi, tenerrimi, 5 cm. longi vel ultra, vage subpinnatim ramosi, iter iterumque ramulosi, ramulis saepius gracillimis flagelliformibus; rami complanati, flavo-virides, subnitidi. Folia *caulina et ramea distiche complanata, patentia,* 2 mm. longa, vix concava, *sicca saepe plicato-striatula,* e basi *amplexicauli valde constricta subdecurrente anguste lanceolata, argute stricte acuminata,* marginibus per totam longitudinem tenuiter, superne argutius denticulatis, planis, ad infimam basin tantum angustissime brevissime reflexis; costa *angusta,* ad 1/2-2/3 folii longitudinem evanescens. Folia ramulina multo minora, minus complanata, brevius acuminata, sicca haud striata. Cellulae superiores longiuscule lineares, flexuosae, basin versus paullo latiores, parietibus subincrassatis, subporosis, ad insertionem una serie magnae, subvesiculosae, ellipticae; alares *numerosae, parvae, opacae,* irregulariter subquadratae vel breviter rectangulares, *alas minimas inconspicuas* formantes. Cetera ignota. Dioica videtur.

Hab.: Loc. 3,630 meters, No. 1573.

Forming large, thin, very soft mats several inches across, of interlacing stems repeatedly branched, the branches often very delicate and subflagelliform. In absence of fruit the generic position is doubtful; the stems and primary branches are rather robust for Rhynchostegiella and suggest Rhynchostegium, but the small auricles of minute cells obscure with chlorophyll strongly indicate Rhynchostegiella. This is the opinion of Mons. Thériot, to whom I submitted a specimen, and he points out a resemblance to the leaves of *R. hawaiica* (C. M.). It is a much larger plant than *R. Holstii* Broth. from Usambara and Belgian Congo and of quite different habit. The leaves are sharply and narrowly, but not at all delicately, somewhat rigidly acuminate.

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EXPLANATION OF PLATES

Plate 1

Fig. 1. *Sphagnum Keniae.* *a,* Stem leaf, × 20, with upper cell, dorsal view, × 200. *a′,* branch leaf, × 20; *f,* transverse section of branch leaf, × 200.

Fig. 2. *Hymenostylium crassinervium.* *a,* Stem, nat. size; *a′,* do. of forma *robusta;* *b,* leaf, × 20; *c,* apex of leaf, × 50; *d,* upper marginal cells, × 200; *e,* basal cells, × 200.

Fig. 3. *Leptodontiopsis elata.* *a,* Stem, nat. size; *b,* leaf, × 20; *c,* apex of leaf, × 50; *d,* upper cells, × 200; *e,* basal cells, × 200.

Fig. 4. *Rhacomitrium defoliatum.* *b,* Leaf, × 20; *d,* upper cells, × 200; *c,* alar cells, × 200; *f,* nerve section, × 100.

Fig. 5. *Andreaea kilimandscharica.* *a, a′,* Capsules, × 5.

Fig. 6. *Leptodontium pumilum.* Basal areolation; *a,* pellucid, *d,* orange cells.

Plate 2

Fig. 7. *Philonotis speirophylla.* *b,* Leaves, × 20.

Fig. 8. *Breutelia stricticaulis.* *b,* Leaf, × 10; *c,* apex of leaf, × 50.

Fig. 9. *Breutelia subgnaphalea.* *c,* Apex of leaf, × 50.

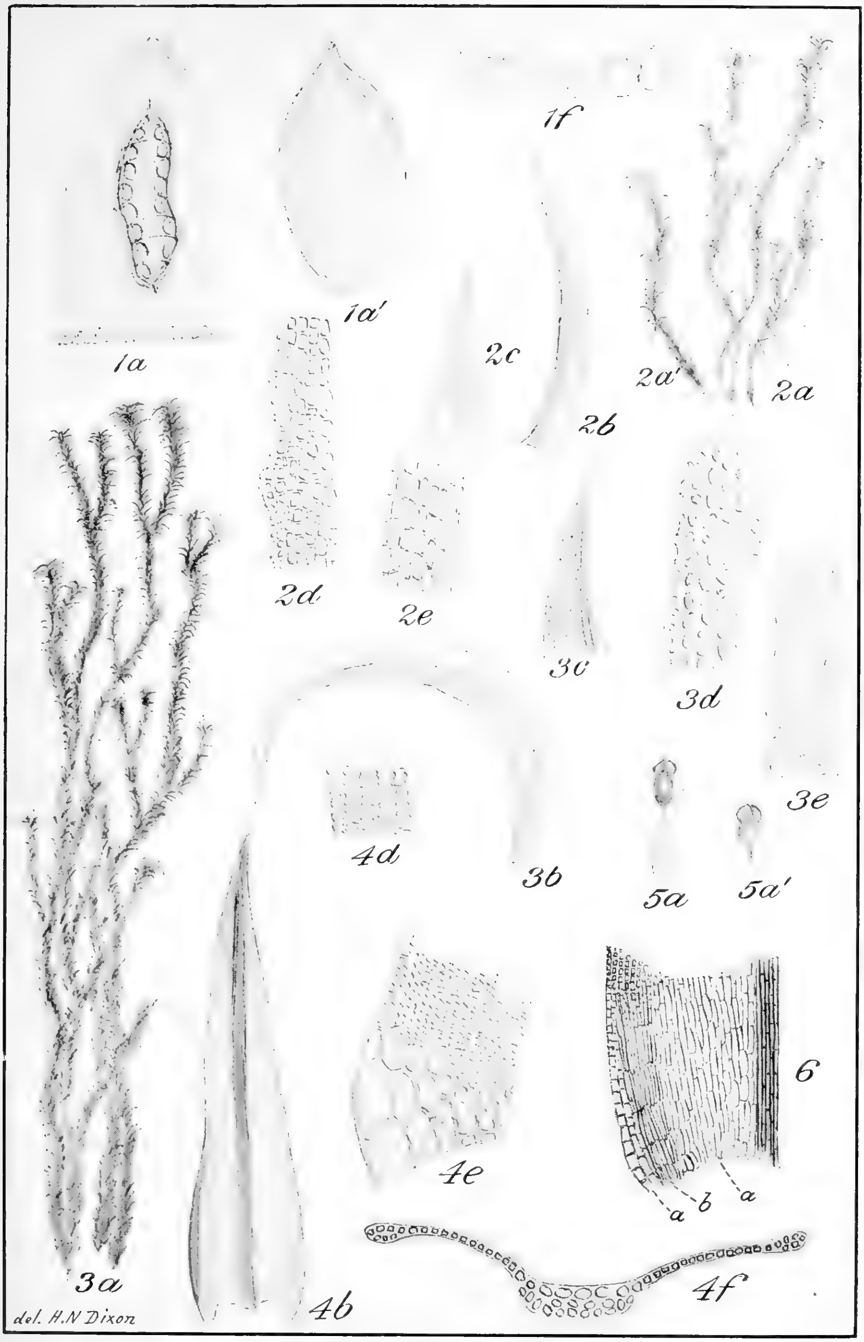
Fig. 10. *Polytrichum Keniae.* *b,* Leaf, × 4; *f,* marginal cells, × 50; *g,* transverse section of lamellae, × 200.

Fig. 11. *Hygroamblystegium procerum.* *a,* Part of stem, nat. size; *b,* stem leaf, × 20.

Fig. 12. *Calliergon Keniae.* *a,* Stem, nat. size; *b,* leaf, × 20; *c,* apex of leaf, × 20; *e,* basal cells, × 50.

Fig. 13. *Rhynchostegiella Keniae.* *a,* Stem, nat. size; *b,* stem leaf, × 20; *c,* apex of leaf, × 50; *e,* alar cells, × 200.

Fig. 14. *Isopterygium sericifolium.* *a,* Upper part of branch, × 4; *b,* leaf, × 20: *c,* apex of leaf, × 50; *e,* basal cells, × 200.



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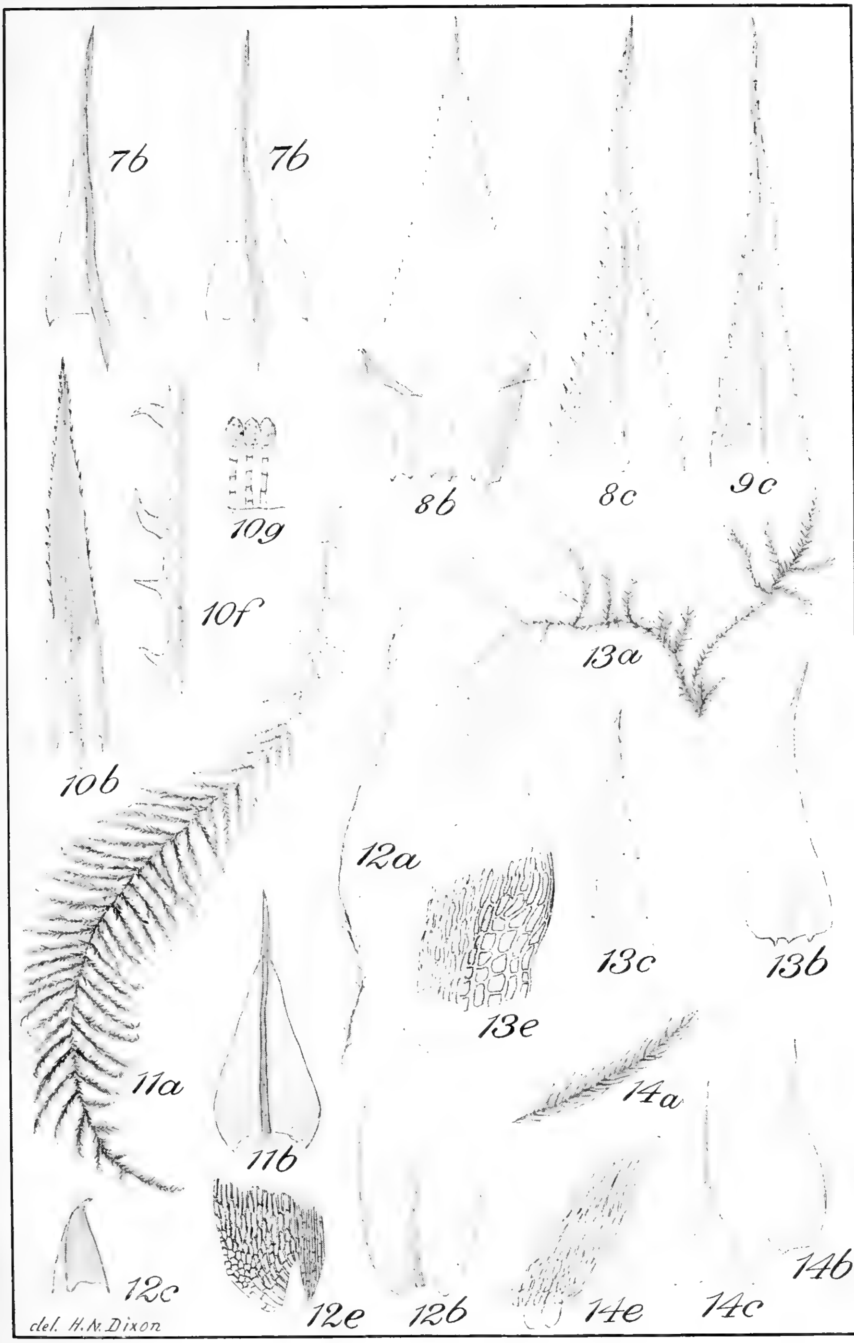

AFRICAN MOSSES

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THE ATMOSPHERIC SCATTERING OF LIGHT

BY

FREDERICK E. FOWLE

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THE ATMOSPHERIC SCATTERING OF LIGHT

By Frederick E. Fowle

Rayleigh has indicated how the amount of energy scattered from a beam of light within a gaseous medium may be used to determine the number of molecules in that medium. It will be shown in what follows that, whereas the application of the process to the enumeration of the number of molecules in dry air leads to normal results, its application to atmospheric aqueous vapor leads to an anomaly. Further, this anomaly, like the aurora and certain atmospheric optical phenomena, seems to be related to certain phases of solar activity.

In the process of determining the intensity of the sun's radiation as it reaches the outside of the earth's atmosphere, certain so-called atmospheric transmission coefficients are obtained.[1] These coefficients express the fractional amounts of the sun's energy incident at the outer limits of the atmosphere which would reach an observer at the earth's surface with the sun in the zenith. They are determined at some 40 different wave-lengths between 0.35 and 2.5 μ. In the following discussion only those values will be considered which belong to the region from 0.35 to 0.57 μ practically free from any complication due to selective or banded absorptions.

These, which for the moment may be called "crude" transmission coefficients, a_λ, will be subjected to several "refining" processes. It will first be assumed that the composition of dry atmospheric air remains in general practically unchanged from day to day above an altitude like that of Mount Wilson (1,730 meters) where the air is nearly free from dust contamination. The amount of aqueous vapor, however, changes many-fold. Let the coefficient a_λ for wave-length λ be assumed composed of two parts, a_{a_λ}, proper to dry air, and $a_{w}{}_\lambda^{w}$ due to an amount of aqueous vapor above the station, which, if precipitated, would form a layer of water w centimeters thick. Then

$$a_\lambda = a_{a\lambda} a_{w\lambda}^{w},$$

or taking logarithms,

$$\log a_\lambda = \log a_{a\lambda} + w \log a_{w\lambda}.$$

If the logarithms of the observed transmission coefficients, $\log a_\lambda$, are plotted as abscissae against the precipitable water, w, as ordinates,

[1] Annals of the Astrophysical Observatory of the Smithsonian Institution, vol. 2, p. 13 *et seq.*, 1908.

the points will be found to lie nearly on straight lines. The tangent which the straight line best representing the points for the wave-length λ makes with the axis of abscissae gives log $a_{w\lambda}$ and its intercept on the axis of ordinates gives log $a_{a\lambda}$.

The observations taken each year at Mount Wilson (generally during the months from June to November, inclusive) have been subjected, year by year, to this refining process. They yield the results given in tables 1 and 2. The process is described in more detail and

TABLE 1.—*Yearly Mean Dry-air Transmission Coefficients,* $a_{a\lambda}$

Obtained at Mount Wilson, altitude 1,730 m., barometer 62.3 cm.

Wave-length, μ	.350	.360	.371	.384	.397	.413	.431	.452	.475	.503	.535	.574
$a_{a\lambda}$, year 1910.	.654	.668	.690	.724	.751	.782	.807	.837	.864	.885	.898	.905
1911.	.674	.672	.679	.707	.752	.783	.810	.842	.863	.885	.898	.904
1913.	.614	.637	.667	.689	.738	.763	.792	.816	.836	.859	.873	.877
1914.	.607	.646	.661	.693	.758	.780	.804	.831	.852	.874	.886	.892
1915.	.631	.650	.681	.706	.764	.775	.805	.829	.851	.885	.897	.903
1916.	.637	.651	.670	.693	.742	.767	.792	.821	.845	.869	.887	.888
Dry dustless air.	(.630)	(.655)	(.686)	.714	.752	.783	.808	.840	.863	.885	.898	.905

TABLE 2.—*Yearly Mean Atmospheric Aqueous-Vapor Transmission Coefficients,* $a_{w\lambda}$

Obtained at Mount Wilson. 1 cm., precipitable water.

Wave-length, μ	.350	.360	.371	.384	.397	.413	.431	.452	.475	.503	.535	.574
$a_{w\lambda}$, year 1910......	.945	.951	.964	.952	.963	.970	.975	.975	.974	.979	.980	.977
1911......	.898	.934	.954	.962	.961	.962	.962	.962	.973	.974	.980	.976
1913......	.933	.948	.923	.929	.962	.938	.944	.955	.951	.957	.964	.966
1914......	.974	.971	.971	.972	.968	.967	.973	.973	.974	.980	.982	.981
1915......	.958	.963	.962	.953	.968	.971	.971	.978	.975	.976	.980	.979
1916......	.963	.967	.969	.972	.974	.975	.979	.979	.980	.980	.980	.982

plots shown in the *Astrophysical Journal,* 38, p. 392, 1913, and 40, p. 435, 1914. Improved apparatus and methods have led to greater accuracy in plots like those of figure 1 of the first of these communications. Because of the presence in the upper atmosphere during 1912 of a great amount of volcanic dust and the considerable variation of its amount from day to day, the observations of that year were not adapted to the present investigation and are omitted.

The coefficients $a_{a\lambda}$ and $a_{w\lambda}$ were then subjected to a second refining process. Following the lead of Rayleigh, Schuster and L. V. King, $a_{a\lambda}$ may be placed equal to e^{-k} where e is the base of the natural logarithms. Then

$$k = \frac{32}{3}\left\{\pi^3 (n-1)^2 \frac{H}{N_0 \lambda^4} + bH\right\}\frac{p}{p_0} + D$$

where n is the index of refraction of air; H, the height of a "homogeneous atmosphere" in cm. when the pressure p_0 is 76 cm. H equals 7.99×10^5; p, the observed atmospheric pressure; λ, the wave-length in cm.; N_0, the number of molecules per cm.[3] at 76 cm. pressure and 0° C; b, a factor to represent the amount of energy absorbed and changed into heat and which approximates zero in the region considered (no selective absorption); D, a coefficient of transmission suitable to whatever dust may be present. This dust is presumed to be composed of particles so large that D is invariable with the wave-length.

Treating N_0 and D as the unknowns, least-square solutions were made by Miss F. A. Graves from the values of $a_{a\lambda}$ grouped year by year. Table 3 contains the results.

TABLE 3

N_0, the number of molecules per cm.³, 76 cm. pressure, 0° C.
D, the value of K for dry atmospheric dust.

1910–11..	$N_0 = (2.73 \pm 0.02)\ 10^{19}$	$D = 0.005 \pm 0.002$	Weight 18
1913.....	$(2.69 \pm 0.03)\ 10^{19}$	0.026 ± 0.003	6
1914.....	$(2.66 \pm 0.05)\ 10^{19}$	0.010 ± 0.006	3
1915.....	$(2.74 \pm 0.05)\ 10^{19}$	0.010 ± 0.005	3
1916.....	$(2.89 \pm 0.08)\ 10^{19}$	0.032 ± 0.007	1
Weighted mean	$(2.72 \pm 0.01)\ 10^{19}$		

(The separate values were weighted inversely as the squares of their probable errors.)

First to be noted is the close agreement of the mean value of the number of molecules per cm.³ with what is probably the best value[1] obtained from other methods $(2.705 \pm 0.003)10^{19}$. The corresponding value of Avogadro's constant is 6.09×10^{23}. Next to be noted are the dust-transmission values. Remembering that $a_d = e^D$, during 1910 to 1911 a_d equals 0.995. That is, only about 0.5 per cent of the in-

[1] Millikan, Philosophical Magazine, 34, p. 3, 1917. See also "The Physical Properties of Colloidal Solutions," Burton, p. 38, 1916, for table of determinations of these constants by various methods.

coming energy from the sun was scattered by this dust or what may be called " dry haziness " in distinction from a somewhat similar condition to be discussed later but associated with water vapor and therefore denoted " wet haziness." During 1912[1] owing to volcanic dust, this scattering by dust particles increased to about 25 per cent on the haziest days. It had decreased, on the average, to 2.6 per cent during 1913, and 1 per cent during 1914 and 1915. During 1916 it increased again to an average value of 3.2 per cent producing a marked streakiness in the sky as seen at dawn at Mount Wilson.

Between wave-lengths 0.35 and 0.57 μ nearly all the loss of light from a beam passing through dry, dust-free air is seen to be due to scattering by the molecules of the air. As has been just noted, during 1910-11 the air was nearly dust free. In the last line of table 1 are given the means of the dry-air coefficients for these two years. They are closely in accord with the values to be expected from Rayleigh's theory. For the first three values, in brackets, theoretical values have been substituted since at these wave-lengths the accuracy of the observed ones is vitiated by field light.

The water-vapor coefficients will next be analysed. Because of the more normal results, the formula will first be applied to a group of transmission coefficients for liquid water obtained by Kreusler,[2] Ewan,[3] and Aschkinass.[4]

TABLE 4.—*Number of Molecules N_0 derived from Liquid Water Transparency*

Wave-length in μ	.200	.210	.220	.230	.240	.260	.300
$(1-\mu)\ 10^3$	.321	.311	.304	.298	.292	.283	.273
k	.00901	.00607	.00568	.00339	.00314	.00253	.00149
$N_0 \times 10^{-19}$	2.85	3.26	2.76	3.70	3.26	2.75	2.44

Wave-length in μ	.415	.430	.450	.475	.487	.500
$(1-\mu)\ 10^3$	.261	.260	.258	.257	.256	.256
k	.00035	.00023	.00020	.00020	.00014	.00020
$N_0 \times 10^{-19}$	2.63	2.84	3.25	2.59	3.32	2.09

The data of the above table were somewhat differently treated in the Astrophysical Journal (38, p. 401, 1913). There the values were graphically reduced using a uniform value of the index of refraction for all wave-lengths. Here $n-1$ is assumed to have the same fractional variation from wave-length to wave-length that liquid water has. However, the observed value of n even for wave-length 0.589 μ must be held very doubtful.

[1] Annals of the Astrophysical Observatory of the Smithsonian Institution, vol. 3, p. 216, 1913.

[2] Annalen der Physik, 6, p. 412, 1901.

[3] Proceedings of the Royal Society, 57, p. 117, 1894.

[4] Annalen der Physik und Chemie, 55, p. 401, 1895.

For the range of wave-lengths utilized in table 4, 0.2 to 0.5 μ, the mean value of N_0 obtained from the liquid-water data is 2.90×10^{19} which though large is of the right order of magnitude and quite as accurate as the accuracy of the data warrants. For these wave-lengths therefore liquid water scatters transmitted radiation just as would the same amount of water in gaseous state according to Rayleigh's theory.[1]

Values of N of quite a different order of magnitude are obtained when based on the transmission coefficients for atmospheric aqueous vapor. A graphical rather than a least-squares method has been resorted to in the present case. N_{tp}, the number of molecules per cm.^{3} at the pressure p and the temperature t, may be derived from the expression[2]

$$k = \frac{32}{3}\left\{\pi^3\left(\frac{(n-1)p}{(1+at)760}\right)^2 \frac{(1+at)760 \times 10^3}{(0.81)p} \frac{1}{N_{tp}\lambda^4}\right\} + D$$

Here $\frac{0.81p \times 10^{-3}}{(1+at)760}$ is approximately the weight of aqueous vapor in grams per cm.^{3}, or in other words the reciprocal of the height of a column 1 cm.^{2} containing 1 cm. precipitable water at the temperature t and the pressure p. Plotting the observations with $(n-1)^2/\lambda^4$ and k as variables and calling M the tangent made by the best representative right line with the X axis, then N_{tp} may be obtained through the equation

$$N_{tp} = \frac{32\pi^3}{3} \cdot \frac{p \times 10^3}{0.81(1+at)760} \cdot \frac{1}{M}$$

Figure 1 shows the graphical steps and the following table the resulting values:

Table 5.—*Number of Molecules N_{tp}, derived from the Transparency of Atmospheric Aqueous Vapor*

Year	$M \times 10^{12}$	$N_{tp}\frac{(1+at)\,760}{p} \times 10^{-17}$	Grade	D
1910	0.88	4.7	Good.	0.015
1911	.98	4.2	Good.	.015
1913	1.52	2.7	Excellent.	.025
1914	.70	5.9	Poor.	.014
1915	.52	7.9	Excellent.	.018
1916	.49	8.4	Excellent.	.013

[1] For shorter wave-lengths greatly decreased transmission is found as the great metallic reflection band at 0.115 μ is approached (Martens, Annalen der Physik, 6, p. 603, 1901), and for wave-lengths greater than 0.50 μ as a region of selective absorption is approached. For metallic reflection and selective absorption the molecular formula would not hold.

[2] Astrophysical Journal, 38, p. 400, 1913.

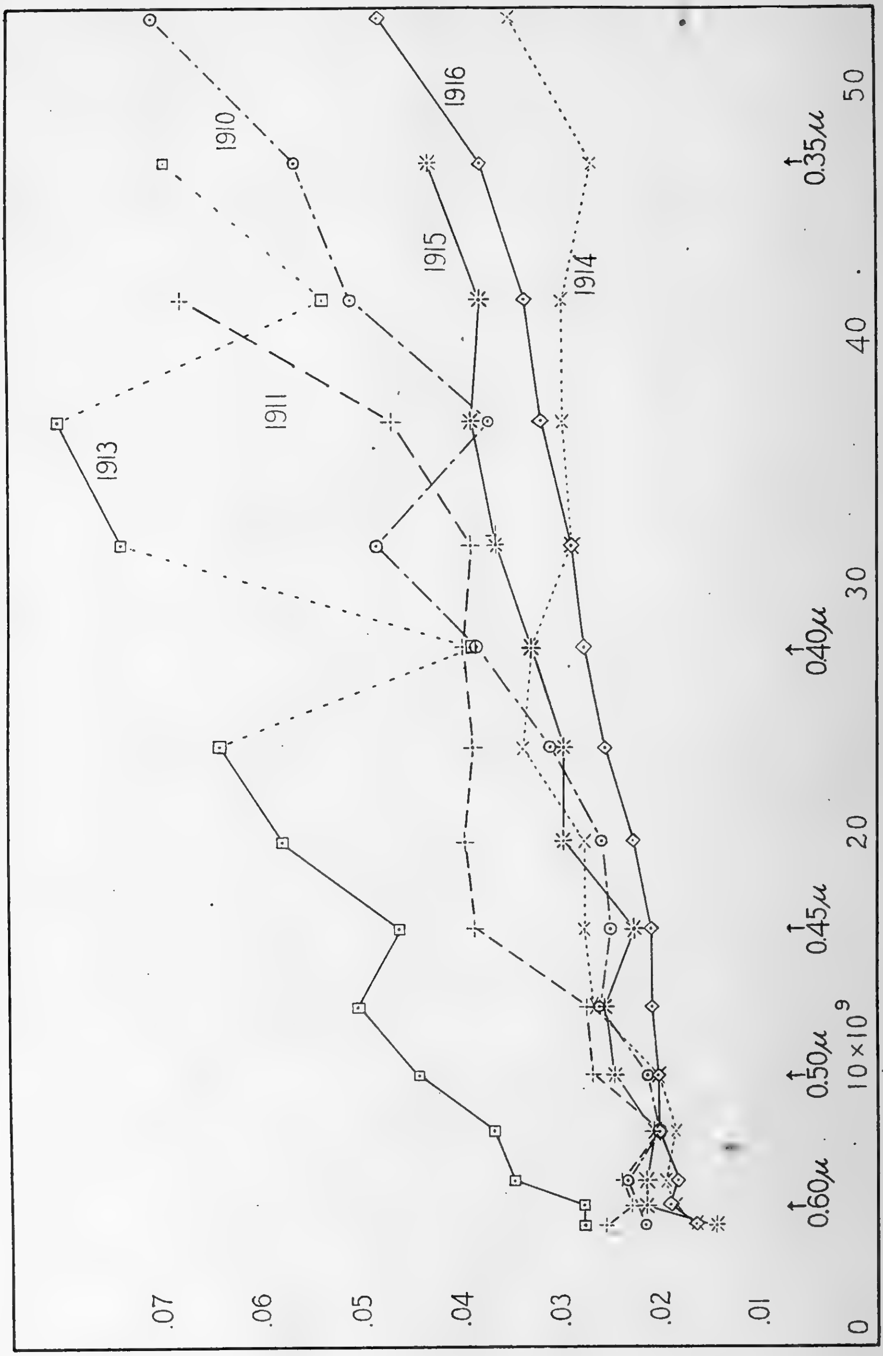

Fig. 1.
Abscissae are $(n-1)^2/\lambda^4$. Ordinates are $K = -\log_e a$.

Over the region plotted k may be considered equal to $1-a_{w\lambda}$, that is the scale of ordinates of figure 1 represents approximately the fractional absorption of energy by 1 cm. of precipitable water in the form of atmospheric vapor. The data for wave-lengths to the right of the region shown (wave-length less than 0.35 μ) and to the left (greater than 0.60 μ) are very inaccurate, the first because of spectroscopic field-light and very small measurable quantities, and the second because of selective absorption. The accuracy with which the observations fall on a straight line is beyond expectation. Within the wave-length limits just named the average departures from a straight line for the different years correspond in absorption as follows:

Year	1913	1915	1916
Per cent departure.......	0.2	0.2	0.1

(1913, omitting poor points.)

The mean value of N_{tp} obtained from the atmospheric aqueous water vapor is about

$$5\times 10^{-17}\left\{\frac{p}{(1+at)760}\right\},$$

whereas assuming Avogadro's law applicable to water vapor, a value of

$$2.7\times 10^{19}\left\{\frac{p}{(1+at)760}\right\}$$

or about 50 times as great would be expected. This anomalous result, already noted in an earlier communication,[1] is therefore confirmed by the results of subsequent years.

There appears to be associated with water vapor what has elsewhere been denoted a "wet haziness" producing a uniform absorption over all the wave-lengths considered and giving a value for D averaging about 0.017 which corresponds to a 2 per cent loss.

There is an apparent peculiarity of the formula for N_{tp} in that the more opaque the vapor, that is the greater k, the smaller the number of molecules per cm.[3] This formula is based upon Rayleigh's

$$k=\frac{32\pi^3}{3N}(n-1)/\lambda_4, \qquad (1)$$

[1] Astrophysical Journal, 38, p. 392, 1913.

which is derived from

$$k = \frac{8\pi^3 N}{3} \frac{(D'-D)^2}{D^2} \frac{T^2}{\lambda_4}, \qquad (2)$$

by substituting from

$$n - 1 = \frac{NT}{2}\left(\frac{D'-D}{D}\right)^2, \qquad (3)$$

where D and D' are now the original and the altered densities of the medium and T the volume of the disturbing particle. That is n, the index of refraction, is a function of N, the number of molecules per cm.[3] In the present case the value of n cannot be observed. A preliminary use of the formula for N_{tp} leads to the suspicion of something abnormal in the condition of atmospheric aqueous vapor. For instance, is it in some colloidal state resulting from some form of ionization of the air? Wilson,[1] for instance, has shown that under the influence of ultra-violet light, in moist dust-free air, nuclei are formed and may grow "till they become large enough to scatter ordinary light." By careful laboratory researches he has shown that oxygen and water vapor alone are necessary for their production; that water vapor is necessary; that saturated vapor is not necessary; that these nuclei persist for some time after their formation; that they are different from ions since they carry no electric charge; that they are probably due to some combination, H_2O_2, which by decreasing the vapor pressure allows drops of water containing one of them to form and grow where pure water drops would evaporate. Bieber[2] has since shown that H_2O_2 is formed by the action of ultra-violet light. Although the ultra-violet energy in sunlight is too weak at the surface of the earth to be very efficient in the formation of these nuclei, in the clear air above Mount Wilson it may well be very active. In such nuclei, dependent directly upon the presence of water vapor, there seems a possible explanation of the increased absorption. Or, is it possibly due to some emanation from the sun producing some change in the condition of the water vapor?

Reverting now to formula (2) it is to be noted that if the molecules cluster together because of some ionization phenomena or otherwise and in such state each cluster acts as a whole in scattering light as ordinarily a single molecule does, then, neglecting for the moment the effect of the factor $(D'-D)^2/D^2$, the intensity of the scattering

[1] Philosophical Transactions of the Royal Society, 192, p. 403, 1899.

[2] Annalen der Physik, 39, p. 1313, 1912.

would vary directly as the sixth power of the diameter of the scattering unit and the first power of N, so that diminishing N by $\frac{1}{2}$, for instance, may increase the T^2 factor by 4-fold thus doubling the scattering. In table 6 formula (2) has been used to avoid introducing the unknown index of refraction for atmospheric water vapor.

TABLE 6.—*The Variation of the Transparency of Atmospheric Water Vapor compared with Solar Phenomena*

Date	$M \times 10^9$	$N_{tp} \cdot \frac{(D'-D)^2}{D^2} \cdot T^2 \cdot \frac{(1+at)\ 760}{p}$	Grade	Sun-spot No.	Intensity of solar radiation. Cal./cm.²/m.
1910	0.60	0.61×10^{-17}	Good.	18.6	1.921
1911	.67	$.68 \times 10^{-17}$	Good.	5.7	1.923
1913	1.03	1.05×10^{-17}	Excellent.	1.4	1.907
1914	.47	$.48 \times 10^{-17}$	Poor.	9.7	1.948
1915	.35	$.36 \times 10^{-17}$	Excellent.	46.0	1.949
1916	.33	$.34 \times 10^{-17}$	Excellent.	60.	1.955

Arranging the figures of the 3d, 5th and 6th columns in order of the increasing intensity of solar radiation the apparent correlation of the three quantities is easily seen.

TABLE 7.—*Solar Phenomena and Atmospheric Water-Vapor Transparency*

Solar radiation...	1.907	1.921	1.923	1.948	1.949	1.955
$N_{tp}\{\ldots\}$	1.05	0.61	0.68	0.48	0.36	0.34
Sun-spot number .	1.4	18.6	5.7	9.7	46.	60.

The relationship between the solar constant of radiation, the sun-spot numbers and the values of $N_{tp}(D'-D)^2T^2/D^2$ is better shown in figure 2, especially in the curves *a*, *b*, and *c*. Additional years of observations will be required to thoroughly establish the relationship.

SUMMARY

The atmospheric transmission coefficients obtained at Mount Wilson in the years 1910 to 1916 for the region free from selective absorptions between wave-lengths 0.35 and 0.50 μ have been analyzed and have yielded the following data and results.

The transmission coefficients for dry air ($a_{a\lambda}$) vary with the inverse fourth power of the wave-length. They are apparently wholly due to molecular scattering since the number of molecules in a cm.³ of air at 76 cm. pressure and 0° C. corresponding to them, $(2.72 \pm 0.01) \times 10^{19}$, is in excellent agreement with the best value, $(2.705 \pm 0.003) \times 10^{19}$ (Millikan), determined by other methods.

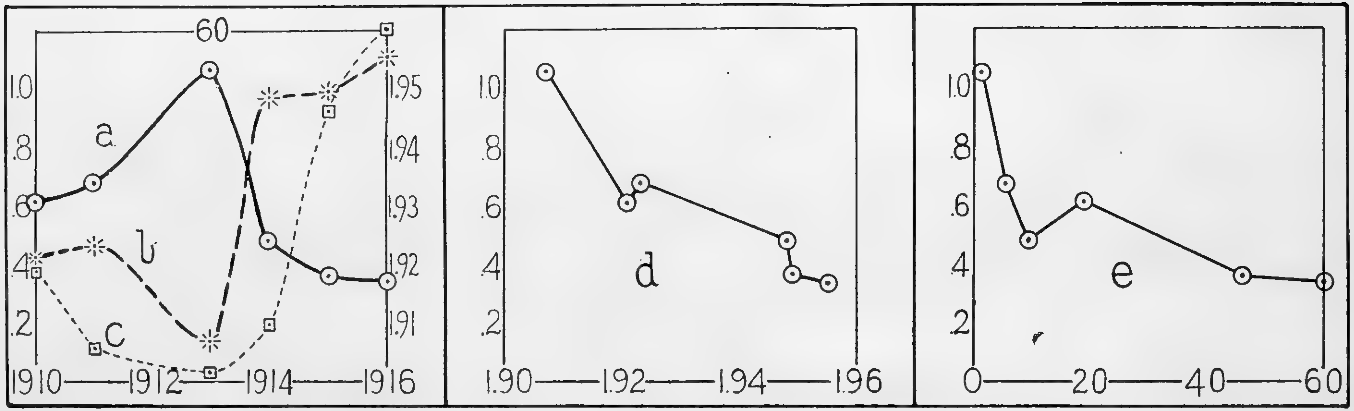

FIG. 2.

Curve *a*, abscissae are years, ordinate $N_{tp}, \left(\frac{D'-D}{D}\right)^2 T^2 \times 10^{17}$ varies as $K.\lambda.^4$

Curve *b*, abscissae are years, ordinates mean yearly solar radiation, cal. cm.^{2} m.
Curve *c*, abscissae are years, ordinates sun-spot numbers.
Curve *d*, abscissae are solar radiations, ordinates same as curve *a*.
Curve *e*, abscissae are sun-spot numbers, ordinates same as curve *a*.

As has been stated in former communications, this strongly confirms the accuracy of our estimations of the atmospheric losses affecting the radiation reaching us from the sun.

There is to be expected above the altitude of Mount Wilson (1,730 meters) a certain amount of what has been called " dry haziness " to distinguish it from a similar haziness associated with aqueous vapor. Before the Mount Katmai eruption of 1912, during 1910 and 1911, this caused a loss of only about ½ of one per cent from the incoming solar radiation when the sun was in the zenith. The mean of the coefficients for these two years (table 1), given in the lower line of that table, may be taken as a close approximation to the transparency of dry, dust-free air. During 1913, this loss due to dry haziness decreased from its enormous value of 25 per cent just subsequent to the Mount Katmai eruption to about 3 per cent and during 1914-15 to about 1 per cent, but it increased again to 3 per cent during 1916.

Within the same spectrum region, the transmission coefficients for atmospheric aqueous vapor (a_{w_λ}) also apparently vary with the inverse fourth power of the wave-length. The scattering of radiation when passing through liquid water is shown to be the same as would be expected from the number of (H_2O) molecules present if the same quantity of water existed in a gaseous state. But the same amount of water in the form of *atmospheric* water vapor should give 50-fold less absorption than that observed. This may be due to some combination $(H_2O)_x$ of a portion, at least, of the vapor. Increasing the effective diameter of the scattering particle may be far more effective in scattering the radiation than is compensated by the resultant decrease in their number; for the scattering varies with the sixth power of the diameter and only directly with the number. This peculiar molecular condition might be supposed connected with some ionization phenomenon, and possibly, like the aurora (Störmer), in some way might be dependent on charged particles coming from the sun. As shown in figure 2 there does seem to be a connection between this phenomenon, curve *a,* the solar radiation intensity, curve *b,* and the sun-spot numbers, curve *c.* This amounts to saying that the smaller the average solar radiation or the sun-spot number, the greater is the absorptive power of atmospheric water vapor. This result requires further testing. It is, however, consistent with the observations of Dorno on various optical atmospheric phenomena and of Störmer on the aurora.

There is a moist haziness associated with water vapor which produces losses from the direct solar beam throughout the spectrum of about 2 per cent. There is perhaps a slight indication that this varies in the same direction and from the same causes as does $a_{a\lambda}$.

ASTROPHYSICAL OBSERVATORY,
SMITHSONIAN INSTITUTION,
WASHINGTON, D. C.,
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ERRATA TO VOL. 68, NO. 8, SMITHSONIAN MISCELLANEOUS COLLECTIONS, WATER VAPOR TRANSPARENCY TO LOW-TEMPERATURE RADIATION, BY F. E. FOWLE.

P. 44: The ordinates of Fig. 15 should have been called "Fractional transmissions."

P. 45, Table 10: The values given for $a_{a\lambda}$ are for the altitude of Mount Wilson, barometer 62.3 cm. For sea level they are as follows:

λ	0.342	0.350	0.360	0.371	0.384	0.397	0.413	0.431	0.452	0.475
$a_{a\lambda}$	.531	.565	.597	.631	.662	.706	.742	.771	.808	.835
λ	0.503	0.535	0.574	0.624	0.686	0.764	0.864	0.987	1.146	1.302
$a_{a\lambda}$	.861	.877	.885	.914	.950	.974	.984	.990	.995	.996
λ	1.452	1.603	1.738	1.870	2.000	2.123	2.242	2.348		
$a_{a\lambda}$	.998	.999	.999	.999	.999	.999	.999	.999		

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EARLY MESOZOIC PHYSIOGRAPHY OF THE SOUTHERN ROCKY MOUNTAINS

(With 4 Plates)

BY
WILLIS T. LEE, Ph. D., GEOLOGIST,
United States Geological Survey

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EARLY MESOZOIC PHYSIOGRAPHY OF THE SOUTHERN ROCKY MOUNTAINS[1]

By WILLIS T. LEE, Ph. D., Geologist

UNITED STATES GEOLOGICAL SURVEY

(With 4 Plates)

INTRODUCTION

This paper results from an attempt to work out the ancient physiographic history of a part of the Rocky Mountain region which in Mesozoic time seems to have constituted a fairly well-defined physiographic unit. Although the history of neighboring provinces must be considered in connection with this one, it is in many ways one which may appropriately be considered independently and with which others may later be compared. The area to which attention is especially directed includes the mountains of Colorado, which extend southward into New Mexico and northward into Wyoming. This has been called the Southern Rocky Mountain Province by some geologists and the Park Range Province by others. From these mountains as a center, our study will lead us in all directions for data which help to interpret phenomena observed in this province.

Stratigraphy has sometimes been called fossil physiography, and a knowledge of ancient physiographic history should be useful in solving some of the difficult stratigraphic problems of this western region. There is a certain uniformity in natural processes which may be relied upon. We may confidently assume that during the Mesozoic era the same laws were in operation that govern the present-day world. Then, as now, highlands were eroded, lowlands were built up by the débris washed onto them, and basins were filled with sediments. It seems clear that physiography might be used to better advantage than it has been used heretofore by the stratigrapher and the historic geologist. I am confident that a study of ancient geography and of the evolution of land forms will lead to conclusive results in correlation in certain places where other lines of investigation fail.

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[1] Published by permission of the Director of the United States Geological Survey.

It is not easy to abandon inherited notions, even when it can be proved that they have no foundation in fact. I have found it necessary in this study, in order to harmonize relations described in a given locality, to take into account many factors, such as the date at which the description was published, the prevailing belief at the time, and the personality of the author—whether progressive or conservative; whether an independent thinker or one fearful lest he stand alone. I have attempted here to keep inherited notions in the background and to carefully distinguish between the facts and their published interpretation. I have attempted to visualize the natural processes by which the observed relations were produced. I have endeavored to follow, step by step, the sequence of events as mountains were thrown up in the midst of the sea and have tried mentally to observe the evolution of the mountainous region as it was slowly molded under the forces of erosion, peneplained, base-leveled, and finally again submerged by the sea. I have attempted to follow the processes by which vast quantities of rock waste were transported from highlands to lowlands and spread out uniformly over hundreds of thousands of square miles. In brief, I have attempted to picture the physiographic processes which resulted in the stratigraphic relations exhibited by the sedimentary rocks of Mesozoic age in the Southern Rocky Mountain region.

One of the main objects of this study is to develop a logical grouping of the sedimentary rocks and to establish a method of correlation which may be applied in certain places where other methods fail. As correlation by physiographic criteria is somewhat unusual, opposition is anticipated. It is probably inevitable that the familiar arguments of established lines of thought will find wider acceptance than those of an untried line. The stratigraphic geologist has become so accustomed to relying on the paleontologist for correlations that he is apt to reject without due consideration any suggestion which seems to be at variance with that derived from the fossils. Chamberlin[1] recognized this attitude of mind when, in urging the merits of diastrophism, he said, "New criteria must not . . . . be judged solely by their concordance with established systems; certain divergences may be but signs of superiority." No claim is made that the investigation here described is a finished one. There are radical differences of opinion on some of the questions discussed

[1] Chamberlin, T. C., Cong. géol. internat. Compte Rendu XII, Ges. Canada, p. 551, 1914.

and there is seeming conflict of evidence. Different classes of data now seem to lead to contradictory conclusions. Conflict of evidence is only another expression for misinterpretation of evidence. There is no conflict when all facts are known, and I am convinced that physiographic principles can be used to great advantage in correlating some of the unfossiliferous sedimentary rocks in the mountain region.

A PRELIMINARY SUMMARY

The succession of events outlined in this paper begins with a time in the Carboniferous period when the sea covered the region where the Southern Rocky Mountains now stand. This sea was expelled and the ancestors of the present Rocky Mountains arose in its place. For long ages these mountains withstood the elements but were finally torn down and swept away. Before they had entirely disappeared other lands were elevated farther west and on them mountains were thrown up. Probably these new mountains were high, for a desert developed east of them, perhaps for the same reason that desert conditions prevail now east of the high mountains of California. The moisture from the Pacific was precipitated on these mountains and the streams carried the rock waste out into the desert, where the winds reworked it, piling the sand into dunes, which are now recognizable in their fossil state.

A broad depression or valley somewhat similar to Mississippi Valley, except that it drained northward, developed between the new mountains and the ancestral Rockies. In the western part of this valley the dune sand accumulated to great depths and graded off toward the east, covering the lower parts of the older, deeply eroded mountain area, but leaving the hilly parts uncovered. After the sands had accumulated in eastern Utah and neighboring regions to a depth of nearly 3,000 feet, the sea advanced in late Jurassic time up the old valley, across British Columbia and the Mountain States as far south as northern New Mexico and Arizona. Much of the submerged area was nearly flat and the sea was shallow in most places. Around it, especially in Utah, New Mexico, and Colorado, were shallow, partly inclosed bays where gypsum was precipitated by evaporation of the sea water. Extensive beds of gypsum have been found in many places which mark the location of these ancient evaporation pans.

The sea was short-lived, and as it retreated, sand drifted over the abandoned areas, covering in some places, but not in all, the gypsum, the fossiliferous limestone, and other beds which had formed in the sea and near it. The correlation of the fossiliferous marine beds with the gypsiferous strata is regarded as the chief contribution offered in this paper, for by this means a narrow zone of rocks, whose age is determined by means of fossils of marine organisms, may be followed far beyond the limits of the fossiliferous beds into unfossiliferous sedimentaries whose age has been in doubt. The area in which these beds are exposed is large and difficult to traverse. It may be many years before this tracing is done and until it is done physiographic data seem to furnish the best available means of correlating the unfossiliferous beds from place to place.

The events following the withdrawal of the Jurassic sea are better known than the preceding events. In the epoch next following this withdrawal, the final stages of planation of the Rocky Mountain region were accomplished and on the extensive plain the sluggish streams formed bayous, swamps, and temporary lakes, and spread out the sediments of the Morrison formation, building up a plain which seems to have been almost perfectly graded from New Mexico to Montana, and from central Utah to eastern Kansas. Over this graded plain advanced the waters of the Lower Cretaceous sea and later those of the great submergence in Upper Cretaceous time, which covered the site of the Rocky Mountains and buried their roots beneath its sediments, where they remained dormant until stirred to life by the post-Cretaceous or post-Laramie movement, when the present Rocky Mountains began to rise.

PRE-MESOZOIC PHYSIOGRAPHY

PENNSYLVANIAN SUBMERGENCE

It is not my purpose to consider the geographic conditions of the Rocky Mountain region, prior to the Mesozoic era, further than is necessary for a proper understanding of Mesozoic physiography. During much of the Carboniferous period sea water covered large portions of the area now occupied by the mountains. Marine limestone of Pennsylvanian age is abundant in central and northern New Mexico and in central and western Colorado. It has been the belief of many geologists that open sea conditions prevailed in western America during the time that the coal measures were forming in the eastern and central parts of the continent. Statements are frequently made that " in the western part of the United States there are no coal accumulations of this age (Pennsylvanian)." [1] There is unques-

[1] Schuchert, Chas., Textbook, p. 745.

tionably a large amount of limestone of marine origin in the rocks of Pennsylvanian age in the Southern Rocky Mountain Province, but there are also thin beds of coal and plant-bearing sedimentary rocks which indicate lowlands and coastal swamps in Pennsylvanian time. These have been found in New Mexico, near Socorro; in the mountains east of Albuquerque; near Santa Fe on the western slope of the main range; in the Pecos Valley between the mountain ranges; east of the main ranges near Las Vegas; and farther to the north in Moreno Valley. Thin beds of coal of Pennsylvanian age have been reported from many places in central and western Colorado and in eastern Utah, both north and south of the Uinta Range. These coal beds are not thick enough to be of commercial value, but they prove that the physiographic conditions of the Rocky Mountain region during the early part of the Pennsylvanian epoch were not so different from those in eastern and central North America as many geologists have supposed. However, later in the epoch these coals were covered by the sea in which was formed the massive limestone of Pennsylvanian age in New Mexico and Southern Colorado, which seems to indicate clear water and open sea conditions. I call attention to these facts because it was in the midst of this sea that the ancient Rocky Mountains were elevated. This is particularly significant, for we shall see later that this process was repeated when the site of the mountains was covered by the sea in the Upper Cretaceous epoch; and in the midst of this sea were formed the present Southern Rocky Mountains.

RISE OF ANCESTRAL ROCKY MOUNTAINS

Some time late in the Carboniferous period these coal-bearing rocks and the marine limestone of Pennsylvanian age were upturned and there followed a period during which the elevated lands furnished red sediment to the neighboring lowlands and seas. Some of these "Red Beds" belong in the Triassic system; others are certainly of Permian age; and still others, such as the Manzano group, have been classed as Pennsylvanian[1] on the basis of the fossil invertebrates, although there is a growing tendency to regard them as Permian. The fossil plants and vertebrates recently discovered in some of the older "Red Beds" tend to establish their Permian age. The subdivision and classification of the "Red Beds" present problems which are not likely to be solved for a long time to come.

[1] Lee, W. T., and Girty, G. H., U. S. Geol. Survey Bull., 389, 1909.

Many geologists believe that the red color of sedimentary rocks denotes cold, arid climate, and the suggestion has been made that the "Red Beds" of the Rocky Mountain region may denote a glacial epoch. No indication of the presence of glaciers has yet been found in these beds, but they seem to be of about the same age as the extensive glacial deposits in India, Australia, and South Africa.[1] If it is true that glacial epochs follow periods of general diastrophism and are caused by changes in oceanic and atmospheric circulation, brought about by earth movements, it seems reasonable to associate these red rocks with glacial conditions and to correlate them with the beds of Permian age in other parts of the world, some of which are known to be of glacial origin. Furthermore, it seems reasonable to assign the elevation of the ancient Rocky Mountains to the period of general diastrophism usually called the Appalachian Revolution, which wrought world-wide changes in climate, geography, and biology.

In this connection it seems not out of place to suggest a line of study that is well worth following, namely, the determination of the date of this ancient uplift of the Rocky Mountains and its relation to this revolution.

Conspicuous evidences of diastrophism are found between Pennsylvanian and Permian, in the restricted area occupied by the Arbuckle Mountains in southern Oklahoma, where the older rocks were uplifted, sharply folded, and eroded so that the beds of Permian age lie across the eroded edges of several thousand feet of strata which range in age from Ordovician to Pennsylvanian. In several places in the Rocky Mountain region an unconformity separates rocks of unquestioned Pennsylvanian age from overlying rocks which may be Permian. However, in some places the Pennsylvanian age of some of the "Red Beds" has never been questioned. Although the indications are that this uplift affected the whole Rocky Mountain region and resulted in a general unconformity between these two series of rocks,[2] the problem has not yet been worked out.

Although much remains to be learned about the time of this uplift and its results, it seems obvious that the sea of Pennsylvanian time was expelled from the Southern Rocky Mountain region and that mountains were raised in its place previous to the time of the principal red-bed accumulation. For our present purpose it is of secondary importance whether these red rocks are of Pennsylvanian

[1] Chamberlin, T. C., and Salisbury, R. D., Textbook III, pp. 632-636, 1906.
[2] Lee, W. T., Geol. Soc. America, Bull., vol. 5, p. 169, 1917.

or of Permian age, but it is of primary importance that highlands were formed where the open sea had been, and that south and east of these highlands lay shallow basins in some of which beds of salt and gypsum were formed. In other places continental deposits accumulated. These consist chiefly of coarse sand with conglomerate in many places. Obviously a large proportion of the red sediments were derived from highlands situated essentially where the Rocky Mountains now stand. These gypsiferous " Red Beds " (the Manzano) of New Mexico and beds of the same age elsewhere, are here regarded as Permian, and the question naturally arises: Are these beds correctly included in the Carboniferous system or should they constitute a separate system? On the principle that the first well-defined movement in a major orogenic disturbance opens a new geologic period and inaugurates a new system, this question becomes pertinent, for there is little doubt that a notable orogenic movement preceded the formation of the Permian " Red Beds." This question appears all the more pertinent when we reflect that in few places in the Rocky Mountain region can a line of separation be drawn between Permian and Triassic rocks. Even in places like the Grand Canyon region, where marine invertebrates occur, the fossils once described as Permian are now said to indicate Triassic age. In brief, so far as now known, there is a much greater break in sedimentation between the Pennsylvanian limestone and the Permian " Red Beds " than there is between the latter and the rocks now classed as Triassic.

TRIASSIC PHYSIOGRAPHY

UPLIFT AND EROSION

Whatever may be the final answers to the questions just raised, it is obvious that previous to the formation of rocks now called Triassic, there were highlands in the Southern Rocky Mountain region, although their original volume had been greatly reduced by the removal from them of great quantities of the detritus which constitutes the older " Red Beds." Also, the greater part of the North American continent was above sea-level, for only small parts of it are now occupied by Triassic rocks of marine origin.

The sedimentary rocks of Triassic age in some parts of the Southern Rocky Mountains have not been differentiated from the older rocks. But those of undoubted Triassic age are non-marine and are classed as Upper Triassic, such as the Shinarump conglomerate and Chinle formations of northern Arizona, and their equivalents in neighboring regions. The land from which the sediments were derived seems to have been relatively high, but the character of the rocks indicates that the mountains were lower than they had been in Permian time. It is important in our present study to note that the mountains had been reduced to such a condition that they furnished little coarse material for the beds to the east, although in western Colorado, eastern Utah and elsewhere they are conglomeratic. It is not certain, however, that the material of the Shinarump conglomerate came from the ancient Rocky Mountains. It may have come from lands farther to the west or south. The sedimentary rocks are relatively thin and probably represent only a small part of the Triassic system. The period seems to have been chiefly one of erosion, not only in the mountain region, but over most of the North American continent.

More is known of the Triassic rocks west of the Rocky Mountains than east of them and these have a significant bearing both on the Triassic physiography of the mountain region and on the changes which closed the Triassic period. These rocks, 1,700 feet thick in western Colorado (Dolores formation), thin to 1,000 feet or less in northern Arizona (Chinle formation), and still farther to the west the Upper Triassic (equivalents of Chinle formation) are only a few hundred feet thick. (See fig. 2, p. 13.) Although the differences in thickness may be due in some measure to post-Triassic erosion, the differences in thickness suggest derivation of the sediments from the east. Also the occurrence of marine Triassic rocks farther to the west and north (Moenkopi formation, classed by some as Permian (?)), seems to strengthen the belief that a large volume of Triassic sediments moved in late Triassic time from the Southern Rocky Mountain region westward to the sea across a low-lying plain on which the sand and gravel of the Shinarump conglomerate, and Chinle formation were laid down.

A search through geologic literature shows that Triassic rocks have been found in relatively few places in North America. Areas occupied by sedimentary rocks of this age are found only along the Pacific Coast and in the western interior of the continent. An inspection of existing maps and descriptions shows that certain "Red Beds" in the mountain region are regarded as Triassic by some geologists and as Permian or Pennsylvanian by others. The scarcity of fossils in the "Red Beds" renders it difficult in many places to distinguish between Triassic and older rocks. In large part, at least, the Triassic sedimentaries of the mountain region represent upland accumulation. Some of the beds east of the mountains which have been referred to the Triassic system contain salt, gypsum, and other evidences of sea connection. It may not be out of place here to question whether these beds do not really belong in some other system. Similar deposits occur in this region in the Permian series and accumulated at a time when marine waters had access freely to the Southern Rocky Mountain Province. Also, it will be shown later that certain younger beds of gypsum are probably Jurassic in age and were derived from sea water late in Jurassic time.

Inasmuch as the greater part of the continent was above sea-level in Triassic time, it is not easy to understand how marine waters could reach the Southern Rocky Mountain region and deposit the gypsum. The reference of the gypsiferous beds to the Triassic in the vicinity of the mountains does not harmonize with the evidence which tends to prove that this region was one of erosion and of the accumulation of sediments of continental type during the latter part of the Triassic period. At present we are confronted with seeming conflict of evidence. Apparently the Triassic rocks consist of débris which came from the mountains situated in the midst of this region of sedimentation; that is, the site of the present Rocky Mountains. Until more convincing evidence is brought forward than I have found thus far, I prefer to think of the older salt and gypsum beds as belonging in the Permian series of the Carboniferous system with the other beds of marine origin, and of the younger gypsum as part of the Jurassic system. (The gypsiferous Moenkopi formation is not known to extend eastward to the mountains proper.) If this relationship can be established, there is nothing that I know of in the Rocky Mountain region to negative an orderly succession of events such as follows: (1) The low-lying flats and shallow seas of Pennsylvanian time were disturbed by the uplift of mountains which rose in the region of the present Southern Rocky Mountains. (2) There followed a time in the Permian epoch during which detrital matter from the newly formed mountains gathered in the neighboring shallow seas and on gypsum flats and salt marshes. In many places it gathered as upland deposits on the plains which sloped away from the mountains, just as detrital matter is accumulating now in the western interior in places which are thousands of feet above sea-level. (3) There followed a time not well recorded in the mountain region during which many events of importance occurred farther west. An arm of the Pacific extended eastward into Colorado and New Mexico in late Permian or early Triassic time; was later expelled; the rocks which formed in it (Moenkopi formation) exposed to erosion; and some change in the relation of highlands and lowlands effected, which caused the streams to spread out, over a wide area, the sand, gravel and mud of the Shinarump conglomerate and other rocks of late Triassic age, both west and east of the mountains. (4) The period was brought to a close by the rise of a land mass of continental proportion in the Pacific Coast region, which persisted through all of Jurassic and Cretaceous time and furnished the enormous quantities of fragmental rocks which make up these two systems. This rise seems to have affected the Rocky Mountain region but little, for erosion continued there until stopped by the accumulation of younger sediments on the peneplain.

CLOSE OF TRIASSIC PERIOD

There is little known from the Southern Rocky Mountain region to indicate the events which closed the Triassic period, for this region was one of erosion during most of Triassic and Jurassic time. For evidence of these events we must look farther west, and here also much of the record has been destroyed by later erosion. However, an examination of the Jurassic formations described later indicates that the vast quantities of material composing them came from the west (see accompanying sections); hence it seems certain that the sea which had extended from the Pacific Ocean eastward into Nevada and Utah was blotted out and a land mass of great magnitude formed in its place. Further, the physical characteristics of the sedimentary rocks of the La Plata group indicate accumulation under desert conditions. It seems probable that the mountains of this western continent were high enough to precipitate the moisture from the westerly winds, just as the Sierra Nevada does at the present time, and that the streams thus formed washed rock débris into the Jurassic desert where it was reworked by the winds. This elevation of land to the west seems to have formed a broad valley similar to the Mississippi Valley between the ancient Rocky Mountains, now greatly reduced, and the new western highlands. It was in this valley that the desert sands accumulated and were later covered by the Jurassic sea, hence it is with this valley and its filling that we are much concerned in working out the physiographic history of the Jurassic period.

JURASSIC PHYSIOGRAPHY

INTRODUCTORY STATEMENTS

With the Jurassic we approach the main subject of this paper. The evidence from the sedimentary rocks is still meager, but enough to make some of the history of the period plain. The ancient Rocky

Mountain region was still a highland, but was reduced before the close of the Jurassic to a peneplain, and thin deposits of sediment accumulated on it toward the close of the period. But the interpreta-

FIG. 1.—Sketch map of area occupied by sedimentary rocks of Jurassic age. (The numerals 1-33 denote location of sections used in figures 2-6.)

tion of Jurassic events is based chiefly on a study of the deposits in the old valley.[1]

In order to determine the physiographic conditions under which the stratified rocks were formed, it is necessary to observe their litho-

[1] In order to make the study complete the entire filling of the valley should be considered. But as this paper deals chiefly with the Rocky Mountain region, little is said of the principal deposits of the La Plata group, which are situated in the western part of the old valley.

logic character and their stratigraphic relations over an area of considerable size, where the rocks can be traced at the outcrop or where exposures are so close together that correlation by lithology or otherwise is satisfactory. From these observed relations the governing physiographic conditions may be judged. If judged correctly, the physiographic criteria help in correlating the rocks in a field examined later or perhaps in correcting the correlations made without their help. To apply this principle in the present study, it is necessary to review the information relating to the La Plata sandstone and its age equivalents and to test by the new criterion the correlations which have been made from time to time.

In the accompanying groups of sections I have indicated by means of the names attached to some of them the correlations which have been made in the published descriptions. The symbols and connecting lines indicate my personal inclinations as to correlation which in several instances differs from that made by the different authors. The data presented have been gleaned chiefly from the literature, but much unpublished information is used which has been gathered in part by myself and in part by several of my associates on the United States Geological Survey, who have freely contributed from unpublished manuscripts and notes. The most that can be claimed for the grouping is that it represents possible relations. The implied correlations should be tested rigorously by observations in the field and modified as newly established relationships are determined. Most of the sections have been grouped with reference to the top of the Morrison as a datum plane. This plane was close to sea-level and formed the floor on which the Dakota sandstone was deposited.

COMPARISON OF SECTIONS

ARIZONA TO NORTHERN UTAH AND EASTERN WYOMING

The La Plata sandstone described by Cross[1] in southwestern Colorado has been traced by Gregory[2] southward into Arizona, where the upper sandstone is called Navajo, the lower sandstone Wingate, and the beds separating the two Todilto. These subdivisions have not been carried far to the north in the walls of the canyon of the Colorado River, but it seems probable that the Gray Cliff and Vermilion Cliff sandstones in the region of Henry Moun-

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[1] Cross, Whitman, U. S. Geol. Survey Geol. Atlas. La Plata folio (No. 60), 1899.

[2] Gregory, H. E., U. S. Geol. Survey Prof. Paper 93, 1917.

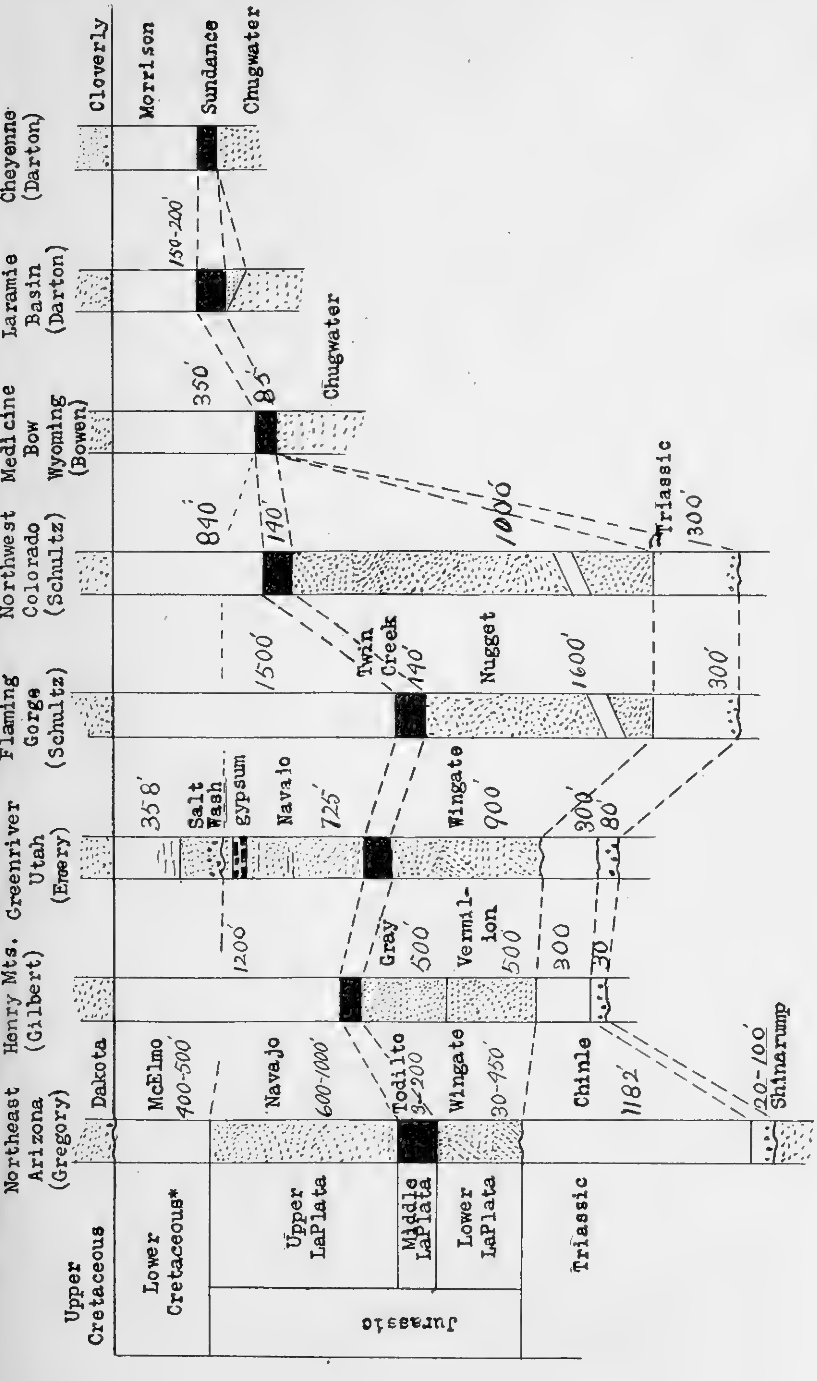

FIG. 2.—Group of columnar sections from Arizona to eastern Wyoming, showing correlations of sedimentary formations ranging in age from Triassic to Upper Cretaceous.

* The Morrison and McElmo formations are classed by the U. S. Geological Survey as Cretaceous (?).

tains, described by G. K. Gilbert, may correspond to the Wingate or Lower La Plata and the limestone above the Gray Cliff to the Todilto on the one hand and the marine Jurassic on the other. Equivalents of other formations seem to occur here, as shown in figure 2. They are described by Powell, Dutton, and others, as exposed continuously in the canyon walls northward as far as the Uinta Mountains.

Emery[1] recognized these subdivisions near Greenriver, Utah, where he correlates the marine Jurassic rocks with Todilto and the overlying sandstone with Gregory's Navajo and the upper sandstone of Cross' La Plata. These beds were both included in the McElmo by Lupton.[2] Still higher in the section is the conglomeratic Salt Wash member and overlying variegated beds. These contain fossil dinosaurs which seem to correlate them with the Morrison formation.

The occurrence of gypsum in this region above the supposed equivalent of the Navajo (see also the Castle Valley section, fig. 4, p. 17) is not easily explained unless there were two incursions of the Jurassic sea (see p. 27).

In northwestern Colorado, south of the Uinta Mountains, a similar section has been described by Gale,[3] who correlated the rocks below the variegated beds with La Plata and with White Cliff,[4] describing them as consisting, like the original La Plata, of two sandstones of equal thickness separated by shale. Marine fossils were found within the upper sandstone and also above it. The variegated beds are presumably the same as those from which the collectors for the Carnegie Museum secured dinosaurs of the Morrison type.

Schultz[5] has more recently examined the sedimentary rocks upturned around the Uinta Mountains, including those formerly examined by Gale. He measured a section near Flaming Gorge north of the mountains, and one at the eastern end of the Uintas in northwest Colorado. In both of these sections there are beds equivalent in character and position to the Morrison. Also in both there are beds several hundred feet thick between the Morrison and the marine Jurassic (Twin Creek) which may correspond to the Upper sandstone of the La Plata group. The cross-bedded sandstone (Nugget) below the Twin Creek obviously corresponds to Gale's White Cliff

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[1] Emery, W. B., Paper in preparation.

[2] Lupton, C. T., U. S. Geol. Survey Bull. 541, pp. 115-133, 1914.

[3] Gale, H. S., U. S. Geol. Survey Bull. 340, 1908.

[4] Gale, H. S., U. S. Geol. Survey Bull. 415, p. 51, 1910.

[5] Schultz, A. R., Unpublished manuscript.

and to lower La Plata. Still lower in the sections are beds lithologically like the Shinarump conglomerate and the Chinle formation.

East of the Uinta Mountains the rocks of Jurassic age are covered for many miles. But near Medicine Bow, Wyo., the variegated beds (Morrison) lie with apparent conformity on marine Jurassic (here called Sundance), and this in turn on Chugwater or typical "Red Beds." Apparently the La Plata group has no representative here unless the Sundance be included in that group.

In the Laramie Basin, Wyo., Morrison and Sundance are present. The Sundance is described as resting in some places on typical Chugwater, but in other places on beds which, although included in the Chugwater formation, are described[1] as not like Chugwater. Special attention is called to these because similar beds in several places farther south will be compared with them.

The section east of the mountains, near Cheyenne, differs from the Laramie Basin section only in the apparent absence of the beds between Sundance and Chugwater.

NORTHWEST COLORADO TO NORTHEAST COLORADO

Attention is next directed to a group of sections a few miles south of those last described, starting with northwest Colorado. Farther east, near Meeker, the variegated beds, which are doubtless equivalent to the Morrison, are separated from the typical "Red Beds" by sandstones, which Gale[2] regards as probably equivalent to his White Cliff (Nugget of Schultz), but no marine beds of Jurassic age were found.

In the vicinity of Encampment, Wyo.,[3] and a little farther south, near Hahns Peak, Colo. (Encampment section), the Sundance lies between Morrison and typical "Red Beds." There seems to be no representative of the La Plata sandstone. Still farther to the east in North Park, Colo., no representative of the Sundance was found, but a sandstone of variable thickness, which corresponds in character with the La Plata sandstone and with the unnamed beds between Sundance and Chugwater in the Laramie Basin section, occurs near the base of what Beekly[4] classed as Morrison. In the foothills

[1] Darton, N. H., *et al.,* U. S. Geol. Survey Geol. Atlas, Laramie-Sherman folio (No. 173), 1910.

[2] Gale, H. S., U. S. Geol. Survey Bull. 340, 1908.

[3] Spencer, A. C., U. S. Geol. Survey Prof. Paper 25, 1904.

[4] Beekly, A. L., U. S. Geol. Survey Bull. 596, 1915.

region east of the mountains yellow and pink sandstone, having a maximum thickness of 150 feet, occurs between the Morrison and the typical "Red Beds" at the horizon of the Sundance or near it, and Butler,[1] suggests that it may belong to that formation. In view of the relation of the La Plata sandstone to the marine beds as determined west of the mountains, it seems more probable that this sand-

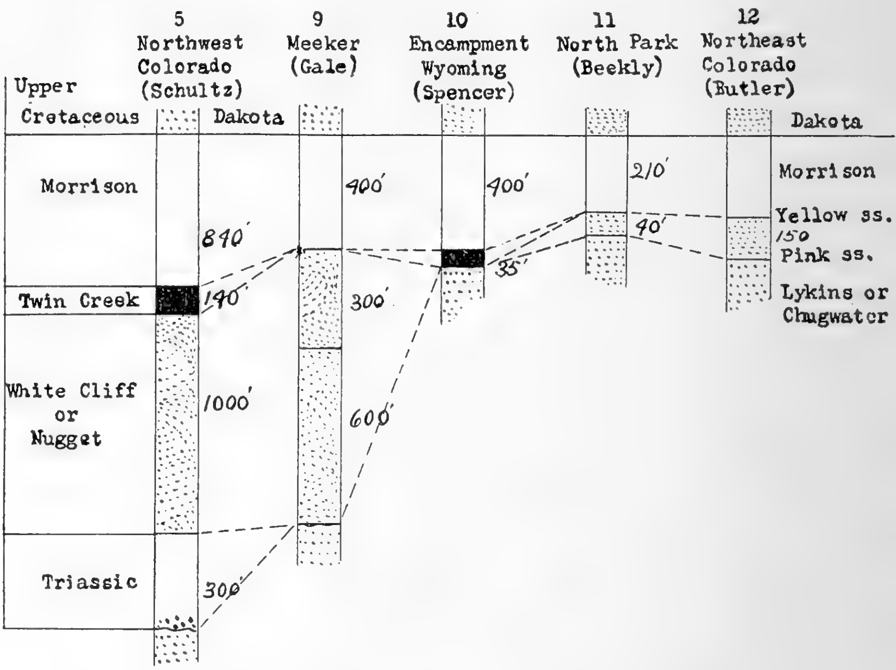

FIG. 3.—Group of columnar sections from northwestern Colorado to northeastern Colorado, showing the correlations of formations ranging in age from Triassic to Upper Cretaceous. (For location of sections see fig. 1, p. 11.)

stone is equivalent to the unnamed sandstone of the Laramie Basin section lying below the Sundance and to some part of the La Plata sandstone.

CENTRAL UTAH TO DENVER, COLORADO

A series of sections from central Utah eastward to Denver, Colo., shows relationships somewhat similar to those just described but differing from them in some ways which are significant. The section in Castle Valley differs from that near Greenriver only in the greater

[1] Butler, G. M., Colorado Geol. Survey Bull. 8, 1914.

thickness of the formations. Similar formations have been observed from place to place between Greenriver, Utah, and Grand Junction,

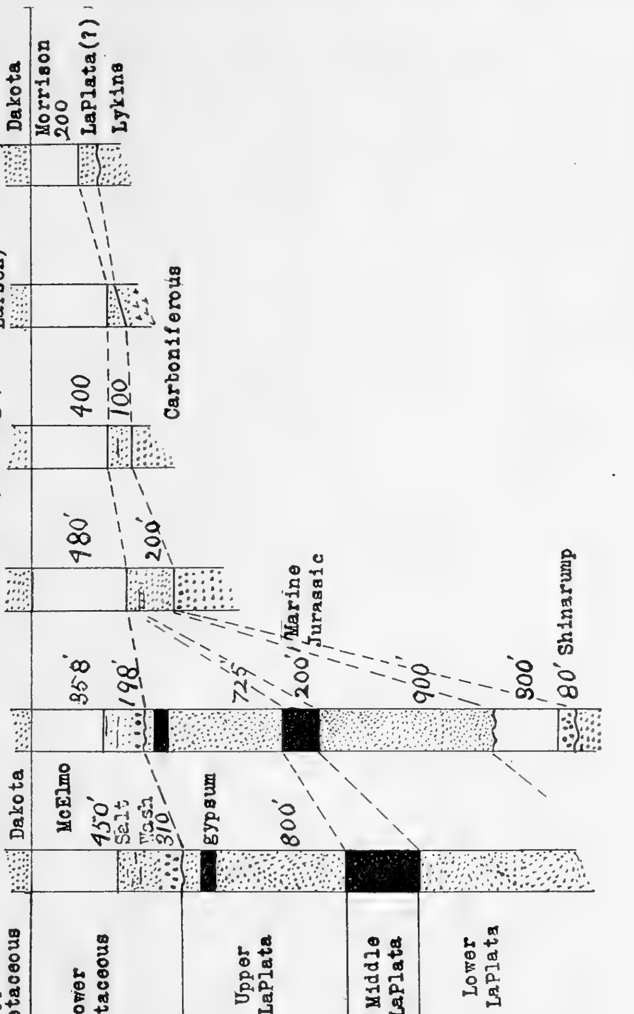

FIG. 4.—Group of geologic sections from eastern Utah to eastern Colorado, showing correlation of formations ranging from Triassic to Upper Cretaceous. (For location of sections see fig. 1, p. 11.)

Colo., where they constitute the Gunnison formation.[1] The upper part of the Gunnison consists of variegated beds similar to the Morrison, and by means of dinosaurs found in these upper beds near

[1] Lee, W. T., U. S. Geol. Survey Bull. 510, 1912.

Fruita, Colo., they have been correlated with the Morrison. The lower part of the Gunnison near Grand Junction consists of flaggy sandstones with a few layers of limestone, and rests unconformably on "Red Beds" supposed to be of Carboniferous age. This lower part of the Gunnison is doubtless equivalent to some part of the La Plata group. Farther to the east, near Crested Butte, a white sandstone near the base of the rocks there classed as Gunnison probably represents the La Plata, for in the same general region Cross and Larsen,[1] the former of whom originally named and described the La Plata, recognized it east of the town of Gunnison, where it overlaps the older sedimentary rocks onto the Archean.

The Dakota and Morrison formations are present in the intermontane basins, such as Middle Park and South Park, although little is definitely known about their relations there. But east of the mountains, at Morrison, Colo., is the type locality of the Morrison formation. Between this formation and the underlying "Red Beds" (Lykins), formerly called "Upper Wyoming," there are beds of sandstone and limestone which have been included in the Morrison, but which are lithologically different. Butler[2] has suggested that these may represent the sandstones farther north (northeast Colorado section), which he correlates with the Sundance. I am inclined to regard them as the attenuated edge of the Nugget or lower La Plata sandstone. It seems probable that the limestone and gypsum at or near this horizon farther south[3] may represent the extension of the Jurassic sea beyond the localities where its waters were suitable for the support of marine organisms.

NORTHERN ARIZONA TO SOUTHEAST COLORADO

Relations still farther to the south are shown by sections situated along a broken line extending from northern Arizona eastward to Purgatoire Canyon in southeast Colorado. The Rico and Ouray sections are essentially the same as the La Plata section at the type locality of the La Plata sandstone. A significant feature in this southwestern area is the limestone and calcareous shale of the middle of the La Plata group. Near Telluride,[4] situated between Rico and

[1] Cross, Whitman, and Larsen, E. S., Washington Acad. Sci. Jour. vol. 4, p. 237, 1914.

[2] Butler, G. M., Colorado Geol. Survey Bull. 8, 1914.

[3] Richardson, G. B., U. S. Geol. Survey Geol. Atlas, Castle Rock folio (No. 198), 1915.

[4] Cross, Whitman, U. S. Geol. Survey Geol. Atlas, Telluride folio (No. 57), 1899.

Ouray, the limestone is described as 6 to 16 feet thick and varies in character from black and massive to thin-bedded and shaly. Near Placerville, situated in this same general region, the limestone between the two sandstones of the La Plata is described orally by Frank L. Hess, who has examined it, as consisting of small masses which seem to occupy channels eroded after the lower La Plata sandstone was formed. Still farther to the north, according to members of the Colorado Survey (personal communication), the upper sandstone of the La Plata group is absent in some places. The formations included in these sections have been identified by Gregory in Arizona, as shown by the lines connecting the Arizona and Rico sections in figure 5, and Cross and Larsen have traced them eastward to the base of the Rocky Mountains. In Piedra Valley in southern Colorado[1] these observers recognized the two sandstones of the La Plata group, separated by dark-colored thin-bedded bituminous limestone having a maximum thickness of 30 feet. In some places this limestone is distinctly brecciated. The lower La Plata is normal in thickness and character and overlaps older sedimentary beds onto the Archean. The upper sandstone of the La Plata group is absent in some places.

Still farther to the southeast, on Chama River, N. Mex., the upper La Plata seems to be represented by 75 feet of sandstone, the middle La Plata by a bed of gypsum, and the lower La Plata by the Wingate sandstone.[2] This section may be regarded as characteristic of the western foothills region of southern Colorado and northern New Mexico. Similar beds outcrop in the foothills east of these mountains. In the Pueblo section, which has been selected to represent this eastern region, all rocks between the Purgatoire and the underlying "Red Beds" were formerly classed as Morrison.[3] However, beds of gypsum in the lower part of these rocks may represent the marine Jurassic to the north and the middle La Plata to the west. If the stratigraphic relations have been correctly interpreted here, the Morrison of the Pueblo region overlaps Carboniferous beds (Fountain) onto the Archean.

In Purgatoire Canyon in southeast Colorado the Morrison is present and in some places, but not in all, there are thick beds of gypsum between it and the typical "Red Beds." I described this gypsum

[1] Cross, Whitman, and Larsen, E. S., Washington Acad. Sci. Jour. vol. 4, p. 237, 1914.

[2] Darton, N. H., Unpublished manuscript.

[3] Gilbert, G. K., U. S. Geol. Survey Geol. Atlas, Pueblo folio (No. 36), 1897.

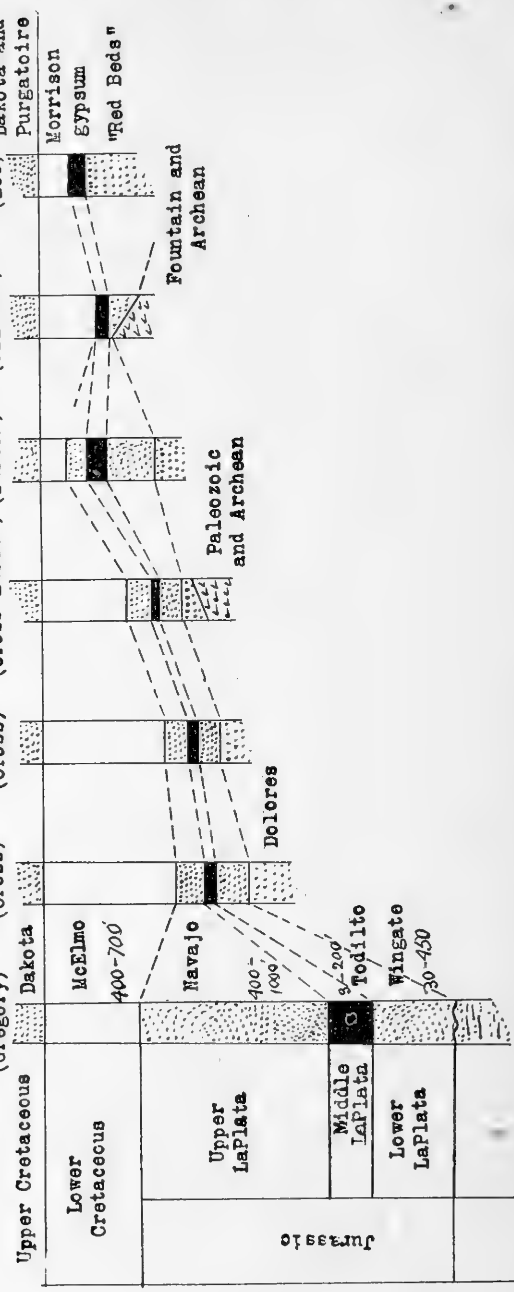

FIG. 5.—Group of geologic sections from northeastern Arizona to eastern Colorado, showing the correlations of formations ranging in age from Triassic to Upper Cretaceous. (For location of sections see fig. 1, p. 11.)

several years ago[1] as a part of the "Red Beds," but on further study I am inclined to believe rather that the gypsum is of the same age as that which occurs in the middle of the La Plata group in many places in southwestern Colorado and northern New Mexico.

SOUTHERN UTAH TO NORTHEASTERN NEW MEXICO

The southernmost group of sections here described extends from northern Arizona, where Gregory has correlated the formations with those of the type locality of the La Plata, westward through Utah and eastward through New Mexico. The Shinarump conglomerate is a persistent and easily recognized stratum and forms a convenient datum plane for grouping the sections of Utah and Arizona. The overlying beds of Triassic age (Chinle) were eroded and later covered with the sands of Vermilion Cliff and White Cliff. These sandstones have been supposed to constitute two separate formations, the older one of Triassic and the younger of Jurassic age. They are separated in some places, but not in all, by shaly beds, but the horizon of the shaly parting seems to vary from place to place. Also the color of the sandstone is variable, the white of the upper sandstone disappearing entirely in some places where the brilliant colors of the Vermilion Cliff extend to the top of the sandstone. Gregory[2] correlates the Todilto of northwest Arizona with the shaly beds which separate the Vermilion Cliff from the White Cliff in the canyon walls along Colorado River. On the other hand, Emery recognizes the marine Jurassic of the Greenriver region, which is above the White Cliff sandstone as probably the Todilto of the Arizona section. But the marine Jurassic of southern Utah is also above the White Cliff, hence the question arises again, Are there two marine Jurassic horizons or is the Todilto of Arizona to be correlated with the marine beds of Utah, as indicated in figure 6, rather than with the shaly beds lower in the sections.

Less uncertainty exists in the correlation of the Arizona section with those of northern New Mexico and southern Colorado. According to Gregory the tripartite division of the La Plata group is even more conspicuous in Arizona than it is in southern Colorado. The Wingate sandstone is traceable eastward to Thoreau in New Mexico, and the Navajo is probably equivalent to the two sandstones, 290 feet thick, of the Thoreau section which underlie the variegated beds.

[1] Lee, W. T., Jour. Geol., vol. 9, pp. 343-352, 1901.
[2] Gregory, H. E., U. S. Geol. Survey Prof. Paper 93, 1917.

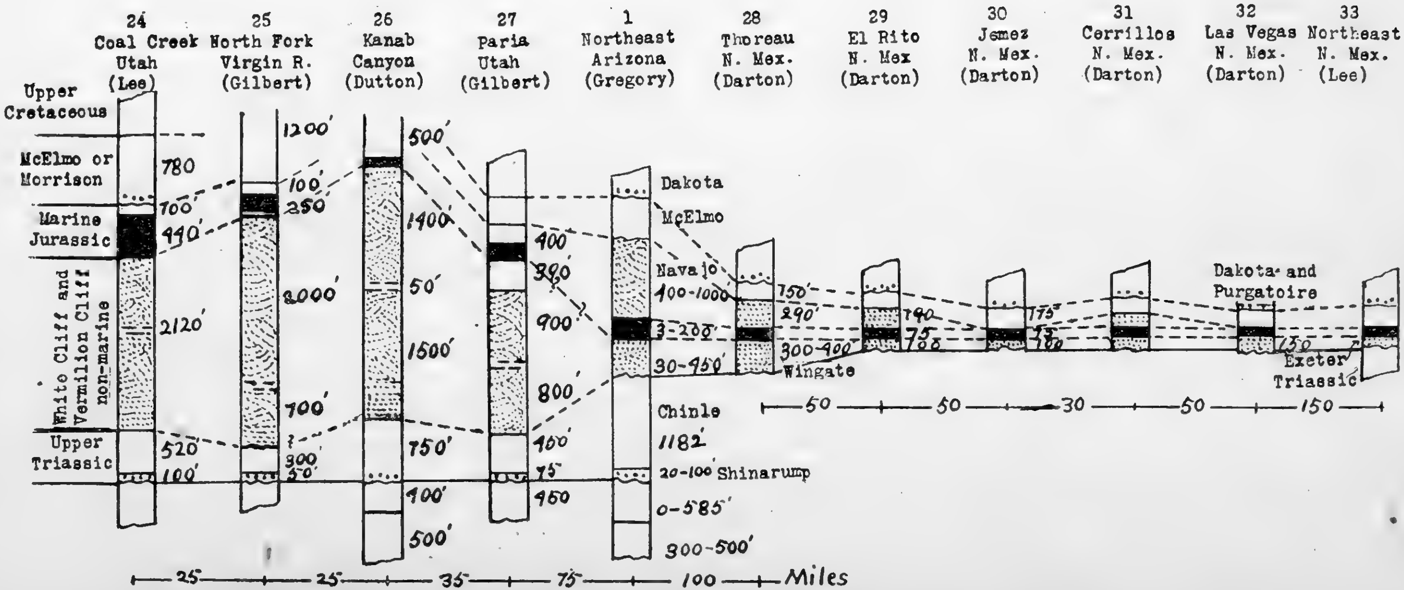

FIG. 6.—Group of geologic sections from southern Utah to northeastern New Mexico, showing the correlation of formations ranging in age from Triassic to Upper Cretaceous. (For location of sections see fig. 1, p. 11.)

The Todilto is represented in western New Mexico by a thin limestone which is described as appearing "singularly out of place" between two massive sandstones.

Farther to the east this limestone is recognized as the peculiar bituminous shaly limestone which underlies the gypsum of the El Rito section, with typical Wingate sandstone below it and another sandstone above.

Still farther east, near Jemez, N. Mex.,[1] the limestone and gypsum appear above the Wingate, but no equivalent of the Navajo is found unless it is included in the lower part of the beds here classed as McElmo. However, near Cerrillos, south of Santa Fe, and also in the Sandia Mountains, east of Albuquerque, the gypsum, limestone, and Wingate sandstone are typically developed, according to Darton, and between the gypsum and the overlying variegated beds are rocks composed chiefly of pink and yellow sandstone which may represent upper La Plata. These beds east of the Rio Grande are separated from those farther to the west by a covering of younger rocks, and the correlations must be made chiefly on lithologic similarity of beds and on sequence of formations.

About 25 miles east of the point where the Cerrillos section was measured, and a few miles south of Lamy, N. Mex., a sandstone between typical "Red Beds" and typical Morrison (pl. 2, fig. 1) is regarded as Wingate by Darton, although no gypsum has been found above it. However, still farther to the east, near Las Vegas, N. Mex., the sandstone which holds the same relative position has a thin limestone above it, which is described as being the same as that which caps the Wingate sandstone of localities farther to the west. This limestone separates the sandstone from the Morrison and there seems to be no room here for an equivalent of the upper La Plata sandstone. Darton regards the sandstone as equivalent to the Wingate, although in the Santa Fe guidebook[2] it is labeled Triassic (?). On the other hand, I became convinced some years ago, while working in that part of the country, that this sandstone is the same as the Exeter sandstone (pl. 3, fig. 1) of northeastern New Mexico which I then referred with the query to the Triassic.[3] Like the Wingate, this sandstone is overlain at its type locality by limestone and gypsum, but unlike the Wingate it is variable in thickness and is entirely absent in some

[1] Darton, N. H., Manuscript in preparation.

[2] Darton, N. H., U. S. Geol. Survey Bull. 613, fig. 13, 1915.

[3] Lee, W. T., U. S. Geol. Survey Bull. 389, 1909.

places. In the canyon of the Dry Cimarron, in northeastern New Mexico, it rests with angular unconformity on the older "Red Beds." Inasmuch as recent investigations tend to show that the Exeter may be equivalent to the Wingate, it seems advisable to class it as Jurassic, rather than Triassic.

In brief, the Wingate of Arizona and New Mexico seems to be the southward extension of the lower sandstone of the La Plata group, and this sandstone is traceable eastward to the Rio Grande. East of that river and on both sides of the Rocky Mountain axis a sandstone of similar character and holding the same stratigraphic position seems to be equivalent to typical Wingate and lower La Plata. It occurs in many places, but not in all, as far east as Oklahoma.

The middle La Plata or Todilto is traceable by means of the limestone and gypsum eastward to the Rio Grande and is recognizable by peculiar lithologic characters in many places farther east. It seems probable that the limestone and gypsum east of the mountains above the Exeter sandstone denotes the same horizon. The gypsum is not continuous for great distances. It occurs in more or less restricted lenses. The thin limestone underlying it is more persistent and occurs in places where there is no gypsum.

The upper La Plata (Navajo) seems to be less persistent than the lower formations of the group. It thins out in some places in the Zuni Mountain region of western New Mexico and has not been found near Jemez. It seems to have a representative in the Cerrillos section, but has not been reported from localities farther east.

PREPARATION FOR JURASSIC SEDIMENTATION

The reduction of the ancient Rocky Mountains, which had been in progress during much of Permian and all of Triassic time, seems to have reached a stage of advanced peneplaination by the opening of the Jurassic period. However, the region was still above sea-level, and erosion continued during a long interval which, with minor interruptions, lasted through Jurassic and Lower Cretaceous time. During all of this time the greater part of the North American continent was above sea-level and exposed to erosion.

It seems desirable in this connection to attempt to picture the physiographic conditions in the Southern Rocky Mountain Province previous to Jurassic time. In my opinion, it is necessary occasionally, in order to obtain the best results, to stand off at a distance from a problem and take a comprehensive view of it in its relation to other problems. The constant tendency of the investigator is to confine attention to the minutiæ of his problem until he grows scientifically nearsighted and fails to see that some line of evidence other than his own may have an important bearing on his problem.

The meager information as to physiographic events in the Rocky Mountain region in late Triassic time is widely scattered through geologic literature. A brief summary is probably all that the present discussion calls for. Sedimentation which had been in progress both east and west of the mountains was terminated at the end of the period for some reason not now known and the Triassic rocks subjected to erosion. Before sedimentation was renewed in the Jurassic period this erosion appears to have reduced large parts of the region to a nearly level plain. It cut away the mountains, truncated domes and anticlines, and removed such large parts of the older sedimentary rocks that the sediments of the La Plata group were spread out on a floor consisting of all the older rocks of the region from Triassic down to Archean. This plain, completed over a vast area in early Jurassic time, may be called the *La Plata peneplain,* for on it the sediments of the La Plata group were laid down.

The peneplaination continued throughout Jurassic and Lower Cretaceous times in areas not covered by La Plata, the central portions of Colorado being the last of the uplands in the Southern Rocky Mountain Province to disappear. It was on the lowest parts of this peneplain that sediments began again to accumulate in late Jurassic time.

Farther west, Jurassic sedimentation began earlier, possibly at the beginning of the period, when the sands of the Vermilion Cliff began to accumulate in the old valley. By the time the accumulations had pushed across the valley to the present mountainous region of Colorado, the Jurassic period was well advanced, and only thin, isolated representatives of the La Plata sandstone were formed there.

JURASSIC DEPOSITS

Years ago the marine sedimentary rocks of late Jurassic age were regarded as the oldest representatives of the Jurassic system in the Rocky Mountain region, the underlying " Red Beds " being referred to the Triassic. But for several years there has been a growing tendency to include in the Jurassic system some of these unfossiliferous older rocks. In some places in the mountain region these are thin; in other places they are absent. But west of the mountains, rocks which seem to be the age equivalents of these thin beds are very thick and persistent over a large area. For this reason they must be considered in connection with those of the mountains proper. They constitute what is here called the La Plata group (see pl. 2, fig. 2). They occur principally in Colorado, eastern Utah, northern New Mexico and Arizona. The group takes its name from southwestern Colorado, where Cross[1] first studied and described the deposits as the La Plata sandstone. The original La Plata and its approximate age equivalents cover some such areas as that shown in the accompanying figure 1, page 11. It includes the White Cliff and Vermilion Cliff sandstones of Utah; the Navajo, Todilto, and Wingate of Arizona; the Wingate and other formations in western New Mexico; the Exeter sandstone of eastern New Mexico, and rocks in other places which have been grouped by some geologists with the underlying Triassic and by others with the overlying Morrison, but which are here regarded as being of essentially the same age.

The La Plata sandstone and the formations believed to be its age equivalents consist chiefly of massive cross-bedded, cliff-forming sandstone (see pl. 1). They contain a subordinate amount of shale, and in some places there are thin limestones which contain a few shells of fresh-water invertebrates. In the southern part of the area occupied by these deposits gypsum is abundant in the center of the group. The typical La Plata is prevailingly light-colored, but in northeastern Arizona and northwestern New Mexico its equivalent formations are red, and in northeastern New Mexico they are pink to buff-colored. In lithologic character and stratigraphic position the White Cliff and Vermilion Cliff sandstones correspond closely with lower La Plata, but there seems to be lack of general agreement as to their exact correlation. Some facts seem to indicate that these correspond to the two sandstones of the La Plata group; others, that they represent only the lower sandstone, and are together equivalent to the Wingate—a view which I am inclined to advocate after seeing them in southern Utah. There is further disagreement as to the relations in northern Colorado and Utah, some geologists correlating the cliff-making sandstone (White Cliff of that region which some call Nugget) with La Plata as a whole, others with lower La Plata only. The correlation embodied in figure 2, page 13, harmonizes with the known facts.

Emery,[2] who is familiar with the formations in the Navajo country in Arizona and who has recently (1917) examined the similar forma-

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[1] Cross, Whitman, U. S. Geol. Survey Geol. Atlas, La Plata folio (No. 60), 1899.

[2] Emery, Wilson B., Manuscript in preparation.

tions in eastern Utah recognizes near Greenriver the equivalent of the Wingate—called White Cliff in this region by some geologists and La Plata by others; the Todilto, which is here gypsiferous and contains marine Jurassic invertebrates; and an equivalent of the Navajo, formerly included in the McElmo of this region. My own observations in southern Utah in 1917 convinced me that the Vermilion Cliff and White Cliff sandstones are essentially one great formation. There is little difference between them except in color, and this distinction sometimes fails, for in some places the sandstone is all red. Also, while there is often a shaly division, it is not obvious that the shale is at the same horizon in all places. Furthermore, the fossiliferous marine Jurassic limestone and associated gypsum is above the White Cliff sandstone of southern and eastern Utah.

The possible correlation of Todilto with the marine Jurassic, as indicated in figures 2 and 6, is made on the assumption that there was only one invasion by the Jurassic sea. A suspicion has been entertained by some geologists that there were two invasions by this sea, separated by a relatively short interval of time. The Ellis formation in Montana has been regarded as the time equivalent of the Sundance in Wyoming. Recently some of the fossils from these formations have been critically examined by John B. Reeside, Jr., who has kindly permitted me to examine his manuscript. He concludes that the Ellis is older than the Sundance, the former corresponding to the Lower Oxfordian and the latter to the Upper Oxfordian of Haug.[1] Another suggestion of two separate invasions is derived from the descriptions by Mansfield and Roundy,[2] who find in southeast Idaho marine Jurassic fossils at two horizons separated by an unconformity and by more than 1,000 feet of unfossiliferous sandstone.

It seems fairly certain that the limestone and gypsum in northern New Mexico which are correlated with the Todilto formation were deposited in sea water. If Gregory's correlation of the Navajo and Grand Canyon sections is correct, these beds (Todilto) are represented by shaly beds about 1,000 feet below the marine Jurassic of the canyon region. If, on the other hand, there was only one incursion of the Jurassic sea it seems probable that the Todilto is equivalent to the marine Jurassic beds which overlie the White Cliff, and that the correlation shown in figure 6, page 22, is correct.

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[1] Haug, Emil, Text, p. 998.

[2] Mansfield, G. R., and Roundy, P. V., U. S. Geol. Survey Prof. Paper 98, p. 81, 1917.

All things considered, it seems probable that in spite of the great difference in thickness the Vermilion Cliff-White Cliff sandstone is equivalent to Wingate or lower La Plata; the marine Jurassic to Todilto; while the upper La Plata has been included in McElmo in some places and was eroded away in other places before McElmo time.

Much might be said of the rocks in other places, which are here included in the La Plata group. But in this paper a tedious review may be omitted, with the statement that I have consulted every available source of information and embodied the results in the correlations shown in the accompanying figures. In brief, the sedimentary rocks of Jurassic age are very thick in the plateau region of Utah and thin eastward. The evidence tending to prove that the sandstones originated largely as wind-blown deposits is in harmony with the supposition that the material came from the newly formed mountains to the west and gradually thinned toward the east.

SIGNIFICANCE OF LOWER LA PLATA CONTACT

In southwestern Colorado the La Plata sandstone rests unconformably on the Dolores formation which is classed as Triassic and which has a known range in thickness from something more than 1,700 feet to 100 feet or less. Similar relations obtain in northeastern Utah, but in southern Wyoming (fig. 2) marine Jurassic rocks rest unconformably on Chugwater, which is classed by some geologists as Triassic and by others as Permian. In northern, central and southern Colorado west of the Rocky Mountains, rocks correlated with the La Plata rest unconformably on "Red Beds" and overlap these onto the Archean. Also east of the mountains, sandstones which may be age equivalents of the La Plata overlap Triassic and older rocks down to the Archean. It is obvious therefore that there is a broad, well-defined plain of unconformity here called the La Plata peneplain separating the La Plata group from older formations.

It is further obvious that the few feet of Jurassic strata in the Rocky Mountain region cannot represent the entire time required for the accumulation of the deposits of this age in Utah which are more than 3,000 feet thick (fig. 6, p. 22). The thinning of the rocks eastward points to a western source of the sediments, and the fossils of the marine beds above the White Cliff denote late Jurassic time. It is therefore probable that the upland deposits—such as the sand of the Vermilion Cliff and White Cliff sandstones—accumulated in early or middle Jurassic time, while the areas farther east were still undergoing erosion, and that the deposits spread eastward as time went on until this upland deposition was interrupted by the invasion of the sea. There is reason, therefore, for correlating the Wingate sandstone with both the White Cliff and Vermilion Cliff sandstones. There is equally good reason for believing that the unconformity at the base of Vermilion Cliff, the only obvious unconformity between the rocks of undoubted Triassic age and the marine Jurassic in Utah, is the westward extension of the great unconformity now well known at the base of the La Plata group in Arizona, New Mexico, and Colorado.

If the correlations as outlined are correct, it seems probable that most of the material constituting the La Plata group was derived from the highlands in western Arizona, Nevada, and neighboring regions. The thinning of the La Plata where it overlaps onto the Archean in the Rocky Mountain region in central Colorado seems to prove that such lands as existed there at that time were so low that they furnished little sediment. It follows that the mountains in Colorado which had furnished the great quantities of coarse material for the older "Red Beds" had been reduced to a peneplain before La Plata time.

The old valley in which the sediments of the La Plata group accumulated was partly filled with sand and depressed so that the surface was near sea-level in late Jurassic time and may or may not have been occupied by a trunk stream. It lay so low that a slight rise of water level caused the marine waters to spread out in it as a broad, shallow sea. It is not known how far this ancient valley-plain extended southward and eastward, but the great length of time that the western interior had been subjected to erosion was sufficient for the reduction to a low-lying plain of any mountains which may have existed.

I picture the physiographic conditions at the opening of La Plata time something as follows: The broad valley had developed during the early part of the Jurassic period between the ancient mountains of Colorado and the newly formed continental land mass farther west, somewhat similar to the Mississippi Valley of the present day. It may have been formed partly by subsidence, but it seems probable that it was an area cut off from the ocean by uplift to the west and later shaped by erosion. In few places unusual thicknesses of the sedimentary rocks seem to denote local basins caused by downwarping. But the uniform thickness of the sediments which were spread out over extensive areas on this plain proves that a large part of it was practically unaffected by warping during the deposition of the Jurassic sediments.

The old valley seems to have been so near sea-level that a slight land movement would shift the courses of the streams or even reverse the direction of their flow, much the same as a relatively slight movement now in central North America would modify the drainage between the Hudson Bay and the Gulf of Mexico. Except in a few localities where the sedimentary rocks of Jurassic age are thick, as previously noted, the uniform thinness of the marine Jurassic rocks (Sundance) indicates that the waters of the Jurassic sea spread out over a nearly level floor.

If the red color of sedimentary rocks and the occurrence of gypsum are sufficient indications of aridity, southwestern America had not recovered in La Plata time from the arid conditions that seem to have prevailed there in Permian and Triassic time. Indeed the strong colors of the Vermilion Cliff seem to have been responsible for the early reference of this sandstone to the Triassic system. It seems probable, however, that the arid conditions under which the sediments of the La Plata group gathered (pl. 1) were caused by the western mountains, as already suggested. For some reason not all of the sediments brought into this old valley in La Plata time were carried away. The physiographic conditions there may have been such as would obtain in the Mississippi Valley should the climate for any reason become so arid that the Mississippi River and its tributaries would be unable to transport the material delivered to them. The streams would then bring débris from the highlands and spread it out over the lowlands, there to be reworked by the winds and the local streams on a large scale. In this way relatively coarse débris is now being spread out in the bolsons of the semiarid southwest and in the "dead" valleys of the Great Basin. Perhaps still better illustrations of these conditions are to be found in the great deserts of North Africa, Asia Minor, and central Australia. To complete the picture the desert should be practically at sea-level and the water have easy access to it so that a slight subsidence of land or a rise of water level would shift the strand line far up the valley.

PROJECTION OF THE MARINE HORIZON BEYOND THE LIMITS OF THE FOSSILIFEROUS BEDS

Gypsum is commonly derived from sea water, and its occurrence in fossiliferous marine Jurassic rocks proves that conditions were favorable for the deposition of gypsum around the Jurassic sea. The gypsum in the unfossiliferous rocks is so near the same horizon as to render it probable that water from the Jurassic sea had access to localities beyond those where marine fossils have been found. Where tracing of the beds is possible, ultimtae correlations naturally will depend on detailed work. But in many places such tracing will not be accomplished for many years to come. Also there are places where tracing is impossible because of erosion or because of cover by younger rocks, and other methods must be employed. As gypsum is derived chiefly from sea water, it is difficult to understand where the gypsum which occurs above the White Cliff sandstone in Utah and above the Wingate sandstone in New Mexico came from if not from the waters of the Jurassic sea. The correlation of the gypsum beds above the Wingate sandstone in northwestern New Mexico and above the Exeter sandstone in northeastern New Mexico with the marine Jurassic beds is in harmony with the correlation of these two sandstones with sandstone below the marine beds in Utah and elsewhere. Also, by means of the gypsum below the Morrison, the correlation may be carried northward through regions east of the mountains where the Exeter is not known, to southern Wyoming, there to connect again with the marine Jurassic (Sundance). Gypsum occurs in many places east of the mountains in Colorado at or near the same horizon and so near the line of separation between the Morrison and the older formations that in the supposed absence of an intermediate division it seems to have been chiefly a matter of personal judgment whether it should be classed with the beds above it or with those below. The correlations here suggested indicate that the gypsum and associated rocks may be of Jurassic age and represent a distinct stratigraphic horizon between the Morrison and the underlying "Red Beds."

Throughout the region here described, the gypsum classed as middle La Plata occurs in relatively isolated bodies, as if it had been deposited in separate basins. There are several possible explanations for this manner of occurrence, four of which are suggested below.

(1) A continuous bed or series of overlapping beds of gypsum may have been formed and later cut away in some places by erosion. The lack of evidence of such erosion renders this explanation improbable.

(2) Gypsum derived from upland sources, as, for example, from the erosion or solution of older deposits, may have accumulated in inclosed basins in some such manner as gypsum beds are forming now in the vicinity of Alamogordo, N. Mex., where the gypsum is derived from older gypsiferous beds in the surrounding hills. The

extremely low relief of the region in Jurassic time renders this explanation improbable.

(3) Water of the Jurassic sea may have found its way into the lowest places on the partly submerged peneplain by more or less circuitous routes, and because of poor connection or perhaps because of intermittent connection with the sea, evaporated and deposited gypsum. Some of these partly inclosed arms of the sea must have received enough fresh water from the drainage of the surrounding country to prevent precipitation of gypsum, or even to keep the water essentially fresh, hence the occurrence of fresh-water limestone and non-gypsiferous clastic sediments in some places at a horizon which seems to be the same as that of the gypsum beds. The absence of salt from the gypsiferous middle La Plata indicates that concentration in the arms of the sea did not reach so advanced a stage as it did in the older seas in this region. In this connection it may be pointed out that some of these arms should have contained water suitable for the marine life that flourished in the main body of the sea. Doubtless the boundary of this sea, shown in figure 1, p. 11, will be extended as new information is obtained, and it is possible that careful examination will disclose the presence of marine fossils where they have not yet been found.

(4) The gypsum deposits, although at nearly the same horizon, may differ slightly in age, and the several deposits represent temporary basins partly or wholly cut off from the broad but very shallow sea. Such basins would be formed readily on the partly submerged peneplain by slight warping of the surface; by sand bars; by vegetable growth; or in other ways.

Little need be said in this connection of the occurrence of limestone where marine fossils are found nor of the ordinary fresh-water limestone which occurs in thin beds in the La Plata group and in the McElmo formation. But there are some limestones which are quite different from the others, in that they are dark-colored and bituminous, and which by reason of their peculiar nature are easily recognized. They seem to be confined to a very narrow zone and hence are valuable horizon markers. The dark-colored limestone and limy shale occur in the middle of the La Plata group in southwest Colorado and are described as being easily recognized by their lithologic character. At the same horizon in southern Colorado, in Piedra Valley, this limestone is dark-colored and bituminous, and is shaly in some places and brecciated in others. Farther south in New Mexico a thin, dark-colored, bituminous, shaly limestone underlies the gypsum beds in many places, but occurs at some localities where the gypsum is absent. Darton found this limestone so persistent and its peculiar character so constant that it proved valuable in tracing the formations over wide areas. He describes its occurrence as far east as Las Vegas, N. Mex.[1] An impure limestone of somewhat different character occurs near the gypsum in northeast New Mexico.[2] Although this was examined long before there was any suspicion that special significance might be attached to it, it was found to be enough different from the limestones of the overlying Morrison to attract attention. It seems probable that by reexamination of sections described years ago, this limestone and gypsum horizon in eastern New Mexico and Colorado may be identified as middle La Plata in age.

INVASION OF JURASSIC SEA

EXTENT AS DETERMINED BY FOSSILS

The sea water entered the interior of the North American continent in late Jurassic time, submerging a large part of the Northern Rocky Mountain Province and extending southward through Utah to Arizona. The waters of this sea apparently represent the maximum submergence of land during the Jurassic period. It is possible, of course, that this advance of the sea water may have been due to a subsidence of land, but it is equally possible, and in my opinion more probable, that the submergence was due to a rise of sea-level and that the water flowed over the lower parts of the old valley in much the same way that a rise at the present time would cause the Gulf waters to submerge the lower part of Mississippi Valley.

The area covered by this Jurassic sea has been outlined by W. N. Logan[3] (fig. 1, p. 11) to include all localities where marine Jurassic fossils have been found. There is a tendency to assume that the boundary line marks the maximum extent of the sea, whereas in reality it denotes only the extent of fossiliferous strata. Sediments were probably accumulating under conditions which were not favorable for marine life, over a much larger area.

Relatively little can be learned now of the physiographic conditions west of this sea because of erosion since Jurassic time, but in the southern and eastern parts of the area occupied by it there is abundant evidence that the water spread out in a thin sheet over

[1] Personal communication.

[2] Lee, W. T., Jour. Geol., vol. 10, p. 46, 1902.

[3] Logan, W. N., Jour. Geol., vol. 8, pp. 241-273, 1900.

a plain which was nearly level. The fossiliferous beds deposited in this sea in eastern Wyoming constitute the Sundance formation. These beds are uniformly thin over a large area. Even where the Sundance has not been clearly differentiated from the rocks above and below it there is little room for variation in its thickness within the region represented by the sections here described. There are many critical places for which no convincing descriptions are obtainable. Perhaps the most confusing of these are in eastern Utah, where gypsum occurs at two horizons nearly 1,000 feet apart. As the rocks of the lower horizon contain marine Jurassic fossils, they have been correlated with the fossiliferous and gypsiferous rocks elsewhere. But there remains the possibility that some of these beds elsewhere may represent the upper, rather than the lower, gypsiferous horizon.

It is possible, as already suggested (p. 27), that the difficulties in correlating these rocks with those of other regions may be due to the presence of marine Jurassic rocks at two horizons, whereas only one has been recognized.

DETERMINATION OF AGE

The Sundance fauna is described as similar to the Oxfordian fauna of Europe. On this basis the Sundance formation has been correlated with the Oxford, which in Europe represents a stage referred by some geologists to the base of the upper third of the Jurassic system and by others to Middle Jurassic. It has been said, therefore, that the Sundance belongs in the lower part of the Upper Jurassic or the upper part of the Middle Jurassic. If this correlation is correct and if the overlying or Morrison beds are Lower Cretaceous in age, as many geologists believe, evidence of a hiatus should be found at the top of the Sundance. But little evidence of such hiatus has yet been found unless the absence of certain beds, as indicated by the groups of sections, be accepted as evidence. The structural relations are such as would be expected if the Sundance were late Jurassic, formed near the close of the period. On the other hand, if the Sundance is represented by the beds in the middle of the La Plata group, and if any considerable part of the upper La Plata sediments accumulated after the retreat of the sea, the time of this accumulation must be represented by a hiatus at the top of the Sundance where upper La Plata is not represented.

In considering the evidence of a lapse of time between the Sundance and the overlying Morrison, the physical conditions of this region in late Jurassic time must be taken into account. From all that I have been able to learn the whole region was so near sea-level that an easily recognizable unconformity is not to be expected.

The fact that little evidence of a hiatus has been found between Sundance and Morrison is not proof either that there is or is not a hiatus. The problem must be solved on such broader considerations as change in general physiographic conditions, and their causes; changes resulting in differences in lithology, and in distribution of the formations; in overlap relations and in the presence of interwedging formations.

On the principle that a period ends with a maximum retreat of the sea, the Sundance of the Rocky Mountain region should hold a position in the time scale slightly below the theoretical upper limit of the Jurassic system, and there should be found evidence of a slight hiatus corresponding in time to the wedge of upper La Plata sandstone. This naturally raises a question as to the basis of correlation.

Comparison with formations previously described and classified calls up the question: What weight should be given in intercontinental correlation to similar fossil forms and to similar faunas; to identical species and identical faunas? The question is an old one and will probably never be answered to the satisfaction of all geologists. The uses and perhaps also some of the misuses of such data are familiar. One geologist places great weight on similarity of faunas, and another places little weight on this similarity. Some geologists maintain that the similarity of the Sundance fauna to the Oxfordian fauna is sufficient to fix the position of the Sundance in the time scale at the base of the upper third of the Jurassic system. Others admit that so far as the fossil evidence at present available is concerned, the Sundance might as reasonably be placed near the end as near the middle of the system; and that the two faunas are separated by such distances that differences in environmental conditions and barriers to migration might readily negative close correlation on the basis of fossils alone.

This naturally suggests the query, Can we find criteria for correlation that are more reliable than those derived from the fossils? One method has been proposed which seems attractive, but which in the opinion of many geologists has not yet been adequately tested. It is based on the well-known principle that a movement of any considerable part of the mass of the earth is likely to change the capacity of the ocean basins and therefore to shift the strand line. A disturbance in the solid mass of the globe in one place, such as the settling of an oceanic sector, will cause internal readjustments which will manifest themselves in one way or another at the surface in other places. The greater disturbances, which are appropriately recognized as introducing and terminating periods and systems, are likely to cause the most obvious movements of the strand line. It seems possible that a downward mass-movement may be compensated in part by the rise of a neighboring mass, but it seems improbable that such compensating movements would be so nearly equal that the strand line would remain unaffected. Inasmuch as the constant tendency of rock masses under the influence of gravity is downward toward the center of the earth, it is difficult to conceive of the actual (as distinct from apparent) upward movement of any great mass of the globe except as a result of some still greater mass-movement downward.

This is not the place to enter into a discussion of diastrophism. But there are some questions which refer to the cause of diastrophic movements and which bear so directly on the problems connected with the Jurassic marine invasion that it seems advisable to at least ask them, even though they cannot be answered. Were the great disturbances which caused the major fluctuations of sea-level, movements constantly in progress, or were they relatively short interruptions of a state of general repose in the mass of the earth? Locally applied, was the advance of the water into the Jurassic sea caused by subsidence in western North America, or was it caused by a decrease in the capacity of the ocean basins, due perhaps to submarine vulcanism or the discharge of sediments into the sea? Was the drainage of the sea due to a rise in western North America of the land which had previously subsided, or was it caused by an increase in the capacity of the oceans, due perhaps to subsidence of some part of an ocean bed? Are great land masses as fickle as some geologists are wont to suppose, rising and falling frequently, or are many of the supposed movements of land only apparent because of movements of sea-level? Was the Jurassic sea drained quickly, or did the retreat of its waters occupy an appreciable length of geologic time? To be still more explicit, was the sea advancing during all of lower La Plata time and retreating during all of upper La Plata time?

The Jurassic sea apparently represents the maximum advance of sea water over the North American continent and therefore the maximum rise of sea-level during the Jurassic period. But inasmuch as only small parts of the continent were covered, the transgression seems to have been a relatively small one. On the principle of wide uniformity of action, apparently necessary if diastrophic principles are to be of material use in long-distance correlation, a similar advance of the sea over the other continents should be found. The great development of the Jurassic system in Europe shows that large parts of that continent were under water during much of the period, but the greatest submergence seems to have been in late Jurassic time. E. W. Berry, who has recently reviewed the conditions in Europe during this time, is of the opinion [1] that the transgression of the Jurassic sea, which commenced at about the close of the middle Jurassic, reached its maximum extent in the Upper Jurassic (Kimeridgian stage), and that its subsequent withdrawal, which marks the close of the Jurassic period, was probably contemporaneous with the similar withdrawal of the Jurassic sea in western North America, and both series of events may have been the result of a common cause. In other parts of the world relatively small areas comparable in size with the Jurassic areas of North America were submerged also in late Jurassic time. (See fig. 341 of Haug's textbook.)

Also, attention may be called to the fact that the Jurassic seems to have been a period of general continental stability. There were land movements in places and some of these movements attained considerable importance, but the continents were chiefly above sea-level and subjected to erosion throughout the period. The Jurassic has been termed a period of repose in contrast to the Cretaceous, which as a whole was a period of diastrophic activity. If the continents were really as stable as they seem to have been, the marine invasion may have been due to a rise of sea-level. It seems reasonable to attribute this rise to the discharge into the basins of sediments derived from long erosion of the lands. It has been shown that the volume of land now above sea-level is sufficient to raise the level of the sea 650 feet. If the Jurassic was a period of world-wide continental repose, we may reasonably attribute the submergence of low-lying areas to a general rise of sea-level. Also, we may reasonably assume that aside from the effect of local warping of the surface, maximum submergence at widely separated localities denotes equivalency in time.

DRAINAGE OF JURASSIC SEA

Following this hypothesis still further, if the Jurassic submergence was due to transfer of rock waste from the land to the sea, with resulting rise of sea-level, what was the cause of the withdrawal of

[1] Berry, E. W., Personal communication.

the water? Also, did this withdrawal occur within the period or at its close? At this point a definite answer is needed to the question previously asked, Was the sea drained quickly or slowly? If the Jurassic was a period of continental repose, it would seem appropriate to regard any diastrophic movement which had sufficient magnitude to cause the drainage of the submerged portions of the continents, as appropriately marking the close of the period. It seems probable that the draining of the sea was due to the first or introductory movement—perhaps a relatively slight one—of the diastrophism which characterized the Cretaceous period.

In western North America the Jurassic period was closed by crustal movements called the Sierra Nevada disturbance by Schuchert; the Sierra Nevada movement by Whitney; the Nevadian movement by Blackwelder; and the Cordilleran revolution by Smith. It seems probable that the Jurassic movement to which S. F. Emmons[1] ascribed the expulsion of the Jurassic sea from the Rocky Mountain region was part of this diastrophic movement which closed the period; for there seems to be good reason for doubting that this so-called Jurassic movement was a local movement of land in the Southern Rocky Mountain Province. The draining of the sea may have been due to a general lowering of sea-level, caused perhaps by the sinking of some part of an ocean basin. And it seems reasonable to believe that this movement was a part of the diastrophic disturbance which terminated the long period of continental repose and introduced the equally long period of diastrophic activity which followed. If the land in the Southern Rocky Mountain Province was elevated at all, the elevation must have been slight. The sediments of the Morrison formation were spread out over a nearly level plain only slightly above sea-level and nearly 1,000 miles long and 500 miles wide. It is inconceivable that the nearly base-leveled area covered by the Jurassic sea could have been elevated to any great extent and then have settled back to form the extremely regular surface on which the Morrison sediments were deposited. Such a plain could have been formed only under the gradational processes of standing or running water. In this, as in the maximum advance of the sea, there seems to be an analogy between America and Europe, for in Europe the period is described as closing with a retreat of the sea from the continent without notable disturbance of land.

[1] Emmons, S. F., U. S. Geol. Survey Mon. 27, p. 21, 1896.

SUMMARY OF PHYSIOGRAPHIC CONDITIONS IN LATE JURASSIC TIME

I picture the physiographic conditions of this time something as follows: The Rocky Mountain region had become degraded in late Jurassic time to a peneplain so low that it furnished little sediment. West of the present mountain system the broad valley previously developed had been filled chiefly with sand (lower La Plata) and graded so that its surface was a continuation of the peneplain. This sand brought from the western mountains thinned out toward the east, where it accumulated only locally in the low-lying portions of the Southern Rocky Mountain Province, the beds thinning out in some places on the slopes of the higher portions.

These deposits now constitute the lower sandstone of the La Plata group—that is, the Vermilion Cliff, White Cliff, Wingate, Exeter, and possibly other sandstones of the eastern foothills region, which have been included by some geologists in the "Red Beds," and by others in the Morrison. These continental deposits seem not to have extended northward far into Wyoming.

At a slightly later date, if not during the time these continental deposits were accumulating, the marine waters entered the old valley from the north and spread over the lowest portions of the area formerly occupied by the ancient Rocky Mountains. In Wyoming the sea covered the eroded surface of the older "Red Beds," but in Utah and western Colorado it covered the older non-marine deposits of Jurassic age. Water suitable for the support of marine animals probably extended southward as far as Arizona and spread over some such area as that shown in figure 1. Sea water, which by evaporation became too saline for these animals, extended farther south and east over the lower parts of the peneplain and gathered in partly inclosed shallow basins or "pocket seas," where they deposited gypsum in much the same way that saline deposits are being formed now in some parts of Great Salt Lake. Doubtless there were many of these pocket-seas formed by local warping of the surface and in other ways, in which concentration of water did not reach the degree at which gypsum may be deposited. In still others the supply of fresh-water was sufficient to expel the marine. In such basins limestone formed. In some places the presence of fossils proves this to be fresh-water limestone, but in most places no fossils of any kind are found in it. It is a matter of observation that at some localities this limestone occurs at the same general horizon as the gypsum. No gypsum is present in the layers with the marine fossils, although these layers may occur below or even be interbedded with the gypsum. Careful observation is needed to determine, first, whether the unfossiliferous limestone is, in fact, of fresh-water origin and, second, whether it is actually at the same horizon as neighboring beds of gypsum. It is conceivable that bodies of fresh water and of salt water existed side by side. It is also conceivable that the bodies of shallow water shifted from place to place as the surface was built up.

If the significance of the gypsum is correctly interpreted, the saline water extended south into New Mexico and east over much of central and eastern Colorado. Because of later erosion, it is not possible now to determine how much of the present mountainous region was covered by it, but the occurrence of the gypsum on both sides of the Rocky Mountains indicates that the marine water may have covered considerable portions of the present mountainous area. The large areas where no La Plata rocks are known render the occurrence of Jurassic " islands " possible. Also, because of erosion, the maximum southern extent of the sea cannot now be determined and because of cover by younger rocks its eastern extent is not known.

It is not easy to picture the physiographic conditions of the Southern Rocky Mountain Province in late Jurassic time. I doubt if there is an area of any considerable size in the world to-day that exhibits an approximation to them. The whole province seems to have been so far degraded that a change of a few feet in the water level of the sea would have shifted the strand line many miles. An advance of the sea over such a peneplain would produce an intricate pattern of shallow, interlacing channels, bays, lagoons, gypsum pans, and salt marshes.

Continental deposits probably continued to accumulate around the sea during the whole period that it occupied the interior of the continent. Following its retreat they must have still continued to accumulate and to cover the marine beds in some places. These accumulations constitute the upper part of the La Plata group, which seems to form a wedge entering from the west and thinning eastward between marine Jurassic beds and those of the McElmo or Morrison formation. The rocks of this wedge are not as regular in thickness as those of the lower La Plata. They thin out to the south and east and also in some places in the midst of the area where the upper La Plata is typically developed. Where these beds are absent, the Morrison and its age equivalents rest on the marine beds or Sundance wherever this formation is present; on the beds of gypsum which are believed to be the age equivalents of the Sundance; or on still older rocks at localities where the marine Jurassic is not present. It seems reasonable to believe that the waters of the Jurassic sea may have been advancing up the old valley during the time that the sediments of the lower La Plata were accumulating; that the gypsum beds represent maximum extent of the sea water; and that the upper La Plata sediments accumulated as the sea was retreating. Hence the marine Jurassic beds, although relatively thin, may be partly equivalent in age to the sandstones of the La Plata group.

As gauged by the thickness of the sediments deposited in it, the sea occupied the Rocky mountain region only a short time. However, these deposits probably represent a longer time than would the same thicknesses of material deposited in a sea surrounded by higher lands. The country to the east of it seems to have been so near base-level that it furnished little detritus. This may explain in part the fact that the Sundance is all there is along much of the eastern margin of this sea to represent the thick Jurassic sediments which gathered farther west.

It was on the graded plain abandoned by the Jurassic sea and the peneplained area surrounding it that the streams of early Cretaceous time spread out the sediments of the Morrison formation. The story of this formation and its significance is well known [1] and that of the relation of the later Cretaceous formations to the Rocky Mountains has already been presented.[2] The papers describing these Cretaceous events, and the present paper, which should have been published first, give the sequence of events, as I picture them, by which the ancient Rockies were peneplained; submerged by the Cretaceous sea; and buried by its sediments, from which they finally emerged at the close of Cretaceous time.

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[1] See Geol. Soc. America Bull., vol. 26, pp. 295-348, 1915. Mock, Charles C., New York Acad. Sci. Annals, vol. 27, pp. 39-191, 1916.

[2] Lee, W. T., U. S. Geol. Survey Prof. Paper 95-C, 1915.

4

Wind-blown sand, old and new, near Tuba, Arizona, showing a recent accumulation of dune sand at the right, and at the left sandstone of La Plata group which is composed in part of ancient sand dunes consolidated into rock. Photograph by H. E. Gregory.

FIG. 1.—Wingate sandstone near Lamy, New Mexico. A massive light red sandstone about 100 feet thick, resting on beds of purple sandstone and shale. Photograph by N. H. Darton.

FIG. 2.—Rocks of La Plata group near Segi Mesas, Arizona, showing the Navajo sandstone above, the Wingate sandstone below, and the space from which the softer shaly beds of the Todilto formation has been removed, now occupied by an ancient cliff-dwelling known as the Keet Steel village. Photograph by H. E. Gregory.

FIG. 1.—Exeter sandstone in northeastern New Mexico, the supposed equivalent of the Wingate sandstone exposed in the south wall of the canyon of the Dry Cimarron, overlain by the Morrison and Purgatoire formations and Dakota sandstone. The sharp line at the base of the light-colored ledge is the unconformity separating the Triassic red beds from the Jurassic. Photograph by W. T. Lee.

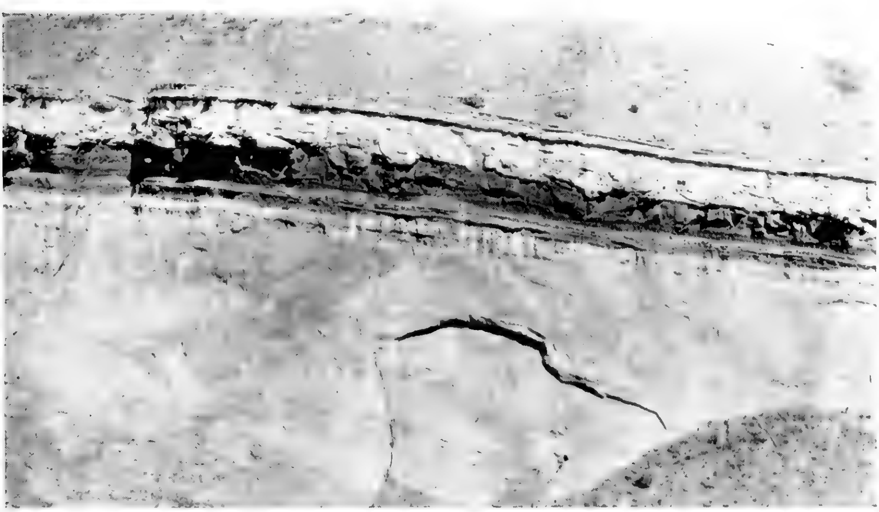
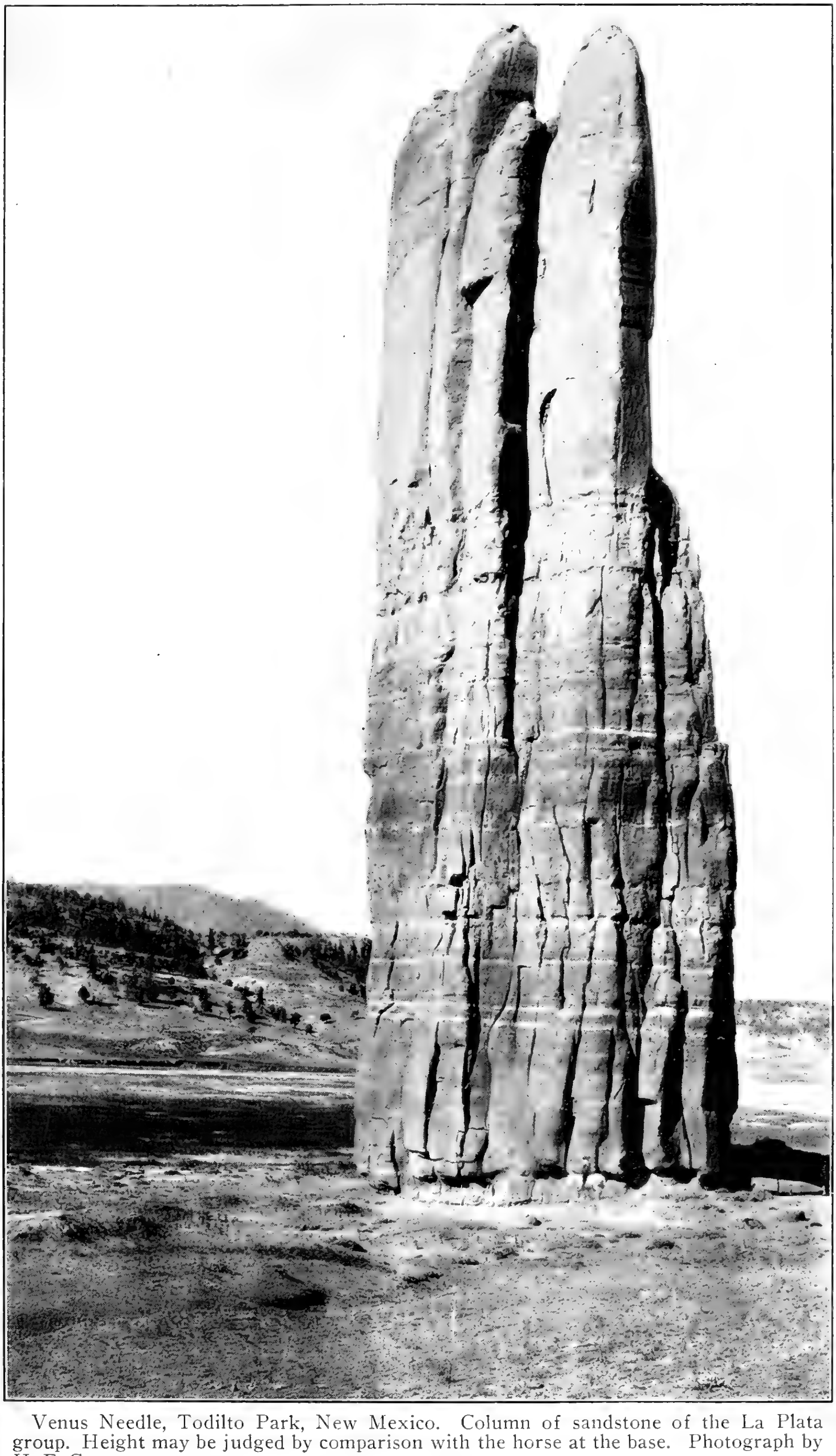


FIG. 2.—The Navajo-McElmo contact in northeastern Arizona, showing the Navajo sandstone below and the McElmo formation above, separated by 3 feet of sandy calcareous shale. Photograph by H. E. Gregory.



Venus Needle, Todilto Park, New Mexico. Column of sandstone of the La Plata group. Height may be judged by comparison with the horse at the base. Photograph by H. E. Gregory.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
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MAMMALS OF PANAMA

(With Thirty-nine Plates)

BY
EDWARD A. GOLDMAN
Assistant Biologist, Bureau of Biological Survey, U. S. Department of Agriculture

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(With 39 Plates)

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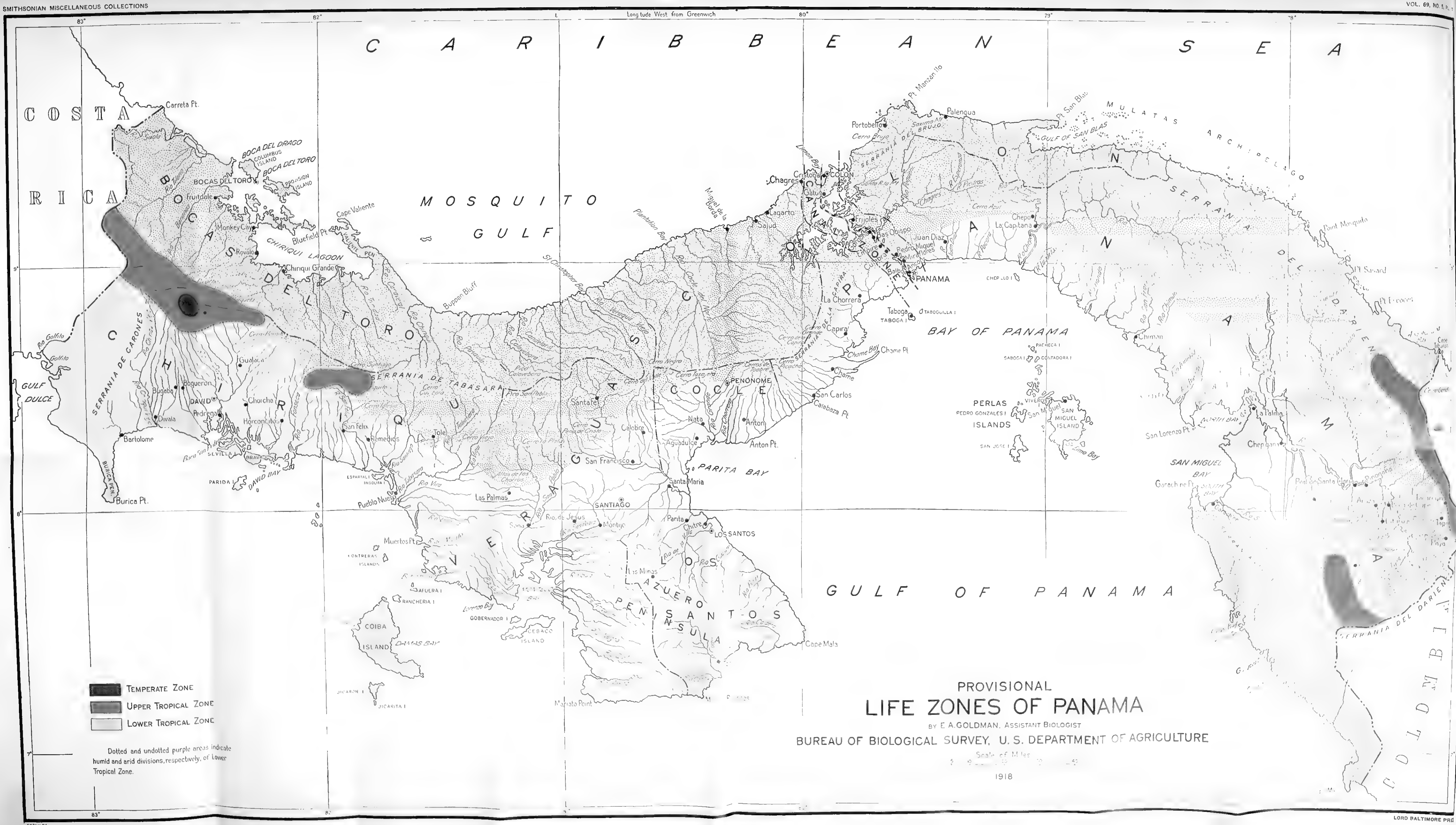
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Dotted and undotted purple areas indicate humid and arid divisions, respectively, of Lower Tropical Zone.
PROVISIONAL
LIFE ZONES OF PANAMA
BY E. A. GOLDMAN, ASSISTANT BIOLOGIST
BUREAU OF BIOLOGICAL SURVEY, U. S. DEPARTMENT OF AGRICULTURE
Scale of Miles
1918
LORD BALTIMORE PRESS

TEXT FIGURES

INTRODUCTION

The following report contains an account of all the mammals known to occur in Panama. It is based mainly on the material gathered in the course of the biological survey of the Panama Canal Zone, undertaken in 1910 by the Smithsonian Institution with the approval of the President of the United States and in cooperation with various government departments including the Department of Agriculture and the War Department. The initiation of the survey at this time was due to a realization on the part of naturalists of the importance of making field investigations before the completion of the Panama Canal, when disturbed natural conditions would be likely to complicate problems of geographic distribution in this important region. While the author was assigned to investigate the mammals and birds, and somewhat incidentally the reptiles and amphibians, the personnel of the survey also included field naturalists representing various other branches of natural history. In the preparation of the present report specimens of mammals in various museums have been examined and published records referred to in order to bring together as complete data on the subject as practicable.

The region is of surpassing biological interest, owing to peculiar configuration, varied topography, and geographic position, forming as it does a slender artery blending the complex elements or converging life currents of two continents, and through which countless migrations of non-volant terrestrial animals probably passed during the Tertiary or early Quaternary ages. But of recent migratory movements in the region we have no evidence, and how effective a barrier the completed Panama Canal may prove to be in limiting the distribution of species remains to be determined. The country, said to have been named " Panama " from an Indian word meaning rich in fish, might with equal propriety have received an appellation meaning rich in mammals, or birds.

FIELD INVESTIGATIONS

WORK CONDUCTED BY AUTHOR

In December, 1910, I was detailed by the Chief of the Biological Survey, United States Department of Agriculture, to field work in Panama and arrived in the Canal Zone for that purpose on the 28th day of the month. Proceeding at once to Culebra, the administrative headquarters for the construction of the Panama Canal, I met Colonel (now Major-General) George W. Goethals, the Chairman and Chief Engineer, who expressed the desire of the Isthmian Canal

FIG. 1.—Camp on Cerro Azul. A palm-thatched roof affords shelter from the hardest rain.

FIG. 2.—Field party resting on slope of Cerro Azul. The most practical route is up the bed of a stream.

FIG. 1.—Rio Indio, a small tidal tributary of the Rio Chagres near Gatun, Canal Zone. A favorable collecting ground for mammals and birds.

FIG. 2.—Tidal forest along lower course of Rio Chagres, showing trees with characteristic buttressed bases and aerial roots.

Commission to do everything possible to further the work. A day or two was spent in examining the canal route, and Gatun was chosen as the most favorable point from which to prosecute field work in the Gatun Lake area. Field investigations were begun in that region owing to the obvious importance of making as thorough collections as possible before the biological changes resulting from the transformation of a forest into a lake 164 square miles in area should take place.

For aid in the field I was fortunate in securing Mr. Adan Lizano whose training and experience as taxidermist of the Museo Nacional of Costa Rica rendered him an invaluable assistant. In addition to study and collection of the mammals much time was devoted to the birds, and smaller collections of reptiles and amphibians were made. While the work for the season was concentrated largely in the Gatun Lake area, collections were also made at various localities along the line of the Panama Railroad south to the Pacific coast and at points to the east of the Canal Zone.

On the morning of March 17 we left Panama by launch for Chepo, about 40 miles to the east, en route to the mountains near the headwaters of the Chagres River. Early in the afternoon we entered the broad mouth of the Bayano River and ascended for about 12 miles between lines of low tidal forest to Hato Bayano at the mouth of the Mamoní where we were landed, and the launch continued on up the Bayano to the property of the Bayano Lumber Company. The Bayano is here a large, deep stream with low, but usually rather steep, muddy banks left exposed at low tide. Many alligators, sunning themselves in places where the bank receded, slid slowly into the water as we approached. A dugout canoe was secured and late in the evening our outfit was taken on the high tide to the head of navigation about three miles up the Mamoní River. Leaving our outfit for the night we continued on foot about three miles farther to Chepo, a rambling native village of about 1,000 inhabitants. Chepo is situated on the west bank of the Mamoní River, and near the edge of the most easterly of the open savannas which extend at intervals along the Pacific coast to beyond the Costa Rican frontier. Six or eight miles north of the town a wooded ridge, rising rather steeply from the coastal plain, extends eastward from the main range of the interior, and maintains a general height of about 1,000 feet to the point where it ends rather abruptly in an elbow of the Mamoní. Our objective point was the Cerro Azul, a dominant peak about 3,000 feet high near the continental divide, northwest of Chepo. Two days were spent in outfitting. Small ponies were secured for use as far as the base of the mountains, and native packers for work on the steep, forested slopes.

On March 20 we left Chepo and traveled about 20 miles, mainly in a westerly course over the "sabanas," crossing the Rio Pacora and turning northward into the forest which forms here a heavy, unbroken cover from the basal slopes of the mountains to their summits and across the Isthmus to the Atlantic coast. The line of demarcation is sharply drawn and we passed almost at a single stride from the broad expanse of brilliantly sunlit savanna into the somber depths of the forest. The pack animals were sent back, and the following day our porters moved the camp equipment about three miles up stream courses, through rough, rocky country to a place called "Cabobré," at 800 feet altitude, on a branch of the Rio Pacora.

A palm-leaf shelter was erected and a comfortable permanent camp established for work on the mountains. Myriads of tiny ticks and innumerable larger ones were, however, found somewhat troublesome at this locality.

Taking two porters, provided with machetes for clearing a trail, and a native hunter, I ascended from camp to the summit of Cerro Azul, March 22. Except in a few places the way was only moderately steep, the most difficult part being at the lower levels where the most practicable route was along stream beds strewn with large, smooth, slippery boulders. Especially when wet these boulders afford a very insecure foothold and several of us were precipitated into the stream, much to the amusement of the remainder of the party. On the upper slopes the forest is of smaller but denser growth, and evidences a much more humid climate above 2,000 feet elevation. The summit, at 3,000 feet, and north slopes for at least 500 feet below, are clothed with a dense growth of low trees, loaded with moss, orchids, and bromeliaceous plants, and similar vegetation is massed in places upon the ground. The Cerro Azul is the highest peak of a range extending north of east from Culebra, increasing in height toward the eastern end west of the Pacora River. Owing to the heavy forest no very clear view could be obtained toward the northwest from the summit, but in that direction a lower range evidently connects with the mountains along the Atlantic coast and separates the Chagres and Pacora watersheds. The northern and eastern slopes are steep and descend to the Pacora, the upper course of which is through rugged country, the river partially encircling the mountain. The air was hazy, but over low, uniformly forested mountains toward the northeast the Caribbean Sea could be seen;

FIG. 1.—Forest along lower course of Rio Chagres, Canal Zone.

FIG. 2.—Forest, extensively invaded by tide, along lower course of Rio Tuyra.

FIG. 1.—Tidal forest, largely mangroves, near Porto Bello.

FIG. 2.—Tidal forest interior near Porto Bello.

also small islands and what appeared to be the western shore of the Gulf of San Blas. The Pacific coast was much more clearly visible, the shore line standing out sharply from near the mouth of the Bayano River as far west as Panama. The dry season was at its height and the coastal plains or "sabanas" resembled a vast, irregular checker-board, the brown areas of grass-land being separated by narrow, parallel belts of green forest marking the courses of streams. The checker-board, or patched appearance, was heightened by numerous lines of fire, advancing over the savannas and leaving blackened areas in their wake.

Exploration, mainly of the upper slopes of Cerro Azul, was continued for several days and on March 27 we returned to Chepo, arriving opportunely to find a launch on which we were able to engage passage to Panama on the following day.

Field work in the Canal Zone was resumed at various points and pushed steadily until May 22, when transportation on a Government tug was secured to Porto Bello. This town is situated on a small bay about 25 miles northeast of Colon. At the Government rock quarry, the source of the supply of much material used in Canal construction, quarters for a large force of men were maintained, and ample facilities afforded for our investigations in the immediate vicinity. Mountains with peaks, including the Cerro Brujo, rise rather steeply to over 3,000 feet, and closely parallel the coast line southward and westward; a lower spur to the north terminating in the rock quarry, encircles the watersheds of the Rio Cascajal, Rio Moré and other short streams converging to the head of the bay. The general shore line is rugged, but mangrove lagoons and swamps occur near the mouth and along the lower course of the Rio Cascajal. The period from June 3 to June 9 was devoted to exploration of the Cascajal River and slopes of Cerro Brujo. Camp equipment was carried by Jamaica negroes who were unaccustomed to such work and proved to be inefficient woodsmen.

The rainy season had begun and the first day out from Porto Bello slow progress was made in traversing swampy country along the lower course of the Cascajal River. Certain boggy areas were crossed by stepping from one small tussock of grass to another. These tussocks, when not too widely spaced, enabled us to pass comfortably over a number of dangerous places, but in spite of great care several members of the party slipped off and, hampered by heavy loads, required prompt assistance in extricating themselves from ooze of unknown depth into which they were rapidly sinking.

Camp for the night was made on the bank of the river where shelter from nearly continuous rain was secured by covering an abandoned native hut with a tent fly. On the following day the swamps were left behind and, as in many other parts of Panama, we found the most practicable route lay along the bed of the stream. Accordingly, we entered the river and waded steadily for eight or ten miles, the water varying from a few inches to waist deep, and care being necessary to avoid the deeper places. The difficulties increased as we advanced toward the interior, as the river banks, at first low, became high and finally merged with the steep general slopes of mountains whose tops were no longer visible, and the bed of the stream assuming a sharper angle became littered in places with huge boulders. The day had been partially clear, but late in the afternoon it began to rain very hard, the river rose several feet in a few minutes and we were obliged to camp at a point on the left bank, indicated by bearings to be about abreast of Cerro Brujo, and which I later decided to use as a base for general work. Poles were cut to form a frame work over which long palm fronds were placed in overlapping position, and a secure shelter from the hardest rain was soon finished. One of our most difficult problems here was to build and maintain a fire. Matches, even when kept well covered, soon absorb sufficient moisture to become unreliable under forest conditions during the rainy season. The natives of the region use flint and steel to generate the spark, which is projected into a small charred roll of cotton cloth kept dry and carefully guarded for the purpose. A smouldering fire in a point of the cloth is used to ignite kindling, and charred remains are always preserved for future use. The only material we found dry enough to burn was the hard heartwood of certain trees, and as we carried only machetes the securing of this firewood entailed considerable labor. Moreover, when gathered, it burned so slowly that the fire barely sufficed for our scanty cooking operations, leaving practically no surplus for drying purposes. I kept one suit of clothing dry for wear in camp, but was obliged each morning to don wet garments for work in the forest.

Wishing to reach as high an elevation as possible on the mountain, the contours of which were difficult to determine, our camp being on the main stream in the bottom of a gorge, a trail was cut through the forest along a narrow ridge between two tributaries whose size indicated distant sources and that the ridge was a spur of the main range. Slopes of varying steepness were encountered and an altitude of about 2,000 feet was reached at a point from which Cerro Brujo,

FIG. 1.—Old line of Panama Railroad, abandoned and nearly submerged by rising waters of Gatun Lake. Looking from Gatun Dam toward Lion Hill, April 30, 1911.

FIG. 2.—Gatun Lake with water rising. New canoe landing near Gatun; old line of Panama Railroad in distance, April 30, 1911.

FIG. 1.—Destruction of forest by rising waters of Gatun Lake.

FIG. 2.—Destruction of forest by rising waters of Gatun Lake.

or a peak in its vicinity, was clearly visible. The outlook from a towering rock showed that our route had been well chosen as it had led steadily upward while jumbled ridges lay to the right and left across deep canyons; but we were separated from the mountain by a rugged depression several hundred feet deep beyond which the main peak rose almost sheer at least 1,000 feet above us. A steep slope to the right appeared practicable for an ascent to the top, but several days had been devoted to working up to this altitude in almost steady rain. With heavy showers frequently recurring and hampering operations, specimens could not be dried and began to mold, and we were forced to retrace our way down the river to Porto Bello where we arrived the evening of June 9, and returned to the Canal Zone, June 14.

Field operations became increasingly difficult owing to the heavy rains and it was decided to discontinue them for the season. I sailed for New York June 24 on the steamer "Colon" and arrived in Washington, June 30.

At the end of the rainy season plans were matured for continuing field work in the Canal Zone under the same auspices, and I left New York for the Isthmus January 9, arriving at Colon on the steamer "Panama" January 15, 1912. Comfortable and convenient quarters at Empire were assigned to me by the Isthmian Canal Commission, and work was at once resumed, largely along the line of the Panama Railroad. My Costa Rican assistant of the previous year, Adan Lizano, was unable to rejoin me and I engaged George G. Scott, who rendered faithful and efficient services throughout the season. Special attention was given to the Gatun Lake area, in the lower parts of which final preparations were being made for raising the water level. Many old houses in process of being demolished afforded unusual opportunities to capture specimens of rare bats. For this same purpose a trip was made about the end of January to caves on the Chilibrillo River, a small tributary entering the Chagres River near Alhajuela at the extreme upper end of the proposed lake basin. The caves were reported to contain remarkable colonies of bats, which would be driven out by the rising water. Water was found flowing through the caves which were formed by large rifts in the limestone formation with numerous lateral chambers resulting from water erosion. One of the larger of the latter was circular, 30 to 40 feet in diameter and about 25 feet from floor to roof. This chamber was totally dark and to the roof large bats of the genus *Phyllostomus* were clinging in dense patches. Several tons of bat guano on the floor evidenced the occupation of the cave for a long period. Bats of several other species were located in smaller caves and clefts in the vicinity.

Collections of the more easily obtainable species of mammals and birds of the Canal Zone being now fairly complete, a trip to eastern Panama was decided upon in order to determine the relation of the fauna of the Canal Zone to that of South America. In accordance with this plan, arrangements were made through Mr. Pablo Pinel, the Panama agent of the Darien Gold Mining Company, Ltd., to visit the San Miguel Bay region and the company's plant, a favorable location for work in the high mountains near the Colombian frontier. We sailed from Panama on the little steamer "Cana," the evening of February 21. Early on the following morning we were off the mouth of San Miguel Bay. The mangrove-fringed coast was low and no high mountains were at first visible, but the abrupt slopes of Mount Pirre soon began to loom on the southeastern horizon and increased in distinctness as we bore in that direction. The entire day was spent in steaming up the bay and estuary of the Rio Tuyra. Short stops were made at La Palma and Chepigana, native villages, built mainly of palm-thatched houses picturesquely grouped on the southern shore. Along the northern side of the Tuyra, extensive tidal forests included an abundant growth of "cocobola" (*Dalbergia retusa*), the hard wood of which was being cut by a Chinese company for use in the manufacture of knife handles and for other purposes. Anchor was cast in the mouth of the Chucunaque River about dark in the evening, and we were obliged to wait an hour for the tide to rise high enough to enable the little steamer to proceed, arriving about 9.30 p. m. at Marraganti, the station of the Darien Gold Mining Company, near the head of steam navigation, about one and one-half miles above the town of Real de Santa Maria. We were cordially welcomed by the agent, Mr. Pedro Campagnani, to whom I became much indebted for courtesies extended at various times during my stay in the region. On February 23 we continued up the Rio Tuyra about 30 miles by dugout canoe, or "piragua," to Boca de Cupe. Unlike the dugout canoes of the Canal Zone the piragua of this region is truncated and has a platform for the canoeist at each end, admirably adapting it for poling, the native method of progressing either up or down stream. The river banks are low and rather uniformly forested to near the edge of the water, the gigantic "cuipo" trees (*Cavanillesia platanifolia*) presenting striking features and tending to relieve the general monotony. We

FIG. 1.—Rio Tuyra at Boca de Cupe, June 17, 1912

FIG. 2.—Rio Cascajal near Porto Bello, May 25, 1911.

FIG. 1.—Cuipo tree (*Cavanillesia platanifolia*), a giant of the semi-arid forest ranging from South America north to the Canal Zone.

FIG. 2.—Base of Cuipo tree showing characteristic buttresses and trunk expanded above them.

arrived after nightfall and the piragua was half dragged over shoals by the men who were obliged to jump into the water in places and hold the bow and stern in their hands. The river was very low, owing to the long drought, and the current sets heavily at this season through narrow places which become difficult to navigate in the dark. Boca de Cupe, the last village of importance on the Tuyra, connects with the tramroad to the mines at Cana, in the mountains, 30 miles southward. The first stage of the journey over the tramroad was by a short train drawn by a gasoline motor; this section of the line ending at Mount Kitchener, in the lower foothills of the mountains. Beyond this point the track, winding in tortuous curves up the steep mountain side, was suitable for lighter traffic only, and the 12 miles to Paca were slowly and laboriously traversed by push car, a platform placed on trucks and pushed by men from behind. In descending, the cars, allowed to run by gravity, were rather insecurely controlled by coils of rope wound on the axles. At Paca we were met by a mule-drawn car running to the mines, six miles farther.

The Darien gold mines are located at 2,000 feet altitude near the southeastern base of Mount Pirre, the name applied to the crest of a short range projecting northward from the continental axis formed by the Serrania del Darien. A small plateau, or slightly sloping valley, at about 1,800 feet, extends from near the town across to Mount Setetule, a prominent peak about 4,000 feet high near the center of the amphitheatre formed by the crescentic curve of the mountains bounding the upper Tuyra watershed. Numerous converging streams, principally the Rio Cana, Rio Seteganti, Rio Escucha Ruido and Rio Limon unite in the marshy valley to form the Rio Grande, a local name applied to the upper trunk of the Rio Tuyra. The history of the mines is romantic, dating as it does from the early part of the 16th century when the Spaniards were probably guided to the locality by the Indians. In the 17th century they were reputed to be among the richest gold mines in America, at one time attracting a population of 20,000. They are said to have been reached during this period by a paved road over the mountains from Real de Santa Maria; unbroken forest now covers the route and no one seems to know the exact course followed. Raids by buccaneers and Indian troubles led to their final abandonment by the Spaniards in the 18th century. About 30 years ago they were reopened by an English company, and at irregular intervals have since produced much gold. Various bodies of rich ore are said to have been exhausted and operating companies became bankrupt before reorganization and further development led to the discovery of new lodes. At the time of our visit a French company was in possession and through the courtesy of the manager, M. Masse, and directors, M. Michel and M. Degoutin, comfortable quarters, transportation and other facilities were provided, without which much of the work accomplished would have been difficult or impossible. The mines were almost ideally located as a base from which to carry on field investigations. Heavily forested mountain slopes cut by numerous streams were of easy access behind the town, while open fields, old clearings and marshy meadows in the valley added to the wealth of environmental combinations.

From February 24 to April 11 work was pushed as rapidly as possible, mainly at various levels from 1,800 to 3,500 feet altitude in the vicinity of the mines.

In early March two days were devoted to a trip to the crest of Mount Pirre to locate a convenient point from which to carry on more extensive exploration of the upper slopes. Although only five or six miles distant from the mines, the top of the range is almost unknown, except to the Choco Indians. An old Indian route along the crest is distinct in places and obliterated in others. Choosing a ridge between the canyons of the Rio Escucha Ruido and the Rio Limon a trail was cut through the forest from the Cana Valley to the summit near the extreme headwaters of the latter stream where my aneroid, set at the known elevation at the mines, and carried up the same day, recorded an altitude of 5,300 feet, and a spring at 5,100 feet was fixed upon as a field base. The dry season affecting the general region was at its height, but above about 4,500 feet we entered a zone shut in by clouds and the forest dripping with moisture contrasted strongly with the arid conditions prevailing a short distance below.

In the latter part of March a week spent at Marragantí enabled me to secure rare material in the tidal area under the favorable conditions afforded by the long drought and resulting low water.

Early in April several thunder storms occurred, but the weather at the gold mines still continued generally dry, and the air became very noticeably hazy, a condition regarded by the people as presaging the coming of the rainy season. Meanwhile the stridulation of cicadas had increased in volume until the notes of many insects often blended in a shrill, vibrant chorus loud enough to interfere appreciably with the detection of other forest sounds.

About this time a swarm of grasshoppers appeared suddenly in some abandoned brush-grown clearings near the gold mines. The insects covered the vegetation over an area 40 or 50 acres in extent so thickly and fed so voraciously that all leaves and tender twigs disappeared in a few hours; and the weight of their bodies broke down many bushes an inch in diameter. They soon disappeared, rising and flying off over the forest, leaving the affected area as sharply outlined as though it had been swept by fire.

On April 12 field equipment was transported by men from the mines to the spring which had previously been chosen on the watershed of the Rio Limon about 200 feet below the crest of Mount Pirre. A small clearing was cut in the forest and a palm-thatched shelter soon erected. We found conditions about as at the time of our brief visit in March, but after April 20 heavy showers became increasingly frequent, indicating the opening of the rainy season. When there was no rain, mist and fog continued to envelop the upper slopes, except for brief intervals during which certain vantage points afforded excellent views of the Serrania del Darien across the Tuyra Valley. The higher mountains visible to the northeast in the vicinity of Mount Tacarcuna appeared to reach about the same height as Mount Pirre. From the Pirre range Vasco Nuñez de Balboa is believed to have discovered the Pacific Ocean in 1513. My outlook in that direction was always obstructed by distant cloud banks or nearer forested ridges converging into the valley of the Rio Tucutí. The cloud effects were sometimes marvellously beautiful, especially in early morning, when distant peaks simulated islands emerging from a frozen sea, or a rift in the floating barrier disclosed the play of a thousand lights and shadows on the dark forest beneath. But such scenes were seldom enjoyed for, although the mountain slopes are steep, they are in few places precipitous, and the dense forest seldom permits an unobstructed view in any direction.

With the progress of the rainy season toads and frogs of widely varying size and form became numerous. As night approached, their peculiar irregularly mingled calls coming from everywhere, in the trees as well as on the ground, began to break the general stillness characteristic of the higher altitudes, and were continued until long after dark. In attempting to secure a specimen that attracted attention in the twilight one evening, it slipped through my fingers, as such amphibians are prone to do, and I was surprised to find that several tadpoles were left in my hand. Other examples of the same species were soon found, bearing six or seven young upon their backs. A strictly nocturnal note, apparently the stridulation of a cricket or other orthopterous insect was heard only at this locality. The note, cr-r-r-i-i-ick-ít, prolonged tremulously, with a short pause followed by a sharply emphasized terminal syllable was repeated monotonously throughout the night.

Investigation of the various slopes above 4,000 feet was continued until May 6 when we descended to the mines with a valuable collection, which had been dried and maintained in that condition by a camp-fire kept constantly burning. Collections were packed, and I embarked on the first boat for the Canal Zone in order to insure their prompt shipment to Washington and to secure much needed supplies, returning to the Darien region on the same boat, May 17. On May 18, the Tuyra was again ascended by canoe from Marraganti to Boca de Cupe. The river had risen about six feet during the previous night and the strong, dark flood extending from shore to shore contrasted strongly with the clear, shoaly stream up which my men had poled in February. On the following day the journey over the tramroad to Cana was delayed at several points where cuipo trees had fallen across the track. These giants of the forest have comparatively short roots and their hold in the earth is obviously insecure. During storms, especially in the rainy season, numbers of them topple over. The wood is very soft and spongy, and a tree that I chanced to see fall began crumpling in the air and landed in a crushed mass at the bottom of a small canyon.

Field work, temporarily interrupted, was resumed in the vicinity of Cana, May 20. The fauna of the region, especially the birds to which much attention was devoted, seemed inexhaustable. Important additions to collections were made almost daily until June 13, when we returned by the railroad to Boca de Cupe. A week was spent at this point, where the altitude is about 250 feet, and a number of lowland species of mammals and birds were secured. On June 20 we descended the river to Marragantí. A few specimens were obtained the next day and preparations made for embarking on the steamer "Cana" for the Canal Zone, June 22. The steamer sailed at 10 a. m. and made the usual stops at Chepigana and La Palma in passing down the estuary. The aspect of the forest along the shores had changed markedly in appearance, having assumed a brighter green since the advent of the rainy season. Shortly before dark the little steamer began to rock unsteadily in the confused currents of San Miguel Bay, and the receding shore line was suddenly blotted out by a torrential downpour of rain. We reached Panama at

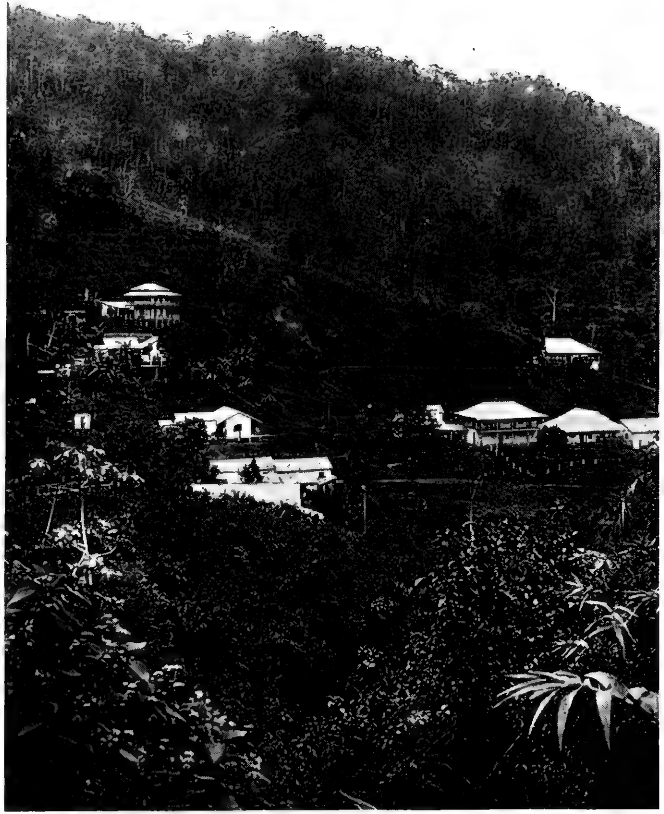

FIG. 1.—Cana, eastern Panama, altitude 2,000 feet, showing adjacent forested slopes. Here are located the Darien Gold Mines.

FIG. 2.—Cana, Panama. Looking east across Cana Valley, Mount Setetule in far distance.

FIG. 1.—Humid Lower Tropical Zone near Cana, eastern Panama, altitude 2,000 feet. Rio Setegantí in foreground; Pirre Range 5,000 feet high in background.

FIG. 2.—Humid Lower Tropical Zone. Forest interior at 300 feet altitude on northern basal slope of Mount Pirre.

11 a. m., June 23, and continued by rail to Empire early in the afternoon. The rainy season being well advanced, preparations were made to return to Washington. On June 27 I sailed from Cristobal on the steamer "Allianca," arriving at New York the afternoon of July 3, and Washington the evening of the same day.

WORK CONDUCTED BY OTHERS

The observations of Lionel Wafer, on which he based his quaint description of the Isthmian fauna in the latter part of the 17th century, furnished for more than 150 years about all that was known of the mammals of the region. While the rich avifauna began to attract attention about the middle of the 19th century, the mammals have, until recently, been neglected; the specimens available for study being limited to a small number taken incidentally by residents, travelers crossing the Isthmus, exploring parties, and collectors who devoted their chief attention to other branches of natural history.

Among the earlier workers was Mr. Thomas Bridges, who arrived at David, Chiriqui, in January, 1856, and remained there until March collecting orchids, also obtaining five species of mammals, as recorded by Sclater (1856, p. 139). Another early visitor to western Panama was the Danish traveler, Andreas Sandøe Örsted, for whom the titi monkey of the region was named by Reinhardt (1872, p. 157).

Enrique Arcé, a native of Guatemala, collected for Messrs. Osbert Salvin and F. Du Cane Godman in Guatemala and Costa Rica, and proceeded about 1865 to Panama, where several years were spent in collecting at various localities in the vicinity of Santiago and in northern Veragua. About 1869 or 1870 he visited David and the Volcan de Chiriqui. His collections were mainly of birds, but a few mammals were sent to the British Museum.

It was not until the year 1900 that mammal collecting by modern methods began in earnest. In March of that year Mr. Wilmot W. Brown, Jr., who was employed by Edward A. and Outram Bangs, began work in Panama that was prosecuted with remarkable success for about a year and a half. Very large bird collections made by him did not preclude the accumulation of extensive series of the mammals. Mr. Brown's first station was Lion Hill, on the Panama Railroad, where, however, few mammals were obtained, the locality being of special ornithological importance. The period from the latter part of April to the middle of May was devoted to a trip to San Miguel, the largest of the Pearl Islands in the Bay of Panama, where he secured specimens representing practically all of the species of land mammals that occur there, with the possible exception of some bats. Transferring his activities to western Panama he spent nearly a year in intensive work centered in the area between the Pacific coast at David and Pedregal and the summit of the lofty Volcan de Chiriqui. The intermediate localities visited were Divala, Bugaba and Boquete. The results of this work, which also included birds, covering a section with an altitudinal range from sea level to over 11,000 feet, were published by Outram Bangs (1902)[1] and constitute one of the most important contributions to our zoological knowledge of a single area in Middle America. Under the auspices of the John E. Thayer Expedition of 1904, Mr. Brown made a second trip to the Pearl Islands in February, March and April of that year. He visited San Miguel, Saboga and Pacheca islands, but added few mammals to the collection made in 1900. The greater part of May, 1904, was spent by Mr. Brown at Caledonia, near the city of Panama and on the edge of the savanna of the same name, making general collections of vertebrates, especially birds, the locality proving to be poor in mammals.

In 1900 and 1901, while Mr. Wilmot W. Brown, Jr., was engaged in field work in western Panama, a part of the same region was visited by Mr. J. H. Batty. Mammals were collected by him mainly at or near Boqueron and Boquete, but also on Coiba and other islands near the coast. His collection aggregating over 1,000 specimens was divided, a part being acquired by the Hon. Walter Rothschild and a part sold to the American Museum of Natural History. It formed the basis of papers published by Mr. Oldfield Thomas and Dr. J. A. Allen, tending to amplify data in the general field covered by Mr. Outram Bangs. Mr. H. J. Watson, the owner of extensive plantations at Bugaba, Chiriqui, began sending many mammals to the British Museum prior to 1900. Those proving to be new were described at intervals, mainly by Mr. Oldfield Thomas, thus adding further to the comparatively full knowledge of a restricted area in southwestern Panama.

Dr. Thomas Barbour visited the Isthmus early in 1909. From headquarters at Ancon excursions were made between the last of February and the first of April to various points in the Canal Zone, and to some of the islands in the Bay of Panama. His collections were mainly of anatomical and embryological material, including a considerable number of bats from San Pablo. A few bats and other

[1] Accounts of birds were published as follows: Auk, Vol. 18, pp. 355-370, Oct., 1901; Proc. New England Zool. Club, Vol. 3, pp. 15-70, Jan. 30, 1902.

mammals were also collected at various localities by Mr. Henry Pittier, Mr. W. R. Maxon, Dr. S. E. Meek, Mr. S. F. Hildebrand and Mr. August Busck, members of the Smithsonian survey party engaged chiefly in other investigations.

In February, 1912, Mr. Wilfred H. Osgood and assistant passed through the Canal Zone en route to South America, and while waiting about a week for the steamer at Balboa collected mammals, mainly bats. One of the results of his brief work at that point was the re-discovery of *Liomys adspersus* Peters, the exact habitat of which was previously unknown.

During the years 1914 and 1915 several collections were made in Panama for the American Museum of Natural History. In February and March Mr. George Shiras, 3d, well known as a student and photographer of North American mammals, visited the Canal Zone. His work centered in the Gatun Lake area and the results were published the following year. Mr. Shiras was accompanied by Mr. H. E. Anthony, who secured collections of mammals. In October, 1914, the American Museum of Natural History sent Mr. William B. Richardson to eastern Panama, where he collected mammals and birds in the lowlands of the Tuyra Valley until the middle of February, when he met Mr. H. E. Anthony and Mr. D. S. Ball, of the same institution, at Panama. The party outfitted and on February 8 proceeded by launch to Real de Santa Maria. From this point it ascended the Rio Tuyra to the limit of canoe navigation at Tapalisa. Richardson remained at Tapalisa several weeks, while Anthony and Ball continued into the mountains to the old Indian village of Tacarcuna, where collecting was carried on at an elevation of 2,600 feet. Late in March a camp was established for work at 5,200 feet altitude on the upper slopes of Mount Tacarcuna. About the middle of April they were forced by the rainy season to abandon work at the higher elevations. Mr. Anthony and Mr. Ball returned to New York, but Mr. Richardson spent the latter part of April and the month of May collecting at Cituro and Boca de Cupe, in the lowlands of the Tuyra Valley. A general report on the mammals obtained by these expeditions has been published by Anthony (1916).

While the Canal Zone and other limited sections of Panama are now fairly well known, large areas, including important mountain ranges, remain unexplored. One of the least known parts of Panama is the elevated region between the headwaters of the Rio Bayano and the Rio Chucunaque, an area until very recently, at least, controlled by the San Blas Indians, and from which other natives of Panama, as well as foreigners, were excluded. The region tempted native rubber gatherers inhabiting adjoining territory, who informed me that a spear set in the middle of trails was recognized as a dead line beyond which they passed at their peril. Exploration of mountain ranges between the Canal Zone and the lofty Volcan de Chiriqui would add much to our knowledge of the distribution of many mountain mammals now known only from the extreme eastern or western parts of the republic.

ACKNOWLEDGMENTS

While engaged in field operations in Panama material assistance was received from many persons, some of whom it is impracticable to mention by name, but to all I extend most sincere thanks. Special acknowledgments are due first to Colonel (now Major-General) George W. Goethals, who, as Chairman and Chief Engineer of the Isthmian Canal Commission, furnished transportation, quarters and other facilities, and whose unfailing kindness and courtesy contributed to the pleasure as well as the success of work in the Canal Zone. Other officers to whom special credit should be given are the division engineers, the late Colonel D. D. Gailliard, Colonel (now Major-General) William L. Sibert, and to Chief Quartermaster, Colonel (now Major-General) C. A. Devol; also District Quartermasters Robert M. Gamble, James H. K. Humphrey and Walter G. Ross. Appreciation of the aid of my field assistants, Adan Lizano and George G. Scott, as well as various officials of the Darien Gold Mining Company, has already been expressed in these pages, but I wish to emphasize it again here.

In order to complete the account of the mammals of the region, those of western Panama have been included in the report. For the unrestricted use of material and other favors my thanks are due to the officials of the Museum of Comparative Zoology and American Museum of Natural History, especially Mr. Outram Bangs and Dr. J. A. Allen, under whose direction at the respective institutions the only large collections available from the section named have been brought together. For the loan of certain specimens I am also indebted to Mr. Wilfred H. Osgood of the Field Museum of Natural History. Most of the names of plants used in zone lists have been kindly furnished by Professor Henry Pittier, who had charge of the botanical section of the survey and is the authority on the flowering plants of the region. For a list of characteristic grasses I am under obligations to Professor A. S. Hitchcock. The heads of bats figured were drawn under my direction by Mrs. Ruth Collette Moore.

PHYSIOGRAPHY

The Republic of Panama extends in a sigmoid curve from east to west between the meridians of 77° 15′ and 83° 30′ west from Greenwich and parallels 7° 10′ to 9°-40′ of north latitude. It varies in width from less than 50 miles at the Canal Zone and at the constriction between the mouth of the Rio Chepo and the Bay of San Blas to over 100 miles at the Azuero Peninsula. The most northern points, the small islands and curved coast line about 30 miles northeast of Colon and the disputed territory adjoining Costa Rica northwest of Almirante Bay are in about the same latitude. Except for the Chiriqui Lagoon the northern coast line forms a nearly undented S-shaped curve. The southern coast line, on the contrary, is very irregular. There are numerous inlets or bays, and several peninsulas form prominent salient features. The bays are mainly small, but the Gulf and Bay of Panama together occupy a deep concavity in the eastern section. The smaller bays are mainly the tidal estuaries of the numerous rivers, some of which are of large size. The estuary of the Rio Tuyra permits small steamers to ascend to Real de Santa Maria, about half the distance from the outer shore line across to the Atlantic coast. East of the Gulf of Panama the territory claimed by the republic includes the coast line south to near the mouth of the Rio Juradó in about the same latitude as the southern end of the Azuero Peninsula, which in broadly extended outline bounds the Gulf on the west. Another prominent feature of the southern coast is the narrow Burica Peninsula, a prolongation of the Serrania de Carones near the Panama-Costa Rican boundary. The largest outlying land area is Coiba Island, off the southwestern coast. Immediately south of it is the much smaller island of Jicaron. Numerous small islands lie close to the adjacent coast, of which some of the more important are Cebaco and Leones islands in Montijo Bay, and farther west Insolita, Espartal, Brava, Parida and Sevilla islands. The second largest island is San Miguel, or Rey Island, in the Bay of Panama, which with smaller neighboring islands forms an archipelago known as the Pearl Islands. These islands are rather low, but rugged in contour, with eroding coast lines like those of parts of the adjacent mainland. Taboga Island, a few miles off the Pacific terminus of the Panama Canal, is a health resort utilized during the French as well as American canal construction. Small islands are numerous along the northern coast, but aside from the low, forested archipelago separating the sea from Almirante Bay and the Chiriqui Lagoon, are relatively unimportant.

The general land surface is hilly and irregular, but the only very high mountains are in the extreme western part, where an extension of the highlands of Costa Rica crosses the international boundary about midway between the two oceans and culminates at about 11,500 feet in the volcano of Chiriqui. The higher areas to the east are little known, but the continental divide evidently follows a tortuous course owing to echelon arrangement or other irregularities in the continuity of the principal mountain ranges. It approaches the Pacific side in the vicinity of the Canal Zone and bearing thence diagonally northeastward across the Isthmus continues eastward close to the Atlantic coast, finally curving strongly southward and again approaching the Pacific coast west of the Atrato River Valley.

The rather ill-defined backbone of the Isthmus is divided by comparatively low passes into several irregular sections in which steep, but not usually precipitous, mountain ranges reach varying elevations, in few places exceeding 5,000 feet. One of these, the Serrania de la Capira, lies between the Canal Zone and the slightly elevated region separating the drainage areas of the Rio Coclé del Norte and the Rio Grande de Nata, near the boundary between the provinces of Coclé and Colon. The Serrania del Brujo, beginning near the Atlantic coast a few miles east of Colon, rises near Porto Bello to 3,000 or 4,000 feet, and partially encircling the Chagres River Valley joins the continental axis near Cerro Azul, a mountain about 3,000 feet high on the crest between the Chagres and Pacora river valleys. A short distance east of Cerro Azul are transcontinental gaps probably less than 1,000 feet in altitude where the headwaters of the Rio Mamoní interdigitate with those of streams flowing north into the Gulf of San Blas. Farther east the long, narrow, curved Isthmian backbone, generally known as the Serrania del Darien, reaches in many places an altitude of 3,000 to 5,000 feet, but the crest is interrupted at various points by passes less than 1,000 feet high. Among the lowest gaps known are those near the heads of the Rio Membrillo, the Rio Sucubti and other tributaries of the Rio Chucunaque, whose sources are within a few miles of the Atlantic Ocean. Farther east is Paya Pass where, except at the dryest season, only a few miles separate canoe navigation on the Rio Paya, a Panama tributary of the Rio Tuyra, and the Rio Cacarica, a Colombian affluent of the Rio Atrato. Mount Pirre is the name applied to a dominant spur, slightly exceeding 5,000 feet in altitude and projecting northward into the Tuyra basin in a crescentic curve with the axial trend of the continent along the Panama-Colombian frontier. The Serrania del

Sapo forms a prominent but little-known range extending from Garachine Point at the southern entrance to the Bay of San Miguel, southward along the Pacific coast to a junction with the main range near the international border.

Aside from the higher mountain ranges that form the Isthmian backbone, a multitude of rather steep, extensively eroded ridges separating narrow river valleys ramify throughout the greater part of the republic. Extensive and fairly level plains occur at various elevations, however, in the province of Chiriqui and along the Pacific coast from the Bayano River west to the Canal Zone.

Owing to the narrowness of the Isthmus most of the rivers are short, and from their sources commonly interdigitating along the opposite sides of the deeply eroded continental divide, flow directly to the sea, but there are several notable exceptions. All of the larger rivers of South America, including the Atrato, flow into the Atlantic; it is therefore of interest to note that in eastern Panama the course of the major streams is reversed in conformity with the abruptly altered trend of the continental mass, and a shifting of the crest from the Pacific to the Atlantic side along the Colombian frontier. The greatest river system of the republic is the Tuyra-Chucunaque. After draining a large and very humid area, these two rivers unite near the middle of the Isthmus and in combination with several other large streams pour an immense volume of water into the Gulf of San Miguel. The second river of the republic in point of size is the Rio Bayano, which takes a westerly course and joining the Rio Mamoní, a much smaller stream, turns southward and under the name Rio Chepo enters the Bay of Panama. The most important river of the Atlantic drainage is the Rio Chagres, whose watershed is an interior basin. The general course of the stream is westerly to a point near where it enters the Canal Zone and bends north to the Caribbean Sea. The Chagres, whose waters are now impounded in Gatun Lake, 164 square miles in area, furnishes the water for operating the locks of the Panama Canal, and through the locks at the southern end of Gailliard Cut a part of its flow is diverted into the Pacific Ocean.

While climatic conditions vary considerably in different parts of Panama, the region as a whole is subject to the influence of two annual seasons, the duration of which are correlated with the direction of the prevailing winds. During the so-called "dry" season the northeast trade wind blowing daily from about the month of December to the month of May, at times with considerable violence.

is accompanied by comparatively light, but not infrequent, precipitation along most parts of the Atlantic slope. At this season rather light cloud formations discharge their moisture along the northern side of the Isthmus, the rainfall of the coast depending in a measure on the height and proximity of the mountains. At the higher elevations fogs are very prevalent, and are often so dense that one's vision penetrates only a few feet, and the dimly lighted forest becomes still darker as the cloud mass settles down; a fine spray drifts through the trees and soon the leaves are dripping steadily. The Pacific coast, in marked contrast, has a true dry season, during which little or no rain falls. During the wet season, beginning usually about the latter part of May and ending about the first of December, southerly winds become dominant and rains are more general throughout the Isthmus. At the Canal Zone, which is a cross-section of the Isthmus about 50 miles in extent, the annual rainfall on the Atlantic coast is about double that on the Pacific coast. Official records for 1909 show a total rainfall of 93.06 inches at Balboa, and 183.41 inches at Cristobal; but the average for 13 years at the former station is 71.67, and for 40 years at the latter station 130.03. This relative humidity of the two sides probably obtains as far west as the Costa Rican frontier, but in eastern Panama the difference is less marked. In much of the Darien region the total rainfall is increased to an annual precipitation of perhaps more than 200 inches[1] which renders this area one of the wettest in America.

Excepting at the Canal Zone and limited areas in western Panama the republic is sparsely populated by man; clearings are few, and aside from the rather extensive, open, grassy savannas near the Pacific coast and smaller grass areas in the Chagres Valley, the Isthmus is a practically unbroken expanse of forest. Under the stimulating influence of frequently recurring showers and continuously moist conditions throughout the year, the Atlantic watershed maintains a much more exuberant growth of vegetation than the Pacific watershed, where long periods of drought check vegetative vigor. At the height of the dry season these climatic differences are manifested in the contrasting aspect of the forests on the two slopes. While the trees of the Atlantic forest are clothed with brilliant evergreen foliage, those of the Pacific forest, truly deciduous for the most part, present bare stems, and the landscape has an

[1] During the construction of the Panama Canal 237.28 inches was recorded in a single year, and 58 inches in a single month at Porto Bello, Panama; the annual average, however, was 178.67 during three years of record.

autumnal appearance, relieved to some extent along the borders of streams. It is in this dry forest that one notes the strange habit, possessed by various unrelated species, of producing flowers and ripening fruits while the trees are in a leafless condition.

FAUNAL RELATIONS

The geological structure and history of Panama and Central America in general are, as yet, very imperfectly known. The attenuation of the isthmian region and the slight elevation of various trans-isthmian passes, irrespective of other data, suggest the probable former isolation of the two greater Americas. Some of the passes are less than 500 feet above sea level, and a subsidence of 1,000 feet of the present continental mass would establish interocean connections at various points. Beginning on the south some of these are marked by gaps in the mountains at the source of the Rio Napipi, a tributary of the Rio Atrato, at the Sucubti, an affluent of the Rio Chucunaque, at the Canal Zone, and farther north at Lake Nicaragua and at the Isthmus of Tehauntepec. Such a division would leave a chain of islands, several of the more southern of which would be 3,000 to 4,000 feet high, and it would isolate the high mountains of Costa Rica and Guatemala.

Geological investigations, especially those pursued in connection with Panama Canal construction, indicate that oceanic waters did in fact extend across, at least at the Canal Zone, during the Oligocene period; but the date of land emergence has not been very definitely determined. The slight depth of the water to a submarine escarpment far out along the coasts of Panama, and the present rapid rate of erosion, indicate that the Isthmus was formerly much broader than at present. The encroachment of the sea is well shown along much of the northern coast line, where cliffs receive the full battering effect of the waves swept in by the northerly trade winds. Southerly winds are less dominant, but the southern coast is constantly subjected to the erosive influence of tremendous tides.

Coiba Island and the large islands of the Pearl Archipelago lie in shallow water upon the continental shelf and may have formed parts of an ancient mainland. The excessive rainfall and tendency of isthmian rocks in general to disintegrate rapidly on exposure to the elements also greatly accelerate the reduction of the general land mass.

The Miocene mammalian faunas of southern South America and of North America are known to have been widely different, but a great gap exists in our knowledge of the contemporaneous fauna of Central America, and northern South America may have been isolated by an Amazonian gulf. Various authorities, however, including Hill,[1] and Scott[2] concur in the belief that North and South America have been united from the Miocene to the present time. Intermigratory movements, probably setting in during the Miocene period, extended through the Pliocene and into the Pleistocene when the interchange of mammalian groups reached its maximum and was followed by extensive extinction, leaving both regions comparatively impoverished. Notably numerous contributions from the North American fauna have, however, persisted and maintain a high state of development in Central and South America.

The mammalian fauna of Panama, as a whole, is South American in the sense that most of the genera and many of the species are common to both regions.

The eastern and western parts of the republic with the Canal Zone as a convenient dividing line, however, present important faunal differences. The former section is more truly South American, especially the mountainous parts, while western Panama partakes of the character of the Central American subregion. The following genera range from South America into eastern Panama, but are not known from the western part of the republic: *Peramys, Rhipidomys, Neacomys, Diplomys, Hydrochœrus, Icticyon, Lonchorina, Macrophyllum, Lonchophylla, Vampyressa, Molossops* and *Leontocebus*. Some of the bats may not improbably prove to be more widely distributed in Central America, but the limits of the other genera in that direction are believed to be approximately fixed. Several rodent genera assignable to the Central American subregion are apparently restricted in the republic to the highlands of the western part, as follows: *Nyctomys, Scotinomys* and *Syntheosciurus*. A few North or Middle American elements, as *Reithrodontomys, Peromyscus, Macrogeomys* and *Cryptotis,* reach the mountains of extreme eastern Panama or cross the Colombian frontier, but are not known from the Canal Zone.

The tendency of the Canal Zone to delimit faunas is indicated by the distribution of various species. The genus *Saimiri* ranges in South America and is apparently absent in eastern and central

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[1] Hill, R. T. The Geological History of the Isthmus of Panama and Costa Rica. Bull. Mus. Comp. Zool., Vol. 28, p. 270, June, 1898.

[2] Scott, W. B. The Isthmus of Panama in its Relation to the Animal Life of North and South America. Science, N. S., Vol. 43, No. 1100, p. 117, January 28, 1916.

Panama, but reappears in the western part of the republic where *Saimiri örstedii* is a common species. In *Sciurus hoffmanni* is presented a remarkable case of discontinuous distribution of a species. This common squirrel, living at high and low elevations in Costa Rica and western Panama, appears to be excluded from similar regions throughout eastern Panama, but specimens from Colombia seem indistinguishable from Costa Rican examples. Eastern Panama, it may be noted, is occupied by another common species, *Sciurus gerrardi,* which also has a wide altitudinal range and apparently similar habits. The complementary ranges of these squirrels in the republic, together with the peculiar distribution of *sciurus hoffmanni,* suggests antagonism in ecological relations. Some species, like the two widely dispersed raccoons, *Procyon lotor* and *Procyon cancrivorus,* reach the Canal Zone from opposite directions, but do not pass far beyond it. Several genera have closely allied representatives which are apparently restricted to upper slopes of high mountains of the eastern and western parts of the republic respectively. Examples of such species are *Peromyscus pirrensis* and *Peromyscus flavidus, Oryzomys pirrensis* and *Oryzomys devius.*

LIFE ZONES

Owing to the lack of general knowledge of living forms, as well as of detailed topography of the country and the local distribution of life in Panama, any attempt to delimit life zones at this time must be regarded as provisional. The region as a whole is highly diversified in character, and the number of species of animals and plants to be met with at any given locality is extraordinary. While some generalizations may be based on the field work already accomplished, it is obvious that much more extensive investigations will be necessary before the territory will be adequately known.

Three life zones, or belts, are recognizable in the republic, extending at low elevations from sea to sea, and at higher elevations as belts on the slopes, or embracing the tops of mountain ranges.[1] Beginning at sea level these are the Lower Tropical Zone, of which

[1] The life zones of tropical America, in their general bearings, have been discussed with Dr. Frank M. Chapman, of the American Museum of Natural History, whose special field of study is northwestern South America. Dr. Chapman's work is based on the birds, and it is gratifying to find that, although working independently, we are substantially in accord regarding the number, approximate boundaries, and appropriate nomenclature of the zones. The same general laws clearly apply to the areas studied by Dr. Chapman and myself.

there are well-marked arid and humid divisions; the Upper Tropical, or Subtropical Zone, and the Temperate Zone.

An exhaustive ecological treatment of the animals and plants of the region should recognize aquatic, littoral or riparian, and other associations which, except in a few such instances as those of *Chironectes panamensis, Rheomys raptor, Hydrochœrus isthmius,* and *Trichechus manatus* have comparatively slight significance with reference to mammals alone.

As in the neighboring regions, the life zones are the expression of the influence on organisms of various factors, or varying combinations of factors, of which temperature and moisture, more or less intimately associated, and light, are of prime importance.

The approximate boundaries between zones on different slopes vary in conformity with many of the same modifying conditions as elsewhere; the humidity of a given area is clearly determined by the height of mountains in combination with the direction of prevailing winds.

The zone lists include all of the mammals known from the region, except certain widely ranging species whose distribution have no obvious zone significance. A species or subspecies may occur regularly in two or more life zones, but is usually assignable to one in which it reaches its maximum abundance. Here, as elsewhere, some of the mammals exhibit a tendency to become differentiated in accordance with rather local environmental conditions; thus, a species characterized by dark colors in the humid belt, may be represented by a paler counterpart in more arid territory. The lists of birds are made up mainly of the more characteristic species, and together with the short lists of plants tend to corroborate deductions which might be based on the mammals alone.

LOWER TROPICAL ZONE

The Lower Tropical Zone, an area of high temperature, includes by far the greater part of the Isthmian land surface from the Atlantic and Pacific shore lines across at low elevations from sea to sea and to about 3,000 to 3,500 feet in average altitude along the slopes of the higher mountains. As might be expected, owing to its greater extent, the majority of the animals and plants of the general region are assignable to this zone, and many species, especially of bats, have extended their ranges into all its parts. The zone is, however, divisible into humid and arid divisions, which are denominated the Humid Lower Tropical Zone, and the Arid Lower Tropical Zone,

FIG. 1.—Arid Lower Tropical Zone near southern base of Cerro Azul. Cerro Azul visible in far distance.

FIG. 2.—Humid Lower Tropical Zone at 3,000 feet altitude near summit of Cerro Azul.

FIG. 1.—Humid Lower Tropical Zone. An aquatic environment in the lower Chagres Valley near Bohio, Canal Zone.

FIG. 2.—Humid Lower Tropical Zone. Typical section of forest interior near Gatun, Canal Zone, exposed by clearing of foreground.

respectively. While the total rainfall is more copious in the humid than in the arid division, the most important difference between the two sections is in the comparative continuity of the supply, and its effect on the fauna and flora. Thus, in the humid division moisture in the form of rain or fog is received at very short intervals throughout the year, and when the nights are clear heavy dew exerts its refreshing influence on the vegetation, whereas in the arid division long periods of drought prevail. As a result of these contrasting conditions the leaves are persistent and an evergreen forest, the "rain-forest" of authors, uniformly overspreads the humid division, while in the arid division the leaves are largely deciduous, the forest turns brown during the dry season, and may be interrupted by open, grassy savannas which become parched in appearance. These zonal differences, so well reflected in the character of the flora, are associated with corresponding changes in the fauna.

Mammals of Lower Tropical Zone

[Species marked U. occur also in Upper Tropical Zone].

Chironectes panamensis, Panama Water Opossum.
Didelphis marsupialis etensis, Eten Opossum; Zorro.
Didelphis marsupialis particeps, San Miguel Island Opossum.
Didelphis marsupialis battyi, Batty's Opossum.
Marmosa mexicana isthmica, Isthmian Marmosa.
Marmosa mexicana savannarum, Savanna Marmosa.
Marmosa fulviventer, Fulvous-bellied Marmosa.
Marmosa invicta, Black Marmosa.
Metachirus opossum fuscogriseus, Allen's Opossum; Zorro.
Metachirus nudicaudatus dentaneus, Brown Opossum; Zorro.
Philander laniger derbianus, Derby's Woolly Opossum.
Philander laniger pallidus, Pale Woolly Opossum.
Philander laniger nauticus, Insular Woolly Opossum.
Peramys melanops, Panama Peramys.
Bradypus griseus griseus, Gray Three-toed Sloth.
Bradypus ignavus, Panama Three-toed Sloth.
Cholœpus hoffmanni, Hoffmann's Two-toed Sloth; Perico Lijero.
Cyclopes didactylus dorsalis, Costa Rican Two-toed Anteater.
Tamanduas tetradactyla chiriquensis, Chiriqui Three-toed Anteater.
Myrmecophaga tridactyla centralis, Central American Great Anteater.
Dasypus novemcinctus fenestratus, Costa Rican Four-toed Armadillo.
Cabassous centralis, Central American Five-toed Armadillo.
Trichechus manatus, Manatee.
Pecari angulatus bangsi, Bangs' Collared Peccary; Zahino. U.
Tayassu pecari spiradens, Costa Rican White-lipped Peccary. U.
Odocoileus chiriquensis, Chiriqui White-tailed Deer.
Odocoileus rothschildi, Rothschild's White-tailed Deer.
Mazama sartorii reperticia, Canal Zone Forest Deer.
Tapirella bairdii, Baird's Tapir. U.
Tylomys panamensis, Panama Climbing Rat.
Tylomys watsoni, Watson's Climbing Rat.
Zygodontomys cherriei cherriei, Cherrie's Cane Rat.
Zygodontomys cherriei ventriosus, Canal Zone Cane Rat.
Zygodontomys seorsus, San Miguel Island Cane Rat
Neacomys pictus, Painted Bristly Mouse.
Oryzomys gatunensis, Gatun Rice Rat.
Oryzomys alfaroi dariensis, Darien Rice Rat. U.
Oryzomys bombycinus bombycinus, Silky Rice Rat.
Oryzomys talamancæ, Talamanca Rice Rat.
Oryzomys tectus tectus, Bugaba Rice Rat.
Oryzomys tectus frontalis, Corozal Rice Rat.

Oryzomys fulvescens costaricensis, Costa Rican Pygmy Rice Rat.
Oryzomys caliginosus idoneus, Panama Dusky Rice Rat.
Oryzomys caliginosus chrysomelas, Costa Rican Dusky Rice Rat.
Nectomys alfari efficax, Cana Rice Rat.
Sigmodon hispidus chiriquensis, Boqueron Cotton Rat.
Macrogeomys dariensis, Darien Pocket Gopher. U.
Macrogeomys pansa, Bugaba Pocket Gopher.
Heteromys australis conscius, Cana Pocket Mouse.
Heteromys desmarestianus zonalis, Canal Zone Spiny Pocket Mouse.
Liomys adspersus, Peters' Spiny Pocket Mouse.
Proechimys semispinosus panamensis, Panama Spiny Rat.
Proechimys semispinosus burrus, San Miguel Island Spiny Rat.
Diplomys labilis, Gliding Spiny Rat (San Miguel Island).
Diplomys darlingi, Darling's Spiny Rat.
Dasyprocta punctata isthmica, Isthmian Agouti.
Dasyprocta callida, San Miguel Island Agouti.
Dasyprocta coibæ, Coiba Island Agouti.
Cuniculus paca virgatus, Panama Paca.
Hydrochœrus isthmius, Isthmian Capybara.
Coendou rothschildi, Rothschild's Porcupine.
Sciurus variegatoides helveolus, Panama Squirrel.
Sciurus variegatoides melania, Costa Rican Black Squirrel.
Sciurus hoffmanni chiriquensis, Chiriqui Squirrel. U.
Sciurus gerrardi choco, Darien Squirrel.
Sciurus gerrardi morulus, Canal Zone Squirrel.
Microsciurus alfari browni, Brown's Pygmy Squirrel.
Microsciurus alfari venustulus, Canal Zone Pygmy Squirrel.
Microsciurus isthmius vivatus, Mount Pirre Pygmy Squirrel.
Sylvilagus gabbi gabbi, Costa Rican Forest Rabbit.
Sylvilagus gabbi messorius, Panama Forest Rabbit.
Sylvilagus gabbi incitatus, San Miguel Island Rabbit.
Procyon cancrivorus panamensis, Panama Crab-eating Raccoon.
Procyon lotor pumilus, Little Panama Raccoon.
Nasua narica panamensis, Panama Coati. U.
Bassaricyon gabbii gabbii, Costa Rican Bushy-tailed Olingo.
Bassaricyon gabbii orinomus, Panama Bushy-tailed Olingo. U.
Potos flavus isthmicus, Isthmian Kinkajou. U.
Potos flavus chiriquensis, Chiriqui Kinkajou.
Mustela affinis costaricensis, Costa Rican Bridled Weasel. U.
Tayra barbara biologiæ, Panama Tayra.
Grison canaster, Yucatan Grison.
Conepatus tropicalis trichurus, Panama Skunk.
Lutra repanda, Panama Otter.
Felis onca centralis, Central American Jaguar.
Felis pardalis mearnsi, Mearns' Ocelot. U.
Felis pirrensis, Panama Long-tailed Spotted Cat.
Felis bangsi costaricensis, Central American Puma. U.
Herpailurus yagouaroundi panamensis, Panama Gray and Red Cat.
Rhynchiscus naso priscus, Mexican Long-nosed Bat.
Saccopteryx bilineata bilineata, Greater White-lined Bat.
Saccopteryx leptura, Lesser White-lined Bat.
Peropteryx canina canina, Dog-like Bat.
Centronycteris centralis, Thomas' Bat.
Dirias albiventer minor, Little Bull Dog Bat.
Chilonycteris rubiginosa rubiginosa, Dark Brown Bat.
Micronycteris microtis, Nicaraguan Small-eared Bat.
Lonchorina aurita, Tomes' Long-eared Bat.
Tonatia amblyotis, Round-eared Bat.
Macrophyllum macrophyllum, Long-legged Bat.
Phyllostomus hastatus panamensis, Panama Spear-nosed Bat.
Trachops cirrhosus, Fringe-lipped Bat.
Vampyrus spectrum nelsoni, Nelson's False Vampire Bat.
Glossophaga soricina leachii, Leach's Long-tongued Bat.
Lonchophylla robusta, Rusty Long-tongued Bat.
Lonchophylla concava, Panama Long-tongued Bat.
Hemiderma perspicillatum aztecum, Short-tailed Bat.
Hemiderma castaneum, Chestnut Short-tailed Bat.
Uroderma bilobatum, Yellow-eared Bat.
Vampyrops helleri, Heller's Bat.
Vampyrodes major, San Pablo Bat.
Vampyressa minuta, Little Yellow-eared Bat.
Chiroderma isthmicum, Isthmian Bat.
Chiroderma salvini, Salvin's Bat.
Artibeus watsoni, Watson's Bat.
Artibeus jamaicensis jamaicensis, Jamaican Bat.

Artibeus planirostris planirostris, Flat-nosed Bat. U.
Desmodus rotundus murinus, Mexican Vampire Bat.
Natalus stramineus mexicanus, Mexican Straw-colored Bat.
Myotis nigricans, Little Black Bat.
Eptesicus propinquus, Peters' Black Bat.
Dasypterus ega panamensis, Panama Short-eared Bat.
Rhogeëssa tumida, Little Yellow Bat.
Molossops planirostris, Flat-nosed Mastiff Bat.
Eumops nanus, Dwarf Mastiff Bat.
Eumops glaucinus, Chestnut Mastiff Bat.
Molossus coibensis, Coiba Island Mastiff Bat.
Molossus sinaloæ, Sinaloa Mastiff Bat.
Molossus bondæ, Bonda Mastiff Bat.
Saimiri örstedii örstedii, Örsted's Titi Monkey.
Aotus zonalis, Canal Zone Night Monkey.
Leontocebus geoffroyi, Geoffroy's Squirrel Monkey.
Alouatta palliata inconsonans, Panama Howling Monkey. U.
Alouatta coibensis, Coiba Island Howling Monkey.
Cebus capucinus capucinus, Colombian White-throated Capuchin. U.
Cebus capucinus imitator, Panama White-throated Capuchin. U.
Ateles geoffroyi, Geoffroy's Spider Monkey.

Birds of Lower Tropical Zone

Crypturus soui panamensis, Panama Tinamou.
Tinamus castaneiceps, Chestnut-headed Tinamou.
Ibycter americanus, Cacao Hawk.
Herpetotheres cachinnans, Laughing Hawk.
Leucopternis semiplumbea, Dusky-mantled Leucopternis.
Leucopternis ghiesbrechti, Ghiesbrecht's Leucopternis.
Rupornis ruficauda, Rufous-tailed Hawk.
Crax panamensis, Panama Curassow.
Ortalis cinereiceps, Ashy-headed Chachalaca.
Odontophorus melanotis, Black-eared Partridge.
Odontophorus marmoratus, Marbled Partridge.
Odontophorus castigatus, Panama Partridge.
Rhynchortyx cinctus, Banded Partridge.
Eurypyga major, Sun Bittern.
Oreopeleia violacea albiventris, White-bellied Quail Dove.
Oreopeleia chiriquensis, Chiriqui Quail Dove.
Leptotila cassini cassini, Cassin's Dove.
Leptotila rufinucha, Rufous-naped Dove.
Claravis pretiosa, Blue Ground Dove.
Chaemepelia rufipennis rufipennis, Ruddy Ground Dove.
Chaemepelia minuta elæodes, Plain-breasted Ground Dove.
Lepidœnas speciosa, Scaled Pigeon.
Amazona farinosa virenticeps, Green-headed Parrot.
Amazona ochrocephala panamensis, Panama Parrot.
Pionus menstruus, Blue-headed Parrot.
Pyrilia hæmatotis coccinicollaris, Red-necklaced Parrot.
Brotogerys jugularis, Tovi Paroquet.
Eupsittula ocularis, Veragua Paroquet.
Aratinga finschii, Finsch's Paroquet.
Crotophaga ani, Ani.
Crotophaga major, Greater Ani.
Crotophaga sulcirostris, Groove-billed Ani.
Neomorphus salvini, Salvin's Ground Cuckoo.
Coccycua rutila panamensis, Panama Cuckoo.
Veniliornis kirkii neglectus, Divala Woodpecker.
Veniliornis kirkii dariensis, Darien Woodpecker.
Chloronerpes chrysochlorus aurosus, Golden Green Woodpecker.
Chloronerpes callopterus, Panama Green Woodpecker.
Tripsurus pucherani pucherani, Pucheran's Woodpecker.
Tripsurus chrysauchen, Golden-naped Woodpecker.
Centurus subelegans wagleri, Wagler's Woodpecker.
Centurus seductus, San Miguel Woodpecker.
Picumnus olivaceus panamensis, Panama Piculet.
Picumnus olivaceus flavotinctus, Veragua Piculet.
Capito maculicoronatus maculicoronatus, Spotted-crowned Barbet.
Capito maculicoronatus pirrensis, Pirre Barbet.
Selenidera spectabilis, Cassin's Araçari.
Pteroglossus torquatus torquatus, Collared Araçari.
Pteroglossus frantzii, Frantzius' Araçari.
Ramphastos piscivorus brevicarinatus, Short-keeled Toucan.
Galbula melanogenia, Black-chinned Jacamar.
Jacamerops aurea. Great Jacamar.
Chrysotrogon caligatus, Gartered Trogon.
Trogonurus curucui tenellus, Graceful Trogon.

Trogon strigilatus chionurus, White-tailed Trogon.
Trogon bairdii, Baird's Trogon.
Curucujus massena, Massena Trogon.
Curucujus melanurus macrourus, Large-tailed Trogon.
Nonnula frontalis, Panama Nonnula.
Malacoptila panamensis panamensis, Panama Malacoptila.
Ecchaunornis radiatus fulvidus, Fulvous Puff-Bird.
Notharchus tectus subtectus, Panama Pied Puff-Bird.
Hylomanes momotula obscurus, Panama Tody-Motmot.
Urospatha martii semirufa, Greater Rufous Motmot.
Electron platyrhynchum suboles, Darien Motmot.
Electron platyrhynchum minor, Lesser Broad-billed Motmot.
Momotus lessonii lessonii, Lesson's Motmot.
Otus vermiculatus, Vermiculated Screech Owl.
Nyctibius griseus panamensis, Panama Potoo.
Lepidopyga cæruleogularis, Duchassain's Humming Bird.
Polyerata amabilis, Lovely Humming Bird.
Polyerata decora, Charming Humming Bird.
Damophila panamensis, Panama Humming Bird.
Goldmania violiceps, Goldman's Humming Bird.
Chalybura isauræ, Baroness de Lafresnaye's Plumeleteer.
Phæochroa cuvierii cuvierii, Cuvier's Humming Bird.
Phæochroa cuvierii saturatior, Coiba Island Humming Bird.
Threnetes ruckeri, Rucker's Hermit.
Glaucis hirsuta affinis, Lesser Hairy Hermit.
Phæthornis longirostris cephalus, Nicaraguan Hermit.
Eutoxeres aquila salvini, Salvin's Sickle-Bill.
Dendrocincla homochroa ruficeps, Panama Ruddy Dendrocincla.
Dendrocincla lafresnayei ridgwayi, Brown Dendrocincla.
Dendrocincla anabatina saturata, Carriker's Dendrocincla.
Deconychura typica, Cherrie's Deconychura.
Xiphorhynchus lachrymosus lachrymosus, Black-striped Woodhewer.
Xiphorhynchus lachrymosus eximius, Striped-bellied Woodhewer.
Automolus pallidigularis pallidigularis, Pale-throated Automolus.
Automolus pallidigularis exsertus, Chiriqui Automolus.
Hyloctistes virgatus, Striped Hyloctistes.
Xenops genibarbis mexicanus, Mexican Xenops.
Pittasoma michleri michleri, Michler's Ant-pitta.
Phænostictus mcleannani mcleannani, Mc-Leannan's Antthrush.
Hylophylax nævioides, Spotted Antbird.
Formicarius moniliger hoffmanni, Hoffmann's Antthrush.
Formicarius moniliger panamensis, Panama Antthrush.
Myrmeciza læmosticta, Salvin's Antbird.
Myrmeciza zeledoni, Zeledon's Antbird.
Myrmeciza exsul exsul, Sclater's Antbird.
Myrmeciza exsul occidentalis, Cherrie's Antbird.
Gymnocichla nudiceps nudiceps, Bare-crowned Antbird.
Gymnocichla nudiceps erratilis, Costa Rican Bare-crowned Antbird.
Herpsilochmus rufimarginatus exiguus, Rufous-winged Antvireo.
Microbates cinereiventris semitorquatus, Half-collared Antwren.
Myrmopagis fulviventris, Lawrence's Antwren.
Myrmopagis melæna, Black Antwren.
Cymbilaimus lineatus fasciatus, Fasciated Antshrike.
Pachyrhamphus cinnamomeus, Cinnamon Becard.
Sirystes albogriseus, Panama Sirystes.
Microtriccus brunneicapillus, Brown-capped Tyrannulet.
Cotinga ridgwayi, Ridgway's Cotinga.
Cotinga nattererii, Natterer's Cotinga.
Laniocera rufescens, Rufous Manakin.
Manacus vitellinus, Gould's Manakin.
Manacus aurantiacus, Salvin's Manakin.
Myiophobus fasciatus furfurosus, Bran-colored Flycatcher.
Mitrephanes eminulus, Green-backed Flycatcher.
Cnipodectes subbrunneus, Brown Flycatcher.
Camptostoma pusillum flaviventre, Yellow-bellied Camptostoma.
Copurus leuconotus, White-backed Copurus.
Tyranniscus vilissimus parvus, Lesser Paltry Flycatcher.
Rhynchocyclus marginatus, Yellow-margined Flycatcher.
Prædo audax, Black-billed Flycatcher.
Craspedoprion æquinoctialis, Equinoctial Flycatcher.
Lophotriccus squamæcristus minor, Zeledon's Helmeted Flycatcher.
Todirostrum nigriceps, Black-headed Tody-Flycatcher.
Oncostoma olivaceum, Lawrence's Bent-billed Flycatcher.
Planesticus grayi casius, Bonaparte's Thrush.

FIG. 1.—Ivory nut palm (*Phytelephas*), Humid Lower Tropical Zone near Porto Bello, showing method of gathering nuts.

FIG. 2.—Ivory nut gatherer's hut, showing product of his industry heaped in foreground.

FIG. 1.—Ferns of Humid Lower Tropical Zone near Cana, eastern Panama, altitude 2,000 feet. *Polypodium aureum* in center.

FIG. 2.—Ferns of Humid Lower Tropical Zone, near Cana, eastern Panama, altitude 2,000 feet. Largely *Dicranopteris bifida*.

Polioptila superciliaris superciliaris, Lawrence's Gnatcatcher.
Leucolepis lawrencii, Lawrence's Musician Wren.
Thryophilus castaneus castaneus, Bay Wren.
Thryophilus galbraithii galbraithii, Galbraith's Wren.
Henicorhina prostheluca pittieri, Pittier's Wood Wren.
Troglodytes musculus inquietus, Panama House Wren.
Pheugopedius fasciatoventris albigularis, Panama Black-bellied Wren.
Pheugopedius fasciatoventris melanogaster, Black-bellied Wren.
Pheugopedius hyperythrus, Tawny-bellied Wren.
Heleodytes albobrunneus, White-headed Cactus Wren.
Pachysylvia aurantiifrons aurantiifrons, Lawrence's Pachysylvia.
Anthus parvus, Panama Pipit.
Basileuterus rufifrons mesochrysus, Sclater's Warbler.
Basileuterus semicervinus veraguensis, Buff-rumped Warbler.
Compsothlypis pitiayumi speciosa, Chiriqui Parula Warbler.
Rhodinocichla rosea eximia, Panama Thrush-Warbler.
Dacnis cayana ultramarina, Ultramarine Dacnis.
Sturnella magna inexspectata, Central American Meadowlark.
Leistes militaris, Cayenne Red-breasted Blackbird.
Icterus mesomelas salvinii, Salvin's Oriole.
Cacicus microrhynchus, Small-billed Cacique.
Cacicus vitellinus, Lawrence's Cacique.
Mitrospingus cassini, Cassin's Tanager.
Chlorothraupis carmioli, Carmiol's Tanager.
Chlorothraupis olivaceus, Yellow-browed Tanager.
Tachyphonus nitidissimus, Veraguan White-shouldered Tanager.
Tachyphonus delatrii, Tawny-crested Tanager.
Tachyphonus luctuosus panamensis, White-shouldered Tanager.
Chrysothlypis chrysomelas chrysomelas, Black and Yellow Tanager.
Tanagra luteicapilla, Yellow-crowned Euphonia.
Tangara florida arcæi, Arce's Emerald Tanager.
Tangara inornata, Plain-colored Tanager.
Saltator atriceps lacertosus, Panama Black-headed Saltator.
Saltator magnoides intermedius, Panama Buff-throated Saltator.
Cyanocompsa concreta cyanescens, Panama Blue Grosbeak.
Arremon aurantiirostris, Orange-billed Sparrow.
Ammodramus savannarum obscurus, Minatitlan Sparrow.
Sporophila minuta minuta, Minute Seed-eater.
Arremonops conirostris conirostris, Lafresnaye's Sparrow.

HUMID LOWER TROPICAL ZONE

The Humid Lower Tropical Zone occupies the crests of most of the mountain ranges, and nearly all that part of the Atlantic watershed of Panama lying below about 3,000 feet altitude. It is replaced, however, in the Chagres Valley by a strip of the Arid Lower Tropical Zone which extends from the Pacific coast across the continental divide in the vicinity of the Panama Canal, but the transition to humid conditions is rapid to the northward of Empire and the bend of the Chagres River. The area is comparatively uniform in character, usually heavily forested, and includes the most luxuriant vegetation on the Isthmus. Trees of large size cast so dense a shade that the undergrowth may be scanty, but wherever much light is admitted the ground cover is very thick, and tangled masses of vines tend to impede progress through the forest. The highest and most massive forest growth, however, is in general at the lower levels. On the upper, or steeper, slopes of the mountains forest cover of a lower growth is apparently the result of unfavorable soil conditions.

Although such slopes are densely wooded, erosion of the entire surface may be rapid, the torrential rains sweeping away humus as fast as deposited.

Mammals of Humid Lower Tropical Zone

Chironectes panamensis, Panama Water Opossum.
Marmosa mexicana isthmica, Isthmian Marmosa.
Marmosa invicta, Black Marmosa.
Metachirus nudicaudatus dentaneus, Brown Opossum; Zorro.
Philander laniger derbianus, Derby's Opossum.
Peramys melanops, Panama Peramys.
Mazama sartorii reperticea, Canal Zone Forest Deer.
Tapirella bairdii, Baird's Tapir.
Zygodontomys cherriei ventriosus, Canal Zone Cane Rat.
Neacomys pictus, Painted Bristly Mouse.
Oryzomys gatunensis, Gatun Rice Rat.
Oryzomys alfaroi dariensis, Darien Rice Rat.
Oryzomys bombycinus bombycinus, Silky Rice Rat.
Oryzomys talamancæ, Talamanca Rice Rat.
Oryzomys tectus frontalis, Corozal Rice Rat.
Oryzomys caliginosus idoneus, Panama Dusky Rice Rat.
Nectomys alfari efficax, Cana Rice Rat.
Heteromys australis conscius, Cana Pocket Mouse.
Heteromys desmarestianus zonalis, Canal Zone Spiny Pocket Mouse.
Dasyprocta punctata isthmica, Isthmian Agouti.
Microsciurus alfari venustulus, Canal Zone Pygmy Squirrel.
Bassaricyon gabbii gabbii, Costa Rican Bushy-tailed Olingo.
Lutra repanda, Panama Otter.

Birds of Humid Lower Tropical Zone

Leucopternis ghiesbrechti, Ghiesbrecht's Leucopternis.
Crax panamensis, Panama Curassow.
Odontophorus marmoratus, Marbled Partridge.
Eurypyga major, Sun Bittern.
Oreopeleia violacea albiventris, White-bellied Quail Dove.
Leptotila cassini cassini, Cassin's Dove.
Neomorphus salvini, Salvin's Ground Cuckoo.
Coccycua rutila panamensis, Panama Cuckoo.
Chloronerpes callopterus, Panama Green Woodpecker.
Tripsurus pucherani pucherani, Pucheran's Woodpecker.
Picumnus olivaceus panamensis, Panama Piculet.
Capito maculicoronatus maculicoronatus, Spotted-crowned Barbet.
Capito maculicoronatus pirrensis, Pirre Barbet.
Jacamerops aurea, Great Jacamar.
Selenidera spectabilis, Cassin's Araçari.
Ramphastos piscivorus brevicarinatus, Short-keeled Toucan.
Curucujus melanurus macrourus, Large-tailed Trogon.
Nonnula frontalis, Panama Nonnula.
Ecchaunornis radiatus fulvidus, Fulvous Puff-Bird.
Notharchus tectus subtectus, Panama Pied Puff-Bird.
Hylomanes momotula obscurus, Panama Tody-Motmot.
Electron platyrhynchum minor, Lesser Broad-billed Motmot.
Electron platyrhynchum suboles, Darien Motmot.
Urospatha martii semirufa, Greater Rufous Motmot.
Polyerata amabilis, Lovely Hummingbird.
Damophila panamensis, Panama Hummingbird.
Goldmania violiceps, Goldman's Hummingbird.
Chalybura isauræ, Baroness de Lafresnaye's Plumeleteer.
Threnetes ruckeri, Rucker's Hermit.
Glaucis hirsuta affinis, Lesser Hairy Hermit.
Eutoxeres aquila salvini, Salvin's Sicklebill.
Dendrocincla lafresnayei ridgwayi, Brown Dendrocincla.
Xiphorhynchus lachrymosus lachrymosus, Black-striped Woodhewer.
Automolus pallidigularis pallidigularis, Pale-throated Automolus.
Hyloctistes virgatus, Striped Hyloctistes.
Pittasoma michleri michleri, Michler's Antpitta.
Phænostictus mcleannani mcleannani, McLeannan's Antthrush.
Hylophylax nævioides, Spotted Antbird.
Formicarius moniliger panamensis, Panama Antthrush.
Myrmeciza læmosticta, Salvin's Antbird.
Myrmeciza zeledoni, Zeledon's Antbird.
Myrmeciza exsul exsul, Sclater's Antbird.

Gymnocichla nudiceps nudiceps, Bare-crowned Antbird.
Microbates cinereiventris sumitorquatus, Half-collared Antwren.
Myrmopagis fulviventris, Lawrence's Antwren.
Myrmopagis melæna, Black Antwren.
Cymbilaimus lineatus fasciatus, Fasciated Antshrike.
Herpsilochmus rufimarginatus exiguus, Rufous-winged Antvireo.
Pachyrhamphus cinnamomeus, Cinnamon Becard.
Sirystes albogriseus, Panama Sirystes.
Microtriccus brunneicapillus, Brown-capped Tyrannulet.
Cotinga nattererii, Natterer's Cotinga.
Laniocera rufescens, Rufous Manakin.
Manacus vitellinus, Gould's Manakin.
Mitrephanes eminulus, Green-backed Flycatcher.
Cnipodectes subbrunneus, Brown Flycatcher.
Rhynchocyclus marginatus, Yellow-margined Flycatcher.
Prædo audax, Black-billed Flycatcher.
Craspedoprion æquinoctialis, Equinoctial Flycatcher.
Lophotriccus squamæcristus minor, Zeledon's Helmeted Flycatcher.
Todirostrum nigriceps, Black-headed Tody-Flycatcher.
Leucolepis lawrencii, Lawrence's Musician Wren.
Thryophilus castaneus castaneus, Bay Wren.
Thryophilus galbraithii galbraithii, Galbraith's Wren.
Pheugopedius fasciato ventris albigularis, Panama Black-bellied Wren.
Pachysylvia aurantiifrons aurantiifrons, Lawrence's Pachysylvia.
Compsothlypis pitiayumi speciosa, Chiriqui Parula Warbler.
Dacnis cayana ultramarina, Ultramarine Dacnis.
Icterus mesomelas salvinii, Salvin's Oriole.
Tachyphonus delatrii, Tawny-crested Tanager.
Chlorothraupis carmioli, Carmiol's Tanager.
Chlorothraupis olivaceus, Yellow-browed Tanager.
Tachyphonus luctuosus panamensis, White-shouldered Tanager.
Chrysothlypis chrysomelas chrysomelas, Black and Yellow Tanager.
Tangara florida arcæi, Arce's Emerald Tanager.
Tangara inornata, Plain-colored Tanager.
Saltator atriceps lacertosus, Panama Black-headed Saltator.
Cyanocompsa concreta cyanescens, Panama Blue Grosbeak.
Arremonops conirostris conirostris, Lafresnaye's Sparrow.

Plants of Humid Lower Tropical Zone

Lycopodium dichotomum.
Polypodium aureum.
Dicranopteris bifida.
Anthurium acutangulum.
Anthurium hacumense.
Anthurium maximum.
Montrichardia arborescens.
Philodendron brevispathum.
Xanthosoma helleborifolium.
Aechmea dactylina.
Aechmea tillandsioides.
Guzmania angustifolia.
Guzmania zahnii.
Pitcairnia atrorubens.
Heliconia wagneriana.
Piper aduncum.
Piper cordulatum.
Brosimum utile.
Piratinera panamensis.
Cecropia arachnoides, Guarumo.
Cecropia longipes, Guarumo.
Cecropia mexicana, Guarumo.
Ficus panamensis, Panama Wild Fig.
Ficus hemsleyana, Hemsley's Wild Fig.
Ficus pittieri, Pittier's Wild Fig.
Inophleum armatum, Maragua; Cocuá.
Orycthanthus ligustrinus.
Guatteria amplifolia.
Virola panamensis.
Acacia hayesii, Hayes' Acacia.
Acacia melanoceras.
Acacia multiglandulosa.
Inga goldmaniana.
Inga portobellensis.
Pithecolobium cognatum.
Pithecolobium fragans.
Pithecolobium latifolium.
Prioria copaifera.
Swartzia grandiflora.
Swartzia panamensis, Cutaro.
Erythrina costaricensis, Costa Rican Erythrina.
Meibomia adscendens.
Coumarouna panamensis.
Acalypha diversifolia leptostachya.
Croton billbergianus.
Euphorbia ammannioides.
Sapium giganteum.
Cupania fulvida.
Sloanea megalophylla.
Heliocarpus appendiculatus.
Hibiscus bifurcatus.
Hibiscus spathulatus.
Lopimia dasypetala.
Pavonia racemosa.
Peltæa ovata.

Sida rhombifolia.
Pachira aquatica.
Quararibea pterocalyx.
Eschweilera panamensis.
Eschweilera reversa.
Gustavia nana.
Gustavia parvifolia.
Combretum coccineum.
Combretum epiphyticum.
Combretum punctulatum.
Aciotis purpurascens.
Clidemia dentata.
Clidemia petiolaris.
Conostegia speciosa.
Conostegia subcrustulata.
Leandra cinnamomea.
Leandra mexicana.
Miconia barbinervis.
Miconia nervosa.
Oxymeris cinnamomea.
Oxymeris heterobasis.
Sagræa petiolata.
Styrax argenteum.
Mimusops dariensis?
Malouetia panamensis.
Enallagma cucurbitina.
Jacaranda copaia.
Macfadyena uncinata.
Aphelandra sinclairiana.
Aphelandra tetragona.
Diodia radula.
Cassupa panamensis.
Macrocnemum glabrescens.
Morinda panamensis.
Psychotria magna.
Rustia ferruginea.
Rustia occidentalis.
Watsonamra gymnopoda.
Watsonamra macrophylla.
Watsonamra magnifica.
Watsonamra pittieri.
Watsonamra pubescens.

ARID LOWER TROPICAL ZONE

The Arid Lower Tropical Zone extends in a belt of varying width, mainly at low elevations, all along the southern side of the Isthmus, excepting possibly the extreme southeastern part, from the Pacific coast line to near the base of the higher mountains, reaching farthest inland along the valley of the Tuyra River and at the base of the Azuero Peninsula. In the vicinity of the Canal Zone it crosses the continental divide and invades a part of the valley of the Chagres River; important islands off the coast are also included in its scope.

The total rainfall is by no means scanty, and in the wet season the forested parts of this zone differ little in appearance from Humid Lower Tropical areas, truly arid conditions prevailing only during the dry season when much of the forest, except near water, is leafless and the contrast with the continuously humid areas is very striking. A number of trees exhibit the strange habit of devoting the wet season to purely vegetative functions; under the stimulation of the first rains newly formed leaves and rapidly lengthening branches give the forest a spring-like appearance, but the flowering and maturing of fruit is deferred until the dry season, when the leaves have fallen and general growth has stopped.

Mammals of Arid Lower Tropical Zone

Didelphis marsupialis particeps, San Miguel Island Opossum (San Miguel Island).

Didelphis marsupialis battyi, Batty's Opossum (Coiba Island).

Marmosa mexicana savannarum, Savanna Marmosa.

Marmosa fulviventer, Fulvous-bellied Marmosa (San Miguel Island).

Philander laniger pallidus, Pale Woolly Opossum.

Philander laniger nauticus, Insular Woolly Opossum.

Odocoileus chiriquensis, Chiriqui White-tailed Deer.

Odocoileus rothschildi, Rothschild's White-tailed Deer (Coiba Island).

Zygodontomys cherriei cherriei, Cherrie's Cane Rat.
Zygodontomys seorsus, San Miguel Island Cane Rat (San Miguel Island).
Oryzomys tectus tectus, Bugaba Rice Rat.
Oryzomys fulvescens costaricensis, Costa Rican Pygmy Rice Rat.
Oryzomys caliginosus chrysomelas, Costa Rican Dusky Rice Rat.
Macrogeomys pansa, Bugaba Pocket Gopher.
Liomys adspersus, Peters' Spiny Pocket Mouse.
Proechimys semispinosus burrus, San Miguel Island Spiny Rat (San Miguel Island).
Diplomys labilis, Gliding Spiny Rat (San Miguel Island).
Dasyprocta callida, San Miguel Island Agouti (San Miguel Island).
Dasyprocta coibae, Coiba Island Agouti (Coiba Island).
Sciurus variegatoides helveolus, Canal Zone Squirrel.
Sciurus variegatoides melania, Costa Rican Black Squirrel.
Microsciurus alfari browni, Brown's Pygmy Squirrel.
Sylvilagus gabbi incitatus, San Miguel Island Rabbit (San Miguel Island).
Alouatta coibensis, Coiba Island Howling Monkey (Coiba Island).

Birds of Arid Lower Tropical Zone

Rupornis ruficauda, Rufous-tailed Hawk.
Odontophorus castigatus, Panama Partridge.
Leptotila rufinucha, Rufous-naped Dove.
Eupsittula ocularis, Veragua Paroquet.
Crotophaga sulcirostris, Groove-billed Ani.
Centurus seductus, San Miguel Woodpecker (San Miguel Island).
Veniliornis kirkii neglectus, Divala Woodpecker.
Veniliornis kirkii dariensis, Darien Woodpecker.
Tripsurus chrysauchen, Golden-naped Woodpecker.
Picumnus olivaceus flavotinctus, Veragua Piculet.
Pteroglossus frantzii, Frantzius' Araçari.
Trogon bairdii, Baird's Trogon.
Polyerata decora, Charming Hummingbird.
Phæochroa cuvierii cuvierii, Cuvier's Hummingbird.
Phæochroa cuvierii saturatior, Coiba Hummingbird (Coiba Island).
Dendrocincla homochroa ruficeps, Panama Ruddy Dendrocincla.
Dendrocincla anabatina saturata, Carriker's Dendrocincla.
Deconychura typica, Cherrie's Deconychura.
Xiphorhynchus lachrymosus eximius, Striped-bellied Woodhewer.
Automolus pallidiventris exsertus, Chiriqui Automolus.
Formicarius moniliger hoffmanni, Hoffmann's Antthrush.
Gymnocichla nudiceps erratilis, Costa Rican Bare-crowned Antbird.
Myrmeciza exsul occidentalis, Cherrie's Antbird.
Cotinga ridgwayi, Ridgway's Cotinga.
Carpodectes antoniæ, Antonia's Cotinga.
Manacus aurantiacus, Salvin's Manakin.
Myiophobus fasciatus furfurosus, Bran-colored Flycatcher.
Camptostoma pusillum flaviventre, Yellow-bellied Camptostoma.
Pheugopedius hyperythrus, Tawny-bellied Wren.
Pheugopedius fasciatoventris melanogaster, Black-bellied Wren.
Anthus parvus, Panama Pipit.
Basileuterus semicervinus veraguensis, Buff-rumped Warbler.
Sturnella magna inexspectata, Central American Meadowlark.
Leistes militaris, Cayenne Red-breasted Blackbird.
Lanio melanopygius, Black-rumped Shrike-Tanager.
Ammodramus savannarum obscurus, Minatitlan Sparrow.
Sporophila minuta minuta, Minute Seed-eater.

Plants of Arid Lower Tropical Zone

(Excepting those of Savanna Area and Semi-forested Savanna borders)

Anthurium gracile.
Aechmea setigera.
Piper grandifolium.
Piper hispidum.
Ficus glaucescens, Glaucous Wild Fig.
Ficus isophlebia.
Ficus oerstediana, Örsted's Wild Fig.
Ficus williamsii, Williams' Wild Fig.
Loranthus avicularius.
Loranthus polyrhizos.
Loranthus theobromæ.
Orycthanthus occidentalis.
Struthanthus orbicularis.
Annona hayesii, Hayes' Annona.
Annona frutescens.
Hirtella americana.
Licania arborea.
Licania hypoleuca.
Licania platypus.
Acacia penonomensis, Penonomé Acacia.

Calliandra emarginata.
Calliandra pittieri, Pittier's Calliandra.
Enterolobium schomburgkii.
Enterolobium cyclocarpum.
Inga cocleensis.
Inga hayesii.
Inga laurina.
Inga mucuna.
Inga paciflora.
Inga pittieri.
Mimosa panamensis, Panama Mimosa.
Mimosa somnians.
Mimosa williamsii, William's Mimosa.
Pithecolobium oblongum.
Bauhinia hymenææfolia.
Bauhinia inermis.
Bauhinia pauletia.
Browneopsis excelsa, Cuchillito.
Cassia foliolosa.
Cassia pauciflora.
Chamæcrista brevipes.
Chamæcrista flexuosa.
Chamæcrista tristicula.
Hymenæa courbaril.
Andira inermis.
Centrolobium patinense, Amarillo de Guayaquil.
Centrolobium yavizanum.
Erythrina rubrinervia.
Lennea viridiflora.
Lonchocarpus velutinus.
Macherium purpurascens.
Meibomia spiralis.
Platymiscium polystachyum.
Lesbania macrocarpa.
Sweetia panamensis.
Peltogyne purpurea.
Dimorphandra megistosperma, Alcornoque.
Dalbergia retusa, Cocobola.
Platypodium maxonianum.
Cedrela fissilis.
Cedrela mexicana, Spanish Cedar.
Guarea williamsii.
Swietenia macrocarpa, Mahogany.
Vochysia ferruginea.
Caperia panamensis.
Euphorbia apocynoides.
Hieronymia alchorneoides.
Anacardium rhinocarpus, Espavé.
Cupania guatemalensis.
Serjania grandis.
Serjania seemanni.
Talisia panamensis.
Goethalsia isthmica.
Heliocarpus arborescens.
Abutilon graveolens.
Hibiscus costatus.
Malache panamensis.
Malvaviscus mollis.
Bambacopsis sessilis.
Ceiba pentandra.
Cavanillesia platanifolia, Cuipo.
Melochia hirsuta.
Eschweilera garagaræ.
Eschweilera verruculosa.
Gustavia microcarpa.
Combretum alternifolium.
Combretum jacquini.
Combretum lepidopetalum.
Clidemia dependens.
Clidemia spicata.
Miconia gracilis.
Sagræa rubra.
Achras sapota.
Styrax argenteum.
Mimusops panamense.
Cordia riparia.
Cordia ulmifolia.
Vitex masoniana.
Amphilophium panniculatum.
Anemopægma orbiculatum.
Arrabidæa pachycalyx.
Jacaranda felicifolia.
Aphelandra pectinata.
Barleria micans.
Elytraria squamosa.
Palicourea parviflora.
Rondeletia panamensis.
Watsonamra brachyotis.
Watsonamra tinajita.

SAVANNA AREA AND SEMI-FORESTED SAVANNA BORDERS

Two principal upland associational divisions, with important bearing on mammalian life, are recognizable in the Arid Lower Tropical Zone. These are an arid or semi-arid forest association, and a savanna and savanna border association. The forests are generally continuous along the basal slopes of the mountains and cover irregular contours to near the sea. They also extend as semi-arid belts along the river valleys. Small patches of forest in savanna regions may be the result of softer soil or other local conditions. Open, grassy plains or savannas, often of wide extent, cover generally level areas along the Pacific slope from near the Costa Rican frontier

FIG. 1.—Savanna near southern base of Cerro Azul, southern Panama.

FIG. 2.—Savanna near Corozal, Canal Zone.

FIG. 1.—Upper Tropical Zone at 3,500 feet altitude on Mount Pirre. Looking over forest and clouds in Cana Valley.

FIG. 2.—Upper Tropical Zone near summit of Mount Pirre, altitude 5,000 feet. Palms and ferns are more abundant here than at lower elevations.

eastward to the Bayano River. Savannas also occur in the valley of the Chagres River, east of the Canal Zone. Some mammals and birds are not very definitely assignable to either area, as they find their most congenial habitat along the forest borders where they seek food in the open spaces and retire to the woodland for shelter. The savannas are now devoted largely to stock raising and during the dry season large parts of their surface are swept by fire which destroys much of the smaller animal life. Some of the hawks are said to have learned to patrol the fire lines, ready to pounce upon small rodents and other creatures attempting to escape. While viewing the smoking plains from a vantage point on Cerro Azul, one of my native packers told me that a large hawk is locally known as "bebe-humo" (literally, "drink smoke") from its habit of flying close to the fire.

Mammals of Savanna Area and Semi-forested Savanna Borders

Marmosa mexicana savannarum, Savanna Marmosa.
Philander laniger pallidus, Pale Woolly Opossum.
Odocoileus chiriquensis, Chiriqui White-tailed Deer.
Zygodontomys cherriei cherriei, Cherrie's Cane Rat.
Oryzomys tectus tectus, Bugaba Rice Rat.
Oryzomys fulvescens costaricensis, Costa Rican Pygmy Rice Rat.
Oryzomys caliginosus chrysomelas, Costa Rican Dusky Rice Rat.
Macrogeomys pansa, Bugaba Pocket Gopher.
Liomys adspersus, Peters' Spiny Pocket Mouse.
Sciurus variegatoides helveolus, Canal Zone Squirrel.
Sciurus variegatoides melania, Costa Rican Black Squirrel.
Sylvilagus gabbi consobrinus, Savanna Rabbit.

Birds of Savanna Area and Semi-forested Savanna Borders

Rupornis ruficauda, Rufous-tailed Hawk.
Crotophaga sulcirostris, Groove-billed Ani.
Pheugopedius hyperythrus, Tawny-bellied Wren.
Anthus parvus, Panama Pipit.
Sturnella magna inexspectata, Central American Meadow Lark.
Leistes militaris, Cayenne Red-breasted Blackbird.
Ammodramus savannarum obscurus, Minatitlan Sparrow.
Sporophila minuta minuta, Minute Seed-eater.

Plants of Savanna Area and Semi-forested Savanna Borders

Andropogon bicornis.
Andropogon condensatus.
Andropogon fastigiatus.
Andropogon hirtiflorus.
Andropogon leucostachyus.
Andropogon tener.
Axonopus compressus.
Axonopus marginatus.
Cymbopogon bracteatus.
Elionurus tripsacoides.
Paspalum gardnerianum.
Paspalum heterotrichon.
Paspalum minus.
Paspalum notatum.
Paspalum pilosum.
Paspalum plicatulum.
Paspalum stellatum.
Sporobolus indicus.
Thrasya campylostachya.
Trachypogon montufari.
Bromelia pinguin.
Roupala complicata.
Xylopia grandiflora.
Chamæcrista tagera.
Diphysa carthagenensis.
Indigofera pascuorum.
Indigofera suffruticosa.
Meibomia angustifolia.
Phaseolus gracilis.
Byrsonima cumingiana, Nancé.

Sloanea quadrivalvis.
Peltæa sessiliflora.
Sida jamaicensis.
Sida linifolia.
Guazuma ulmifolia, Guacimo.
Curatella americana.
Miconia rubiginosa.
Miconia fulva.
Lantana camara.
Cornutia pyramidata.
Duranta plumieri.
Diodia rigida.
Pectis elongata.
Pectis swartziana.

UPPER TROPICAL ZONE

With the exception of the lofty Volcan de Chiriqui, the Upper Tropical Zone embraces the slopes and crests of mountains above 3,000 to 8,500 feet altitude. Its upward extent on the Volcan de Chiriqui has not been accurately determined, but probably reaches on general slopes to near the 8,000-foot contour line or somewhat higher. Practically the entire area is densely forested, but the forest, largely of palms, is of somewhat smaller growth than in much of the Lower Tropical Zone. While the zone as a whole is humid, no very definite divisions on the basis of moisture being now recognizable in Panama, variations in humidity due to slope exposure are often marked. The northeast trade winds cause precipitation or cloud formation, affecting the northern slopes of the mountains in this zone during the so-called "dry" season. Fogs and generally moist conditions extending across the summits reach about 500 feet down the southern slope, below which their influence rapidly diminishes, the altitude of the line of demarcation depending on that of the crest. An extract from the itinerary of Mr. W. W. Brown, Jr., quoted by Mr. Outram Bangs[1] is descriptive of this zone on the Volcan de Chiriqui. It runs as follows:

> On the further side of the llano, at an altitude of 3,500 feet, the trail leaves the plain and passes through valleys and over hills, in a cool luxuriant forest with swiftly running streams and brooks rippling among fern-covered rocks. One begins to see an immense number of birds, all of different species from those of the lowlands—water ouzels dart about on the rocks in the foaming, rushing streams, small thrushes (*Catharus*) and solitaires are singing everywhere in the jungle and the branches overhead are full of tanagers and warblers. This Zone extends up to about 5,000 feet. Between 5,000 and 8,000 feet another change in the bird life is noticed, but not so marked a one.

More complete knowledge of the 4,500 to 5,000 feet of altitudinal extent assigned to this zone may point to the desirability of making divisions which are not satisfactorily recognizable now.

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[1] The Auk, Vol. 3, p. 17, Jan. 30, 1902.

Mammals of Upper Tropical Zone

[Species marked L. occur also in Lower Tropical Zone.]

Pecari angulatus crusnigrum, Chiriqui Collared Peccary. L.
Reithrodontomys mexicanus cherrii, Cherrie's Harvest Mouse.
Peromyscus flavidus, Volcan Mouse.
Peromyscus pirrensis, Mount Pirre Mouse.
Peromyscus nudipes, La Carpintera Mouse.
Nyctomys sumichrasti nitellinus, Chiriqui Vesper Rat.
Rhipidomys scandens, Mount Pirre Climbing Mouse.
Tylomys fulviventer, Fulvous-bellied Climbing Rat.
Scotinomys teguina apricus, Boquete Brown Mouse.
Oryzomys alfaroi alfaroi, Alfaro's Rice Rat. L.
Oryzomys devius, Boquete Rice Rat.
Oryzomys pirrensis, Mount Pirre Rice Rat.
Oryzomys fulvescens vegetus, Volcan Chiriqui Pygmy Rice Rat.
Rheomys raptor, Panama Water Mouse.
Macrogeomys cavator, Chiriqui Pocket Gopher.
Heteromys desmarestianus repens, Chiriqui Spiny Pocket Mouse.
Heteromys desmarestianus panamensis, Panama Spiny Pocket Mouse.
Heteromys desmarestianus crassirostris, Mount Pirre Spiny Pocket Mouse.
Dasyprocta punctata dariensis, Darien Agouti.
Coendou mexicanum lænatum, Chiriqui Porcupine.
Sciurus hoffmanni chiriquensis, Chiriqui Squirrel. L.
Sciurus gerrardi choco, Darien Squirrel. L.
Microsciurus boquetensis, Chiriqui Pygmy Squirrel.
Syntheosciurus brochus, Groove-toothed Squirrel.
Icticyon panamensis, Panama Bush Dog.
Bassariscus sumichrasti notinus, Panama Bassariscus.
Nasua narica panamensis, Panama Coati. L.
Bassaricyon gabbii orinomus, Panama Bushy-tailed Olingo. L.
Potos flavus isthmicus, Isthmian Kinkajou. L.
Mustela frenata costaricensis, Costa Rican Bridled Weasel. L.
Conepatus tropicalis trichurus, Panama Skunk. L.
Felis pardalis mearnsi, Mearns' Ocelot.
Felis bangsi costaricensis, Central American Puma.
Cryptotis merus, Mount Pirre Shrew.
Diclidurus virgo, Costa Rican White Bat (Probably also Lower Tropical).
Sturnira lilium parvidens, Northern Yellow-shouldered Bat (Probably also Lower Tropical).
Diphylla centralis, Central American Vampire Bat (Probably also Lower Tropical).
Eptesicus fuscus miradorensis, Mirador Brown Bat.
Nycteris borealis mexicana, Mexican Red Bat.
Alouatta palliata inconsonans, Panama Howling Monkey. L.
Cebus capucinus capucinus, Colombian White-throated Capuchin. L.
Cebus capucinus imitator, Panama White-throated Capuchin. L.
Ateles dariensis, Darien Black Spider Monkey. L.

Birds of Upper Tropical Zone

Leucopternis princeps, Barred-bellied Leucopternis.
Odontophorus guttatus, Spotted Partridge.
Odontophorus leucolæmus, White-throated Partridge.
Oreopeleia goldmani, Goldman's Quail Dove.
Claravis mondetoura, Mondétour's Ground Dove.
Urochroma dilectissima, Blue-fronted Parrotlet.
Pyrrhura hoffmanni gaudens, Chiriqui Paroquet.
Dryobates villosus extimus, Boquete Woodpecker.
Aulacorhynchus cæruleogularis cæruleogularis, Blue-throated Toucanet.
Aulacorhynchus cæruleogularis cognatus, Darien Blue-throated Toucanet.
Pharomachrus mocinno costaricensis, Costa Rican Quetzal.
Otus nudipes, Bare-legged Screech Owl.
Nesophlox bryantæ, Costa Rican Wood-Star.
Selasphorus scintilla, Scintillant Hummingbird.
Eugenes spectabilis, Admirable Hummingbird.
Panterpe insignis, Irazu Hummingbird.
Oreopyga castaneoventris castaneoventris, Chiriqui Mountain Gem.
Colibri cyanotus, Lesser Violet-Ear.
Callipharus nigriventris, Black-bellied Hummingbird.
Eupherusa egregia, Egregious Hummingbird.
Hemistephania veraguensis, Veraguan Lance-Bill.
Goethalsia bella, Goethals' Hummingbird.

Eriocnemis floccus, Wool-tufted Hummingbird.
Phæthornis guy coruscus, Bangs' Hermit.
Dendrocolaptes validus costaricensis, Costa Rican Woodhewer.
Rhopoctites rufobrunneus, Streaked Automolus.
Xenicopsis subalaris lineatus, Lineated Xenicopsis.
Philydor panerythrus, Ochraceous Philydor.
Pseudocolaptes lawrencii, Lawrence's Pseudocolaptes.
Acrorchilus erythrops rufigenis, Lawrence's Spinetail.
Premnoplex brunnescens brunneicauda, Costa Rican Premnoplex.
Margarornis rubiginosa, Costa Rican Margarornis.
Margarornis bellulus, Beautiful Margarornis.
Xenops rutilus heterurus, Streaked Xenops.
Grallaricula costaricensis, Costa Rican Grallaricula.
Grallaricula flavirostris brevis, Darien Grallaricula.
Formicarius rufipectus, Rufous-breasted Antthrush.
Dysithamnus mentalis suffusus, Olive-sided Antvireo.
Scytalopus argentifrons, Silvery-fronted Scytalopus.
Idiotriccus zeledoni, Zeledon's Tyrannulet.
Cephalopterus glabricollis, Bare-necked Umbrella Bird.
Myiochanes lugubris, Lugubrious Flycatcher.
Elænia frantzii frantzii, Frantzius' Elænia.
Pseudotriccus pelzelni berlepschi, Berlepsch Flycatcher.
Myadestes coloratus, Varied Solitaire.
Myadestes melanops, Black-faced Solitaire.
Planesticus plebejus, Cabanis' Thrush.
Catharus frantzii frantzii, Frantzius' Nightingale Thrush.
Catharus griseiceps, Gray-headed Nightingale Thrush.
Catharus fuscater mirabilis, Darien Nightingale Thrush.
Zeledonia coronata, Wren-Thrush.
Cinclus ardesiacus, Costa Rican Dipper.
Henicorhina leucophrys collina, Chiriqui Wood Wren.
Troglodytes festinus, Mount Pirre Wren.
Troglodytes ochraceus, Irazu Wren.
Cyanolyca argentigula, Silver-throated Jay.
Vireosylva josephæ chiriquensis, Chiriqui Vireo.
Vireo carmioli, Carmiol's Vireo.
Basileuterus melanotis, Black-eared Warbler.
Basileuterus melanogenys ignotus, Mount Pirre Warbler.
Myioborus torquatus, Collared Redstart.
Myioborus aurantiacus, Yellow-bellied Redstart.
Oreothlypis gutturalis, Irazu Warbler.
Chrysothlypis chrysomelas ocularis, Black and Gold Tanager.
Tangara icterocephala, Silver-throated Tanager.
Tangara fucosus, Green-naped Tanager.
Chlorospingus novicius novicius, Bangs' Tanager.
Chlorophonia callophrys, Costa Rican Chlorophonia.
Hylospingus inornatus, Mount Pirre Tanager.
Caryothraustes canadensis simulans, Black-masked Finch.
Pheucticus tibialis, Irazu Grosbeak.
Pezopetes capitalis, Large-footed Sparrow.
Pselliophorus tibialis, Yellow-thighed Sparrow.
Buerremon brunneinuchus, Chestnut-capped Buerremon.
Atlapetes gutturalis, Yellow-throated Sparrow.
Lysurus crassirostris, Barranca Sparrow.
Brachyspiza capensis peruviana, Peruvian Sparrow.

Plants of Upper Tropical Zone

Lycopodium stamineum.
Lycopodium tortile.
Lycopodium foliaceum.
Lycopodium lancifolium.
Lycopodium cuneifolium.
Lycopodium subulatum.
Lycopodium podocarpum.
Lycopodium watsonianum.
Marattia pittieri.
Anthurium joseanum.
Monstera parkeriana.
Monstera pertusa.
Piper pseudopropinquum.
Quercus warscewiczii.
Quercus bumelioides.
Quercus chiriquensis, Chiriqui Oak.
Cecropia maxoni, Maxon's Guarumo.
Loranthus densiflorus.
Phoradendron corynarthron.
Phoradendron nervosum.
Desmopsis maxonii.
Persea veraguensis.
Prunus occidentalis.
Rubus floribundus.
Lupinus clarkii.
Macherium seemannii.
Meibomia maxoni.
Euphorbia barbellata.
Euphorbia graminea.
Triumfetta speciosa.

Malache maxoni.
Centrademia inæquilateralis.
Miconia caudata.
Monchætum bracteolatum.
Lopezia pariculata.
Symplocos chiriquensis.
Lamourouxia gutierrezii.
Begonia chiriquina.
Begonia brevicyma.
Begonia seemanniana.
Begonia setosa.
Begonia stigmosa.
Dicliptera iopus.
Geissomeria lolioides.
Justicia glabra.
Deppea longipes.
Hoffmannia pittieri.
Nertera depressa.
Palicourea chiricana.
Psychotria aggregata.
Psychotria anomothyrsa.
Psychotria chiricana.
Psychotria goldmanii.
Psychotria panamensis.
Rondeletia affinis.
Rondeletia laniflora.
Rondeletia versicolor.
Sommera mesochora.
Senecio arborescens.

TEMPERATE ZONE

The Volcan de Chiriqui was not visited by me and has been very incompletely explored by others. Conditions on the upper slopes are apparently analogous to those known to obtain in similar regions elsewhere in Middle America. There seems to be a diminution in moisture above about 8,000 feet altitude and temperatures below the freezing point are registered near the summit. Mr. Henry Pittier,[1] who has visited the Volcan de Chiriqui, describes conditions on the very similar mountains in Costa Rica and points out changes in the forest above an altitude of 2,600 meters. The trees become progressively reduced in size, with short trunks and widely spreading branches, and at about 3,000 meters, although still dense and covering extensive areas on the slopes, no longer deserve the name of forest. The Lauraceae, species of *Podocarpus, Talauma* and even *Quercus* have disappeared and are replaced by Ericaceae, Mirtaceae, Miricaceae and other groups. Mr. Outram Bangs,[2] quoting the field notes of Mr. W. W. Brown, Jr., who collected birds and mammals on the mountain, says:

> At 10,000 feet the character of the forest changes decidedly, the trees become low and stunted, their trunks and branches are thickly covered with cold, saturated moss. On some of the branches globular formations of moss give an odd appearance to the tree. The undergrowth is chiefly of berry-bearing shrubs and two species of cane, with ferns and flowering herbs.
>
> One shrub produces a berry about the size of a cherry, which has a rich flavor, and of which doves and big Merula (*M. nigrescens*) are very fond. At 11,000 feet the forest ends, and at the timber line the characteristic species are the Junco (*Junco vulcani*), a big-footed finch (*Pezopetes capitalis*), the long-tailed ptilogonys and a curious little wren with peculiar notes, that lives in the cane brakes (*Troglodytes browni*). The country is open, broken, barren and very rocky, but there is a growth of low huckleberry-like shrubs that average 10 inches in height and are literally black with berries. There are also low flowering plants, and some tiny ferns, different from any seen below.

[1] Ensayo Sobre las Plantas Usuales de Costa Rica, 1908.
[2] The Auk, Vol. 3, p. 18, Jan. 30, 1902.

Standing up high above this desolate region is the great rocky peak of Mt. Chiriqui, which I believe I am the only man to have climbed. The summit is a towering rock, its extreme point so sharp and narrow that I had to straddle it. Under one foot was a sheer fall of some 900 feet, under the other a sharp slope of 600 or 700. I found no signs of any previous ascent, but left two records of my own visit. From the top I looked down on the waters of the Caribbean Sea and of the Pacific Ocean, seeing distinctly the indentations of both coasts. To the west I could see the Costa Rican Mountains, and to the east stretched an ocean of small peaks. My aneroid registered 11,500 feet.

This zone seems to be representative of the several boreal life zones recognizable in North America, but its exact relation to them remains to be determined.

Mammals of Temperate Zone

Reithrodontomys australis australis, Irazu Harvest Mouse (occurs also in upper Tropical Zone).
Reithrodontomys creper, Chiriqui Harvest Mouse.
Scotinomys xerampelinus, Chiriqui Brown Mouse.
Sigmodon austerulus, Chiriqui Cotton Rat.

Birds of Temperate Zone

Chlorœnas albilinea crissalis, Costa Rican Band-tailed Pigeon.
Selasphorus torridus, Heliotrope-throated Hummingbird.
Casmarhinchos tricarunculatus, Costa Rican Bell-Bird.
Empidonax atriceps, Black-capped Fly-catcher.
Planesticus nigrescens, Sooty Thrush.
Catharus gracilirostris accentor, Chiriqui Nightingale Thrush.
Thryorchilus browni, Brown's Wren.
Ptilogonys caudatus, Costa Rican Ptilogonys.
Phainoptila melanoxantha, Salvin's Ptilogonys.
Basileuterus melanogenys eximius, Chiriqui Warbler.
Diglossa plumbea, Costa Rican Diglossa.
Chlorospingus pileatus, Sooty-capped Chlorospingus.
Junco vulcani, Volcan Junco.

Plants of Temperate Zone

Lycopodium chiricanum.
Lycopodium hippuridium.
Dendrophthora biserrula.
Dendrophthora costaricensis.
Dendrophthora wrightii.
Maytenus blepharodes.
Arcytophyllum lavarum.

LIST OF THE MAMMALS OF PANAMA

Chironectes panamensis.
Didelphis marsupialis etensis.
Didelphis marsupialis particeps.
Didelphis marsupialis battyi.
Marmosa mexicana isthmica.
Marmosa mexicana savannarum.
Marmosa fulviventer.
Marmosa invicta.
Metachirus opossum fuscogriseus.
Metachirus nudicaudatus dentaneus.
Philander laniger derbianus.
Philander laniger pallidus.
Philander laniger nauticus.
Peramys melanops.
Bradypus griseus griseus.
Bradypus ignavus.
Cholœpus hoffmanni.
Cyclopes didactylus dorsalis.
Tamanduas tetradactyla chiriquensis.
Myrmecophaga tridactyla centralis.
Dasypus novemcinctus fenestratus.
Cabassous centralis.
Trichechus manatus.
Pecari angulatus crusnigrum.
Pecari angulatus bangsi.
Tayassu pecari spiradens.
Odocoileus chiriquensis.
Odocoileus rothschildi.

Mazama sartorii reperticia.
Tapirella bairdii.
Reithrodontomys australis australis.
Reithrodontomys creper.
Reithrodontomys mexicanus cherrii.
Peromyscus flavidus.
Peromyscus pirrensis.
Peromyscus nudipes.
Nyctomys sumichrasti nitellinus.
Rhipidomys scandens.
Tylomys panamensis.
Tylomys watsoni.
Tylomys fulviventer.
Scotinomys teguina apricus.
Scotinomys xerampelinus.
Zygodontomys cherriei cherriei.
Zygodontomys cherriei ventriosus
Zygodontomys seorsus.
Neacomys pictus.
Oryzomys gatunensis.
Oryzomys alfaroi alfaroi.
Oryzomys alfaroi dariensis.
Oryzomys bombycinus bombycinus.
Oryzomys talamancæ.
Oryzomys devius.
Oryzomys pirrensis.
Oryzomys tectus tectus.
Oryzomys tectus frontalis.
Oryzomys fulvescens costaricensis.
Oryzomys fulvescens vegetus.
Oryzomys caliginosus idoneus.
Oryzomys caliginosus chrysomelas.
Nectomys alfari efficax.
Sigmodon hispidus chiriquensis.
Sigmodon austerulus.
Rheomys raptor.
Rattus rattus rattus.
Rattus rattus alexandrinus.
Mus musculus musculus.
Macrogeomys dariensis.
Macrogeomys cavator.
Macrogeomys pansa.
Heteromys australis conscius.
Heteromys desmarestianus repens.
Heteromys desmarestianus zonalis.
Heteromys desmarestianus panamensis.
Heteromys desmarestianus crassirostris.
Liomys adspersus.
Proechimys semispinosus panamensis.
Proechimys semispinosus burrus.
Hoplomys gymnurus goethalsi.
Diplomys labilis.
Diplomys darlingi.
Dasyprocta punctata isthmica.
Dasyprocta punctata dariensis.
Dasyprocta punctata nuchalis.
Dasyprocta callida.
Dasyprocta coibæ.
Cuniculus paca virgatus.
Hydrochærus isthmius.
Coendou mexicanum lænatum.
Coendou rothschildi.
Sciurus variegatoides helveolus.
Sciurus variegatoides melania.
Sciurus hoffmanni chiriquensis.
Sciurus gerrardi choco.
Sciurus gerrardi morulus.
Microsciurus boquetensis.
Microsciurus alfari browni.
Microsciurus alfari venustules.
Microsciurus isthmius vivatus.
Syntheosciurus brochus.
Sylvilagus gabbi gabbi.
Sylvilagus gabbi messorius.
Sylvilagus gabbi incitatus.
Sylvilagus gabbi consobrinus.
Icticyon panamensis.
Bassariscus sumichrasti notinus.
Procyon cancrivorus panamensis.
Procyon lotor pumilus.
Nasua narica panamensis.
Bassaricyon gabbii gabbii.
Bassaricyon gabbii orinomus.
Potos flavus isthmicus.
Potos flavus chiriquensis.
Mustela affinis costaricensis.
Tayra barbara biologiæ.
Grison canaster.
Conepatus tropicalis trichurus.
Lutra repanda.
Felis onca centralis.
Felis pardalis mearnsi.
Felis pirrensis.
Felis bangsi costaricensis.
Herpailurus yagouaroundi panamensis.
Cryptotis merus.
Rhynchiscus naso priscus.
Saccopteryx bilineata bilineata.
Saccopteryx leptura.
Peropteryx canina canina.
Centronycteris centralis.
Diclidurus virgo.
Dirias albiventer minor.
Chilonycteris rubiginosa rubiginosa.
Micronycteris microtis.
Lonchorina aurita.
Tonatia amblyotis.
Macrophyllum macrophyllum.
Phyllostomus hastatus panamensis.
Trachops cirrhosus.
Vampyrus spectrum nelsoni.
Glossophaga soricina leachii.
Lonchophylla robusta.
Lonchophylla concava.
Hemiderma perspicillatum aztecum.
Hemiderma castaneum.
Sturnira lilium parvidens.
Uroderma bilobatum.
Vampyrops helleri.
Vampyrodes major.
Vampyressa minuta.
Chiroderma isthmicum.
Chiroderma salvini.
Artibeus watsoni.
Artibeus jamaicensis jamaicensis.
Artibeus planirostris planirostris.

Desmodus rotundus murinus.
Diphylla centralis.
Natalus mexicanus.
Myotis nigricans.
Myotis ——— sp.?
Eptesicus propinquus.
Eptesicus fuscus miradorensis.
Nycteris borealis mexicana.
Dasypterus ega panamensis.
Rhogeëssa tumida.
Molossops planirostris.
Eumops nanus.
Eumops glaucinus.
Molossus coibensis.
Molossus sinaloae.
Molossus bondae.
Saimiri örstedii örstedii.
Aotus zonalis.
Leontocebus geoffroyi.
Alouatta palliata inconsonans.
Alouatta coibensis.
Cebus capucinus capucinus.
Cebus capucinus imitator.
Ateles geoffroyi.
Ateles dariensis

GENERAL ACCOUNT OF THE MAMMALS

Class MAMMALIA

Order MARSUPIALIA. Marsupials

Family DIDELPHIIDAE. Opossums

The opossums, which constitute the only large American family of existing Marsupials,[1] are represented in Panama by six genera. They vary in type from the large familiar opossum of the southeastern United States to the woolly opossums, the web-footed water opossum, and species so small that ordinary observers often mistake them for rats or mice. The small species, to which the rather misleading term " murine " is often applied, may perhaps be most easily recognized as opossums by the wide mouth and numerous teeth visible, the opposibility of the toes, and the remarkable resemblance to hands exhibited by both fore and hind feet. The American Marsupials are as a group essentially tropical in distribution, although one or two species push well northward into the temperate zone in North America and ascend to the upper slopes of high mountains in Middle America.

Genus CHIRONECTES Illiger

The water opossums are distinguished from the other opossums by black and gray marbled dorsal markings, the rounded black areas confluent along the median line of the back. The fur is dense, somewhat like that of an otter; the hind feet are completely webbed and the animal generally fitted for an aquatic life. In general structure *Chironectes* is very similar, however, to the other opossums. It was regarded by Thomas [2] as most nearly related to the genus *Metachirus*.

[1] The other existing American family of the order, Cænolestidæ, includes the aberrant genera *Cænolestes* and *Orolestes* which are restricted to South America.

[2] Cat. Marsup. Brit. Mus., p. 366, 1888.

FIG. 1.—Chiriqui White-tailed Deer (*Odocoileus chiriquensis*) now ranging throughout much of the Canal Zone as far north as the Atlantic Coast.

FIG. 2.—Allen's Opossum (*Metachirus opossum fuscogriseus*), caught in trap placed at base of tree in forest near Gatun, Canal Zone.

Darien Pocket Gopher (*Macrogeomys dariensis*) at mouth of one of its tunnels near Cana, eastern Panama, altitude 2,000 feet.

CHIRONECTES PANAMENSIS Goldman

Panama Water Opossum

[Plate 20, figs. 2, 2*a*]

Chironectes panamensis GOLDMAN, Smiths. Misc. Coll., Vol. 63, No. 5, p. 1, March 14, 1914. Type from Cana, eastern Panama, altitude 2,000 feet.

The water opossums are little known. They occur in suitable localities entirely across South America and northward through Middle America to Tuxtla Chico in extreme southern Mexico, but are rare, and few specimens have found their way into museum collections. A specimen from Cana, eastern Panama, has been made the type of a species apparently differing from *C. minimus* of northeastern South America mainly in various cranial details, especially the longer, evenly tapering and posteriorly pointed, instead of truncate, nasals. The type was caught in a steel trap baited with fish and set beneath the surface of the water in a small rock-bordered stream at 2,000 feet altitude. In Brazil, according to Waterhouse,[1] " two of Dr. Natterer's specimens, that gentleman informed me, were caught near water not far from Rio Janeiro, and a third was captured in the water, alive, near Para, in a basket similar to those used for catching eels in this country: it had made its way through the funnel-shaped opening, and could not return; thus proving that the animals are good divers. They feed upon crustaceans, and no doubt upon other aquatic animals."

Specimens examined: Aside from the type mentioned, no specimens of *Chironectes panamensis* have been recorded from Panama, but ten examples have been examined by me from localities in Colombia, Costa Rica and Nicaragua.

Genus DIDELPHIS Linnæus

The typical genus of the family includes the largest species of the region, the type of animal that inhabits the southeastern United States. The forms are externally distinguished from the other opossums by the coarse hair, or bristles, which project conspicuously beyond the shorter and softer under fur.

DIDELPHIS MARSUPIALIS ETENSIS Allen

Eten Opossum; Zorro

Didelphis marsupialis etensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 16, p. 262, August 18, 1902. Type from Eten, Piura, Peru.

Large opossums of the common coarse-haired *Didelphis virginiana* type are abundant nearly throughout the region. The status of the

[1] Nat. Hist. Mamm., Vol. 1, p. 535, 1846.

continental form is not, however, entirely clear; specimens examined, as remarked by Allen (*l. c.*), seem " not apparently distinguishable " from typical *D. m. etensis.* On the other hand they are not very unlike typical examples of the apparently larger subspecies *D. m. richmondi* of Nicaragua, and may be somewhat intermediate in general characters. As in other forms of the general group two color phases are shown. The usual color of the pelage is blackest at the tips, but in about one-third of the individuals examined, long whitish hairs are predominant among the black ones. This dichromatism has led to the belief in many localities that two distinct species exist side by side.

While this form may be said to be abundant it occurs in smaller numbers at most localities than *Metachirus opossum fuscogriseus.* It favors the vicinity of streams or other water, along the muddy borders of which numerous palmate tracks may be seen. While using a hunting lamp in quest of more important game a number were shot at night along the banks of streams. The species is easily taken in steel traps baited with meat or fruit, especially bananas, of which they are very fond. When caught the ground and vegetation within reach are thoroughly torn up by the animal in frantic struggles to free itself, but on hearing some one approach it instantly becomes quiescent and " possums " in the characteristic manner. The body becomes motionless, in a half-crouched position, the head drops slightly, and unless the eyeballs are touched the eyes have a fixed stare. Given a slight push the opossum tumbles over on its side and lies with rigid limbs and muscles as though dead. In this condition it may be handled freely, making no attempt to bite or even to stir and about the only sign of life is its regular breathing. Removed from the trap it may be left lying motionless and apparently dead upon the ground. But it is sure to be gone if the trapper retires and returns to search for it a few minutes later.

A female trapped at Gatun had five hairless and sightless young all firmly attached to teats within her pouch. When the young were forcibly drawn away the much elongated teats were seen to have extended well into their throats. Several other litters of similar young were examined. The lips seem to be practically immobile; the mouth a very small, round opening into which the teat fits so snugly that one wonders how it could have been introduced at the time of the birth of so embryonic an animal. When the young are detached the open mouth retains the shape of the teat; they begin at once to show their discomfort by making a slight hissing noise, twisting their limbs and bodies about and rolling over and over on the ground. In this pitiful condition they may live for hours.

Several stomachs of opossums shot at night were examined and found to contain the remains of crabs and small quantities of some unidentifiable fruit. It is evident that crabs are an important element of the diet of these animals, at least near the seacoasts.

Under the name *Didelphis richmondi*, Bangs (1902, p. 19) noted specimens collected by W. W. Brown, Jr., at Boquete. Later in the same year Allen (*l. c.*) recorded 33 examples from Boqueron and a smaller series from Boquete, all taken by J. H. Batty. Specimens probably referable to this form were listed as *Didelphis marsupialis* by Thomas (1903*a*, p. 42) from Sevilla, Afuera, Gobernador, Tologa, Brava and Cebaco, all small islands off the southern coast of western Panama. He adds "as on the mainland, these island opossums differ much among themselves, but none are as uniformly brown-faced as the Coiba form *D. m. battyi*." Anthony (1916, p. 364) regarded the species as not uncommon in the Canal Zone, but rarer in the Darien region. He recorded specimens from Boca de Cupe, Cituro, Real de Santa Maria and Gatun.

Through a peculiar transposition of names "zorro" for the male and "zorra" for the female, commonly and more properly applied by the people to the foxes in much of Middle America, are used instead for the opossums in Panama and Costa Rica. While the termination employed depends usually on the sex of individuals the masculine form is used in a generic sense to designate the species, or an individual whose sex is unknown. In Costa Rica where foxes occur they have received the misnomer "tigrillo" (little tiger).

Specimens examined: Ancon, 1; Boca de Cupe, 1[1]; Boqueron, 18[1]; Boquete, 7[2,4]; Cana, 8; Cituro, 1[1]; Empire, 3; Gatun, 13[3]; Lion Hill, 2; Mount Pirre, 1; Porto Bello, 1; Real de Santa Maria, 1.[1]

DIDELPHIS MARSUPIALIS PARTICEPS Goldman

San Miguel Island Opossum

Didelphis marsupialis particeps GOLDMAN, Proc. Biol. Soc. Washington, Vol. 30, p. 107, May 23, 1917. Type from San Miguel Island, Bay of Panama.

In recording two opossums from San Miguel Island as *Didelphis karkinophaga caucæ* Allen, Bangs (1906, p. 633) remarks: "These

[1] Collection Amer. Mus. Nat. Hist.
[2] Six specimens in Mus. Comp. Zool.
[3] Five specimens in Amer. Mus. Nat. Hist.
[4] One specimen in Amer. Mus. Nat. Hist.

have been compared by Dr. J. A. Allen with extensive material from South and Central America; and it is Dr. Allen's opinion that they are best referred to this form, though they do not represent it in its extremes." Later studies have led to the recognition of these as representing an insular race with less blackish face and skull characterized by relatively broader rostrum, narrower braincase and posteriorly expanded zyzomata in comparison with the form inhabiting the adjacent mainland.

Specimens examined: San Miguel Island, 2.[1]

DIDELPHIS MARSUPIALIS BATTYI Thomas

Batty's Opossum

Didelphis marsupialis battyi THOMAS, Novitates Zoologicæ, Vol. 9, p. 137, April, 1902. Type from Coiba Island, Panama.

Batty's opossum is described as a rather small dark-faced insular race. It was originally compared with *D. m. caucæ* of Colombia, but is probably most nearly allied to the form inhabiting the adjacent mainland.

Allen (1902, p. 264) in his review of the group, after quoting the original description, says, "*D. m. battyi* seems to represent a small insular race, as shown by several topotypes kindly presented by the collector, Mr. J. H. Batty, to this Museum. I am also indebted to Mr. Batty's kindness for a transcript from his note-book of the measurements of the specimens taken before skinning. I am thus able to supplement Mr. Thomas's description with the flesh measurements of not only his type, but also of seven additional specimens. . . . . The four females, rather strangely, happen to range rather larger than the four males, doubtless owing to the fact that the females had reached a greater maturity than the males. If the females of the Coiba Island series and the females of the Boqueron and Boquete series [referred by him to *D. m. etensis*] be taken as the basis of comparison, the apparent difference in size practically vanishes." Specimens examined by me are somewhat darker on the face than *etensis* as represented at Boqueron on the adjacent mainland.

Specimens examined: Coiba Island, 3.

Genus MARMOSA Gray

The genus *Marmosa* includes a number of small, slender, long-tailed species commonly termed "Murine" opossums, owing to a very superficial resemblance to rats. They are rat-like, however,

[1] Specimens in Mus. Comp. Zool.

only in size, as a glance at the wide mouth, numerous teeth, and characteristically opossum feet show. The skull of *Marmosa* is similar to that of *Philander* in the permanent separation of the temporal ridges, but it differs in other important respects, especially the absence of distinct postorbital processes, the straight and anteriorly much converged maxillary toothrows, and in the relative size of the first and third upper molars. In *Marmosa* the third upper molar is larger than the first, while in *Philander* the reverse is usually true. For many years a single form was supposed to range northward from South America to southern Mexico, but several distinct species are now known to inhabit Middle America.

MARMOSA MEXICANA ISTHMICA Goldman

Isthmian Marmosa

[Plate 21, figs. 3, 3*a*]

Marmosa isthmica Goldman, Smiths. Misc. Coll., Vol. 56, No. 36, p. 1, February 19, 1912. Type from Rio Indio, near Gatun, Canal Zone, Panama.

The isthmian marmosa is about the size of a large rat. It closely resembles *M. mitis* Bangs, of the Santa Marta region of Colombia, in color, but differs from that animal in larger size, relatively larger braincase, broader interorbital space and actually smaller audital processes of alisphenoids. The general color of the upperparts is brownish cinnamon (about sayal brown of Ridgway, 1912), lighter on the middle of the face, and becoming dull ochraceous buff on the sides of the neck and flanks; the underparts are between pinkish buff and cream buff. It is probably a common species throughout Panama. The type was trapped in an old banana plantation only a few feet above sea level near Gatun. At Cana, where the opossums are fairly abundant, a number of specimens were caught in banana-baited traps set on hanging bunches of the ripening fruit in a plantation. The bunches of fruit were visited by the opossums nearly every night. Other specimens were taken in dense undergrowth on the ground in old clearings.

Under the name *Didelphys murina,* Alston (1879, p. 200) notes a small opossum which may have been this form collected by Arcé in Veragua. A specimen of this subspecies was recorded by Bangs (1902, p. 19) as *Marmosa mexicana* from Boquete, Chiriqui. More recently a large series, in the aggregate, of this opossum has been recorded by Anthony (1916, p. 363) from Real de Santa Maria, Gatun, Maxon Ranch (Rio Trinidad), Tapalisa and Tacarcuna. All of these localities are in the eastern half of Panama, ranging from near sea level to over 4,000 feet in altitude. Anthony noted the fact that the males were much larger than the females.

Specimens examined: Boquete, 1[1]; Cana, 14; Gatun, 7[1]; Maxon Ranch (Rio Trinidad), 2[1]; Real de Santa Maria, 4[2]; Rio Indio (type locality), 1; Tacarcuna (2,650-4,200 feet), 33[2]; Tapalisa, 2.[2]

MARMOSA MEXICANA SAVANNARUM Goldman

Savanna Marmosa

Marmosa mexicana savannarum GOLDMAN, Proc. Biol. Soc. Washington, Vol. 30, p. 108, May 23, 1917. Type from Boqueron, Chiriqui, Panama.

Specimens of this little opossum were recorded by Bangs (1902, p. 19) as *Marmosa mexicana* from Bugaba, and by Allen (1904, p. 56) as *Marmosa murina mexicana* from Boqueron, Chiriqui. On comparison with subsequent accessions of material from various localities these specimens appear to represent a geographic race distinguished by small size and pale coloration, the latter character shared with other mammals inhabiting the same generally open savanna region, and evidently the result of the environmental conditions prevailing. This pallid subspecies may range along the Pacific coast of Panama as far east as the Bayano River where the savannas end abruptly.

Specimens examined: Boqueron, 2[2]; Bugaba, 3.[1]

MARMOSA FULVIVENTER Bangs

Fulvous-bellied Marmosa

Marmosa fulviventer BANGS, Amer. Nat., Vol. 35, p. 632. August, 1901. Type from San Miguel Island, Panama.

The fulvous-bellied marmosa is an insular representative of the group to which *M. isthmica* Goldman of the adjacent mainland belongs. It differs from that animal in darker color, the underparts being deep buff or fulvous instead of cream buff or pinkish buff. It is known only from five specimens collected on the islands of San Miguel and Saboga by W. W. Brown, Jr., in the spring of 1900.

The example from Saboga, a small island in the northern part of the archipelago, is slightly paler throughout than specimens from San Miguel and may represent an unrecognized form. The incomplete skull, however, is not very appreciably different.

Specimens examined: Saboga Island, 1[1]; San Miguel Island, 4.[1]

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[1] Collection Mus. Comp. Zool.

[2] Collection Amer. Mus. Nat. Hist.

MARMOSA INVICTA Goldman

Black Marmosa

[Plate 21, figs. 2, 2a]

Marmosa invicta GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, p. 3, September 20, 1912. Type from Cana, eastern Panama (altitude 2,000 feet).

A blackish species of pygmy opossum, mouse-like in size and superficial appearance, was discovered at Cana, in the mountains of eastern Panama. The marsupial pouch is absent as usual in the genus. The mammae in an adult female were enclosed in a cinnamon brownish abdominal area. Examination before skinning showed the mammae, five in number, irregularly placed, three being ranged in a row on the right side, one on the left, and the other on the median line. Two specimens only were obtained, both of them at the same locality in traps placed among rocks in second growth forest.

This species has no known near relative in Middle America, but may be allied to some of the South American forms of the large unrevised genus to which it belongs.

Specimens examined: Two from the type locality.

Genus METACHIRUS Burmeister

The members of this genus are of medium size, the pelage short, rather straight, without the projecting bristles present in *Didelphis*, and lacking the long lax woolly quality of the pelage of *Philander*. With advancing age the temporal ridges unite to form a high, trenchant sagittal crest similar to that developed somewhat earlier in *Didelphis*. Two species range into Panama.

METACHIRUS OPOSSUM FUSCOGRISEUS Allen

Allen's Opossum; Zorro

Metachirus fuscogriseus ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 13, p. 194, October 23, 1900. Type locality, Greytown, Nicaragua.[1]

Of the several species of opossums inhabiting the region this form is by far the most abundant at low elevations. It is about the same in size, and in general appearance resembles its Panama congener, *Metachirus nudicaudatus dentaneus*, by which it is largely replaced on the upper slopes of the mountains. It differs, however, in dark grayish instead of brownish general coloration, and the light markings on the head are grayish instead of ochraceous buffy. The two

[1] Type locality fixed by Allen, Bull. Amer. Mus. Nat. Hist., Vol. 30, p. 247, Dec. 2, 1911.

species occur together at low elevations, but are very distinct as shown by important cranial characters.

A number of specimens were caught in traps set in the hope of attracting more important game. Several shot at night along the banks of streams were located by their shining eyes as seen under the glare of a hunting lamp. Unlike *Didelphis* when taken in steel traps these opossums are always ready to fight savagely. The stomach of one taken at Gatun was well filled with fragments of crabs. Fragments of birds alone, or of birds, including their feathers, and crabs intermixed, were the stomach contents of several others at the same locality. These limited observations indicate that birds suffer much from the depredations of the opossums. A female obtained carried five young in her pouch; although they were small they did not seem to cling so closely to the teats as similar young of *Didelphis.*

A nest of one of these opossums was found three feet from the ground on a fallen log. The log lay in the dense thicket of an old clearing and was heavily overhung with vines and bushes. The nest, globular in form and about a foot in diameter, was placed in a well-hidden spot among the vines. It was made entirely of the banana-like leaves of a native plant rather neatly laid together. The opening at one end faced outward along the log. The occupant slipped quietly out of the nest, when I was within three feet, ran rapidly along the log and disappeared in the thick vegetation. The nest cavity was clean and about the size of the animal's body.

In his original account of *M. o. fuscogriseus,* Dr. Allen (*l. c.*) gave the type region as " Central America " and stated that " the locality of the type of *M. fuscogriseus* is unfortunately not definitely known; the specimen was found in a bunch of bananas in unloading a fruit steamer from a Central American port, most likely Colon." In view of his indefinite reference to Colon and the fact that Panama and Nicaragua appear to be inhabited by the same form I accept his later fixation of the type locality. It is probably not very unusual for animals of this general group to be carried away among bunches of bananas. For example, a specimen of a large species of *Marmosa* was transshipped and carried to an interior point in Texas before being discovered.

Bangs (1902, p. 19) recorded specimens collected by W. W. Brown, Jr., at Boquete and Bugaba, Chiriqui. The species was noted by Thomas (1903*a,* p. 42) from Sevilla Island off the south coast of western Panama. Allen (1904, p. 57) states that Boqueron specimens collected by J. H. Batty " agree well with the type of

M. fuscogriseus, which, however, proves to have been a young adult that had not reached full size. The males have a patch (probably glandular) of pale greenish yellow on each side of the flanks just in front of the thighs; in the females the fur around the edge of the pouch, and also lining it, is bright rusty chestnut." Anthony (1916, p. 363) records a specimen taken by him at Gatun.

The native name *zorro* is applied to this species and to all of the other large opossums inhabiting the region.

Specimens examined: Bugaba, 3[1]; Boqueron, 5[2]; Boquete, 1[1]; Buenaventura Island (near Porto Bello), 1; Empire, 4; Gatun, 12[3]; Tabernilla, 3.

METACHIRUS NUDICAUDATUS DENTANEUS Goldman

Brown Opossum; Zorro

[Plate 20, figs. 1, 1*a*]

Metachirus nudicaudatus dentaneus GOLDMAN, Smiths. Misc. Coll. Vol. 56, No. 36, p. 3. February 19, 1912. Type from Gatun, Canal Zone, Panama.

In size and superficial appearance this opossum resembles *Metachirus opossum fuscogriseus,* but is distinguishable by brown instead of dark grayish general coloration, and by ochraceous buffy instead of plain grayish light areas on the head.

It occurs sparingly at low elevations where *M. o. fuscogriseus* is an abundant species, but apparently becomes more numerous and largely replaces that animal on the middle slopes of the mountains. The general habits of the two appear to be the same, and both are northern representatives of widely ranging South American species.

Specimens are recorded by Anthony (1916, p. 364) from Gatun, Maxon Ranch (Rio Trinidad), 3; Tacarcuna, 2.

Specimens examined: Cana, 4; Cerro Azul, 1; Gatun (type locality), 5[4]; Maxon Ranch (Rio Trinidad), 1[2]; Tacarcuna, 2.[2]

Genus PHILANDER Brisson

The opossums of this genus are handsome animals of about the same medium size as *Metachirus,* but may be readily distinguished from that genus by longer, softer, more woolly pelage, and richer, more contrasting colors. The face is marked by a dark median stripe. In *Philander* the temporal ridges remain permanently separate much as in *Marmosa,* but the skull differs notably from that of the latter

[1] Collection Mus. Comp. Zool.
[2] Collection Amer. Mus. Nat. Hist.
[3] One specimen in Amer. Mus. Nat. Hist.
[4] Three in collection Amer. Mus. Nat. Hist.

genus in the well-developed postorbital processes, the arcuate instead of straight and anteriorly much-converged maxillary toothrows, and in important dental details.

PHILANDER LANIGER DERBIANUS Waterhouse

Derby's Woolly Opossum

Didelphys derbianus WATERHOUSE, Jardine's Naturalist's Library, Mamm., Vol. XI, p. 97, 1841. Type region, Cauca Valley, Colombia.[1]

The beautiful woolly opossums of the *Philander laniger* group are distributed throughout much of South America and range northward to southern Mexico. Their more ornate appearance, as compared with the other opossums of the region, has already been indicated in the remarks on the genus.

The specimens from eastern Panama agree fairly well with descriptions and are assumed to represent *P. l. derbianus* which seems to be distinguishable among the subspecies credited to the republic by its rich cinnamon rufescent coloration. This form has a distinct grayish stripe several inches in length on the median line between the shoulders sometimes referred to as the "withers mark."

Derby's opossum appears to be less numerous than the other large species of the region, but this apparent scarcity may be partly due to more arboreal habits. None were caught in traps set on or near the ground where the other species were readily taken. At Cana a specimen obtained by using the hunting lamp at night was located in a tall forest tree by the glare of its eyes in the restricted field of light. At Tabernilla one was discovered in a nest of leaves placed in a tangled mass of vines in the top of a small tree near the edge of the forest. The localities show that *P. l. derbianus* ascends from sea level to at least 1,800 feet altitude on the slopes of the mountains.

Alston (1879, p. 199) noted a specimen in the British Museum obtained by Arcé at Chepo.

Specimens examined: Cana, 1; Tabernilla, 1.

PHILANDER LANIGER PALLIDUS Thomas

Pale Woolly Opossum

Philander laniger pallidus THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 4, p. 286, October, 1899. Type from Bugaba, Chiriqui, Panama (altitude 800 feet).

As Thomas (*l. c.*) remarks, "This appears to be a pale inornate race of the ordinary brightly marked *Ph. l. derbianus.*" Although somewhat variable, some specimens approaching *P. l. derbianus,* the general color is paler and the markings less distinct than in that form.

[1] As restricted by Allen (1904, p. 57) and Thomas (1913, p. 358).

Bangs (1902, p. 19) listed specimens collected by W. W. Brown, Jr., at Bugaba and Divala. Allen (1904, p. 56) provisionally referred to this form nine examples taken by J. H. Batty of which six were from Boqueron and three from Parida Island. The latter series apparently represent the form more recently described as *Philander laniger nauticus.* Of the general collection he says: "No two of the Chiriqui specimens are alike in coloration; all but one distinctly show the pale gray median stripe over the shoulders seen in *derbianus,* but with varying distinctness from very clear and strong to subobsolete, while the sides of the neck and shoulders and the middle dorsal region are rufous, varying in different specimens from light, clear rufous to dark, almost chestnut rufous. The other specimen (one of the Parida Island series) has the whole upperparts bright, nearly uniform rufous, even to the proximal half of the forelegs and the entire hind legs, with no trace of the gray stripe on the shoulders."

As at present known this subspecies may be assigned an indefinite range near the arid Pacific coast in western Panama, but until more material is available its exact relationship to neighboring forms cannot be determined.

Specimens examined: Boqueron, 3[1]; Bugaba, 4[2]; Divala, 2.[2]

PHILANDER LANIGER NAUTICUS Thomas

Insular Woolly Opossum

Philander laniger nauticus Thomas, Ann. Mag. Nat. Hist., Ser. 8, Vol. 12, p. 359, October, 1913. Type from Gobernador Island, off south coast of Panama.

According to the description this insular race is most nearly allied to *Philander l. pallidus* of the adjacent mainland, to which the specimens on which it is based were formerly referred by Thomas (1903*a*, p. 42). The general color is given as "sayal brown." The grayish withers mark or median stripe between the shoulders in *P. l. derbianus* and *P. l. pallidus* is said to be imperceptible.

Philander l. nauticus described recently was based on four specimens from Gobernador (type locality), Brava and Cebaco, all small islands close to the southwestern coast of Panama. Under the name *Caluromys laniger pallidus,* Allen (1904, p. 56) recorded three specimens from Parida Island which are probably referable to this race, although one only lacks all trace of the shoulder stripe.

Specimens examined: Parida Island, 3.[1]

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

Genus PERAMYS Lesson

The tiny opossums of this genus are characterized by short ears and limbs, and very short, apparently non-prehensile tails.

PERAMYS MELANOPS Goldman

Panama Peramys

[Plate 21, figs. 1, 1*a*]

Peramys melanops GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, p. 2, September 20, 1912. Type from Cana, eastern Panama (altitude 2,000 feet).

The short-tailed opossums of the genus *Peramys* are apparently rare in Panama. The type and only known specimen of *P. melanops* is a small but robust animal with a non-prehensile tail less than two and one-half inches in length. The upperparts are plain and very dark brown in general color, the dorsal stripes, or spots, present in some South American species being absent.

The type specimen was taken in a trap set among rocks in the heavy forest on the bank of the Cana River.

Order EDENTATA. Edentates

Family BRADYPODIDAE. Three-toed Sloths

The three-toed sloths are strictly arboreal animals with short, rounded heads, rudimentary tails, and sharp, strongly curved, hook-like claws with which they hang back downward from the branches of trees. The fore limbs are provided with three instead of two digits as in Choloepodidae. The pelage of the top of the head is inclined forward and forms a frontal ruff. The anterior teeth in the upper jaw are reduced in size until they are the smallest of the series and only slightly functional. The anterior teeth in the lower jaw are large with a prominent longitudinal median ridge. These teeth shear mainly with the second pair, the largest of the series in the upper jaw.

Genus BRADYPUS LINNAEUS. Three-toed Sloth

Perhaps the best recognition mark of the genus is the possession of three digits on the fore foot, a character already mentioned in remarks on the family. Two species are known to inhabit Panama.

BRADYPUS GRISEUS GRISEUS (Gray)

Gray Three-toed Sloth

Arctopithecus griseus GRAY, Ann. Mag. Nat. Hist., Ser. 4, Vol. 7, p. 302, April, 1871. Type from Cordillera del Chucu, western Panama.

The three-toed sloths of Middle America, as far south as the Canal Zone, are assignable to two fairly well-marked forms: *B. casta-*

neiceps (Gray), from Jabali Gold Mine (2,000 feet) Chontales District, Nicaragua,[1] and the animal described as *B. griseus* (Gray), originally ascribed to Costa Rica, but as shown by Alston (1879, p. 183) really from western Panama. The latter species was placed by Alston (1879, p. 183) in the synonymy of *B. infuscatus* Wagler, of western Brazil, but his identification, evidently based on scant material, seems open to question. It is less distinctly marked with white spots than an Ecuadorean specimen assumed to represent *B. infuscatus*, and along with *B. castaneiceps* lacks the rather conspicuous white spotting which seems to characterize South American species in general. Moreover, it seems to be replaced in eastern Panama by a more spotted species, *B. ignavus*. Until some of the South American forms are better known it seems best to recognize the animal of western Panama as a distinct species.

Specimens from various localities in Costa Rica and as far east as the Canal Zone, are therefore referred to *Bradypus griseus griseus* which seems to differ from *Bradypus griseus castaneiceps*[2] as represented by examples from Escondido River, Nicaragua and Patuca River, Honduras, only in color. *B. g. griseus* lacks most of the chestnut marking the head of *B. g. castaneiceps*, and the ruff across the frontal region is black instead of grayish, or pale brownish. In addition the short fur on the face is whiter and contrasts more strongly with the coarser pelage composing the ruff. An example from Gatun is recorded by Anthony (1916, p. 364).

In the Canal Zone this three-toed sloth and the two-toed species *Choloepus hoffmanni* occur in about equal numbers. Like the latter it was usually found curled up in a ball in the top of a tall tree. The greenish shade, especially of the back, in freshly killed animals is, according to Alston (1879, p. 183), due to small green algæ, also present in *Choloepus*. The misapprehension of the natives in regard to the call of the large goatsucker, or potoo (*Nyctibius*), and their association of its cry with the "perico lijero" seems to apply to both *Bradypus* and *Choloepus* as noted beyond (see p. 60).

Specimens examined: Chorrera, 1[3]; Gatun, 4[3]; Lion Hill, 2.[4]

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[1] For exact locality as here given see letter of Dr. Berthold Seemann to Dr. J. E. Gray (Proc. Zool. Soc. London, 1871, p. 429).

[2] *Arctopithecus castaneiceps* Gray, placed in synonymy by Allen (Bull. Amer. Mus. Nat. Hist., Vol. 28, p. 93, April 30, 1910) should stand as *Bradypus griseus castaneiceps* (Gray) on the basis of color differences pointed out.

[3] One specimen in Amer. Mus. Nat. Hist.

[4] One specimen in Mus. Comp. Zool.

BRADYPUS IGNAVUS Goldman

Panama Three-toed Sloth

[Plate 22, figs. 1, 1*a*]

Bradypus ignavus Goldman, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 1-2, February 28, 1913. Type from Marragantí (about 2 miles above Real de Santa Maria), near the head of tide-water on the Rio Tuyra, eastern Panama.

The three-toed sloth of eastern Panama, apparently a distinct species, is somewhat similar to *B. griseus griseus* of western Panama in color, but the upperparts are more distinctly spotted with white and the frontal ruff is grayish brown instead of black. The skulls of *B. griseus castaneiceps* of Nicaragua and *B. g. griseus* seem indistinguishable while that of *B. ignavus* differs from both in apparently important details, the nasals being shorter, with the anterior border concave or emarginate, the emargination deepest at the median suture; the squamosal arm of the zygoma is broader, more rounded, less acutely pointed anteriorly; the palate is less deeply grooved posteriorly; and the mandible is less produced anteriorly beyond the plane of the first molars.

In color pattern as well as cranial details *B. ignavus* differs markedly from *B. g. griseus* and *B. g. castaneiceps* and is more like some of the South American species. It appears to be unlike those described, but its exact relationship to some of the South American members of this unrevised group cannot be determined at present, owing to lack of knowledge of their real characters. While the wide range of variation seen in a series of specimens from a given locality would include many of the characters used as specific by Gray in his diagnoses of various species (1871*a*, pp. 428-449), this variation is shown by examination of Middle American forms to be within definite limits, and when ample material is available the distinctive characters of the species will become better known.

The type specimen was found one day in the extreme top of a very tall tree where it was resting, its body doubled and limbs folded in such a manner that it might easily be mistaken for the nest of a squirrel or some large bird.

Specimens recorded by Anthony (1916, p. 364) from Cituro, Real de Santa Maria and Tapalisa in the region of the type locality are darker, more chocolate brownish in general color, and the light dorsal spots are yellowish instead of nearly pure white as in the type.

Specimens examined: Cituro, 1[1]; Marragantí, 1 (type)[2]; Real de Santa Maria, 3[1]; Tapalisa, 1.[1]

[1] Collection Amer. Mus. Nat. Hist.

[2] Two specimens in the U. S. National Museum, from the Atrato River, Colombia, are referable to the same species.

Family CHOLOEPODIDAE. Two-toed Sloths

The two-toed sloths, family Choloepodidae, are similar in habits to the three-toed sloths, family Bradypodidae, but differ notably in details of structure. The number of digits and claws on the fore limbs is reduced to two. The pelage of the top of the head is inclined backward and there is no frontal ruff. The anterior teeth in both jaws are greatly developed, exceedingly sharp, triangular and canine-like, and shearing together exclusively, present a condition very different from that exhibited by the Bradypodidæ. The anterior nares are broad and low. The nasals, laterally expanded between the orbits, articulate with the lachrymals. The audital bullæ are reduced to bony rings. The angle of the mandible is very short and the condyle considerably extended transversely.

Genus CHOLOEPUS Illiger. Two-toed Sloths

The recognition marks of the genus are the same as those of the family.

CHOLOEPUS HOFFMANNI Peters

Hoffmann's Two-toed Sloth; Perico Lijero

Choloepus hoffmanni PETERS, Monatsber. k. preuss. Akad. Wissensch. Berlin, 1858, p. 128. Type from Costa Rica.

Hoffmann's sloth, originally described from Costa Rica, apparently ranges throughout Panama where it is the only member of the family with the digits and claws of the fore foot reduced to two in number. Specimens from Panama are apparently typical; like those from Costa Rica they exhibit varying intensity of the brownish tone of the underfur. The greenish outer color of the long hairs is now known to be due to the presence of small green algae (Alston, 1879, p. 183), which assist materially in rendering the animal inconspicuous, especially when among masses of epiphytic vegetation.

Under the name *Choloepus didactylus*, Sclater (1856, p. 139) notes the collection of the species by Mr. Bridges in western Panama as follows: "From the vicinity of David. I believe neither this Sloth nor the Little Anteater has been hitherto observed so far north."

These sloths are rather common in the northern end of the Canal Zone where they were usually seen curled up in a ball in the extreme top of some rather tall tree. They commonly choose a fork in which to rest, with their heads upward and the long hooked limbs clasping the main trunk. When shot they often strike out frantically with their long arms, and after a moment slowly loosen their hold and drop crashing to the ground. One was found feeding early in the afternoon, suspended from a low limb of a tree overhanging the Rio Indio, near Gatun. The animal reached out and with the two-hooked hand drew a small leafy branch to its mouth. Soon noting my canoe, only a few feet distant, the sloth stopped feeding and began to climb slowly away. No specimens were obtained in extreme eastern Panama, but I saw one which had been captured in the forest at 2,000 feet near the Darien gold mines at Cana, and was kept alive for a time by a local resident.

A peculiar prolonged cry occasionally heard in the forest at night was attributed by my men to the *perico lijero,* a name applied in the Canal Zone to both the two-toed and three-toed sloths. When questioned further, however, they were unable to name the species, or ignored the existence of two kinds (*Choloepus* and *Bradypus*) in the same forest. According to Eugène André[1] and other observers this cry, elsewhere believed by natives to be given by a sloth, is in reality the call of the large goatsucker, or potoo (*Nyctibius*). It has a rather weird quality when heard in a tall, partially moonlit forest at such an hour.

Specimens of *C. hoffmanni* collected by W. W. Brown, Jr., at Bugaba and at 4,000 to 4,800 feet near Boquete are listed by Bangs (1902, p. 20). Examples taken for the British Museum by J. H. Batty are recorded by Thomas (1903*a,* p. 42) from Espartal, Sevilla and Cebaco, small islands off the coast of southwestern Panama. The same collector obtained specimens for the American Museum of Natural History, which are noted by Allen (1904, p. 58) as follows: " Five adults and 3 young, as follows, selected from a large series: Parida Island, 1 adult male, Nov. 22; Boquete, 1 adult female, Sept. 14; Boqueron, 1 adult male, 2 adult females, and 3 young, Oct. 13-24, Nov. 22, and Dec. 1.

Mr. Batty's large series of some 50 specimens shows a wide range of individual variation in color, some being much lighter or darker than the average; some have a strong greenish tinge over the whole head and shoulders, while others show no greenish tinge whatever.

Specimens examined: Bocas del Toro, 1; Bugaba, 1[2]; Boqueron, 34[3]; Boquete, 6[4]; Lion Hill, 1; Parida Island, 2[3]; Porto Bello, 1; Rio Indio (near Gatun), 2.

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[1] A Naturalist in the Guianas, 1904, p. 144.

[2] Collection Mus. Comp. Zool.

[3] Collection Amer. Mus. Nat. Hist.

[4] Four in collection Mus. Comp. Zool; two in Amer. Mus. Nat. Hist.

Family MYRMECOPHAGIDAE. Anteaters

The anteaters are the only really toothless American members of the order Edentata. The three well-known South American genera range northward through Panama.

Genus CYCLOPES Gray. Two-toed Anteaters

The genus *Cyclopes* includes very small species at once distinguishable by the reduction of the toes on the fore foot to two, instead of three, as in the other genera of the family. The tapering tail is strongly prehensile, and the general pelage soft and silky.

CYCLOPES DIDACTYLUS DORSALIS (Gray)

Costa Rican Two-toed Anteater

Cyclothurus dorsalis GRAY, Proc. Zool. Soc. London, 1865, p. 385, pl. 19. Type from Costa Rica.

The presence of two toes only on the fore foot, and the golden yellowish general coloration and soft silky quality of the pelage of this handsome little anteater readily distinguish it from the other mammals of the region. It is more yellowish, or golden, less grayish in color than typical *C. didactylus,* as originally described and as pointed out by Thomas,[1] who seems fully justified in regarding the Costa Rican animal as a geographic race of the South American species. The animal ranges from Costa Rica into Panama, at least as far east as the Canal Zone where its occurrence was reported by the natives, but I was unable to secure specimens.

The two-toed anteater is more strictly arboreal than the other genera, and owing to this fact, together with its nocturnal habits and small size, easily escapes observation. Of its life history little is known. Bates[2] describes the capture of a living specimen of the allied form in Brazil by an Indian who found it clinging motionless inside a hollow tree. He says: "It remained nearly all the time without motion, except when irritated, in which case it reared itself on its hind legs from the back of a chair to which it clung, and clawed out with its fore paws like a cat. Its manner of clinging with its claws, and the sluggishness of its motions, gave it a great resemblance to a sloth. It uttered no sound and remained all night on the spot where I had placed it in the morning. The next day I put it on a tree in the open air and at night it escaped. These small Tamandúas are nocturnal in their habits, and feed on those species of termites which construct earthy nests that look like ugly excrescences on the

[1] Ann. Mag. Nat. Hist., Ser. 7, Vol. 6, p. 302, September, 1900.

[2] Naturalist on the Amazons, Vol. 1, 1883, p. 178.

trunks and branches of trees." In Costa Rica an example was kept alive for a few days by Dr. A. von Frantzius[1] who says in his account of the animal that it remained motionless during the day, completely rolled up and hanging by its claws from a bar of the cage in which it was confined; but as soon as night came it began to climb slowly about, searching persistently for some avenue of escape. It refused to take any food offered, and as it became noticeably thinner and was abrading its skin in constant efforts to escape from the cage he was reluctantly obliged to kill it. In the same connection Dr. von Frantzius states that this animal, in its habits of climbing, suspending itself by its claws, and rolling the body together, greatly resembles *Cholœpus,* with the superior climbing power afforded by the prehensile tail.

The earliest record of the occurrence of this species in Panama seems to be that of Sclater (1856, p. 139) who as *Cyclothurus didactylus* notes the animal in a collection from Mr. Bridges as follows: " From the vicinity of David. Also seen near Panama. A strictly nocturnal animal."

Under the name *Cycloturus didactylus,* Alston (1879, p. 193) mentions the collection of the species by Enrique Arcé in Chiriqui, but the exact locality is not given. Nine specimens taken by W. W. Brown, Jr., are listed by Bangs (1902, p. 20) from Divala and Bugaba. Measurements of an adult female taken at Boqueron by J. H. Batty are published by Allen (1904, p. 59).

Specimens examined: Bas Obispo, 1[2]; Boqueron, 1[3]; Bugaba, 2[2]; Divala, 7.[2]

Genus TAMANDUAS Gray. Three-toed Anteaters

The anteaters of this genus agree with those of the genus *Myrmecophaga* in the possession of three toes on the fore foot, but differ widely in other respects. The tail is long, tapering and prehensile.

TAMANDUAS TETRADACTYLA CHIRIQUENSIS Allen

Chiriqui Three-toed Anteater

Tamandua tetradactyla chiriquensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 395, text fig. 4, October 29, 1904. Type from Boqueron, Chiriqui, Panama.

In this species there are three toes on the fore feet as in the great anteater, but the tapering and prehensile instead of bushy tail, and much smaller general size are distinguishing characters.

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[1] Archiv. für Naturg., 1869, p. 309.
[2] Collection Mus. Comp. Zool.
[3] Collection Amer. Mus. Nat. Hist.

Although seldom seen these anteaters doubtless range throughout Panama. Specimens from as far east as the Canal Zone and Porto Bello are referred to the form described from western Panama as *Tamandua tetradactyla chiriquensis,* the skulls of which are characterized by the broader, flatter frontal region, longer nasals and correspondingly shorter parietals, as shown by comparison with the Mexican subspecies, *T. t. tenuirostris.* The exact relationship of the Panama animal to "*Myrmecophaga sellata*"[1] Cope from Honduras, however, remains to be determined, the latter being based on an imperfect skin without skull. A skull from Plantain River, Honduras, assumed to represent *T. t. sellata* has a very narrow braincase, but is otherwise somewhat intermediate in general characters between *T. t. tenuirostris* and *T. t. chiriquensis.*

This anteater is partly arboreal, partly terrestrial in habits, while the little two-toed anteater, *Cyclopes,* is strictly arboreal and the great anteater, *Myrmecophaga,* is wholly terrestrial. It comes out to feed, mainly at least, at night; a specimen secured at Porto Bello was killed in the road by a hunter who was carrying an ordinary lantern. He described coming upon the animal suddenly, and how when very near it reared up on its hind feet and struck out with its claws until knocked down by a blow from his gun used as a club. Near Gatun one seen in the forest shortly before dusk one evening was on the ground, but noting my approach clambered rather hastily for five or six feet up the trunk of a tree and disappeared in a hole. At the same locality an example brought in by a native hunter had at least a pound of ants in its stomach. These have been determined by Theo. Pergande of the U. S. Bureau of Entomology and found to represent five genera as follows: *Camponotus atriceps* Smith, *Dolichoderus bispinosus* Mayr, *Pseudomyrma pallida* Smith, *Aphaenogaster* ———— sp.? and *Cremastogaster* ———— sp? Most of the ants were in a larval condition, but some were already winged.

The species is known from various localities in western Panama. Under the name *Uroleptes sellata,* Bangs (1902, p. 20) listed two specimens, one from near the Pacific coast at Divala and the other from 5,000 feet on the slope of the Volcan de Chiriqui. Both were collected by W. W. Brown, Jr., in the course of his field work in the general region. Specimens in the American Museum of Natural History taken by J. H. Batty at Boqueron and Boquete were first

[1] This name, placed by Miller (Bull. 79, U. S. Nat. Mus., 1912, p. 401), in the synonymy of *T. t. tenuirostris,* has priority over the latter and the form seems entitled to stand as *Tamanduas tetradactyla sellata* (Cope).

referred by Allen (1904, p. 59) to *Tamandua tetradactyla* and later in the same year were described by him (1904*b*, p. 395) as a new subspecies. Regarding the distribution of the new form he says: "An adult female from the Rio Cauquita, southwestern Colombia, is exactly like the Boqueron [type locality] specimens in size, coloration and cranial details. A skull, without skin, from near San José, Costa Rica, is also indistinguishable from the adult Boqueron skulls. Apparently *T. t. chiriquensis* will be found to range from Costa Rica to the Cauca region of western Colombia." As *Tamanduas tetradactylus* the species was recorded by Thomas (1903*a*, p. 42) from Gobernador and Cebaco islands, near the coast of southwestern Panama. Anthony (1916, p. 364) listed specimens from Chepigana and Maxon Ranch (Rio Trinidad).

Specimens examined: Boqueron, 3[1]; Boquete, 1[1]; Chepigana, 1[1]; Divala, 1[2]; Gatun, 1; Maxon Ranch (Rio Trinidad), 1[1]; Porto Bello, 1; Volcan de Chiriqui, 1.[2]

Genus MYRMECOPHAGA Linnaeus. Great Anteaters

The anteaters of the genus *Myrmecophaga* are externally easily recognizable by their large size and bushy horse-like tail. As in the genus *Tamanduas* the fore foot is provided with three toes.

MYRMECOPHAGA TRIDACTYLA CENTRALIS Lyon

Central American Great Anteater

Myrmecophaga centralis Lyon, Proc. U. S. Nat. Mus., Vol. 31, p. 570, November 14, 1906. Type from Pacuare, Costa Rica.

Owing to its large size and bushy horse-like tail the great anteater is not likely to be confused with any of the other mammals of the region. Although apparently rare it doubtless ranges in suitable localities throughout Panama. No specimens were obtained, but I examined the skin of an animal said to have been killed in the forest near Gatun. According to a native hunter the great anteater crouches down on the ground and covering itself with the long-haired tail becomes very inconspicuous in the forest cover.

The first published notice of the animal in Panama was by Dampier (1698, p. 60) who found it on the "Sambaloes" or "Samballoes" as the islands in the present Gulf of San Blas were known to English navigators of the latter part of the 17th century. Dampier's quaint account of the great anteater, quoted by Alston (1879, p. 192) seems worth repeating here:

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

"The Ant-Bear[1] is a four-footed Beast, as big as a pretty large Dog, with rough black-brown Hair: It has short Legs; a long Nose and little Eyes; a very little Mouth, and a slender Tongue like an Earthworm about five or six Inches long. This Creature feeds on Ants; therefore you always find them near an Ants Nest or Path. It takes its Food thus: It lays its Nose down flat on the Ground; close by the Path that the Ants travel in, (whereof here are many in this Country) and then puts out its Tongue athwart the Path: the Ants passing forwards and backwards continually, when they come to the Tongue, make a stop, and in two or three Minutes time it will be covered all over with Ants; which she perceiving, draws in her Tongue and then eats them; and after puts it out again to trapan more. They smell very strong of Ants, and taste much stronger; for I have eaten of them. I have met with these creatures in several places of *America,* as well as here; (*i. e.*, in the *Sambaloes* [Islands in Gulf of San Blas, Panama.]) and in the *South Seas,* on the *Mexican Continent.*" Bates[2] relates how the great anteater, when attacked by a dog, may inflict severe wounds with the powerful claws with which the fore feet are armed.

Alston (1879, p. 192) mentions a specimen received by Messrs. Salvin and Godman from their collector, Enrique Arcé, while working in Veragua. A specimen recorded by Bangs (1902, p. 20) was taken by W. W. Brown, Jr., at Divala, Chiriqui. Comparison of rather scanty material in the principal American museums indicates that the Central American great anteater is closely allied to the South American form.

Specimens examined: Divala, 1[3]; Gatun, 1.

Family DASYPODIDAE. Armadillos

The armadillos, like the sloths, are by no means toothless, as the appellation of the order to which they belong indicates. The bony carapace, or protective armor covering the exposed parts, at once distinguishes them from all other American mammals. Two species representing different genera and subfamilies inhabit the region under consideration.

Subfamily DASYPODINAE. Four-toed Armadillos

The subfamily Dasypodinæ forms a well-marked division with only four toes on the fore foot. The head is narrow, the ears close together, and the snout long and slender. The tail is about as long

[1] Dampier's Voyage, Vol. 2, p. 60, 1698.
[2] Naturalist on the Amazons, Vol. 1, 1863, p. 177.
[3] Collection Mus. Comp. Zool.

as the body, definitely ringed basally, and armored throughout its length.

Genus DASYPUS Linnaeus. Four-toed Armadillos

Many separative characters are available for the genus *Dasypus* which in Panama requires comparison only with the genus *Cabassous.* Of the four toes on the front foot the middle pair are subequal in size. The skull as a whole is narrow, with a long, slender, nearly parallel-sided rostrum; the jugal is broadest anteriorly, the outer surface deeply furrowed; the upper tooth series is implanted well in front of the orbital fossæ; the coronoid process of the mandible is long and slender, and rises high over the condyle.

DASYPUS NOVEMCINCTUS FENESTRATUS Peters.

Costa Rican Four-toed Armadillo

Dasypus fenestratus Peters, Monatsber. k. preuss. Akad. Wissensch. Berlin, 1864, p. 180. Type from Costa Rica.

The common armadillo, the Linnaean species *Dasypus novemcinctus,* is divisible into several slightly differentiated geographic races, but their number and relationships are not well known. Externally the forms seem so much alike that, allowing for individual variation, there is no readily apparent character by which to separate *D. novemcinctus novemcinctus* of Brazil from the North American subspecies reaching central Texas. The skulls, however, differ in details which are fairly constant and therefore useful in determining the status of the forms. The skull of *D. n. novemcinctus,* as represented by Brazilian specimens, is characterized by the depressed, less inflated frontal region as compared with *D. novemcinctus mexicanus*[1] and *D. novemcinctus texanus;* the jugal and squamosal meet at or behind the highest point of the posterior process on the upper border of the zygoma (meeting in front of this point in *D. n. mexicanus* and *D. n. texanus*) ; the antorbital foramen is shorter; and the palatines extend rather well forward along the median line between the posterior molars. The skulls of *D. novemcinctus texanus,* the most northern form, are usually distinguishable from those of *D. n. mexicanus* by decidedly larger size. The name *D. n. mexicanus,* with which *Tatusia leptorhynchus* Gray is probably synonymous, seems applicable to the form occurring as far south as eastern Honduras.

The skull of a specimen from Gatun, Canal Zone, is very similar to one from Talamanca, Costa Rica, assumed to represent *Dasypus*

[1] Type locality fixed by Bailey as Colima, State of Colima, Mexico (North Amer. Fauna, No. 25, p. 52, Sept. 26, 1901).

fenestratus Peters which was based on an old and a young example from Costa Rica received through Drs. Hoffmann and Von Frantzius. *D. n. fenestratus* seems to be intermediate in cranial characters as well as geographic position between *D. n. mexicanus* and typical *D. n. novemcinctus.* The skull differs from that of *D. n. mexicanus* and approaches that of *D. n. novemcinctus* in the depressed frontal outline, the shorter antorbital foramen, and in the union of the jugal and squamosal near the postorbital process of the zygoma. On the other hand it is nearer *D. n. mexicanus* and departs from the typical form in the tendency toward anterior shortening of the palatines between the last molars, and the laterally swollen condition of the maxillae in front of the lachrymals. Dr. Glover M. Allen[1] has pointed out characters distinguishing the Middle American animal from the typical form, but would unite *D. n. fenestratus* and *D. n. mexicanus* under the former name.

D. n. fenestratus doubtless ranges throughout Panama, and is probably a rather common animal, but owing to nocturnal habits is seldom seen. Specimens have been taken in the western part of the republic. Under the name *Tatu novemcinctus* three specimens collected by J. H. Batty at Boqueron are listed and their measurements given by Allen (1904, p. 60).

Specimens examined: Gatun, 1; Boqueron, 3.[2]

Subfamily CABASSOUINAE. Five-toed Armadillos

The armadillos of the subfamily Cabassouinæ, unlike those of the subfamily Dasypodinæ, are provided with five toes on the fore feet. The head is broad, the ears widely separated and the snout short and broad; the tail is shorter than the body and covered with skin.

Genus CABASSOUS McMurtrie. Five-toed Armadillos

Some of the more important characters of this genus have been given in remarks on the subfamily. The skull differs widely from that of *Dasypus* in general contour as well as in detail. It is short and broad, with a short, stout and rapidly tapering rostrum; the jugal is broadest posteriorly, the outer surface flat; the upper tooth series extends posteriorly well beyond the anterior plane of the orbital fossæ; the coronoid process of the mandible is very short and exceeded in height by the condyle.

[1] Bull. Mus. Comp. Zool., Vol. 54, pp. 198-199, July, 1911.

[2] Collection Amer. Mus. Nat. Hist.

CABASSOUS CENTRALIS (Miller)

Central American Five-toed Armadillo

Tatoua (*Ziphila*) *centralis* Miller, Proc. Biol. Soc. Washington, Vol. 13, p. 4, January 31, 1899. Type from Chamelicon, Honduras.

Aside from the differing number of toes on the fore foot, as compared with *Dasypus c. fenestratus* in Panama, the Central American five-toed armadillo is easily recognized by the great size and sickle-like shape of the middle claw.

At Gatun I was shown the bony covering of a *Cabassous* which I took to be of this species. It had been removed from the body and rolled together so that when dry it formed a crude basket. The animal was shot at night near Mindí (between Gatun and Colon) by an American who located it by the light of a hunting lamp. The species is said to be rare in Panama, and few examples have been taken in any part of Middle America. In Costa Rica it is known as "Armado de zopilote" owing to its disagreeable odor, which is likened to that of the black vulture (*Catharista urubu*).

Specimens examined: Gatun, 1.

Order SIRENIA. Sirenians

Family TRICHECHIDAE. Manatees

The manatees are a peculiar group of aquatic mammals inhabiting the delta regions along the Atlantic side of Middle America, northern South America, and western Africa.

Genus TRICHECHUS Linnaeus. Manatees

The genus *Trichechus* includes a manatee which has been reported from the northern coasts of Panama. The manatee is remarkable for the absence of the posterior pair of limbs, the reduction of the anterior pair to paddles, and the transverse expansion of the rudder-like tail.

TRICHECHUS MANATUS Linnaeus

Manatee

Trichechus manatus Linnaeus, Syst. Nat., ed. 10, Vol. 1, p. 34, 1758. Type from West Indies.[1]

A manatee, doubtfully referable to this species, still inhabits the Chiriqui Lagoon region where it was noted by Dampier (1698, pp. 33-37) on the "coasts of Bocca del Drago" (Boca del Drago) and "Bocco del Toro" (Bocas del Toro). Dr. R. E. B. McKenney,

[1] Locality fixed by Thomas, Proc. Zool. Soc. London, March, 1911, p. 120.

who has spent several years near Bocas del Toro, informs me that the animal is occasionally reported by native boatmen. The species has probably become scarce here as in many other localities where it was formerly common. I have no record of its occurrence on any other part of the Panama coast. Dampier's general account of the manatee as he observed it from the Bay of Campeche to the "River of Darien" (Rio Atrato) is so interesting that it is quoted at length:

"While we lay here [coast of Nicaragua], our *Moskito* men [Mosquito Indians] went in their Canoa, and struck us some Manatee, or Sea-Cow. Besides this *Blewfields* River, I have seen of the Manatee in the Bay of Campeachy, on the Coasts of *Bocca del Drago* [Panama], and *Bocco del Toro* [Panama], in the River of *Darien,* and among the South Keys or little Islands of *Cuba*. . . . . This creature is about the bigness of a Horse, and 10 or 12 foot long. The mouth of it is much like the mouth of a Cow, having great thick Lips. The Eyes are no bigger than a small Pea, the Ears are only two small holes on each side of the Head. The Neck is short and thick, bigger than the Head. The biggest part of this Creature is at the Shoulders, where it hath two large Fins, one on each side of its Belly. Under each of these Fins the Female hath a small Dug to suckle her young. From the Shoulders towards the Tail it retains its bigness for about a foot, then groweth smaller and smaller to the very Tail, which is flat and about 14 inches broad, and 20 inches long, and in the middle 4 or 5 inches thick, but about the edges of it not above 2 inches thick. From the Head to the Tail it is round and smooth without any Fin but those two before mentioned. I have heard that some have weighed about 1200 l. but I never saw any so large. The Manatee delights to live in brackish water; and they are commonly in Creeks and Rivers near the Sea. . . . . Sometimes we find them in salt Water, sometimes in fresh; but never far at Sea. And those that live in the Sea at such places where there is no River nor Creek fit for them to enter, yet do commonly come once or twice in 24 hours to the mouth of any fresh water River that is near their place of abode. They live on Grass 7 or 8 inches long, and of a narrow blade, which grows in the sea in many places, especially among Islands near the Main. This Grass groweth likewise in Creeks or in the great Rivers, near the sides of them, in such places where there is but little tide or current. They never come ashore, nor into shallower water than where they can swim. Their flesh is white, both the fat and the lean, and extraordinary sweet wholesome meat. The tail of a young Cow is most esteemed; but if old both head and tail are very tough. A Calf that sucks is the most delicate meat; Privateers commonly roast them; as they do also great pieces cut out of the Bellies of the old ones.

"The Skin of the Manatee is of great use to Privateers, for they cut them into straps, which they make fast on the sides of their Canoas through which they put their Oars in rowing, instead of tholes or pegs. The Skin of the Bull, or of the back of the Cow is too thick for this use; but of it they make Horse-whips, cutting them 2 or 3 foot long: at the handle they leave the full substance of the Skin, and from thence cut it away tapering, but very even and square all the four sides. While the Thongs are green they twist them, and hang them to dry: which in a weeks time becomes as hard as Wood. The *Moskito*-men have always a small Canoa for their use to strike Fish, Tortoise, or Manatee, which they keep usually to themselves, and very neat and clean. . . . . One of the *Moskitoes* (for there go but two in a Canoa) sits in the stern, the other kneels down in the head, and both paddle till they come to the place where they expect their game. Then they lie still or paddle very softly, looking well about them, and he that is in the head of the Canoa lays down his paddle, and stands up with his striking staff in his hand. This staff is about 8 foot long, almost as big as a mans Arm, at the great end, in which there is a hole to place his Harpoon in. At the other end of his staff there is a piece of light wood called Bobwood, with a hole in it, through which the small end of the staff comes; and on this piece of Bobwood, there is a line of 10 to 12 fathom wound neatly about, and the end of the line made fast to it. The other end of the line is made fast to the Harpoon, which is at the great end of the Staff, and the *Moskito* man keeps about a fathom of it loose in his hand. When he strikes, the Harpoon presently comes out of the staff, and as the Manatee swims away, the line runs off from the bob; and although at first both staff and bob may be carried under water, yet as the line runs off it will rise again. Then the *Moskito* men paddle with all their might to get hold of the bob again, and spend usually a quarter of an hour before they get it. When the Manatee begins to be tired it lieth still, and then the *Moskito* men paddle to the bob and take it up, and begin to hale in the line. When the Manatee feels them he swims away again, with the Canoa after him; then he that steers must be nimble to turn the head of the Canoa, and holding the line, both sees and feels which way the Manatee is swimming. Thus the Canoa is towed with a violent motion, till the Manatee's strength decays. Then they gather in the line, which they are often forced to let all go to the very end. At length when the creatures strength is spent, they hale it up to the Canoas side, and knock it on the head and tow it to the nearest shore, where they make it fast, and seek for another; which having taken they go on shore with it, to put it into their Canoa: for 'tis so heavy that they cannot lift it, but they hale it up in shoal water, as near the shore as they can, and then overset the Canoa, laying one side close to the Manatee. Then they roll it in, which brings the Canoa upright again, and when they have heav'd out the water, they fasten a line to the other Manatee that lieth afloat, and tow it after them. I have known two *Moskito* men for a week every day bring aboard 2 Manatee in this manner; the least of which hath not weighed less than 600 pound, and that in a very small Canoa, that 3 *English* men would scarce adventure to go in. When they strike a cow that hath a young one, they seldom miss the Calf, for she commonly takes her young under one of her Fins. But if the Calf is so big that she cannot carry it, or so frightened that she only minds to save her own life, yet the young never leaves her till the *Moskito* men have an opportunity to strike her.

"The manner of striking Manatee and Tortoise is much the same; only when they seek for Manatee they paddle so gently, that they make no noise, and never touch the side of the Canoa with their paddle; because it is a Creature that hears very well. But they are not nice when they seek for tortoise, whose Eyes are better than his Ears."

The manatee was also recorded from near the eastern boundary of Panama by Maack (1874, p. 171) who says: "The manati is frequently caught by the natives in the Atrato and in the Cacarica. Its meat is highly prized by the natives, and I had the pleasure, during my stay at the Cacarica hills, to partake with some caoutcheros [rubber gatherers] of such a Manati dinner."

Order ARTIODACTYLA. Artiodactyls or Even-toed Ungulates

Family TAYASSUIDAE. Peccaries

The family Tayassuidae includes two genera of peccaries, or pig-like species fairly well known in the region under review. Both have extremely short tails. Large glands opening upon the back give off a peculiar rank odor by which the proximity of a herd to windward may often be detected long before the animals can be heard or seen.

Genus PECARI Reichenbach. Collared Peccaries

The collared peccaries are smaller, more grizzled in color, than the white-lipped peccaries of the genus *Tayassu*. They are also recognizable by the light shoulder stripes forming the so-called "collar." Generic distinction is, however, better shown in the skull: The rostrum is much narrower, more highly arched along the median line above; the maxillæ are not laterally expanded over the first molars; the palate has a distinct ridge extending from the canine to the anterior premolar; the molar teeth have rather more-developed cingula, and the cusps are less closely connected by intermediate cusplets.

PECARI ANGULATUS CRUSNIGRUM (Bangs)

Chiriqui Collared Peccary

Tayassu crusnigrum BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 20, April, 1902. Type from Boquete, Chiriqui, Panama (altitude 4,000 feet).

The collared peccary of western Panama and adjacent portions of Costa Rica is a remarkably dark, richly colored animal with tawny instead of whitish shoulder stripes, or "collar," usual in the group.

The original description was based on specimens collected by W. W. Brown, Jr. Mr. Bangs described it as a distinct species "because the relationship of the North American forms and the South American *T. tajacu* [*Pecari tajacu*] are not as yet clearly understood."

The exact relationship to South American species still remains to be determined, but examination of specimens from numerous localities indicates that all of the collared peccaries of Middle America may be regarded as subspecies of *Pecari angulatus*. Specimens from Honduras are intermediate in color and in cranial details also indicate intergradation between the present dark form and the pallid subspecies, *P. a. yucatanensis,* which inhabits the peninsula of Yucatan.

The range of *P. a. crusnigrum* is little known. It includes the highlands of the western part of the republic, and lowlands of eastern Costa Rica. In the Canal Zone and eastward it is replaced by the paler form, *P. a. bangsi*.

Specimens examined: Boquete, 3.[1]

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[1] Collection Mus. Comp. Zool.

PECARI ANGULATUS BANGSI Goldman

Bangs Collared Peccary; Zajino

Pecari angulatus bangsi GOLDMAN, Proc. Biol. Soc. Washington, Vol. 30, p. 109, May 23, 1917. Type from Boca de Cupe, eastern Panama (altitude 250 feet).

In paler coloration the collared peccary of eastern Panama differs markedly in appearance from the darker, richer-hued animal inhabiting western Panama.

As "zajino" it is well known to the natives of the Canal Zone and doubtless ranges in the forests throughout the eastern part of the republic. Although occurring in much smaller herds than the white-lipped peccary it is more frequently met with and seems to exceed that species in numbers. Parties of five or six to twelve or fifteen individuals are not uncommonly met with, and lack of time to devote to the species alone prevented me from securing a large series of specimens.

A few small tracks and the depressions left where these peccaries have been rooting or wallowing in mud may often be seen in isolated parts of the forest. Fresh peccary work was seen nearly every day not far from camp in the forest at about 800 feet on the basal slope of Cerro Azul, but I did not see any of the animals, probably owing to their becoming alarmed at shots frequently fired at other game.

The earliest account of this peccary in Panama, and the Indian method of hunting it, is that of Lionel Wafer (1729, p. 328) whose observations, made in 1681, are quoted as follows:

"The Country has of its own a kind of Hog, which is called *Pecary,* not much unlike a Virginia Hog. 'Tis black, and has little short Legs, yet is pretty nimble. It has one thing very strange, that the Navel is not upon the Belly, but the Back: And what is more still, if upon killing a *Pecary* the Navel be not cut away from the Carcass within 3 or 4 hours after at farthest, 'twill so taint all the flesh, as not only to render it unfit to be eaten, but make it stink insufferably. Else 'twill keep fresh several days, and is very good wholesome Meat, nourishing and well tasted. The *Indians barbecue* it when they keep any of it longer. . . . . These Creatures usually herd together, and range about in Droves; and the Indians either hunt them down with their Dogs, and so strike them with their Lances, or else shoot them with their Arrows, as they have Opportunity."

Wafer evidently mistook the dorsal gland for the navel. As stated by him the part is removed as soon as possible after an animal is killed, and should not be allowed to touch meat intended for food.

Collared peccaries are still hunted with dogs; they are smaller, more easily overtaken, and are not regarded as so dangerous either to the dogs or hunters as the white-lipped peccary.

Alston (1879, p. 107) recorded the species from Panama as living in the gardens of the Zoological Society of London.

Specimens now recognized as *P. a. bangsi* from Gatun and Real de Santa Maria were assigned by Anthony (1916, p. 364) to *Pecari crusnigrum.*

Specimens examined: Boca de Cupe, 1; Escobal (Gatun Lake), 1[1]; Gatun, 5[2]; Real de Santa Maria, 2.[1]

Genus TAYASSU Fischer. White-lipped Peccaries

The white-lipped peccaries are larger and blacker than the collared peccaries of the genus *Pecari,* and are further distinguished externally by conspicuous white areas extending from the mouth along the sides of the face. The skull of *Tayassu,* contrasted with that of *Pecari,* differs notably as follows: The rostrum is broadly flattened above (not narrow and highly arched along the median line); the maxillae are greatly expanded laterally over the first premolars; the palate lacks the distinct marginal ridge extending in *Pecari* from the canine to the anterior premolar; the molar cusps are more closely connected by intermediate cusplets.

TAYASSU PECARI SPIRADENS Goldman

Costa Rican White-lipped Peccary; Puerco de Monte

Tayassu albirostris spiradens Goldman, Proc. Biol. Soc. Washington, Vol. 25, p. 189, December 24, 1912. Type from Talamanca, Costa Rica. (Probably near Sipurio, in the valley of the Rio Sicsola.)

The Costa Rican white-lipped peccary inhabits Costa Rica and adjoining territory; and is doubtless generally distributed in the forests of the greater part of Panama. It is one of the few mammals known to occur in the region but of which no specimens are as yet available for examination. Eight skulls in the Museum of Comparative Zoölogy collected by G. A. Maack on the Isthmus of Panama are referable to this form, but the indefinite locality may apply to what is now Colombian territory. In the vicinity of the Canal Zone, where it is known to the natives as "puerco de monte," the white-lipped peccary occurs in much smaller numbers than the collared species. Unlike the latter animal it gathers in herds which may number 100 or more individuals. These herds move steadily about,

[1] Collection Amer. Mus. Nat. Hist.

[2] Three specimens in collection Amer. Mus. Nat. Hist.

usually through parts of the forest remote from civilization. The "puerco de monte" is regarded by the natives here, as elsewhere in Middle America, as more dangerous than the "zahino" or collared peccary, which besides being much smaller, travels in fewer numbers. According to report a herd of white-lipped peccaries may, if unmolested, pass very near and apparently pay no attention to hunters; but if one is wounded or attacked by dogs the entire herd may gather and force the hunters to climb trees. Dogs are said to be not infrequently killed by them.

On Cerro Azul several broad, conspicuous trails left by moving herds of white-lipped peccaries were seen at about 1,500 feet altitude. These trails made by the single passage of a herd were marked by many tracks, freshly mutilated, low growing vegetation, and spots where the animals had stopped to root in the soft soil. Similar trails were noted at about 5,000 feet altitude on the upper slopes of the Pirre Mountains. On one occasion I was near enough to detect the strong characteristic odor of these animals, but when I reached their trail it was nearly dark and I was obliged to return to camp. On the following morning, accompanied by one of my Colombian packers, I followed the trail with difficulty for some distance; it led through densely matted vegetation along a rugged shoulder of the mountain and we were finally obliged to turn back. According to my men the peccaries nearly always skirt a mountain, traveling across the slope rather than choosing a route directly over the top.

Anthony (1916, p. 365) reports encountering a small band supposed to be of this species at 5,000 feet in the vicinity of Mount Tacarcuna, but no specimens were secured by him.

The quaint accounts by Lionel Wafer (1729, pp. 328, 368) apply in part to this species which he calls "warree" and in part to the collared peccary. Referring to the hunting of peccaries by the Indians of eastern Panama, he says:

"The *Warree* is another kind of Wild-Hog they have, which is also very good Meat. It has little Ears, but very great Tusks; and the Hair or Bristles 'tis covered with are long, strong and thickset, like a coarse Furr all over its Body. The *Warree* is fierce, and fights with the Pecary, or any other Creature that comes his way. The *Indians* hunt these also as the other, and manage their Flesh the same way, except only as to what concerns the Navel; the Singularity of which is peculiar to the *Pecary*.

"Their chief Game are the *Pecary* and *Warree;* neither of which are swift of Foot. They go in Droves, often 2 or 300; so that if the *Indians* come upon them unawares, they usually kill some by random

Shot among them. But else, they are many times a whole Day without getting any; or so few, considering how many they start, that it seems a great toil to little Purpose. I have seen about a thousand started, in several Droves, when I was hunting with them; of which we killed but two, as I remember. Sometimes when they are shot, they carry away the Arrows quite. When the Beast is tired, it will stand at a Bay with the Dogs; which will set him round, lying close, not daring to seize, but snapping at the Buttocks; and when they see their Master behind a Tree ready to shoot, they all withdraw to avoid the Arrow. As soon as an *Indian* hath shot a Pecary or Warree, he runs in and lances them; then he unbowels them, throwing away the Guts, and cuts them in two across the Middle. Then he cuts a piece of Wood sharp at both ends; sticks the Forepart of the Beast at one End, and the Hinder-part at the other. So each laying his Stick across his Shoulder, they go to the Rendezvous, where they appointed the Women to be; after which they carry their Meat Home, first barbecuing it that Night."

In connection with his description of the collared species Bangs (1902, p. 21) says: "A white-lipped peccary also occurs in Chiriqui. Mr. Brown [W. W. Brown, Jr.] saw them several times, but those wounded escaped in the dense jungle."

Family CERVIDAE. Deer

The family Cervidæ is composed of several existing subfamilies of deer-like animals of which one, the Cervinæ, ranges in Panama.

Subfamily CERVINAE. Deer

The subfamily, as represented in the region under review, includes the genus *Odocoileus* to which the familiar Virginia deer belongs, and the genus *Mazama* which is restricted to South and Middle America.

Genus ODOCOILEUS Rafinesque

The genus *Odocoileus* is externally distinguished from the genus *Mazama* by larger general size, and the possession of well-developed branching antlers.

ODOCOILEUS CHIRIQUENSIS Allen

Chiriqui White-tailed Deer; Venado

Odocoileus rothschildi chiriquensis Allen, Bull. Amer. Mus. Nat. Hist., Vol. 28, p. 95, April 30, 1910. Type from Boqueron, Chiriqui, Panama.

The Chiriqui white-tailed deer may be known by its larger size and branching antlers as compared with the forest deer or brocket;

it also differs from that animal in local habitat. It appears to be restricted in Panama mainly to the partly open savanna region between the coast and the mountains on the Pacific side from the Costa Rican frontier eastward to the Bayano River. It also inhabits savannas in the Chagres Valley east of the Canal Zone and is common in partly cleared spaces all along the Canal route, apparently having followed the old line of the Panama Railroad northward to the vicinity of Colon. The white-tailed deer favors the forest borders or the dense thickets and mixed growth of small trees and shrubby vegetation which springs up wherever the original forest is cut, while the brocket, more retiring in habits, prefers the depths of the forest. It is apparently absent in the unbroken forests of the eastern and northern parts of the republic, regions regularly inhabited by the brocket.

Few specimens have been collected and the exact relationship of the Panama forms to *Odocoileus costaricensis* remains to be determined. Specimens from as far east as the Canal Zone are referred to *Odocoileus chiriquensis*. This deer was described by Allen (*l. c.*) as a subspecies of the insular form, *O. rothschildi*, on the basis of specimens which had previously been assigned by him (1904, p. 63) to *O. costaricensis*. The Chiriqui animal is characterized by him as larger and paler and the young less conspicuously spotted than *O. rothschildi*.

The type of *O. chiriquensis* is a young female with the deciduous premolars still in place and the posterior molar rising from the alveolus. A female topotype has acquired a full series of permanent molariform teeth, but they are very slightly worn. The other topotype material consists mainly of separate horns. As noted by Allen (1910, p. 95) it is somewhat paler than *O. rothschildi*, but the decidedly larger size is a better differential character. It is probably more nearly allied to *O. costaricensis* with which it was first associated, but the latter was founded on a young male; in the absence of properly comparable material the relationship to that form cannot be determined and it seems best to treat it as a distinct species.

During the construction of the Panama Canal white-tailed deer were regularly hunted by organized clubs of white employees using hounds to drive them from cover; and yet the deer remained fairly numerous near points where heavy blasting and other noisy operations were conducted on a large scale.

A freshly killed female specimen from near Corozal was received through the Sanitary Inspector, A. R. Proctor, January 22, 1911. Giving a sharp snort she sprang out before the hounds on the brush-covered slope of a hill. She circled about several times and was finally shot. Her condition showed that she was nursing a fawn, but the latter was not seen. The date indicates earlier, or possibly more irregular, breeding habits than are usual in northern deer.

Sir Victor Brooke (1878, p. 919) recorded specimens of white-tailed deer as collected in Panama by Mr. Salvin, but mentioned no exact locality. The specimens may have been taken by Enrique Arcé, a collector who was employed by Salvin for several years in Veragua and Chiriqui. Brooke is quoted and the same material cited by Alston (1879, p. 115). Bangs (1902, p. 21) records the collection of a young white-tailed deer by W. W. Brown, Jr., at 4,000 feet near Boquete, April 10, 1900, concerning which he says: "This specimen is in the spotted pelage, and is too young to identify. The species was rare, but was well known to the native hunters."

Specimens examined: Boqueron, 9[1]; Boquete, 1[2]; Corozal, 1; Gatun, 3.

ODOCOILEUS ROTHSCHILDI (Thomas)

Rothschild's White-tailed Deer

Dama rothschildi THOMAS, Novitates Zoologicæ, Vol. 9, p. 136, April 10, 1902. Type from Coiba Island, off west coast of Panama.

Rothschild's white-tailed deer is known only from Coiba Island. It was originally described as "Size very small, about the smallest of the genus; general colour above brown tipped with fawn." Allen (1904, p. 60) having obtained topotypes from J. H. Batty compared them with specimens from the mainland which he regarded as representative of *Odocoileus costaricensis* Miller, and later (1910, p. 95) named *Odocoileus rothschildi chiriquensis*. Writing in 1904 he says: "The three males, though adult, vary greatly in size and in the development of the antlers, and show that Mr. Thomas's two specimens on which he based the species were young or undersized adults. As regards the external characters there is little to add to Mr. Thomas's description, except that the upper surface of the tail in most of these examples is dark reddish brown above instead of 'fawn.' The ears in most of the specimens are externally nearly naked." He (1904, p. 63) further states: "*O. rothschildi* is much darker colored when adult than *O. costaricensis,* and the young are less conspicuously spotted with white; it is also much smaller, as stated by Mr. Thomas."

While darker in color as indicated by Thomas (*l. c.*) and Allen (1910, p. 95) the much smaller general size more readily distin-

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

guishes *O. rothschildi* from *O. chiriquensis* of the adjacent mainland. Skulls of the two forms, of comparable age and sex, exhibit close conformity in most characters, but the disparity in size and apparent absence of any trace of intergradation seems to warrant the use of a specific name for the island animal.

Specimens examined: Coiba Island, 3.[1]

Genus MAZAMA Rafinesque. Brockets or Forest Deer

The forest deer of the genus *Mazama* are small species with antlers reduced to simple spikes not exceeding half the length of the head. The body is heavy for so small an animal, but the limbs are very slender. The metatarsal gland, usually present in *Odocoileus*, is absent in this genus.

MAZAMA SARTORII REPERTICIA Goldman

Canal Zone Forest Deer; Cabra de Monte

Mazama tema reperticia GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, p. 2, February 28, 1913. Type from Gatun, Canal Zone, Panama.

The little forest deer, or brocket, known to natives of the Canal Zone and to Costa Ricans as "cabra de monte," is a smaller animal than the white-tailed deer and the antlers of the male are short unbranched spikes as pointed out in the remarks on the genus. The ears are short and rounded. The tail is white on the under side as in the so-called white-tailed deer, but is not conspicuously shown as in that animal when running away. Unlike the white-tailed deer, which favors the forest borders, or partially cleared areas, the brocket prefers thickets in remote parts of the forest. The small tracks were seen in various places and the Canal Zone subspecies is assumed to be the rather common form inhabiting the unbroken forests, especially of the eastern and northern parts of the republic, but owing to extreme shyness is seldom seen and few examples are available for study. *M. s. reperticia* differs from *M. s. sartorii* of Mexico in somewhat larger size and in duller much less rufescent coloration. A richer reddish colored form, *M. s. cerasina* Hollister, recently described from Talamanca, Costa Rica, may replace *M. s. reperticia* in parts of western Panama. In the Middle American brockets the orbital areas and much of the face is rusty reddish; in *Mazama bricenii* Thomas and other South American species, aside from other differential characters, the face including the orbital areas is very dark brown or blackish.

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[1] Collection Amer. Mus. Nat. Hist.

Very few of these small deer were killed in the Canal Zone by the white employees engaged in the construction of the Panama Canal who hunted regularly in well-organized parties using hounds to drive game from cover; the white-tailed deer, on the contrary, were easily obtained often in the immediate vicinity of noisy construction camps.

The early account of deer in eastern Panama by Lionel Wafer (1729, p. 329) seems to apply to this species. Referring to game hunted by the Indians of the region, he says:

"They have considerable Store of *Deer* also, resembling most our *Red Deer;* but these they never hunt nor kill; nor will they ever eat of their Flesh, though 'tis very good; but we were not shy of it. Whether it be out of Superstition, or for any other reason that they forbear them, I know not: But when they saw some of our Men killing and eating of them, they not only refused to eat with them, but seemed displeased with them for it. Yet they preserve the Horns of these Deer, setting them up in their Houses; but they are such only as they shed, for I never saw among them so much as the Skin or Head of any of them that might shew they had been killed by the *Indians;* and they are too nimble for the Warree, if not a Match for him."

Under the name *Mazama sartorii,* Bangs (1902, p. 21) published measurements of three adults collected by W. W. Brown, Jr., at 4,000 to 4,800 feet near Boquete on the southern slope of the Volcan de Chiriqui. In his revision of the genus, Allen (1915*a,* p. 543) records specimens collected by W. B. Richardson at Chepigana, Real de Santa Maria, Tapalisa, Boca de Cupe and Cituro. These records are republished by Anthony (1916, p. 365) with the addition of Maxon Ranch (Rio Trinidad).

Specimens examined: Boca de Cupe, 1[1]; Bocas del Toro, 1; Boquete, 3[2]; Cana, 1; Chepigana, 1[1]; Cituro, 1[1]; Gatun (type locality), 2; Maxon Ranch (Rio Trinidad), 1[1]; Real de Santa Maria, 4[1]; Tapalisa, 3.[1]

Order PERISSODACTYLA. Perissodactyls or Odd-toed Ungulates

Family TAPIRIDAE. Tapirs

The tapirs, the largest indigenous land mammals of Panama, are the only existing American odd-toed ungulates. The single genus *Tapirella* is known from the region; the genus *Tapirus* has not been reported, but may possibly occur.

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

Genus TAPIRELLA Palmer. Tapirs

The genus *Tapirella* ranges in the tropical parts of Middle America from eastern Panama northward to southern Mexico. Generic distinction is found in the differing arrangement of the bony parts supporting the proboscis, as compared with the other genera of the family. The nasals are flat, triangular bones without the stout descending processes which in *Tapirus* of South America meet and overlap the maxillæ; the maxillæ are developed upward in thin vertical plates which embrace an anterior ossified extension of the mesethmoid, absent in Tapirus and in the Asiatic member of the group, *Acrocodia*.

TAPIRELLA BAIRDII (Gill)

Baird's Tapir; Danta

Elasmognathus bairdii GILL, Proc. Acad. Nat. Sci., Philadelphia, 1865, p. 183. Type from Isthmus of Panama.

Baird's tapir is still a rather common animal in the forests of the Canal Zone and of the republic in general; and it ranges from sea level to at least 5,000 feet altitude on the mountains. The species was described from the "Isthmus of Panama" and specimens from the Canal Zone are, therefore, typical.

Dampier's (1698, Vol. 2, p. 102) early account of the habits of the animal, which he never saw himself, seems to refer in part to Baird's tapir in Panama. He says: "This Creature is always found in the Woods near some large River; and feeds on a sort of long thin Grass, or Moss, which grows plentifully on the Banks of Rivers; but never feeds in Savannahs, or Pastures of good Grass, as all other Bullocks do. When her Belly is full, she lies down to sleep by the Brink of the River; and at the least Noise slips into the Water; where sinking down to the Bottom, tho' very deep, she walks as on dry Ground. She cannot run fast, therefore never rambles far from the River; for there she always takes Sanctuary, in case of danger. There is no shooting of her but when she is asleep. They are found, besides this place [Campeche], in the Rivers in the Bay of Honduras; and on all the Main from thence as high as the River of *Darien*. Several of my Consorts have kill'd them there, and knew their Track, which I myself saw in the *Isthmus of Darien;* but should not have known it, but as I was told by them. For I never did see one, nor the Track of any but once."

The occurrence of the tapir in the Canal Zone was noted by Maack (1874, p. 171) who records it as living especially in the lowlands between Gatun and Bas Obispo. Alston (1879, p. 103) quotes Captain Dow as authority for the statement that the favorite haunts of Baird's tapir "appear to be in the hills lying at the back of Lion Hill and the adjoining stations of the Panama Railway. It is only during the rainy season that they seem to seek the lowlands; for it is only at that season that they are captured. They are not hunted by the natives; and it is only when they happen to stray out into the open spaces of the railway that the young ones are sometimes captured alive and the old ones shot." The species remained common in the locality mentioned by Dow until by the recent completion of the Gatun Dam much of the area has been submerged. During the construction of the Panama Canal I was surprised to find tapirs inhabiting the forested areas immediately along the canal route where they seemed to be comparatively unmindful of the heavy blasting and constant movement of men and material. They frequently visited the Mount Hope Reservoir near Colon and the Agua Clara Reservoir near Gatun, apparently enjoying the immunity from molestation afforded by the enforced regulations prohibiting trespassing by the general public on neighboring watersheds.

On the Pirre range in extreme eastern Panama trails made in the forest and regularly used by tapirs were seen at various elevations on steep slopes, and along the tops of the highest ridges. These well-beaten routes were filled with the characteristic tracks of the animals deeply impressed in the muddy ground. Viewed from a short distance they resemble cattle trails. As the trails here show, the rather clumsy looking tapir is able to climb up and down precipitous places; but in the bottom of a narrow gorge I came upon the body of one that had evidently been killed by a fall from the hillside above. Climbing up and examining the slope I was able to locate the exact spot where in attempting to pass across the face of a steep bank, the loose wet soil and leaves covering the underlying clay had slipped from beneath its feet, and in spite of some struggles to regain its balance the tapir had tumbled about 200 feet. Decomposition of the body was well advanced, but there were no indications that carnivorous animals larger than beetles and larval flies had fed upon the flesh.

These tapirs are very shy and seldom venture outside of the denser forest cover. When frightened or pursued by dogs they rush violently through tangled thickets, breaking down vines and other vegetation barring the way. At low elevations near San Miguel Bay I saw places where the tapirs had wallowed in muddy pools in the forest. Tapirs have occasionally been killed in the Canal Zone by hunting clubs using hounds. A fine male specimen obtained through the Gatun Hunting Club was shot one morning near the shore of Gatun Lake by a member who was stationed only about 100 yards from me—so near that I heard the animal tearing its way through the undergrowth before the baying hounds, and heard its heavy fall following the report of my companion's rifle. Like all of the larger terrestrial mammals inhabiting the forests of the region this tapir was infested with ticks, which become troublesome when numbers begin crawling up one's arms; they take advantage of every contact with the animal during the skinning process and transportation of the skin to affix themselves to one's body. The tapirs often escape the hounds by entering the water. As Captain Dow has indicated they are seldom hunted by natives of the Canal Zone, but when killed by foreigners the flesh is sometimes eaten by certain classes of the native population.

The species is known to reach about the same altitude on the mountains of western, as of eastern Panama. Bangs (1902, p. 22) records the collection of a fine old male adult by W. W. Brown, Jr., at 5,000 feet, near Boquete on the southern slope of the Volcan de Chiriqui. Anthony (1916, p. 365) mentions noting frequently the tracks of this species in the Canal Zone and on the slopes of Mount Tacarcuna.

While no specimens of the South American tapir, *Tapirus terrestris,* are known from Panama, a skull of this species in the U. S. National Museum is labeled as collected by William M. Gabb in Talamanca, Costa Rica, along with a number of skulls of *Tapirella bairdii* from the same locality. There seems to be nothing irregular about the record of this skull, but occurrence of the species so far north lacks confirmation.

Specimens examined: Boquete, 1[1]; Cana, 2; Gatun, 2; Mount Hope (near Colon), 1; Mount Pirre, 1.

Order RODENTIA. Rodents

Family MURIDAE

Rats, Mice

The family Muridæ includes a large number of species of rat-like animals, many of which are much alike in general external appearance, their differential characters becoming fully apparent only when the skulls and teeth are examined.

[1] Collection Mus. Comp. Zool.

Subfamily CRICETINAE. Harvest Mice, Rice Rats, Cotton Rats, etc.

Genus REITHRODONTOMYS Giglioli

The harvest mice are among the smallest of the Muridæ. They are slender, long-tailed animals resembling very closely some of the smaller species of *Oryzomys,* but easily distinguished by the distinct longitudinal grooves in the upper incisors.

Subgenus REITHRODONTOMYS Giglioli.

REITHRODONTOMYS AUSTRALIS AUSTRALIS Allen

Irazu Harvest Mouse

Reithrodontomys australis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 7, p. 328, November 8, 1895. Type from Volcan de Irazu, Costa Rica.

Reithrodontomys australis vulcanius BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 38, text figs. 16-17, April, 1902. Type from Volcan de Chiriqui, Chiriqui, Panama (altitude 10,300 feet).

The Irazu harvest mouse ranges from Costa Rica into western Panama. Two specimens collected by W. W. Brown, Jr., at 4,000 feet, near Boquete on the southern slope of the Volcan de Chiriqui have been noted by Bangs (1902, p. 37) who says: "These I have compared with the type of *R. australis* from Volcan de Irazu, Costa Rica, loaned by Dr. Allen. In color they exactly agree, except that the upper surface of the feet is darker, more grayish—the feet being whitish in the type. The skulls of the two Boquete specimens are heavier throughout, especially the rostral part, and in this character they are intermediate between true *R. australis* and the form described below from the summit of the Volcan de Chiriqui." *R. a. vulcanius,* the form referred to by Bangs, has been regarded by Howell (1914, p. 62) as agreeing too closely for separation from typical *R. a. australis.* Specimens from Boquete and from near the summit of the volcano appear very different as indicated by Bangs, but the differences are scarcely beyond the range of individual variation exhibited by a series of typical examples of *R. a. australis.* Additional specimens from Panama are much needed in order to determine the point satisfactorily. If the two forms are inseparable *R. a. australis* has an altitudinal range of over 6,000 feet on the slope of the Volcan de Chiriqui.

R. a. australis belongs to the typical subgenus, *Reithrodontomys,* which lacks the mesostyles and mesostylids present in the subgenus *Aporodon,* the group including the other known forms of the region.

Specimens examined: Boquete, 2.[1]

[1] Collection Mus. Comp. Zool.

Subgenus APORODON Howell

REITHRODONTOMYS CREPER Bangs

Chiriqui Harvest Mouse

Reithrodontomys creper BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 39, April, 1902; text figs. 18-19. Type from Volcan de Chiriqui, Chiriqui, Panama (altitude 11,000 feet).

The Chiriqui harvest mouse is known only from the single example collected by W. W. Brown, Jr., on the cold, barren summit of the Volcan de Chiriqui.

It is a dark brownish species, darker in general color than *Reithrodontomys australis australis* which inhabits the same mountain and reaches nearly the same elevation. It differs widely from its congener in cranial characters and belongs to another section of the genus, one in which the outer wall of the antorbital foramen is narrower and the dentition more complicated by small accessory tubercles than in the more typical forms. This group with more complicated dentition has recently been set apart by Howell (1914, p. 63), as the subgenus *Aporodon*, to which all of the South American species belong.

Specimens examined: Volcan de Chiriqui, 1 (type).[1]

REITHRODONTOMYS MEXICANUS CHERRII (Allen)

Cherrie's Harvest Mouse

Hesperomys (*Vesperimus*) *cherrii* ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 3, p. 211, April 17, 1891. Type from San José, Costa Rica.

The range of Cherrie's harvest mouse closely parallels that of *Reithrodontomys australis australis* from Costa Rica into western Panama where, on the lower slopes of the Volcan de Chiriqui, the two apparently occur at the same locality. *R. m. cherriei* is a larger form than *R. a. australis*, with a tail measuring over 100 millimeters, while in the latter animal the length of the member is usually less than 90 millimeters. Moreover, they belong to different subgenera, the present form being a member of the subgenus *Aporodon*. A very young example from the grassy lake at Gatun is doubtfully assigned to this species.

As *Reithrodontomys costaricensis*, a name synonymized by Howell (1914, p. 73) with *R. m. cherrii*, Bangs (1902, p. 39) notes 30 specimens obtained by W. W. Brown, Jr., at from 4,000-6,000 feet altitude near Boquete. Brown found this harvest mouse one of the more common small mammals of the forest belt of the Volcan de Chiriqui.

[1] Collection Mus. Comp. Zool.

Under the same name Allen (1904, p. 70) records six specimens taken at Boquete by J. H. Batty. Two examples too young for identification listed by Thomas (1903*a*, p. 41) from Cebaco Island near the Pacific coast, may be referable to this form.

Specimens examined: Boquete, 34[1]; Gatun, 1.

Genus PEROMYSCUS Gloger

The genus *Peromyscus* is remarkable for the inclusion of more forms than any other mammalian genus in North America. The species are forest mice, usually with long tails, rather large ears and soft fur. They are usually, but not invariably, distinguishable from the species of *Oryzomys,* a related genus, by the softer fur, larger ears, and smaller, more densely haired, hind feet; several other allied genera are similar externally and difficult to determine without recourse to detailed differential characters presented by the skull. While so numerous in North America in general, very few species range so far south as Panama where they appear to be restricted to the upper slopes of the mountains.

Subgenus PEROMYSCUS Gloger

PEROMYSCUS NUDIPES (Allen)

La Carpintera Mouse

Hesperomys (*Vesperimus?*) *nudipes* Allen, Bull. Amer. Mus. Nat. Hist., Vol. 3, p. 213, April 17, 1891. Type from La Carpintera, Costa Rica.

Peromyscus cacabatus Bangs, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 29, text figs. 8-10, April, 1902. Type from Boquete, Chiriqui, Panama.

Peromyscus nudipes is a large member of the genus, but decidedly smaller than *P. flavidus* which inhabits parts of the same area. It measures 250 to 270 millimeters in total length, while this dimension in the latter species is well over 300 millimeters.

It is known in Panama only from the slopes of the Volcan de Chiriqui where it was collected by W. W. Brown, Jr. It was described by Outram Bangs under the name *P. cacabatus,* which I agree with Allen (1904, p. 67) and Osgood (1909, p. 195) in identifying with *P. nudipes.* Brown found it by far the commonest small mammal of the mountain forest belt of the Volcan de Chiriqui where it does not appear to occur below 4,000 feet and extends thence upward to at least 7,500 feet elevation.

Specimens examined: Boquete, 116[2] (including type).

[1] Twenty-eight specimens in Mus. Comp. Zool.; six in Amer. Mus. Nat. Hist.

[2] 103 in Mus. Comp. Zool.; 11 in Amer. Mus. Nat. Hist.

Subgenus MEGADONTOMYS Merriam

PEROMYSCUS FLAVIDUS Bangs

Volcan Mouse

Megadontomys flavidus BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, text figs. 5-7, p. 27, April, 1902. Type from Boquete, Volcan de Chiriqui, Panama (altitude 4,000 feet).

Peromyscus flavidus is a large member of the subgenus *Megadontomys,* allied to *P. pirrensis,* but paler, more ochraceous in color, with a shorter hind foot. It differs also in cranial and dental details, especially the tendency to division exhibited by the anterior lobe of the first upper molar.

This species was discovered by W. W. Brown, Jr., in the course of his work for Outram Bangs on the Volcan de Chiriqui. He found it common in the upland forest at from 3,000 to 5,000 feet altitude, but no specimens were taken above or below these elevations. The species thus seems to be restricted to about the same altitudinal range as *P. pirrensis* and the two are apparently isolated by low-lying areas unsuited for their habitation.

Specimens examined: Boquete, 32[1] (including type).

PEROMYSCUS PIRRENSIS Goldman

Mount Pirre Mouse

[Plate 23, figs. 5, 5*a*]

Peromyscus pirrensis GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, p. 5, September 20, 1912. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 4,500 feet).

The Mount Pirre mouse is a large member of the subgenus *Megadontomys.* It is similar to *P. flavidus* of the Volcan de Chiriqui but is decidedly darker, less ochraceous in color, and has a longer hind foot; the skull is larger, with longer, slenderer rostrum; the anterior lobe of the first upper molar is very narrow and in some examples entire, in others slightly notched.

While evidently more closely allied to *P. flavidus* than to any other known form, *P. pirrensis* differs from that species notably in dentition. The anterior lobe of the first upper molar is narrower, less extended internally, and the longitudinal notch is faint or absent. The supplementary cusps are rather weakly developed for a *Megadontomys,* and the general form of the tooth suggests the 5-tuberculate condition of typical *Peromyscus.* In *P. flavidus,* on the contrary, the division of the anterior lobe being more complete the cusp

[1] Twenty-five in collection Mus. Comp. Zool.; five in Amer. Mus. Nat. Hist.

arrangement approaches that in the 6-tuberculate genera *Nyctomys* and *Rhipidomys.*

The discovery of a *Peromyscus* on Mount Pirre materially extended the known range of the genus from the western part of the republic to near the Colombian frontier. The specimens were trapped mainly under logs and among the spreading aerial roots of trees, in the unbroken forest, at from 3,500 feet on the slopes to 5,200 feet altitude near the summit of the mountain. None were taken in numerous traps placed at lower elevations, and the species seems to be limited to the upper slopes of the mountains where it is common. Two young were found in a nest about six feet from the ground behind the expanded base of a palm frond, indicating scansorial habits. The nest was composed of pulverized bark, and plant fibers. Worn places over and under logs mark routes regularly used by the species in moving about on and near the ground. Anthony (1916, p. 366) found this species "the commonest rat of southeastern Panama." Numerous specimens were obtained by him at various elevations from 2,650 feet near the old village of Tacarcuna up to 5,200 feet near Mount Tacarcuna.

Specimens examined: Mount Pirre (type locality), 20; Mount Tacarcuna, 47.[1]

Genus NYCTOMYS Saussure. Vesper Rats

The members of the Middle American genus *Nyctomys* are medium-sized mice of a rich yellowish color above. The underparts are white. The tail is about as long as the body, and clothed with rather long hair. In many respects the genus resembles *Rhipidomys,* but the general color is more yellowish than is usual in that genus, and the tail shorter and clothed with longer hair. The skull is short and broad, with a short, slender rostrum and fully expanded braincase. The frontals are much broader than in *Rhipidomys,* the lateral margins projecting well over the orbits. The first upper molar is a rectangular tooth with six tubercles much as in *Rhipidomys,* but in the less complete division of the anterior lobe and the reduced size of the anterointernal cusp suggests gradation toward the 5-tuberculate genus *Peromyscus.*

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[1] Collection Amer. Mus. Nat. Hist.

NYCTOMYS SUMICHRASTI NITELLINUS Bangs

Chiriqui Vesper Rat

Nyctomys nitellinus BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 30, text figs. 11-12, April, 1902. Type from Boquete, Chiriqui, Panama (altitude 4,000 feet).

Nyctomys sumichrasti nitellinus is comparatively pale and yellowish in color above, the general tone decidedly paler than in the allied subspecies, *Nyctomys sumichrasti venustulus* of Nicaragua and Costa Rica, which differs also in the narrower braincase and posterior part of frontal region.

The subspecies is based on six specimens obtained by W. W. Brown, Jr., at the type locality.

Genus RHIPIDOMYS Tschudi. Climbing Mice

Rhipidomys is one of those genera found during the present investigations to range within the limits of Panama. Externally the species resembles some forms of *Oryzomys;* the tail is very long and clothed with rather long hair; the hind feet are short with sharp, strongly curved claws adapting the animal for an arboreal life; cranial examinations are, however, important in order to make accurate generic determinations. The skull of *Rhipidomys* resembles that of *Nyctomys* in many respects, the braincase being large and the rostrum short and narrow. The frontal region is narrower, however, the incisive foramina much longer than the palatal bridge and reaching posteriorly behind the anterior plane of the first molars. The genus *Rhipidomys* differs from *Nyctomys* notably in the form of the anterior upper molar, this tooth bearing six well-developed cusps, while in *Nyctomys* the anterointernal cusp is less prominent and suggests gradation toward the normally 5-tuberculate genus *Peromyscus.*

RHIPIDOMYS SCANDENS Goldman

Mount Pirre Climbing Mouse

[Plate 23, figs. 4, 4*a*]

Rhipidomys scandens GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, p. 8, February 28, 1913. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 5,000 feet).

The type of *Rhipidomys scandens* is unique, and no other specimens of the genus are known from any part of Middle America. The species is closely allied to *R. venezuelæ* with which it may be expected to intergrade, but until more material is available and the various forms of this unrevised group are better known, it seems preferable to treat the Panama representative of the genus as a distinct species. The upperparts are darker colored than in typical examples of *R. venezuelæ* and the skull is decidedly broader across the braincase. In the breadth of the braincase it is similar to *R. cocalensis,* another closely related form, but the frontal region is depressed anteriorly and much narrower, especially posteriorly, the maxillary arm of the zygoma is heavier, and the interparietal is larger.

The specimen which became the type was secured just at dusk one evening, when it was seen running rapidly up the trunk of a tree near my camp in the forest, to a point about 35 feet from the ground where the tree was encircled by a mass of Bromeliaceous plants. The mouse paused a moment among the leaves, its long tail hanging straight downward, and was shot.

Specimens examined: Mount Pirre, 1.

Genus TYLOMYS Peters

The members of the genus *Tylomys* bear some superficial resemblance to large examples of *Mus rattus.* The ears are large and naked, the tail is long and practically bare, the skin of the terminal portion whitish or flesh colored instead of black. The skull is elongated, with low rather flat braincase, and broad frontals which form supraorbital shelves much as in *Nyctomys.* The outer wall of the antorbital foramen is little developed forward, the anterior border concave. The first upper molar is evenly rectangular with six well-developed tubercles arranged about as in *Rhipidomys.*

TYLOMYS PANAMENSIS (Gray)

Panama Climbing Rat

Neomys panamensis GRAY, Ann. Mag. Nat. Hist., Ser. 4, Vol. 12, p. 417, November, 1873. Type from Panama.

The Panama climbing rat was described from a specimen obtained by the British Museum through M. Boucard. To this species I provisionally refer three immature specimens with narrow, elongated skulls, taken near Cana. In cranial characters they are much like *T. miræ,* however, and quite different from a comparably immature example from Cerro Brujo which may represent *T. watsoni.*

One of the specimens was taken in a banana-baited trap placed among rocks at 2,000 feet altitude near the entrance to an abandoned tunnel at the Darien gold mines. One caught in a trap set under a log along the bank of a stream in the forest at 4,500 feet altitude was devoured by some prowling animal. Another was shot in the same vicinity one day by one of my men, as it climbed a palm frond 30 feet from the ground. This was a full-grown animal, but, unfortunately, the head was carried away by the shot and the specimen rendered worthless.

Specimens examined: Cana, 3.

TYLOMYS WATSONI Thomas

Watson's Climbing Rat

Tylomys watsoni THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 4, p. 278, October, 1899. Type from Bugaba, Chiriqui, Panama (altitude 800 feet).

The basis of this species was two specimens "caught on banks of river" at Bugaba by H. J. Watson. The skull is described as much broader and heavier than that of *T. panamensis*. Bangs (1902, p. 32) notes four examples, collected by W. W. Brown, Jr., of which he says: "The specimens from Bugaba are not only topotypes, but were caught on the banks of the same stream as the type." Allen (1904, p. 68) lists a specimen taken by J. H. Batty at Boqueron.

An immature example from Cerro Brujo, with a broad, heavy skull, is quite different from the Cana series and more like *T. watsoni* to which it is provisionally referred, although the nasals and premaxillæ are conterminous posteriorly (in specimens of typical *watsoni* the premaxillæ exceed the nasals in posterior extent). It was taken in a trap placed among the spreading aerial roots of a palm at 1,000 feet elevation on the Atlantic slope of the mountain.

Specimens examined: Bugaba (type locality), 3[1]; Boqueron, 1; Boquete, 1[1]; Cerro Brujo, 1.

TYLOMYS FULVIVENTER Anthony

Fulvous-bellied Climbing Rat

Tylomys fulviventer ANTHONY, Bull. Amer. Mus. Nat. Hist., Vol. 35, p. 366, June 9, 1916. Type from Mount Tacarcuna, Panama (altitude 4,200 feet).

The type and only known specimen of this species seems sufficiently distinguished by the russet and ochraceous-buffy colors of the underparts. In the other species inhabiting the general region the underparts are white. Additional examples are much needed in order to determine the status and relationships of the various forms of the genus. Anthony (*l. c.*) states that this rat was taken in a banana-

[1] Collection Mus. Comp. Zool.

baited trap set at the foot of a large tree in the fairly heavy forest that clothes Mount Tacarcuna.

Specimens examined: The type.[1]

Genus **SCOTINOMYS** Thomas. Brown Mice

The members of the genus *Scotinomys* are very small blackish or dark brownish mice with soft pelage and tails shorter than the head and body. Several species have been described and the group ranges from southern Mexico to western Panama. Until recently[2] the species were included in the genus *Akodon* which, by the segregation of this Middle American group, becomes eliminated from the North American fauna. *Scotinomys* differs from *Akodon* in dental details, the molars being narrower and more elongated in the antero-posterior direction. The lateral compression is especially noticeable in the posterior portion of the first upper molar. An inner view of this tooth shows the posterointernal reentrant angle extending as a deep groove to the alveolar border and in advanced age three root divisions are visible instead of two as in *Akodon*. The lower incisor lacks a tubercular swelling over the root.

SCOTINOMYS TEGUINA APRICUS (Bangs)

Boquete Brown Mouse

Akodon teguina apricus BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 40, text figs. 20-21, April, 1902. Type from Boquete, Chiriqui, Panama (altitude, 4,000 feet).

Scotinomys t. apricus is based on five specimens collected by W. W. Brown, Jr., at from 4,000 to 5,000 feet altitude near Boquete on the basal slope of the Volcan de Chiriqui.

The original description is in part as follows:

"Colors not so black as in true *A. teguina* (the rump and thighs in true *A. teguina* are blackish, in the new form they are scarcely darker than the rest of the upper parts); tail, longer; ears, larger; skull, heavier; rostrum, heavier; molar-form teeth much heavier; tooth rows not so parallel,—much more divergent anteriorly. Pelage, short, close, and fine with decided gloss.

"Upper parts vandyke-brown, slightly more dusky on top of head and along middle of back; under parts dull cinnamon rufous; hands, feet, ears, and tail blackish.

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[1] Collection Amer. Mus. Nat. Hist.

[2] See Thomas, Ann. Mag. Nat. Hist., Ser. 8, Vol. 11, p. 408, April, 1913.

" Through the kindness of Dr. Merriam I was able to compare the series taken by Mr. Brown with a fine adult ♂, No. 76,353, of true *A. teguina* taken by Mr. E. W. Nelson at Ocuilapa, Chiapas, Mexico. This comparison showed that the Chiriqui animal is quite distinct—though it is perhaps better to regard it as a subspecies.

" Mr. Brown caught all five of these curious dark brown little creatures, in open rocky places." (Bangs, *l. c.*)

No representative of the genus was met with by me in the course of extended field work in eastern Panama where the Isthmus is heavily forested from coast to coast.

Specimens examined: Boquete, 5[1] (including type).

SCOTINOMYS XERAMPELINUS (Bangs)

Chiriqui Brown Mouse

Akodon xerampelinus BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 41, text figs. 22-23, April, 1902. Type from Volcan de Chiriqui, Chiriqui, Panama (altitude, 10,300 feet).

Three specimens obtained by W. W. Brown, Jr., near the summit of the Volcan de Chiriqui are the basis of this species, of which the following is the original description in part:

" Apparently specifically distinct from *A. teguina.* Size of that species; tail, longer; pelage very long and fluffy with but little lustre; colors, paler—more yellowish, less reddish brown; under parts grayish (strong cinnamon rufous in *A. teguina*); skull lighter and more delicate; rostrum lighter; nasals narrower; palatal slits rather wider; audital bullæ slightly larger; molar-form teeth heavier—wider.

" Upper parts uniform dark yellowish brown (a color that might perhaps be called tawny burnt-umber) under parts, broccoli-brown; hands, feet, tail, and ears, blackish (slightly grayer, less intense black than these parts in *A. teguina apricus;* due to greater hairiness).

" The little Akodon of the summit of Volcan de Chiriqui is very different from the one found at lower altitudes and is entitled to full specific rank. The three examples were taken on the desolate top of the Volcano, a little below actual timber line, but still where the forest had become stunted and sparse. Like *A. teguina apricus* they were found in open rocky country." (Bangs, *l. c.*)

Scotinomys irazu, a high mountain form of Costa Rica, seems to be somewhat smaller and paler in color.

Specimens examined: Volcan de Chiriqui, 3[1] (including type).

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[1] Collection Mus. Comp. Zool.

Genus ZYGODONTOMYS Allen. Cane Rats

The genus *Zygodontomys* includes medium-sized, ground-inhabiting rodents which are grayish-brown in general coloration, with tails shorter than the head and body. The members are similar to *Oryzomys* in external appearance, but may usually be distinguished by the proportionately shorter tail and shorter hind feet. Recourse to the skull may, however, be necessary in order to make accurate determinations, generic distinction being lodged mainly in dental details, especially the absence of distinct style and stylid ridges and the presence of straight, antero-posteriorly directed commissures in the molar crowns. In Panama *Zygodontomys* superficially resembles the cotton rat, *Sigmodon,* but the ears are smaller and the light and dark elements of the pelage, more finely mixed, produce a less coarsely grizzled combination of color.

ZYGODONTOMYS CHERRIEI CHERRIEI (Allen)

Cherrie's Cane Rat

Oryzomys cherriei ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 7, p. 329, November 8, 1895. Type from Boruca, Costa Rica.

The range of Cherrie's cane rat extends from Costa Rica into Panama where it was first recorded by Bangs (1902, p. 37) on the basis of a young example collected by W. W. Brown, Jr., at Bugaba. He says: "I have compared this example with topotypes, kindly loaned by Dr. Allen and can find no differences." The species was noted by Thomas (1903*a*, p. 40) from Cebaco Island, near the coast of Chiriqui, whence it was sent by J. H. Batty. Allen (1904, p. 69) lists 11 specimens taken at Boqueron by the same collector.

Zygodontomys cherriei is replaced in the Canal Zone by *Z. c. ventriosus,* a larger, paler animal, with the back more uniform in color, less distinctly darkened along the median line.

Specimens examined: Boqueron, 11 [1]; Bugaba, 1 [2]; El Banco, 1.

ZYGODONTOMYS CHERRIEI VENTRIOSUS Goldman

Canal Zone Cane Rat

Plate 23, figs. 3, 3*a*

Zygodontomys cherriei ventriosus GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 8, February 19, 1912. Type from Tabernilla, Canal Zone, Panama.

The Canal Zone form of *Zygodontomys cherriei* is closely allied to the typical form, *Z. c. cherriei,* but is larger and paler in color,

[1] Collection Amer. Mus. Nat. Hist.
[2] Collection Mus. Comp. Zool.

the back less distinctly darkened along the median line. It seems to be the most abundant murine rodent in the grassy clearings, sugar-cane fields, and second growth forest of the region. It was not obtained in the heavy forest and in all probability greatly increased in numbers with the clearing of forest along the line of the Panama Railroad. With the completion of the Gatun dam and the elevation of the level of Gatun Lake much of the cleared space, including the type locality, has been flooded, and the area in which these rice rats and other small rodents were thriving is again restricted. Anthony (1916, p. 368), who visited the Canal Zone early in 1914, reports "This species was found but rarely. It was taken only at low elevations." He records specimens from Gatun, Real de Santa Maria and Old Panama.

Specimens examined: Empire, 4; Gatun, 12[1]; Real de Santa Maria, 1[1]; Old Panama, 1[2]; Tabernilla (type locality), 15.

ZYGODONTOMYS SEORSUS Bangs

San Miguel Island Cane Rat

Zygodontomys seorsus BANGS, Amer. Nat., Vol. 35, p. 642, August, 1901. Type from San Miguel Island, Panama.

San Miguel Island is inhabited by a large, well-marked species, differing from the form of *Z. cherriei* inhabiting the adjacent mainland in much larger size, and much darker, ferruginous coloration.

The basis of the species is a series of 68 specimens collected by W. W. Brown, Jr.

In remarks accompanying the original description, Bangs (*l. c.*) states that "The San Miguel vesper rat is a strongly marked island species, most nearly related to *Z. brevicauda*, of Trinidad, which it precisely resembles in color and character of pelage. Its much greater size, bigger foot, and different tail distinguish it, externally, from the Trinidad species, and the skulls of the two can easily be distinguished.

Z. seorsus was an abundant animal in San Miguel Island, inhabiting the dense, swampy woods, and Mr. Brown found no difficulty in trapping it in numbers."

Specimens examined: San Miguel Island, 54.

Genus NEACOMYS Thomas. Bristly Mice

The members of the genus *Neacomys* are very small, handsome mice related to *Oryzomys*, but with pelage composed of grooved

[1] Four in collection Amer. Mus. Nat. Hist.
[2] Collection Amer. Mus. Nat. Hist.

spines or bristles mixed with slender hairs much as in the unrelated genus *Heteromys*. This genus is one of those whose occurrence within our limits was disclosed during the field work in connection with the present investigations.

NEACOMYS PICTUS Goldman

Painted Bristly Mouse

[Plate 23, figs. 2, 2*a*]

Neacomys pictus GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 6-7, September 20, 1912. Type from Cana, eastern Panama (altitude 1,800 feet).

This handsome little mouse is one of the smaller rodents of the region. The pelage of the upperparts is composed of grooved black-tipped spines or bristles and slender orange rufous hairs. The mouse is easily recognized by the bristly pelage, rich orange rufescent coloration, and the absence of the external cheek pouches present in *Heteromys*.

The adults present remarkably slight variation in size or color, the orange rufous hairs mixed with the black-tipped spines producing a uniformly grizzled effect over the upperparts. The underparts are white, the color changing abruptly below a sharp ochraceous buffy line of demarcation along the sides. A half-grown young individual is in a comparatively soft pelage corresponding to the immature coat seen in *Heteromys* and other genera.

The species seems to be related to *N. pusillus* from the coast region of western Colombia, but is a larger animal with white instead of yellowish feet. The specimens were trapped in grass and small bushes growing among rocks along the edge of a sugar-cane field at 1,800 to 2,000 feet elevation on a steep mountain side near the Darien gold mines. Anthony (1916, p. 369) records the species from a slightly higher altitude, 2,650 feet at the village of Tacarcuna and remarks: "The genus was not encountered elsewhere."

Specimens examined: Cana (type locality), 5; Tacarcuna, 2.[1]

Genus ORYZOMYS Baird. Rice Rats

The genus *Oryzomys* seems to occupy in South America the place filled in North America by the genus *Peromyscus*, as the Murine group including the greatest number of species. But from South America *Oryzomys* pushes northward through Middle America, considerably overlapping the range of *Peromyscus*. In this genus the size is very variable, some forms being so small and slender that in

[1] Collection Amer. Mus. Nat. Hist.

the flesh they are most easily distinguished from *Reithrodontomys* by the smooth instead of grooved upper incisors; others are as large as common rats. The short ears, usually harsh fur, and rather long, thinly haired hind feet will aid in the recognition of the rice rats among the numerous small rodents of the region.

Subgenus ORYZOMYS Baird

ORYZOMYS GATUNENSIS Goldman

Gatun Rice Rat

[Plate 24, figs. 2, 2*a*]

Oryzomys gatunensis GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 7, February 19, 1912. Type from Gatun, Canal Zone, Panama.

The Gatun rice rat is a member of the *O. palustris* group allied to *O. richmondi* of Nicaragua, contrasted with which it is paler, more grayish brown in color; the skull differs in detail, the frontals being decidedly broader with lateral margins more developed as supraorbital shelves; the interparietal is much less extended anteroposteriorly and the nasals are more prolonged posteriorly beyond the premaxillæ.

The type and only known specimen is a young individual which seems to require comparison only with *O. richmondi.* It was trapped in an abandoned sugar-cane plantation on the bank of the Chagres River.

Specimens examined: Gatun, 1 (type).

ORYZOMYS ALFAROI ALFAROI Allen

Alfaro's Rice Rat

Hesperomys (*Oryzomys*) *alfaroi* ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 3, p. 214, April 17, 1891. Type from San Carlos, Costa Rica.

Alfaro's rice rat is a small, slender, dark colored species which ranges into western Panama from Costa Rica. It is closely allied to *O. a. dariensis* of the mountains of the eastern part of the republic. Contrasted with that subspecies the present form is duller, less rufescent in coloration.

Specimens collected by W. W. Brown, Jr., at 4,000 feet altitude near Boquete are recorded by Bangs (1902, p. 33).

Specimens examined: Boquete, 14.[1]

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[1] Eleven in collection Mus. Comp. Zool.; two in Field Mus. Nat. Hist.; one in Amer. Mus. Nat. Hist.

ORYZOMYS ALFAROI DARIENSIS Goldman

Darien Rice Rat

[Plate 24, figs. 1, 1*a*]

Oryzomys alfaroi dariensis GOLDMAN, Proc. Biol. Soc. Washington, Vol. 28, p. 128, June 29, 1915. Type from Cana, eastern Panama (altitude 2,000 feet).

In the richer, more reddish coloration of the upperparts, and usually narrower skull the Darien rice rat differs from the closely allied form, Alfaro's rice rat of western Panama. The Darien animal is rather common in dense thickets at 2,000 to 2,500 feet altitude along the Cana River, near Cana. The same thickets are also inhabited, apparently in smaller numbers, by *O. talamancæ*. On Mount Tacarcuna an immature example recorded by Anthony (1916, p. 368) was secured at 5,200 feet.

Specimens examined: Cana, 11; Mount Tacarcuna, 1.[1]

ORYZOMYS BOMBYCINUS BOMBYCINUS Goldman

Silky Rice Rat

[Plate 24, figs. 3, 3*a*]

Oryzomys bombycinus GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 6, February 19, 1912. Type from Cerro Azul, near headwaters of Chagres River, Panama (altitude 2,500 feet).

The silky rice rat is a dark-colored, forest-inhabiting species with remarkably long, soft pelage for an *Oryzomys*. It was originally compared with *O. carrikeri* and *O. talamancæ,* but is much more nearly related to *O. nitidus* from Peru, as represented by specimens in the National Museum determined by Mr. Oldfield Thomas. *O. bombycinus* differs from *O. nitidus* most noticeably in cranial characters, the braincase being broader, the zygomata more widely spreading posteriorly (zygomata more nearly parallel in *nitidus*), and the audital bullæ larger.

On Cerro Azul a few of these rice rats were taken in traps placed mainly under logs and about the bases of large forest trees at from 2,500 to 3,000 feet elevation near the summit of the mountain. No examples of this species were obtained in the course of extensive field work at the same elevation on the higher mountains near the Colombian frontier. A single individual was taken at about 1,000 feet on the forested basal slope of Cerro Brujo where *O. talamancæ* also occurs.

Specimens examined: Cerro Azul (type locality), 3; Cerro Brujo, 1.

[1] Collection Amer. Mus. Nat. Hist.

ORYZOMYS TALAMANCAE Allen

Talamanca Rice Rat

Oryzomys talamancæ ALLEN, Proc. U. S. Nat. Mus., Vol. 14, p. 193, July 24, 1891. Type from Talamanca, Costa Rica. (Probably near Sipurio, in the valley of the Rio Sicsola.)

Oryzomys panamensis THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 8, p. 252, September, 1901. Type from City of Panama, Panama.

The Talamanca rice rat typifies a group of wide distribution in South America; *O. mollipilosus* and *O. medius* are closely allied Colombian and Venezuelan forms, and others range as far as Brazil. The pelage in *O. talamancæ* is short and close and the general color varies in rich rufescent tones.

It was originally described from Costa Rica and is generally distributed in Panama where it is one of the more abundant species, ranging from sea level in the Canal Zone to 2,500 feet altitude on the slopes of the mountains near the Colombian frontier. Specimens were trapped mainly under logs and rocks and about the bases of large trees in the heavy forest.

Specimens from the Canal Zone which I identify with *O. talamancæ* have been submitted to Mr. Oldfield Thomas for comparison with the type of *O. panamensis* in the British Museum. Regarding them he has written as follows: " We have only one specimen of *O. panamensis* and it is both larger and more rufous than your specimens. But it is older; the skull agrees in general characters and the tooth-row is of exactly the same length. As to the colour I think the difference is only due to the coming on of the faded fulvous stage found in the old specimens of most species of *Oryzomys*. Personally I should certainly refer your specimens to *panamensis*." On the basis of this comparison and other grounds *O. panamensis* seems to belong in synonymy under *O. talamancæ*. Anthony (1916, p. 369) states " the species was found sparingly throughout the lowlands from the Canal Zone to the Darien." He records specimens from Cituro, Maxon Ranch (Rio Trinidad), Tacarcuna and Tapalisa.

Specimens examined: Cana, 7; Cituro, 1 [1]; Cerro Brujo, 1; Gatun, 6; Maxon Ranch (Rio Trinidad), 3 [1]; Tacarcuna, 1 [1]; Tapalisa, 9.[1]

ORYZOMYS DEVIUS Bangs

Boquete Rice Rat

Oryzomys devius BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 34, text figs. 13-14, April, 1902. Type from Boquete, Chiriqui, Panama (altitude 5,000 feet).

The Boquete rice rat is a large species of a group which includes *O. meridensis* and a number of other South American forms. No

[1] Collection Amer. Mus. Nat. Hist.

other member of the group is known to range so far into Middle America, but an allied species, *O. pirrensis,* inhabits the mountains of eastern Panama. The underparts in *O. devius,* unlike those of *O. pirrensis,* are marked by white patches, as usual in the group. The skull is similar, but more smoothly rounded, the zygomata less widely spreading, the supraorbital and temporal ridges less distinct, and the audital bullæ decidedly larger than in *O. pirrensis.*

The species is based on four specimens obtained by W. W. Brown, Jr., from 4,000 to 5,000 feet altitude on the southern slope of the Volcan de Chiriqui, and additional examples from the same locality acquired by the Field Museum of Natural History.

Specimens examined: Boquete (type locality), 6.[1]

ORYZOMYS PIRRENSIS Goldman

Mount Pirre Rice Rat

[Plate 24, figs. 5, 5*a*]

Oryzomys pirrensis Goldman, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 5-6, February 28, 1913. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 4,500 feet).

The Mount Pirre rice rat is a large member of the *O. meridensis* group. It is similar in size to *O. devius* of western Panama, but slightly darker in general color, and the underparts lack the pure white patches usual in the group. The skull is more angular, with zygomata more widely spreading, the supraorbital and temporal ridges more distinct, and the audital bullæ decidedly smaller. The skull combines the large general size of that of *O. devius* with the small audital bullæ of *O. meridensis* and *O. maculiventer;* it differs from both, however, in the development of the supraorbital and temporal ridges.

Like the allied species, *O. devius, O. meridensis* and others of the group, this large rice rat is an inhabitant of the mountains. It was found only in the heavy forest at about 4,500 feet altitude where precipitous slopes border the narrow canyon of the Rio Limon. The animals live in holes under logs and rocks along steep overhanging banks of the stream, where palms and tree ferns are conspicuous vegetation. Several were caught in well-worn paths, bearing many marks of small feet.

Anthony (1916, p. 368) encountered this species at 5,200 feet on the upper slope of Mount Tacarcuna where it did not appear to be common. He notes the external resemblance to the much more

[1] Four in collection Mus. Comp. Zool.; two in Field Mus. Nat. Hist.

abundant species, *Peromyscus pirrensis,* occurring at the same locality, and points out the more naked tail and shorter ears as distinguishing characters.

Specimens examined: Mount Pirre, 8; Mount Tacarcuna, 6.[1]

ORYZOMYS TECTUS TECTUS Thomas

Bugaba Rice Rat

Oryzomys tectus THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 8, p. 251, September, 1901. Type from Bugaba, Chiriqui, Panama (altitude 800 feet).

The two closely allied forms of *O. tectus* are large, rather robust rice rats with generally rich tawny or ochraceous-tawny upperparts. The underparts vary from nearly pure white to pale buff. The skulls are remarkable for the lateral expansion of the frontals as supraorbital shelves. These forms are typical of a group including *O. flavicans* and other South American species. *O. t. tectus,* known only from western Panama and Costa Rica, differs from *O. t. frontalis* of eastern Panama in the brighter tawny coloration of the upperparts and the more buffy underparts. Aside from the type no specimens appear to have been collected in Panama, but two examples from Boruca, Costa Rica, are assumed to be typical.

ORYZOMYS TECTUS FRONTALIS Goldman

Corozal Rice Rat

[Plate 24, figs. 6, 6*a*]

Oryzomys frontalis GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 6, February 19, 1912. Type from Corozal, Canal Zone (altitude 100 feet).

Oryzomys t. frontalis of eastern Panama is closely allied to *O. t. tectus* of western Panama, but the upperparts are duller, less distinctly tawny, and the underparts are whiter, less extensively buffy. It is decidedly larger than the related South American forms, *O. flavicans* and *O. f. illectus,* and differs in cranial details, especially the greater lateral projection of the frontals over the orbits.

At Corozal the type was trapped in grass and bushes near the edge of a swamp a few feet above sea level. Near Cana specimens were taken at 2,000 feet altitude in an abandoned sugar-cane field where a rank growth of grass and shrubbery was springing up. Here it was associated with the Panama dusky rice rat (*Oryzomys caliginosus idoneus*), a much more abundant species. Anthony (1916, p. 369) records a specimen from the village of Tacarcuna.

Specimens examined: Cana, 11; Corozal, 1; Tacarcuna, 1.[1]

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[1] Collection Amer. Mus. Nat. Hist.

Subgenus OLIGORYZOMYS Bangs

ORYZOMYS FULVESCENS COSTARICENSIS Allen

Costa Rican Pygmy Rice Rat

Oryzomys costaricensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 5, p. 329, September 22, 1893. Type from El General, Costa Rica (altitude 2,150 feet).

The Costa Rican pygmy rice rat is a very small form closely resembling some species of *Reithrodontomys* from which it may be easily distinguished in the flesh by the smooth instead of grooved upper incisors. It differs from *O. f. fulvescens* of Mexico mainly in the larger molar teeth, and from *O. f. vegetus* of the Volcan de Chiriqui in smaller size and usually paler color.

Very few specimens have been taken in Panama and the subspecies appears to be restricted to the savanna region from the Costa Rican frontier eastward along the Pacific coast. Anthony (1916, p. 368) records two specimens taken by him on the savanna near Old Panama, and the range of the animal probably extends as far east as Chepo.

Specimens examined: La Chorrera, 1[1]; Old Panama, 2.[1]

ORYZOMYS FULVESCENS VEGETUS Bangs

Volcan Chiriqui Pygmy Rice Rat

Oryzomys (Oligoryzomys) vegetus BANGS, Bull. Mus. Comp. Zool., Vol. 39, text fig. 15, p. 35, April, 1902. Type from Boquete, Volcan de Chiriqui, Panama (altitude 4,000 feet).

Larger average size and a tendency toward darker coloration usually distinguish this small rice rat from *O. f. costaricensis* which inhabits lower elevations.

Five specimens collected by W. W. Brown, Jr., at 3,800 to 4,800 feet altitude near Boquete were referred by Bangs (1902, p. 35) to *O. f. costaricensis* and 13 others from the same locality were at the same time described by him as a new species, *O. vegetus*. *O. vegetus* Bangs was regarded as identical with *costaricensis* by Allen (1904, p. 69), who says: "The type and 12 topotypes of *O. vegetus* kindly sent me for examination by Mr. Bangs do not differ appreciably from the type, three topotypes, and additional Costa Rican specimens of *O. costaricensis*. They also agree with the seven Boquete specimens collected by Mr. Batty, which I unhesitatingly refer to *O. costaricensis*." The specimens assigned by Bangs to *costaricensis* are rather pale and probably indistinguishable by color from many

[1] Collection Amer. Mus. Nat. Hist.

examples of that form, but the larger size, especially noticeable in the skulls, seems to place them with the remainder of the series of *vegetus.*

Specimens examined: Boquete (type locality), 27.[1]

Subgenus MELANOMYS Thomas

ORYZOMYS CALIGINOSUS IDONEUS Goldman

Panama Dusky Rice Rat

[Plate 24, figs. 4, 4*a*]

Oryzomys idoneus Goldman, Smiths. Misc. Coll., Vol. 56, No. 36, p. 5, February 19, 1912. Type from Cerro Azul, near headwaters of Chagres River, Panama (altitude 2,500 feet).

The forms of *Oryzomys caliginosus* range over an extensive area in northwestern South America and northward in Middle America to Nicaragua. Specimens from widely separated regions exhibit the general characters of the species with remarkable constancy and some of the forms now recognized may ultimately prove to be not well founded. *O. c. idoneus* is much like *O. c. columbianus* of northern Colombia from which it is barely recognizable by slightly darker average color and shorter tail. It differs from typical *O. c. caliginosus* of Ecuador in paler, more tawny, instead of russet coloration. Compared with the more northern form, *O. c. chrysomelas,* it is paler and the skull is more constricted between the orbits, the supraorbital borders less projecting laterally.

"*O. phaeopus*" (*O. c. caliginosus*) was made the type of the subgenus *Melanomys*[2] by Thomas, who mentions its short tail and generally Akodont external form, Oryzomyine molars, broad rounded braincase, short muzzle and well-marked supraorbital ridges. The molar crowns are, however, slightly higher than in typical *Oryzomys* and the lachyrmal articulates mainly with the maxilla. The skull differs also in the lateral expansion of the inner wall of the antorbital foramen whereby the broad, rounded antorbital opening of typical *Oryzomys* viewed from above is reduced to a shallow notch.

O. c. idoneus is the most abundant small rodent in the mixed growth of grass, bushes and small trees at 1,800 to 2,000 feet altitude in the Cana Valley and along the bottom of the canyon of the Cana

[1] Fifteen in collection Mus. Comp. Zool.; seven in Field Mus. Nat. Hist.; five in Amer. Mus. Nat. Hist.

[2] The subgenus *Melanomys* has been raised to generic rank by Allen (1913, p. 533) but owing to close agreement with typical *Oryzomys* in dentition and other essential characters such generic recognition seems of very doubtful advisability.

River. It was also taken in smaller numbers in the forest at various elevations up to 2,800 feet on the slopes of the Pirre Range. At the type locality on Cerro Azul it appeared to be rather scarce. Like *Nectomys alfari efficax, Sylvilagus gabbi messorius* and other species living on the ground, this rice rat has evidently increased in numbers, locally, with the clearing of the original forest, the new low growth springing up doubtless providing more suitable food and cover than is found in the heavy forest where seed producing undergrowth is largely crowded out. Anthony (1916, p. 369) found the species quite common in the clearing at 2,650 feet at the old village of Tacarcuna, but it seemed rarer at lower elevations and was not taken above 4,200 feet. He records specimens from El Real, Tacarcuna, Maxon Ranch (Rio Trinidad) and Gatun.

Specimens examined: Cana, 46; Cerro Azul, 1 (type); Gatun, 1 [1]; Maxon Ranch (Rio Trinidad), 3 [1]; Real de Santa Maria, 2 [1]; Tacarcuna, 23.[1]

ORYZOMYS CALIGINOSUS CHRYSOMELAS Allen

Costa Rican Dusky Rice Rat

Oryzomys chrysomelas Allen, Bull. Amer. Mus. Nat. Hist., Vol. 9, p. 37, March 11, 1897. Type from Suerre, Costa Rica.

Under the name *Zygodontomys chrysomelas,* Bangs (1902, p. 37) noted three specimens of this subspecies collected for him at Bogava by W. W. Brown, Jr. These have been referred by Allen (1904, p. 548) in his revision of the group to *Melanomys chrysomelas* with the remark that topotypes " agree perfectly with Chiriqui and Nicaragua specimens of corresponding age." The range of the subspecies is given by him as approximately from Bugaba, Chiriqui, Panama, north to northern Nicaragua.

Specimens examined: Bogava, 3.[2]

Genus NECTOMYS Peters

Members of the genus *Nectomys,* especially the smaller species, externally resemble some species of *Oryzomys.* The genus is nearly related to *Oryzomys* from which it differs notably in rather more hypsodont dentition; the molar crowns have lower tubercles and the outer reentrant angles are shallower so that with continued wear on the crowns the latter close along the outer side, but remain as deep interior enamel folds or islands which persist to extreme old age,

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[1] Collection Amer. Mus. Nat. History.

[2] Collection Mus. Comp. Zool.

the result being a more complicated enamel pattern than in *Oryzomys*. Some of the South American species of *Nectomys* are the largest American Murine rodents.

NECTOMYS ALFARI EFFICAX Goldman

Cana Rice Rat

[Plate 23, figs. 6, 6*a*]

Nectomys alfari efficax GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, p. 7, February 28, 1913. Type from Cana, eastern Panama (altitude 1,800 feet).

Nectomys a. efficax is a richly colored, long-haired animal belonging to the section of the genus including rather small species—*N. esmeraldarum* and others—which lack the fringed feet and toes of the more typical *Nectomys squamipes* group. In the more essential characters, however, the two groups are closely congeneric. *N. a. efficax* is closely allied to *N. a. alfari*[1] of Costa Rica. It differs, however, in the richer, more tawny ochraceous coloration of the upperparts and the skull has a narrower braincase and more massive rostrum. It is somewhat similar to *N. esmeraldarum*, but larger, the color paler, more ochraceous, and the skull more elongated. *N. dimidiatus* of Nicaragua is a much smaller species with a different skull.

This rice rat is one of the more common Murine rodents in the grassy clearings, old cane fields and second growth forest at 1,800 to 2,000 feet altitude on the small plateau commonly known as the Cana Valley. It was especially abundant in the rank grass growing on the marshy valley bottom. No examples were taken in the heavy forest. In examining specimens in the flesh it was noted that the number of tubercles on the sole of the hind foot is variable. In some examples there are five with no trace of a sixth; in others six are distinctly shown, but the postero-external may be very small; in still others the small sixth tubercle is present, but very minute on one foot and absent on the other. Anthony (1916, p. 369) found the Cana rice rat common at 2,650 feet at the village of Tacarcuna, but it "strangely was not taken elsewhere."

Specimens examined: Cana, 23; Tacarcuna, 15.[2]

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[1] This species was described as the type of a new genus, *Sigmodontomys* Allen (Bull. Amer. Mus. Nat. Hist., Vol. 9, p. 39, March 11, 1897), which is clearly identical with *Nectomys* Peters.

[2] Collection Amer. Mus. Nat. Hist.

Genus SIGMODON Say and Ord. Cotton Rats

The members of this genus attain the size of common rats, but are more robust in form with tails usually shorter than the body, rather thick at the base and tapering rapidly to slender tips. The ears are short, but broad and clothed with short fur. The pelage is coarse, and grizzled grayish brown in general color. The skulls are easily distinguished by a spinous process projecting forward from the upper edge of the outer wall of the antorbital foramen.

SIGMODON HISPIDUS CHIRIQUENSIS Allen

Boqueron Cotton Rat

Sigmodon borucæ chiriquensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 68, February 29, 1904. Type from Boqueron, Chiriqui, Panama.

The Boqueron cotton rat is very similar to *S. h. borucæ* of Costa Rica, but the upperparts are somewhat richer, more rufescent in general tone. The underparts are usually white, but in both forms they are sometimes suffused with buff.

The basis of the subspecies is six specimens collected at Boqueron by J. H. Batty. Alston (1879, p. 152) notes examples of *Sigmodon hispidus* "supplied to the British Museum by Whitely from Veragua." As *Sigmodon borucæ,* Bangs (1902, p. 32) lists measured specimens taken by W. W. Brown, Jr., at Bugaba, which he says "appear to be identical with Allen's *S. borucæ* of Boruca, Costa Rica." Thomas (1903*a*, p. 41) records eight examples "mostly young," but probably referable to this form, from Cebaco Island off the southwestern coast of Panama. Anthony (1916, p. 368) records a specimen taken in a low grassy meadow near the Chagres River at Gatun.

Specimens from the Canal Zone are provisionally referred to this form, although the grayer examples are practically indistinguishable from typical *S. h. borucæ.*

Cotton rats are common only locally in the Canal Zone. At Gatun a few were captured in the thick grass growing in places where the forest has been cleared away. Such places are usually overgrown with grass and a few small bushes, with here and there clumps of larger bushes. The cotton rats make fairly well-trodden paths leading away, in various directions, from their holes which commonly enter the ground along low banks. At Tabernilla they are abundant in thick grass and small bushes which have overgrown earth and rock excavated from Culebra cut and dumped there several years ago.

Here, also, well-trodden paths, radiating from their holes off through the vegetation, were noted. The same local area is inhabited by *Zygodontomys cherriei ventriosus*. Both species avoid the heavy forest. Many cleared spaces where they were undoubtedly abundant have been inundated by the recent elevation of the level of Gatun Lake.

Specimens examined: Boqueron, 6[1]; Bugaba, 3[2]; Gatun, 7[3]; Tabernilla, 24.

SIGMODON AUSTERULUS Bangs

Chiriqui Cotton Rat

Sigmodon austerulus BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 32, April, 1902. Type from Volcan de Chiriqui, Chiriqui, Panama (altitude 10,000 feet).

The type, still unique, of *Sigmodon austerulus* was obtained by W. W. Brown, Jr., near the summit of the Volcan de Chiriqui.

The animal is well described as "about the size of *S. borucæ;* tail longer; pelage much more hispid; colors all much paler; skull similar." Quoted further the author says: "The one example from the top of the Volcan de Chiriqui, differs from *S. borucæ* of the adjacent low lands not only in having much more hispid pelage, a much paler coloration throughout, but also a longer tail.

"In the forest belt of the Volcan, where Mr. Brown did much trapping, he did not find *Sigmodon,* and for that reason I give full specific rank to the form of the summit of the Volcan de Chiriqui. It has been my experience that Sigmodons love open fields, savannahs, brushy places, and waste land, and avoid the dense forest."

Specimens examined: Volcan de Chiriqui, 1[2] (type).

Genus RHEOMYS Thomas. Water Mice

The single known species representing this genus in Panama is a small, dark-colored, aquatic mouse with short glossy fur. In general external appearance it suggests a musk rat in miniature. In the peculiar combination of cranial characters it differs widely from the other rodents of the region.

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[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

[3] One in collection Amer. Mus. Nat. Hist.

RHEOMYS RAPTOR Goldman

Panama Water Mouse

[Plate 23, figs. 1, 1*a*]

Rheomys raptor GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, p. 7, September 20, 1912. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 4,500 feet).

Rheomys raptor is a small member of the group which includes *Ichthyomys hydrobates* and several rather aberrant genera of Murine rodents. They are largely aquatic in habits and some species are supposed to catch fish. In the present species there are short webs between some of the toes, and the fringing bristles, together with the character of the pelage, show fitness for an aquatic life. The upper incisors are of a more generalized Murine type than those of *Ichthyomys* which show specialization in form, the heavily beveled internal border resulting in a deeply emarginate cutting edge adapted for seizing and holding soft slippery prey.

The specimens of *R. raptor* were all captured in traps placed in the water among rocks and under logs in places where the water was oozing or trickling out over the banks of a small creek, one of the headwaters of the Rio Limon. There was no evidence that the species preys on fish, but small collections of freshly emptied shells of large water snails noted near the edge of the water in the vicinity suggested another probable food supply. The snails had evidently been gathered by some small predatory animal which had the power to break through the shells. The point chosen for attack was invariably the middle of the largest whorl, which when perforated exposed most of the snail's body. The holes in the shells were such as might readily be made by the incisors of *Rheomys*. Stomachs examined contained small quantities of pulp that may have been the remains of the bodies of snails.

Specimens examined: Mount Pirre (near head of Rio Limon), 3.

Subfamily MURINAE. Rats

Genus RATTUS Fischer. Common Rats

In the genus are included the common rats which are cosmopolitan, everywhere infesting the habitations of man, and many indigenous Old World species.

RATTUS RATTUS RATTUS (Linnæus)

Black Rat

[*Mus*] *rattus* LINNÆUS, Syst. Nat., Ed. 10, Vol. 1, p. 61, 1758. Type locality, Sweden.

The black rat is well established in the republic. Large numbers have been destroyed in the city of Panama as a sanitary measure, and in the vicinity of towns these rats have in places becomes naturalized in the open country.

At Empire one was trapped in a thicket along the edge of a corn field at least a quarter of a mile from the nearest house. On the small island of Buenaventura near Porto Bello the rats were very abundant and generally distributed through the woods.

Bangs (1901, p. 644) notes a specimen collected by W. W. Brown, Jr., on San Miguel Island. The species is recorded by Thomas (1903*a*, p. 40) from Brava and Cebaco, both small islands off the southwestern coast of the republic where specimens were taken by J. H. Batty for the British Museum. Allen (1904, p. 67) lists specimens obtained by J. H. Batty at Boqueron, where he states that this rat was "Very abundant, with the habits of a wild species, being found remote from towns or the dwellings of man."

Specimens examined: Boqueron, 17 [1]; Boquete, 3 [1]; Buenaventura Island (near Porto Bello), 1; Cana, 1; Empire, 1; Gatun, 1.

RATTUS RATTUS ALEXANDRINUS (Geoffroy)

Roof Rat

Mus alexandrinus GEOFFROY, Description de l'Egypte, mammiféres, 1818, p. 733. Type locality, Alexandria, Egypt.

The roof rat seems to be much rarer than the black form in Panama. A specimen collected by W. W. Brown, Jr., on San Miguel Island was recorded by Bangs (1901, p. 644) who says: "The three introduced species of *Mus* could not have been very numerous in San Miguel, as one individual of each was all that fell into Mr. Brown's traps in over three weeks of collecting."

Genus MUS Linnæus. House Mice

The genus *Mus* includes many indigenous Old World species and is represented in America by an immigrant, the familiar house mouse, now cosmopolitan in distribution.

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[1] Collection Amer. Mus. Nat. Hist.

MUS MUSCULUS MUSCULUS Linnæus

House Mouse

[*Mus*] *musculus* LINNÆUS, Syst. Nat., Ed. 10, Vol. 1, p. 62, 1758. Type locality, Sweden.

The only record I have of the occurrence of the house mouse in the republic is that of Bangs (1901, p. 644), based on a specimen taken by W. W. Brown, Jr., on San Miguel Island. The species probably inhabits the towns throughout most of the region.

In many localities these mice take to the fields where they seem to be able to exist under the same conditions, and in competition with native mammals. A dark Mexican form which has apparently developed differential characters has been described as subspecies *Mus musculus jalapæ*.

Family GEOMYIDAE. Pocket Gophers

A single genus of this family inhabits the region under review. The group, represented by other genera, reaches its greatest development farther north in Middle America, but at least one outlying species pushes northward into Canada.

Genus MACROGEOMYS Merriam

The members of this genus are robust burrowing animals, larger than large rats. They are very unlike any of the other mammals of the region and may be easily recognized by the very short ears which are reduced to mere folds in the skin, the deep external cheek pouches, the short, smooth, naked tail, and the large grooved upper incisors. The genus is now known to range from Nicaragua to extreme eastern Panama and probably enters Colombian territory.

MACROGEOMYS DARIENSIS Goldman

Darien Pocket Gopher; Dueño de Tierra; Chuchupa

[Plate 25, figs. 5, 5*a*]

Macrogeomys dariensis GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 8-10, September 20, 1912. Type from Cana, in the mountains of eastern Panama (altitude 2,000 feet).

The Darien pocket gopher is similar in general size to *M. cavator* of western Panama, but in color is a dull brown or black instead of the rich seal brown shade of the latter species. The skull is less massive, more elongated, narrower posteriorly, and differs in many important details; the lambdoid crest is low, nearly straight or slightly convex posteriorly instead of high and sinuous; the squamosals are less extended laterally as postglenoid shelves, the margin being deeply notched and exposing much of the tubular portion of the bulla when viewed from above.

The home of one of these pocket gophers is a network of tunnels in the ground, along the lines of which large piles of earth are pushed out at irregular intervals. During the dry season few fresh workings are seen, but with the return of the rainy season their greater activity is shown by the numerous mounds of fresh earth excavated. They work mainly during the early morning and evening hours and at night. In the vicinity of Cana the pocket gophers are generally distributed over the forested slopes of the mountains up to about 2,500 feet altitude, but are most numerous in clearings, owing no doubt to the greater abundance of succulent roots and small plants available as food. Sugar-cane and banana fields on steep mountain slopes are especially favored. Banana and sugar-cane stalks are cut, and grass and other vegetation bitten off at the surface of the ground. Sugar-cane stalks are drawn gradually into the holes, the animal feeding at the basal end until nearly the whole is consumed. When one hole was opened a number of freshly cut grass stems—sections about three inches in length—were disclosed, all neatly piled at one side of the tunnel. Gophers also bore in ditch banks and are occasionally responsible for troublesome breaks in the ditches of the Darien Gold Mining Company. Gopher workings were noted at intervals along the railroad between the mines and the landing on the Tuyra River at Boca de Cupe. Specimens from the latter locality, where the altitude is about 250 feet, do not differ appreciably from those taken near Cana. The species therefore ranges from very low elevations upward over the basal slopes of the mountains in the Darien region. No traces of pocket gophers were seen in or near the Canal Zone, and there is no record of their occurrence in the central part of the republic. Native names at Boca de Cupe are "dueño de tierra" and "chuchupa."

Anthony (1916, p. 369) encountered the species at Boca de Cupe, Tacarcuna and Tapalisa, the two latter localities on the northern side of the Tuyra Valley. The highest workings noted by him were at about 4,200 feet.

Specimens examined: Boca de Cupe, 7[1]; Cana (type locality), 11; Tacarcuna, 5[2]; Tapalisa, 1.[2]

[1] Three in collection Amer. Mus. Nat. Hist.

[2] Collection Amer. Mus. Nat. Hist.

MACROGEOMYS CAVATOR Bangs.

Chiriqui Pocket Gopher

Macrogeomys cavator BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 42, text figs. 24-25, April, 1902. Type from Boquete, Chiriqui, Panama (altitude 4,800 feet).

The Chiriqui pocket gopher is based on a series of 26 specimens collected by W. W. Brown, Jr., at from 4,000 to 7,000 feet altitude in the vicinity of Boquete on the southern slope of the Volcan de Chiriqui.

The following is from the original description:

"Differs from the four known Costa Rican species, though nearest *M. dolichocephalus* Merriam. Compared with the type of that species, the skull is shorter and wider across zygoma; nasals, longer; distance from postorbital process to back of zygomatic arch, shorter; audital bullæ, flatter; sagittal and lambdoidal crests, heavier; zygomatic arch heavier and more angulated, standing widely and squarely out from skull. Color, very dark and nearly uniform—not pied as in the other species. Pelage, short, close and rather harsh.

"Upper parts dark seal-brown—almost black; under parts similar but slightly grizzled, the pelage sparse, so that the skin shows through; a small white anal patch, and sometimes small white patches under chin and on under side of wrists; whiskers colorless; feet, hands and tail, naked—in dried skin yellowish brown to dusky, the end of the tail black. In many specimens there are longer hairs scattered through the pelage, some of which are silvery, others brown like the general color of the back.

"This very distinct new species was abundant on the slopes of the volcano from 4,000 to 7,000 feet, but was not seen below 4,000 feet. It hardly needs comparison with any of the four previously known species from Costa Rica."

M. cavator seems to be somewhat larger and richer colored than *M. pansa* of the neighboring lowlands, but the two are evidently very closely allied and probably intergrade. The skulls of both differ notably from those of their known Costa Rican congeners in the high sinuous lambdoid crest, and in the greater anterior development of the basioccipital. *M. cavator* is similar in general size to the more recently described species, *M. dariensis* of eastern Panama, but the tail is shorter, the pelage longer and rich seal brown, instead of dull brown or black in color; the skull is less elongated, much broader posteriorly, and differs in many important details.

Additional specimens taken by J. H. Batty at the type locality of this species are recorded by Allen (1904, p. 70).

Specimens examined: Boquete, 24[1] (including type).

MACROGEOMYS PANSA Bangs

Bugaba Pocket Gopher

Macrogeomys pansa BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 44, April, 1902, text fig. 26. Type from Bugaba, Chiriqui, Panama (altitude 600 feet).

Eight specimens collected by W. W. Brown, Jr., at Bugaba are the basis of this foothill form which is evidently closely allied to *M. cavator,* the animal occurring at higher levels on the Volcan de Chiriqui. The close agreement of the two forms in the more essential characters suggests their probable intergradation on the lower slopes of the mountain.

The following forms part of the original description:

"Much smaller than the alpine, *M. cavator;* hind foot proportionally much larger (actually nearly the same size); colors duller and browner, more grayish white on belly; pelage short, close, very sparse on under parts, nose and sides of head and neck where the skin shows through. Skull much smaller and weaker throughout, with less spread to zygoma; nasals, shorter; interorbital width greater; molar-form teeth much smaller.

"Upper parts dull, dusky, chocolate-brown; under parts grizzled, the belly whitish: whiskers mostly colorless; feet, hands, and tail naked (in dried skin) yellowish brown, the tip of the tail dusky.

"In July, when Mr. Brown was at Bugaba, birds were moulting and mostly unfit for specimens; consequently he spent considerable time searching for suitable places for future work, trapping mammals, and collecting a few examples of some of the rarer birds. On one of his long rides he came upon a single isolated colony of pocket gophers. It was in the foot-hills, about 600 feet altitude, and was the only colony he found in the whole region. The members of this colony were rather hard to trap, as pocket gophers sometimes are, and unfortunately the only old ♂ secured was caught in the trap by the head and the skull crushed. The species is very different from the large, black species found so abundantly on the higher slopes of the Volcan de Chiriqui."

[1] Twenty-two in collection Mus. Comp. Zool.; two in Amer. Mus. Nat. Hist.

Contrasted with *M. dariensis* this species seems to be smaller. It is similar in the general character of its pelage, but differs otherwise in about the same characters as *M. cavator*.

Specimens examined: Bugaba, 6[1] (including type).

Family HETEROMYIDAE. Pocket Mice

The pocket mice are small rodents at once distinguishable by the deep external cheek pouches in combination with spiny or bristly pelage. In the character of the pelage they are not very unlike the Murine genus *Neacomys*, but the cheek pouches are distinctive. Two genera, *Heteromys* and *Liomys*, inhabit the region under review.

Subfamily HETEROMYINAE. Pocket Mice

Genus HETEROMYS Desmarest. Pocket Mice

Externally the pocket mice of this genus closely resemble those of the genus *Liomys*, but are more blackish, less grayish in the color of the upper parts, and the sole of the hind foot in the Panama forms is naked to the heel. The generic characters are exhibited by the skull, the dentition being more complex, the interpterygoid fossa V-shaped instead of U-shaped, and the angle of the mandible much less strongly everted than in the genus *Liomys*.

Subgenus HETEROMYS Desmarest

HETEROMYS AUSTRALIS CONSCIUS Goldman

Cana Pocket Mouse

[Plate 25, figs. 4, 4*a*]

Heteromys australis conscius Goldman, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 8-9, February 28, 1913. Type from Cana, eastern Panama (altitude 2,000 feet).

H. a. conscius is a small form of the genus, a rather slightly differentiated northern offshoot of the Ecuadorean species *H. australis*, which belongs to the *Heteromys anomalus* group. It is similar externally to some of the other forms of the region, but the cranial characters are distinctive. It is darker in general color than *H. a. australis*, and the slender hairs among the bristles on the back are grayer than in *H. a. lomitensis*, a closely allied Colombian form. The skull is more elongated, with broader ascending branches of premaxillae than that of *H. a. australis*; from that of *H. a. lomitensis* it differs in the broader upper surface of the maxillary arm of the

[1] Collection Mus. Comp. Zool.

zygoma, and the broad posterior ends of the premaxillæ which are more nearly conterminous with the nasals; in *H. a. lomitensis* the nasals reach farther posteriorly.

This pocket mouse was taken mainly under logs in the forest at from 1,800 to 2,000 feet altitude on the lower slopes of the Pirre Range; the upper slopes, above 4,500 feet, are inhabited by the very different form, *H. desmarestianus crassirostris.*

Specimens examined: Cana, 5.

HETEROMYS DESMARESTIANUS REPENS Bangs

Chiriqui Spiny Pocket Mouse

Heteromys repens BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 45, April, 1902, text fig. 27. Type from Boquete, Chiriqui, Panama (altitude 4,000 feet).

Several apparently well-marked forms of the genus *Heteromys*, clearly referable to the *H. desmarestianus* group, have been described from Panama[1] as distinct species. The alleged species are based on collections from few localities, and while comparison of the various series reveals remarkably constant differences the differential characters suggest probable intergradation and the advisability of reducing these forms to subspecific rank. Their evolution, like that of other groups, appears to be largely a result of widely differing environmental conditions within restricted geographic areas.

The Chiriqui spiny pocket mouse is based on six specimens collected by W. W. Brown, Jr., on the southern slope of the lofty Volcan de Chiriqui. It is a dark colored species similar to *H. desmarestianus desmarestianus* of Guatemala, but smaller and lacking the orange buffy lateral line of that species; it differs also in cranial details, the rostrum broadening more gradually to the zygomata, the nasals reaching posteriorly beyond the premaxillæ, and the molariform teeth smaller. Closer relationship is shown to *H. desmarestianus fuscatus* of Nicaragua, which is about the same in size, with a more blackish face, and differing in slight cranial details, the nasals and premaxillæ being more nearly conterminous posteriorly.

It is also similar to its nearer geographic neighbors in eastern Panama. From *H. desmarestianus zonalis* of the Canal Zone it is distinguished externally by the more ochraceous buffy suffusion of the upperparts. The skull differs in the greater posterior develop-

[1] *Heteromys fuscatus* Allen from Tuma, Nicaragua, may confidently be assigned to the same subspecific series and stand as *Heteromys desmarestianus fuscatus* Allen.

ment of the premaxillæ and in the more massive maxillary arm of the zygoma. Contrasted with *H. desmarestianus panamensis* it is somewhat paler in color and the fore feet are white instead of blackish; the skull differs in detail, the rostrum broadens less abruptly to the zygomata, the interparietal is narrower and the lateral wings of the supraoccipital are broader, more developed over mastoids.

A single specimen taken by J. H. Batty at Boqueron was recorded by Allen (1904, p. 70); the skull of this example exhibits the same shortening of the premaxillæ as compared with the nasals, and the interparietal is broad without a posterior emargination, but in the massive maxillary arm of the zygoma approaches that of *H. d. zonalis* and suggests intergradation with that subspecies.

Specimens examined: Boqueron, 1[1]; Boquete, 7[2] (including type).

HETEROMYS DESMARESTIANUS ZONALIS Goldman

Canal Zone Spiny Pocket Mouse

[Plate 25, figs. 3, 3*a*]

Heteromys zonalis Goldman, Smiths. Misc. Coll., Vol. 56, No. 36, p. 9, February 19, 1912. Type from Rio Indio, near Gatun, Canal Zone, Panama.

The Isthmian representative of the *H. desmarestianus* group is a rather large dark colored animal with the slender hairs inconspicuous among the bristles over the upperparts. Unlike *H. desmarestianus panamensis* and *H. desmarestianus crassirostris,* which have ankles dark all around, a white line extends along the inner side of the hind leg to the foot. Although so widely separated geographically this subspecies seems rather more like *H. desmarestianus desmarestianus* of Guatemala than like the allied forms in Panama. Compared with *H. d. desmarestianus* and *H. d. repens* the general color of the upperparts is darker, the slender hairs projecting beyond the bristles being less ochraceous buffy.

The Canal Zone pocket mouse inhabits the rocky slopes of low heavily forested hills near the Atlantic coast. Anthony (1916, p. 370) records the species from Maxon Ranch (Rio Trinidad).

Specimens examined: Gatun, 3; Maxon Ranch (Rio Trinidad), 1[1]; Rio Indio (near Gatun), 1 (type).

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[1] Collection Amer. Mus. Nat. Hist.

[2] Six in collection Mus. Comp. Zool.; one in Amer. Mus. Nat. Hist.

HETEROMYS DESMARESTIANUS PANAMENSIS Goldman

Panama Spiny Pocket Mouse

[Plate 25, figs. 1, 1*a*]

Heteromys panamensis GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 9, February 19, 1912. Type from Cerro Azul, near the headwaters of the Chagres River, Panama (altitude 2,800 feet).

The Panama spiny pocket mouse is similar to *Heteromys d. repens,* but still darker in color, the fore feet blackish instead of white to near the base of the toes. It is distinguished from its near geographic neighbor, *H. desmarestianus zonalis* of the Canal Zone, by the more ochraceous buffy suffusion of the upperparts, and the skull differs especially in the greater width of the interparietal and correspondingly reduced extent of the parietals along the supraoccipital border.

On the humid slopes of the mountains near the headwaters of the Chagres River this very dark spiny pocket mouse was found inhabiting the dense forest from 2,000 feet upward to the summit at about 3,000 feet altitude. It was also obtained at about 2,000 feet altitude on Cerro Brujo near the Atlantic coast. The specimens were all taken in traps placed on the ground under fallen logs or near crevices at the base of large trees.

Specimens examined: Cerro Azul (type locality), 5; Cerro Brujo, 1.

HETEROMYS DESMARESTIANUS CRASSIROSTRIS Goldman

Mount Pirre Spiny Pocket Mouse

[Plate 25, figs. 2, 2*a*]

Heteromys crassirostris GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 10-11, September 20, 1912. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 5,000 feet).

The discovery of this small spiny pocket mouse on Mount Pirre extends the known range of the *H. desmarestianus* group to near the eastern frontier of Panama, and it doubtless enters Colombian territory. It is similar to *H. desmarestianus panamensis,* but smaller; as in that form the ankles are dusky all around. The skull is remarkable for the unusual breadth of the rostrum.

The spiny pocket mice were evidently numerous at from 4,500 to about 5,000 feet altitude on the densely forested upper slopes of the mountains in the vicinity of the type locality. They were trapped in worn runways under logs where the moist surface is often fairly covered with small tracks and claw marks, and at holes in overhanging banks and in other sheltered places frequented by them while in search of food on the ground. Several were caught in traps set close to the palm-thatched camp; one was taken under my cot where it may have been attracted by some of the provisions. A pocket mouse held by the tail in a trap and still alive when removed set its teeth into clothing and tried to bite my hand. The rather dense undergrowth here consists largely of small palms and ferns. The only other small rodent which was found to occur in similar numbers in the same forest was another representative of a Middle American group, the Mount Pirre mouse, *Peromyscus pirrensis*. The lower slopes of the mountains at 2,000 feet are inhabited by *Heteromys australis conscius,* a form of a species mainly South American in distribution. The latter is similar to *H. d. crassirostris* in size and general external appearance, but the slender hairs among the blackish dorsal bristles are paler in color and the cranial characters indicate that the two forms of the genus which here occur so near together are specifically distinct. Anthony (1916, p. 370) records taking a specimen of *crassirostris* at 5,200 feet on Mount Tacarcuna.

Specimens examined: Mount Pirre, 23; Mount Tacarcuna, 1.[1]

Genus LIOMYS Merriam. Pocket Mice

The general color of the upperparts in the genus *Liomys* is more grayish, less blackish than in the genus *Heteromys,* and the sole of the hind foot is hairy from near the posterior tubercle to the heel (naked to heel in all Panama forms of *Heteromys*). Generic distinction is shown in the skull, the dentition being simpler, the interpterygoid fossa broadly U-shaped instead of V-shaped, and the angle of the mandible much more strongly everted.

LIOMYS ADSPERSUS (Peters)

Peters' Spiny Pocket Mouse

Heteromys adspersus Peters, Monatsber. k. preuss. Akad. Wissensch. Berlin, p. 356, with pl., May, 1874. Type locality, City of Panama.[2]

In general external appearance Peters' spiny pocket mouse is not very unlike *Heteromys desmarestianus zonalis* which also inhabits the Canal Zone, but the upperparts are grayish instead of blackish; the tail is relatively shorter—about equal to or shorter than the head

[1] Collection Amer. Mus. Nat. Hist.

[2] The species was originally described from "Panama," but the type in the Berlin Museum remained unique for nearly 40 years. In view of the rediscovery of the species in the suburbs of the City of Panama that place should be definitely chosen as the type locality.

and body; the sole of the hind foot is hairy from the posterior tubercle to the heel instead of naked to the heel as in all the species of *Heteromys* known to inhabit Panama.

The species as shown by specimens obtained by Messrs. Osgood and Anderson at Balboa for the Field Museum of Natural History, and by me at Empire, Canal Zone, is a large form of the *Liomys crispus* group which ranges thence northward through Middle America to southern Mexico. It has the same general coloration, proportionately short tail, and the dental peculiarities of the other members of the group. In color it approaches *Liomys heterothrix* of Honduras, but the slender tawny hairs which project beyond the dorsal bristles are less numerous. Moreover, it is characterized by larger size than that species.[1] Compared further, the skull has a relatively broader rostrum and the nasals and premaxillae are usually more nearly conterminous posteriorly than in *L. heterothrix.* The exact relationship of this form to the Costa Rican animal described by Thomas as *Heteromys salvini nigrescens* and currently recognized as *Liomys salvini nigrescens* remains to be determined.

Like other members of the *Liomys crispus* group *L. adspersus* inhabits dryer, less heavily forested areas than those usually favored by members of the genus *Heteromys.* It is probably restricted to the arid belt bordering the Pacific coast of Panama and replaced along the Atlantic side of the Isthmus by spiny pocket mice of the genus *Heteromys.* At Empire specimens were trapped among bushes, largely Compositae, along the border of a corn field. The pouches of one contained rolled oats used as bait, and some dead leaves cut in fragments about half an inch in length.

Specimens examined: Balboa, 3[2]; Empire, 2.

Family OCTODONTIDAE. Octodonts

The Octodonts are rodents mainly South American and African in distribution. Of the several subfamilies usually recognized a single group, the Loncherinae, ranges within our limits.

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[1] A rather young female from Empire, Canal Zone, measures as follows: Total length, 245; tail vertebrae, 117; hind foot, 33.5. Skull (of same): Greatest length, 33.5; zygomatic breadth, 16; interorbital breadth, 7.5; nasals, 13.5; width of braincase (between outer sides of squamosals in front of auditory meatus), 14.4; alveolar length of upper molar series, 5.4.

[2] Collection Field Mus. Nat. Hist.

Subfamily LONCHERINAE. Spiny Rats

The subfamily includes three genera now known to enter Panama, *Diplomys, Proechimys* and *Hoplomys.* They are all rather large rat-like animals with grooved spines or bristles mingled with the hair, especially of the back.

Genus PROECHIMYS Allen. Spiny Rats

The genus *Proechimys* is similar to the genus *Hoplomys,* but the dorsal spines are much weaker. The ears are nearly naked as in that genus—not conspicuously tufted as in *Diplomys.* The long supra-orbital vibrissae of *Hoplomys* are replaced by short, inconspicuous hairs. The normally long tail, subject to accident as in *Hoplomys,* is thinly haired. The molariform teeth are cylindrical in form as in *Hoplomys*—not elongated antero-posteriorly as in *Diplomys.* As in the former genus the transverse grooves are shallow and through progressive wear and partial obliteration soon divide to form irregular enamel islands. The claws are long, nearly straight, and associated with terrestrial habits.

PROECHIMYS SEMISPINOSUS PANAMENSIS Thomas

Panama Spiny Rat; Macangué

Proechimys centralis panamensis Thomas, Ann. Mag. Nat. Hist., Ser. 7, Vol. 5, p. 220, February, 1900. Type from Savanna of Panama (near city of Panama), Panama.

Proechimys centralis chiriquinus Thomas, Ann. Mag. Nat. Hist., Ser. 7, Vol. 5, p. 220, February, 1900. Type from Bugaba, Chiriqui, Panama.

Two Panama forms of *Proechimys* were described by Mr. Oldfield Thomas as geographic races of *P. centralis* Thomas, of Nicaragua. Comparisons show that all of the known Middle American members of the genus differ slightly from each other and some of them are scarcely distinguishable from *P. semispinosus* Tomes, of Ecuador. In view of the evident close alliance the Middle American series may be assigned to that species,[1] unless it proves to be typified by an earlier described form. It is interesting to note, in this connection, that the Nicaragua animal was identified with Tomes' species by Dr. F. W. True[2] in 1889.

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[1] The forms should therefore stand subspecifically as follows:
Proechimys semispinosus semispinosus Tomes, Ecuador.
Proechimys semispinosus panamensis Thomas, City of Panama, Panama.
Proechimys semispinosus burrus Bangs, San Miguel Island, Panama.
Proechimys semispinosus rubellus Hollister, Pacuare, Costa Rica.
Proechimys semispinosus centralis Thomas, San Emilio, Nicaragua.

[2] Proc. U. S. Nat. Mus., Vol. 11 (1888) 1889, p. 467.

Proechimys s. panamensis differs from *P. s. semispinosus* in slightly paler coloration; the skulls are practically indistinguishable. *P. s. panamensis* compared with *P. s. centralis* is slightly richer, more ochraceous in color, the incisive foramina are more widely open, less pinched together posteriorly, and the inferior border of the jugal is less developed posteriorly to form a hook. The rich ochraceous coloration of *P. s. panamensis* is intensified in the insular form *P. s. burrus.* In general characters *P. s. panamensis* is about midway between *P. s. centralis* and *P. s. semispinosus. P. s. chiriquinus* seems to be inseparable from *P. s. panamensis.*

In Panama these spiny rats occur nearly everywhere, except on the slopes of the higher mountains. They appear to be terrestrial in habits and were taken by me in traps set usually under logs, projecting roots of trees, or among rocks in the forest. Two were caught on the top of the wall forming a part of one of the old forts on a hill near Porto Bello. The walls were overgrown with bushes, vines and small trees. Others were taken under logs in the edge of a clearing on the Setigantí River near Cana. Bangs (1902, p. 47) records 31 specimens from Divala and Bogava, Chiriqui, and further states that "though very common in the low lands and the foothills of the Volcan de Chiriqui the spiny rat certainly does not ascend the volcano to any great height as Mr. Brown did not find it at Boquete." Allen (1904, p. 70) lists specimens from Boqueron. Specimens in the British Museum are recorded by Thomas (1900*a*, p. 220; 1903*a*, p. 41) from Pacomé, Panama, and as *P. s. chiriquinus* from Governador, Brava and Cebaco, all islands off the southern coast of Chiriqui.

Anthony (1916, p. 370) reports this spiny rat "quite abundant" at low elevations in the Canal Zone and Tuyra Valley, less so at higher points and none were taken by the American Museum expedition on the crest of the range near Mount Tacarcuna. He lists specimens from Boca de Cupe, Cituro, Real de Santa Maria, Gatun, Maxon Ranch (Rio Trinidad), Tacarcuna (altitude 2,650 feet) and Tapalisa.

Tailless individuals are common on the Panama mainland and I noticed in skinning normal freshly killed specimens that the tail parts near the base on very slight strain, so slight, indeed, that in working rapidly care is necessary to avoid mutilating the skin which is easily broken at the same point. On examining museum material I find examples of *P. cayennensis, P. mincæ, P. canicollis* and of *Hoplomys gymnurus* that evidently had no tails when captured. Bangs is quoted on the tailless condition of *P. s. burrus* (p. 123) in

San Miguel Island; Allen and Chapman[1] are authorities for the following observations on *Proechimys trinitatis* of Trinidad:

"Three of the adults were entirely tailless, the loss of the tail having evidently occurred in early life, leaving only a broad cicatrix where the tail joined the body. . . . . The tendency in these animals to lose the tails renders an examination of the posterior portion of the vertebral column of the tailless examples a matter of interest. Fortunately this portion of the skeleton of two of the tailless specimens was preserved, and shows that the amputation occurs at the second vertebra behind the posterior border of the pelvis or just behind the fifth caudal. The four first caudals are normal in size and proportions, and appear to be in a healthy condition; the fifth caudal is abnormal, the posterior third or half having apparently been lost by absorption. A further interesting fact was noted in skinning the specimens in which the tail was still intact, namely, its easy separation at the fifth caudal vertebra, in several specimens the tail breaking at this point in the process of skinning. . . . . There are popularly supposed to be two species, one with and the other without a tail."

The present impaired condition near the base of the tail, and the absence of any evidence that tailless individuals fail to thrive, suggests that a progressive weakening of the part may ultimately produce a normally tailless group of animals.

At Boca de Cupe these spiny rats are eaten to some extent by the native population. The native name is "Macangué."

Specimens examined: Boca de Cupe, 7[2]; Boqueron, 14[3]; Bugaba, 19[4]; Cana, 7; Cituro, 4[3]; Divala, 11[4]; Empire, 2; Gatun, 21[3]; Maxon Ranch (Rio Trinidad), 3[4]; Real de Santa Maria, 8[3]; Rio Indio (near Gatun), 1; Tabernilla, 1; Tacarcuna, 3[3]; Tapalisa, 3.[3]

PROECHIMYS SEMISPINOSUS BURRUS Bangs

San Miguel Island Spiny Rat

Proechimys burrus Bangs, Amer. Nat., Vol. 35, p. 640, August, 1901. Type from San Miguel Island, Panama.

A richly colored insular representative of the widely ranging *P. semispinosus* group of spiny rats inhabits San Miguel Island, in the Bay of Panama. It differs from the neighboring mainland form, *P. s. panamensis,* mainly in somewhat richer reddish color. Mr.

[1] Bull. Amer. Mus. Nat. Hist., Vol. 5, pp. 225-227, 1893.

[2] Three in Amer. Mus. Nat. Hist.

[3] Collection Amer. Mus. Nat. Hist.

[4] Collection Mus. Comp. Zool.

Bangs in describing this form and recording 51 specimens collected by Mr. Brown remarks:

"The San Miguel spiny rat is a slightly differentiated island form of the *centralis* [*P. semispinosus*] series. It was very common in the island, and Mr. Brown easily took as many specimens as he wanted. It is known to the islanders as *raton mockungay*. They, however, believe the tailless individuals are a different animal. About one-third of the specimens taken were tailless. The animal was generally distributed throughout the island, and was often found living in the huts and sheds of the negroes, like the common rat."

Specimens examined: San Miguel Island, 43.[1]

Genus HOPLOMYS Allen. Spiny Rats

The genus *Hoplomys* may easily be recognized among the Octodont genera of Panama by the remarkably stout spiny armature. The blackish spines, nearly two millimeters in greatest breadth, project conspicuously beyond the softer element of the pelage over the back. The ears are nearly naked, instead of conspicuously tufted as in *Diplomys*. The supraorbital vibrissæ are very long, reaching posteriorly to the shoulders. The transverse grooves in the molariform teeth are shallow and their partial obliteration and the formation of enamel islands through wear beginning at an early age results in a complex crown pattern much as in *Proechimys*. Generic distinction rests on the more intricate enamel folds, especially of the last upper molar which has four principal grooves instead of three as in the latter genus. The claws are long, nearly straight, and indicate terrestrial habits. The long, nearly naked tail breaks readily close to the body, the stump heals over, and a tailless animal sometimes believed to be of a distinct species results.

HOPLOMYS GYMNURUS GOETHALSI Goldman

Goethals Spiny Rat

[Plate 26, figs. 2, 2*a*]

Hoplomys goethalsi Goldman, Smiths. Misc. Coll., Vol. 56, No. 36, p. 10, February 19, 1912. Type from Rio Indio, near Gatun, Canal Zone, Panama.

The Isthmian representative of the genus externally resembles *Hoplomys gymnurus* Thomas and *Hoplomys truei* Allen. The heavy zygomata and other cranial characters are distinctive, but additional material obtained since the publication of the original description

[1] Forty-two in collection Mus. Comp. Zool.

indicates probable intergradation. Specimens from extreme eastern Panama show an approach to *H. gymnurus* in somewhat lighter zygomata and slightly smaller audital bullae. Geographic variation of relatively unimportant cranial details suggests the advisability of regarding the Middle American forms as subspecies of *Hoplomys gymnurus*.[1]

Like the species of *Proechimys* this spiny rat seems to be terrestrial in habits. Several examples were trapped under shelter of fallen trees and rocks in the forest. One was caught in a steel trap set on a narrow ledge under an overhanging river bank. Anthony (1916, p. 370) lists specimens from Gatun and the old village of Tacarcuna (2,650 feet).

Specimens examined: Cana, 5; Gatun, 2[2]; Rio Indio (type locality); Tacarcuna, 6.[2]

Genus DIPLOMYS Thomas. Spiny Rats

The spiny rats of the genus *Diplomys* are distinguishable from those of the other genera occurring in Panama by the short and conspicuously tufted ears, the blackish hairs projecting about half an inch beyond the margins. The face is marked by narrow vertical stripes at the posterior base of the whiskers. The dorsal pelage is bristly, but softer than in *Hoplomys* and *Proechimys*. The molariform teeth are more elongated antero-posteriorly, the crowns rectangular instead of cylindrical in general outline, and each divided until old age by three deep transverse furrows. The long tail is well haired. The short, broad hind feet, and short, strongly curved claws exhibit adaptation for an arboreal life.

DIPLOMYS LABILIS (Bangs)

Gliding Spiny Rat

Loncheres labilis Bangs, Amer. Nat., Vol. 35, p. 638, August, 1901. Type from San Miguel Island, Panama.

Concerning this insular species I can add little to Mr. Bangs' full original account. It was discovered by W. W. Brown, Jr., at the

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[1] Pending further revision of the group the forms should therefore stand as follows:

Hoplomys gymnurus gymnurus Thomas, Cachavi, Ecuador.

Hoplomys gymnurus goethalsi Goldman, Rio Indio, near Gatun, Canal Zone.

Hoplomys gymnurus truei Allen, Lavala, Matagalpa, Nicaragua.

[2] Collection Amer. Mus. Nat. Hist.

time of his visit to San Miguel Island in the spring of 1900. From *D. darlingi* of the adjacent mainland it is distinguished at once by much more intense rufescent general coloration. The hind feet are rusty reddish instead of silvery white. Moreover, the skull is relatively narrower, more elongated, with smaller audital bullae.

Regarding the habits of the species Mr. Bangs remarks: "*Loncheres labilis* [=*Diplomys labilis*] was abundant in San Miguel Island, but was wholly arboreal, Mr. Brown catching all his specimens in traps set on the branches of large trees. It appears to be diurnal, and on one or two occasions Mr. Brown saw the animal proceeding along the branches with a curious gliding gait, his account suggesting the name I have used for the species. It is the 'Raton Marenero' of the islanders."

Specimens examined: San Miguel Island, 14.[1]

DIPLOMYS DARLINGI (Goldman)

Darling's Spiny Rat

[Plate 26, figs. 1, 1*a*]

Isothrix darlingi GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 12-13, September 20, 1912. Type from Marragantí (near Real de Santa Maria), on the Rio Tuyra, eastern Panama.

This species of *Diplomys* was first obtained by Dr. S. T. Darling, of the Sanitary Department, Isthmian Canal Commission, at Ancon, Canal Zone. No member of the genus had previously been taken on the Panama mainland, although an insular form described as *Loncheres labilis* Bangs had been discovered on San Miguel Island in the Bay of Panama. *D. darlingi* is much paler in color than *D. labilis,* the general tone of the upperparts being ochraceous buffy mixed with black, instead of the rich rufescent tint of *D. labilis.* The feet are silvery white instead of rusty reddish as in the latter species. The skull is relatively broader, the zygomata more spreading anteriorly and the audital bullae are larger. It may be not very unlike *Diplomys caniceps* (Gunther) from Medellin, Colombia, but the latter seems to be somewhat different in color, with a bushy tail, and the skull, as figured, differs in detail.

Of the habits of *D. darlingi* little is known except that it is an arboreal animal. The type specimen was seen one morning running up the trunk of a tree and was shot when it paused for a moment, partially hidden by the curvature of the trunk. The tree stood on the low forested bank of the Rio Tuyra where that stream meets the

[1] Thirteen in collection Mus. Comp. Zool.

tidewater of San Miguel Bay. The spiny rat climbed with the same facility a tree squirrel might have shown. Two specimens of this apparently rare species collected by W. B. Richardson at Tapalisa are recorded by Anthony (1916, p. 370). They were frightened from a hollow tree by the collector and shot while running along overhanging limbs from which they fell into the river. These adult examples are more rusty reddish on the back than the type specimen which was not fully grown.

Specimens examined: Ancon, 1; Marragantí (type locality), 1; Tapalisa, 2.[1]

Family DASYPROCTIDAE. Agoutis and Pacas

With the exception of the capybara (*Hydrochœrus*) the agoutis and pacas are the largest rodents inhabiting the region. The family includes three genera of which two, *Dasyprocta* and *Cuniculus*, range northward through Middle America to southern Mexico. They are terrestrial species with hoof-like claws, short ears and rudimentary tails. The other genus, *Myoprocta*, with a short but well-formed hairy external tail is restricted to South America.

Genus DASYPROCTA Illiger. Agoutis

The members of this genus, commonly referred to in literature as agoutis, are much more slenderly formed than the pacas of the genus *Cuniculus*. They have narrow, rabbit-like heads and the hind feet are provided with three instead of five toes as in the latter genus. The pelage of the rump is considerably elongated.

DASYPROCTA PUNCTATA ISTHMICA Alston

Isthmian Agouti; Ñequi

Dasyprocta isthmica ALSTON, Proc. Zool. Soc. London, 1876, p. 347. Type from Colon, Panama.

The agoutis or "ñequis" as they are called by the natives are common and well-known game animals of the region, much prized for the quality of their flesh as food. Several closely related forms of the *Dasyprocta punctata* group inhabit Middle America, ranging as a group as far north as southern Mexico, and southward into South America. *Dasyprocta punctata* was originally described from "South America," but according to Alston (1879, p. 172) the types collected during the voyage of the "Sulphur" by Commanders Belcher and Kellett are probably from the west coast of Costa Rica

[1] Collection Amer. Mus. Nat. Hist.

or Nicaragua. *D. punctata isthmica* of the Canal Zone and western Panama is distinguished externally from *D. punctata punctata* by less rich rufescent general coloration, and from *D. punctata dariensis,* its geographic neighbor on the east, by the more nearly uniform color of the back and rump. The elongated hairs of the rump are orange buffy like the back, instead of silvery gray or very pale buffy as in *D. p. dariensis* of eastern Panama.

In the Canal Zone the agoutis live in burrows, usually along steep banks or in rocky places. From the entrances well-beaten paths lead off a few yards through the forest undergrowth, or may connect holes at various points along the front of a ledge. In places their paths up the steep faces of cliffs have been used so long that they are worn deeply into the surface of rather soft sandstone. The agoutis are mainly nocturnal in habits and were shot at night in the forest where they were located by the reflection of their eyes in the field of light projected by a hunting lamp; but they may also be found abroad during the early morning and late evening hours, and in cloudy or rainy weather nearer the middle of the day.

One day while hunting near the Chagres River, a short distance below the mouth of the Rio Indio, I came to a low cliff and saw one of these animals run out of the bushes; it was scaling the rocks as I fired. It fell backward to the ground, and I found a well-worn agouti path leading up at this point. Erosion of the softer rock underneath had left the cliff overhanging near the base so that the animals were obliged to spring upward for about two and a half feet and then scramble up a nearly perpendicular rock on which there appeared to be practically no foothold. Another agouti was seen in a crevice among the rocks in the same vicinity.

Specimens from western Panama correctly referred to this form by Bangs (1902, p. 47) were collected by W. W. Brown, Jr., on the slope of the Volcan de Chiriqui and near Boquete. The other examples listed by Bangs from southwestern Panama represent specimens subsequently described as *D. p. nuchalis.*

Anthony (1916, p. 370) records a specimen collected by him at Maxon Ranch on the Rio Trinidad.

Specimens examined: Boquete, 2[1]; Gatun, 10; Maxon Ranch (Rio Trinidad), 1[2]; Rio Indio (near Gatun), 4.

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[1] Collection Mus. Comp. Zool.

[2] Collection Amer. Mus. Nat. Hist.

DASYPROCTA PUNCTATA DARIENSIS Goldman

Darien Agouti; Ñequi

[Plate 27, figs. 1, 1*a*, 1*b*]

Dasyprocta punctata dariensis GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 11-12, February 28, 1913. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 5,200 feet).

The Darien agouti replaces the Isthmian form of the *Dasyprocta punctata* group east of the Canal Zone where it has an altitudinal range from sea level on San Miguel Bay to over 5,000 feet on the summits of the Pirre Range near the Colombian frontier. Contrasted with *D. p. isthmica* of the Canal Zone, the Darien representative of the group is larger and darker in general color. The top of the head is blacker. The long hairs on the rump lack the basal annulations usually present in *D. p. isthmica,* and the tips of these hairs are very pale buff, silvery gray or whitish, in contrast with the orange buffy back; in *D. p. isthmica* the rump and back are more uniform in general tone. *D. p. dariensis* differs from *D. colombiana* of the Santa Marta region of Colombia, which is doubtless a form of the same group, in more buffy, less grayish coloration and in important cranial details, the rostrum being heavier and the anterior part of the jugal less extended vertically; in *D. colombiana* the jugal, more developed upward along the orbital border, approaches the lachrymal. It may be not very unlike *D. variegata* Tschudi, from Peru, but is very different from Tschudi's figure, and compared with an Ecuadorean specimen in the National Museum, assumed to be near *D. variegata,* is decidedly larger and darker colored. In the pallid coloration of the tips of the elongated hairs on the rump *D. p. dariensis* resembles *D. callida* of San Miguel Island, but the latter is a much grayer animal throughout.

Among the quaint accounts of animals encountered by Lionel Wafer (1729, p. 330) in eastern Panama during the summer of 1681 is one which apparently applies to the Darien agouti. He says:

"Here are *Rabbits,* called by our *English,* Indian Conies. They are as large as our Hares; But I know not that this Country has any Hares. These Rabbits have no Tails, and but little short Ears; and the Claws of their Feet are long. They lodge in the Roots of Trees, making no Burrows; and the *Indians* hunt them, but there is no great Plenty of them. They are very good Meat, and eat rather moister than ours." The statement in regard to burrows is, of course, erroneous.

Like the other forms of the group the Darien agouti is shy and apparently mainly nocturnal in habits; but if carefully searched for it may be found abroad early in the morning or late in the evening, and occasionally during the middle of the day, especially in wet weather. They become alarmed at the slightest noise and scamper away, often giving the characteristic squeak or short bark *eh-h—eh-h* from which the native name "ñequi" is derived. The usual method of hunting them is to proceed slowly and cautiously, mainly along trails through the forest, or wait in the vicinity of their holes until they come out. One day during the dry season, I heard a rustling noise in the dry leaves, and remaining motionless soon saw an agouti which came rapidly nearer and was shot as it stopped suddenly about 20 yards away. The Indians and native colored population hunt the agouti for its flesh and it is one of the favorite game animals of the region. As *Dasyprocta isthmica,* Anthony (1916, p. 370) records specimens from Boca de Cupe, Chepigana, Cituro and Real de Santa Maria.

Specimens examined: Aruza, 1; Boca de Cupe, 3[1]; Cana, 6; Chepigana, 2[1]; Cituro, 1[1]; Mount Pirre (type), 1; Real de Santa Maria, 2.[1]

DASYPROCTA PUNCTATA NUCHALIS Goldman

Black-naped Agouti

Dasyprocta punctata nuchalis Goldman, Proc. Biol. Soc. Washington, Vol. 30, p. 113, May 23, 1917. Type from Divala, Chiriqui, Panama.

The black-naped agouti inhabiting the comparatively arid lowlands near the Pacific coast of the southwestern part of the republic is a handsome subspecies easily distinguished from its geographic neighbors by the contrasting colors of the upper parts. The black nape, tawny back, and buffy rump present a color combination unusual in the group.

The specimens on which *D. p. nuchalis* is based were recorded by Bangs (1902, p. 47) as *Dasyprocta isthmica,* a form at that time very imperfectly known. The black-naped agouti may prove to have an extensive range along the Pacific coast of Panama and adjacent portions of southwestern Costa Rica. It is apparently replaced on the Volcan de Chiriqui, and probably along the Atlantic seaboard of western Panama, by *D. p. isthmica.*

Specimens examined: Bugaba, 2[2]; Divala, 3.[2]

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

DASYPROCTA CALLIDA Bangs

San Miguel Island Agouti

Dasyprocta callida Bangs, Amer. Nat., Vol. 35, p. 635, August, 1901. Type from San Miguel Island, Panama.

The San Miguel Island agouti is easily distinguished from the mainland forms of the group by its much paler coloration. It is most like *D. punctata dariensis* with which it agrees in the whitish tips and lack of basal annulations of the long hairs on the rump.

The species is based on a series of specimens taken by W. W. Brown, Jr., during a visit to the island in the spring of 1900. In connection with the original description Mr. Bangs details the collector's experience with the animal as follows: "The six specimens were all shot by Mr. Brown among mangroves, the leaves of which they are very fond of. The animal is much hunted by the negro pearl divers, and is exceedingly shy and wary, and for some time Mr. Brown was unable to secure one. One day during a storm he noticed that when a mangrove blew over it was at once stripped of its leaves by the agoutis. Acting upon a plan that this habit of the animal suggested to him, he took several large stones with him, and concealed himself in a tree. After a little he sent a stone crashing through the mangroves and presently saw an agouti cautiously approach the spot, thinking a mangrove had fallen over. The first day he shot two specimens in this way, and afterwards four more."

Specimens examined: San Miguel Island, 6.

DASYPROCTA COIBÆ Thomas

Coiba Island Agouti

Dasyprocta coibae Thomas, Novitat. Zoologicæ, Vol. 9, p. 136, April 10, 1902. Type from Coiba Island, Panama.

The Coiba Island agouti is very similar in color to *D. p. isthmica* and the rump hairs are rather distinctly barred to near base. But the skull is decidedly shorter, although similarly massive; the molariform teeth are smaller, the incisors shorter owing evidently to greater wear, the beveled surface reaching to near the alveoli in both jaws and suggesting feeding habits differing from those of the mainland forms; the audital bullæ are smaller and the basioccipital correspondingly broader.

In the original account the animal is described as agreeing with *Dasyprocta punctata punctata* in the annulation of the long hairs of the rump, but in the longer orange tips of these hairs and in the color of the body it is said to bear a closer resemblance to *D. p. isthmica.*

The species is based on five specimens collected by J. H. Batty in the spring of 1902. Four topotypes taken by the same collector and sent to the American Museum of Natural History are recorded by Allen (1904, p. 70) together with measurements of a larger series.

Specimens examined: Coiba Island, 6.[1]

Genus CUNICULUS Brisson. Pacas

The pacas are much more robust in form than the agoutis. The head is broader, the neck short and thick, and the limbs stouter. The toes of the hind feet are five instead of three in number. Another distinctive feature is the white-striped and spotted pelage. The broad head of the paca is due to the extraordinary expansion of the zygomatic arches which enclose a cavity lined with mucous membrane continuous with that of the mouth.

CUNICULUS PACA VIRGATUS (Bangs)

Panama Paca; Conejo Pintado

Agouti paca virgatus Bangs, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 47, April, 1902. Type from Divala, Chiriqui, Panama.

In allusion to its striped and spotted pelage the Panama paca is known to the natives as "conejo pintado." It differs from *C. paca paca* of South America in the encroachment of the white color of the underparts along the sides and the partial obliteration of dark stripes, a character which having proceeded still farther distinguishes the Mexican paca, *C. p. nelsoni,* from the present form.

Pacas are common in the Canal Zone and probably range in similar numbers throughout the forested parts of Panama. They live in burrows in the ground similar to those of agoutis. The burrows are often placed on steep slopes or in rocky places, but may enter soft soil where the ground is level. Like the agoutis they are mainly nocturnal in habits and may easily be located and shot by the reflection of their eyes in the light of a hunting lamp. They are often hunted with dogs and the skins being extremely tender many specimens obtained in this way are much lacerated. The thin, papery skin adheres tightly to the muscles and is also apt to be torn during the skinning process. Owing to the superior quality of their flesh the pacas are among the most important game animals of the region.

While hunting one day in the forest at 2,000 feet near Cana I saw a paca rush suddenly from a mass of leaves and small sticks a few feet away and disappear in the forest undergrowth. On examining the spot I found the animal had been resting in a cavity showing

[1] Collection Amer. Mus. Nat. Hist.

signs of regular use and where it was completely hidden until dislodged by my close approach. A burrow, evidently that of the paca, entered the ground at the base of a neighboring tree.

Specimens examined: Divala, 1[1] (type); Gatun, 8; Rio Indio (near Gatun), 7.

Family CAVIIDAE. Cavies and Capybaras

A single representative of this family, the capybara, until the present survey known only from South America, is among the more interesting mammals whose ranges are now found to extend into Panama.

Genus HYDROCHOERUS Brisson. Capybaras

As the largest existing rodents the capybaras, genus *Hydrochoerus*, are at once distinguished from the other members of the order. They are robust animals about three feet in length, the body thinly clothed with coarse hair. The webbed feet show adaptation for an aquatic life.

HYDROCHOERUS ISTHMIUS Goldman

Isthmian Capybara; Poncho

[Plate 28, figs. 1, 1*a*]

Hydrochoerus isthmius GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 11-12, September 20, 1912. Type from Marragantí, near the head of tide-water on the Rio Tuyra, eastern Panama.

The capybara of Panama is decidedly smaller than *Hydrochoerus hydrochoeris* of northeastern South America and it differs in numerous important cranial details, especially the peculiar, short, thickened condition of the pterygoids.

On the Pacific coast of Panama it is apparently restricted to a limited area near the head of tidewater in the delta region of the Tuyra and Chucunaque rivers. A skull from " Atrato " collected by A. Schott, who accompanied Michler's expedition through the Darien region, seems referable to the same species which may therefore prove to have a wide range in the Atrato river valley. Anthony (1916, p. 371) records the species from El Real de Santa Maria.

At Marragantí many tracks were seen at low tide in early morning where the capybaras had crossed exposed mud banks between the water in the river and low-lying areas overgrown with tall swamp grass and other aquatic vegetation. *Capybaras* were found during the day occupying shallow beds hollowed in the ground, or wallowing in muddy pools, in secluded parts of the swamp. Sometimes they

[1] Collection Mus. Comp. Zool.

permitted me to approach quite near their hiding places and then rushing out in sudden alarm were shot as they crossed narrow open spaces. Their flesh, sometimes eaten by the natives, is not however considered very palatable. The native name of the animal is "poncho."

Specimens examined: Marragantí (type locality), 10.[1]

Family ERETHIZONTIDAE. Porcupines

The porcupines constitute a family of large rodents recognizable externally by the armament of long, stout, acute spines, which are especially well developed over the dorsal surface.

Subfamily ERETHIZONTINAE. American Porcupines

The subfamily Erethizontinæ includes two or three genera of American porcupines, all of which are arboreal in habits.

Genus COENDOU Lacépède

The porcupines of tropical Middle America, genus *Coendou,* are distinguished at once from the similarly spiny species of *Erethizon* inhabiting the northern woods, by the possession of a long, prehensile tail instead of a short brush. A further differential character of the tail, shared, however, with the Brazilian genus *Chætomys,* is that unlike most prehensile-tailed American mammals, the upper instead of the under side of the terminal portion of the member has become modified for direct contact in coiling about branches.

COENDOU MEXICANUM LAENATUM Thomas

Chiriqui Porcupine

Coendou laenatus THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 11, p. 381, April, 1903. Type from Boquete, Chiriqui, Panama.

The Chiriqui porcupine is the Isthmian representative of a densely furred Middle American group which ranges on the north to Mexico, the fur largely concealing the spines. In the other Panama species of the genus, *C. rothschildi,* the spines are fully exposed over the entire body. The type of *C. m. lænatum* is described as smaller, more heavily clothed, and with less inflated skull than *C. m. mexicanum.* Scanty material from Costa Rica and Honduras shows probable intergradation with the more northern forms of the group. Four porcupines collected by J. H. Batty at Boqueron, Chiriqui, and recorded by Allen (1904, p. 70), as *Coendou laenatus* prove to be

[1] Four in collection Amer. Mus. Nat. Hist.

referable to *Coendou rothschildi.* A specimen in the Museum of Comparative Zoology from Boquete was collected by H. J. Watson.

Specimens examined: Boquete, 1.[1]

COENDOU ROTHSCHILDI Thomas

Rothschild's Porcupine

Coendou rothschildi THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 10, p. 169, August, 1902 (see also Thomas, 1903a, p. 41). Type from Sevilla Island, off Chiriqui, Panama.

Rothschild's porcupine is readily distinguished from its Panama congener, *Coendou mexicanum laenatum,* by the exposed spiny covering, the spines in the latter species being mainly concealed by the long overlapping fur.

C. rothschildi, based on five examples from Sevilla Island and one from Brava Island, is a northern representative of a group mainly South American in distribution. The type is described as a spinous short-haired animal related to *C. quichua* Thomas of Ecuador.

The principal differential characters given are the profusely white-speckled back, and the rather larger skull with greater inflation above the orbits and larger nasal opening.

Specimens from Gatun and Rio Indio are provisionally referred to this species. They differ somewhat from the description of the type of *C. rothschildi* in the extent of the light basal color of the dorsal spines. This color reaches less than one-half, instead of three-fifths, the length of the spines, while the black subterminal band occupies one-half or more of the total length. In one individual the dorsal spines are black-tipped, the white tips being restricted to the forehead and sides where they are sparingly distributed.

In cranial characters these specimens conform closely with a series of ten from Boqueron, which are assumed to be typical, and four of which were erroneously recorded by Allen (1904, p. 70) as *C. lænatus.*

One of these porcupines, purchased from a native hunter at Gatun, had its stomach distended with vegetable matter massed in two colors; a greenish part apparently leaves, and a white mass which had the appearance of fruit pulp. The hunter reported locating two in a tree by the light of a hunting lamp, but while he was securing one the other escaped. In felling timber the animals are occasionally dislodged from places of concealment among matted vines in the tops of trees.

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[1] Collection in Mus. Comp. Zool.

Specimens examined: Boqueron, 10[1]; Gatun, 2; Rio Indio (near Gatun), 1; Tabernilla, 1.

Family SCIURIDAE. Squirrels

The family is represented in Panama by species of the familiar genus *Sciurus,* and by pygmy squirrels of the genera *Microsciurus* and *Syntheosciurus.* Like *Sciurus* the latter genera are arboreal in habits.

Genus SCIURUS Linnaeus. Tree Squirrels

The tree squirrels of the genus *Sciurus* inhabiting Panama are easily recognizable by larger size, when contrasted with the genera *Microsciurus* and *Syntheosciurus.* Generic distinction, however, is based mainly on dental characters. *Sciurus* differs from *Microsciurus* notably in the presence of small cusps intermediate in position between the larger tubercles on the outer side in the upper molariform teeth, and from *Syntheosciurus* in the absence of grooved upper incisors.

Subgenus SCIURUS Linnaeus

SCIURUS VARIEGATOIDES HELVEOLUS Goldman

Panama Squirrel

[Plate 29, figs. 2, 2*a*]

Sciurus variegatoides helveolus GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 3, February 19, 1912. Type from Corozal, Canal Zone, Panama.

This large squirrel is amply distinguished from others inhabiting the region by the long black and white tail, the individual hairs of which are broadly tipped with the latter color. The limbs and underparts are paler than in the allied forms, *Sciurus variegatoides variegatoides* and *S. variegatoides dorsalis,* in the color phase with grizzled back. Its distribution area is the arid division lying along the Pacific coast from the vicinity of the city of Panama westward as far as Remedios where a specimen probably referable to this form has been recorded by Allen (1904, p. 66).

The squirrels of the *S. variegatoides* group are very imperfectly known. Several rather localized forms are recognized which in color present a remarkably wide range of individual variation. Large series of typical examplès are much needed to make clear many

[1] Collection Amer. Mus. Nat. Hist.

doubtful points.[1] A specimen from Chorrera kindly loaned for examination by Dr. J. A. Allen of the American Museum of Natural History is like the Corozal specimens in color and agrees with them also in the absence of the small anterior premolar usually present in squirrels of this group. *S. v. helveolus* may intergrade with *S. v. melania* (Gray), a melanistic form described from Costa Rica and reported by Bangs (1902, p. 22) from various localities in Chiriqui.

Near Corozal in the middle of June the squirrels were found in mango trees in an old clearing about two miles east of the railroad station. Approaching the trees quietly I noted their rapid motions while cutting and feeding on the ripening fruit. They were not especially shy, but one that had been watching me suspiciously soon ran down a tree trunk and started rapidly off along the ground, carrying a large mango in its mouth. Five specimens collected by W. W. Brown, Jr., at Caledonia (near Panama) were recorded by Bangs (1906, p. 212) as *Sciurus adolphei dorsalis.*

Specimens examined: Calidonia, 5[2]; Corozal (type locality), 3; Chorrera, 1.

SCIURUS VARIEGATOIDES MELANIA (Gray)

Costa Rican Black Squirrel

Macroxus melania Gray, Ann. Mag. Nat. Hist., Ser. 3, Vol. 20, p. 425, 1867. Type from Point Burica, Costa Rica.

The black squirrel of Costa Rica, apparently a melanistic form, is recognizable at once by the unusual color. In fresh pelage it is nearly all black, the back only being of a dark chocolate shade which through wear fades to a yellowish brown color. Although differing widely in external appearance the animal is clearly related to *Sciurus variegatoides,* and its geographic position between *S. variegatoides dorsalis and S. variegatoides helveolus* suggests probable intergradation with both. Although intergradation has not been demonstrated, and black or chocolate brown appears to be the color of all the individuals occurring at various localities in Costa Rica and western

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[1] The material available indicates that the several known forms should stand subspecifically as follows:

Sciurus variegatoides variegatoides Ogilby, Salvador.
Sciurus variegatoides adolphei (Lesson) Realejo, Nicaragua.
Sciurus variegatoides dorsalis (Gray) Liberia, Costa Rica.
Sciurus variegatoides melania (Gray) Point Burica, Costa Rica.
Sciurus variegatoides helveolus Goldman, Corozal, Canal Zone, Panama.

[2] Collection Mus. Comp. Zool.

Panama, it seems best to treat it for the present as a subspecies of *S. variegatoides*.[1]

Sclater (1856, p. 139) evidently referred to this species in a list of mammals collected by Bridges in Chiriqui and published more than ten years before the original description of *Sciurus melania*, based on Costa Rican material, appeared. Regarding the squirrel, which was referred to the genus *Sciurus*, but the species unnamed, he says: "A black species, difficult to distinguish. Mr. Bridges states that it is common in the immediate vicinity of the town of David, and between that and the port of Boca Chica."

Twenty-one specimens, including adults and young of both sexes collected by W. W. Brown, Jr., at Divala, Bugaba, and Boquete were recorded by Bangs (1902, p. 22) who says: "It is a low-land species, and not found high up the Volcan de Chiriqui, 2,000 feet being the extreme altitude at which Mr. Brown saw it, and but once so high as that. About Bugaba (600 feet) and Divala, it is common and generally distributed in suitable places."

That this squirrel is not confined to the mainland is shown by Thomas (1903*a*, p. 40) who records specimens collected by J. H. Batty on Sevilla, Insoleta, Cebaco, and Brava, all small islands off the coast of the southwestern part of the republic. Ten specimens taken by the same collector at Boqueron for the American Museum of Natural History are recorded by Allen (1904, p. 66). The known general range of the animal is, therefore, the coastal plains and islands, and the basal mountain slopes on the Pacific side in western Panama and adjacent parts of Costa Rica.

Specimens examined: Bugaba, 5[2]; Boqueron, 17[3]; Boquete, 1[2]; Divala, 13.[2]

Subgenus GUERLINGUETUS Gray

SCIURUS HOFFMANNI CHIRIQUENSIS Bangs[4]

Chiriqui Squirrel

Sciurus (Guerlinguetus) aestuans chiriquensis BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 22, April, 1902. Type from Divala, Chiriqui, Panama.

Hoffmann's squirrel is somewhat similar to the subspecies of *Sciurus gerrardi* in general external appearance; the tail, however,

[1] For discussion of the status of this species see Nelson, Proc. Wash. Acad. Sci., Vol. 1, p. 74, 1899, and Bangs (1902, p. 22 and 1906, p. 212).

[2] Collection Mus. Comp. Zool.

[3] Collection Amer. Mus. Nat. Hist.

[4] Allen (1915, p. 212) in reviewing the South American squirrels has erected several new genera including *Mesosciurus*, with *Sciurus hoffmanni* as type. Some of these genera appear to be based on slight characters and I am not convinced of the desirability of such divisions.

is edged with ochraceous buff to the tip, instead of conspicuously tipped with black. The species, originally described from Costa Rica, ranges into western Panama where a form regarded as identical by Allen (1904, p. 66) and as distinct by him (1915, p. 220) has been described as *Sciurus æstuans chiriquensis* (Bangs, 1902, p. 22). As indicated by Allen (1915, p. 220) *S. h. chiriquensis* is distinguished by a slightly richer, more rufescent tone of coloration than typical *hoffmanni* of the Costa Rican highlands, a reversal of the differential characters as interpreted by Bangs in his original description. Dr. Allen also refers to *S. hoffmanni* specimens of a squirrel from the upper Cauca Valley, Colombia. The species was not encountered by me in the course of extensive work at low elevations in the Canal Zone and in the mountains of eastern Panama, and its range is apparently discontinuous in that region. It may, however, occur in the mountains along the Atlantic coast in an area from which I have seen no collections.

This is doubtless the species recorded from Panama under the name *Sciurus aestuans* by Sclater (1856, p. 139) who, referring to a specimen collected by Bridges, remarks: "This seems to agree with Bogota specimens so marked in the British Museum. It is from the Boqueti at the base of the volcano of Chiriqui." It was also regarded as *Sciurus aestuans* by Alston (1879, p. 132) who mentions British Museum material collected at Calovevora by Enrique Arcé. Forty-one specimens taken by W. W. Brown, Jr., at various localities including Divala, Bugaba, Boquete and the Volcan de Chiriqui at 7,500 feet are listed by Bangs (1902, p. 22). Mr. Bangs in his full account of the Chiriqui animal states that "skins from the Volcan de Chiriqui from upwards of 4,000 feet altitude are more woolly with decidedly more under fur than lowland examples, but otherwise they do not differ." Since Divala is near sea level on the Pacific coast this squirrel has a rather unusual altitudinal range. Fourteen specimens obtained by J. H. Batty for the American Museum of Natural History at Boqueron and Boquete were apparently the basis of Dr. Allen's reference of the Chiriqui form to typical *S. hoffmanni*. More recently (1915, p. 220) he assigns them together with examples from Divala, Bugaba, Tacoume, Cebaco Island, Sevilla Island, and Insolita Island to *S. h. chiriquensis*.

Specimens examined: Bugaba, 9[1]; Boqueron, 17[2]; Boquete, 17[3]; Divala (type locality), 14.[1]

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[1] Collection Mus. Comp. Zool.
[2] Collection Amer. Mus. Nat. Hist.
[3] Ten in collection Mus. Comp. Zool.; seven in Amer. Mus. Nat. Hist.

SCIURUS GERRARDI CHOCO Goldman

Darien Squirrel

[Plate 29, figs. 1, 1*a*]

Sciurus variabilis choco GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 4-5, February 28, 1913. Type from Cana, eastern Panama (altitude 3,500 feet).

The *Sciurus gerrardi* group of tree squirrels, widely dispersed in northwestern South America is represented in Panama by two forms, one of which ranges as far north as the Canal Zone. They are recognizable by the varicolored tail, the intense rusty reddish general hue of which contrasts strongly with the broad black tip. In general shade of coloration they are not very unlike the smaller species, *S. hoffmanni,* which inhabits western Panama, but the latter has the tail uniformly washed or broadly edged with ochraceous buff to the tip.

S. g. choco of the Darien region in eastern Panama is closely allied to *S. g. morulus* of the Canal Zone, but is distinguished by darker color throughout; a deep black median dorsal stripe, usually continuous from near the shoulders posteriorly over the upper base of the tail, is absent or only faintly indicated in *S. g. morulus.* The underparts of the body are a darker rusty reddish shade; the under side of the tail is marked by a broader, more distinct black submarginal stripe. Variation from the usual rufescent coloration of the underparts is shown in one individual by limited areas of pure white near the armpits, on the pectoral and inguinal regions, and a very narrow stripe along the median line of the abdomen; in another the white is reduced to a few hairs near the armpits and on the sides of the lower part of the abdomen. These white areas may indicate gradation of this subspecies toward the South American forms of the *S. gerrardi* group in which the underparts are normally white. Specimens from 800 to 2,500 feet altitude, on Cerro Azul near the headwaters of the Chagres River, are somewhat intermediate between *S. g. morulus* and the Darien form, the black dorsal stripe being somewhat indistinct, but in the rich coloration of the underparts they agree with the latter form. *S. g. milleri* from the mountains of southwestern Colombia seems to be a nearly related form with the same pattern of coloration, but it differs in darker, more rusty reddish hue, the darkening due in part to the much narrower subterminal bands of the hairs on the shoulders and flanks.

These squirrels are generally distributed throughout the region visited, ranging upward in the forest from sea level in the Tuyra

Valley to over 5,000 feet altitude on the summits of the Pirre Range. They were usually seen springing through the branches from one tree to another. Occasionally they were found searching for food among the ferns, small palms, and other low ground cover, and on hearing me approach scrambled a few feet up a convenient tree trunk, where a pause was made, apparently to locate the cause of alarm. From such vantage points they sometimes continued upward into the tree top, at other times they turned downward again to the ground. Anthony (1916, p. 365) records specimens from Boca de Cupe, Chepigana, Cituro, Real de Santa Maria, Tacarcuna (2,650 to 5,200 feet) and Tapalisa.

Specimens examined: Cana (type locality), 5; Boca de Cupe, 5[1]; Cerro Azul, 3; Chepigana, 4[2]; Cituro, 6[2]; Marragantí, 3; Mount Pirre, 6; Real de Santa Maria, 7[2]; Tacarcuna (2,650-5,200 feet), 12[2]; Tapalisa, 2.[2]

SCIURUS GERRARDI MORULUS Bangs

Canal Zone Squirrel; Ardita

Sciurus variabilis morulus Bangs, Proc. New England Zool. Club, Vol. 2, p. 43, September 20, 1900. Type from Loma de Leon (Lion Hill), Panama.

The common squirrel of the Canal Zone, locally known as "ardita," is distinguished from *S. g. choco* of the Darien region by paler general coloration. The black median dorsal stripe usually present in the latter form is absent or only faintly indicated and the underparts are a paler rusty reddish shade. The bright rusty reddish instead of black and white tail is a recognition mark by which confusion of this form with *Sciurus variegatoides helveolus,* a larger squirrel of the region, may easily be avoided. *S. g. morulus* apparently intergrades with *S. g. choco* in the mountains near the headwaters of the Chagres River; the limits of its range west of the Canal Zone remain to be determined. Specimens from Obispo and Caimito (near Chorrera) were recorded by Alston (1879, p. 131) and from Gatun by Anthony (1916, p. 365).

This squirrel is one of the few rodents that are diurnal in habits and likely to be met with during a ramble in the forest. Owing to the density of the vegetation it may be passed unnoticed at a very short distance. In spite of bright colors it is not a very conspicuous object unless very near. Sometimes one was heard making a rasping noise as it gnawed the shells of hard fruits or nuts while

[1] Four in collection Amer. Mus. Nat. Hist.
[2] Collection Amer. Mus. Nat. Hist.

itself still invisible in the dense foliage. On approaching cautiously I usually found the squirrel sitting on a palm frond or the branch of a tree, 20 to 35 feet from the ground, its brilliantly colored tail curved over the back. At times they seemed rather indifferent and permitted me to come quite near; at other times they quickly took alarm and disappeared, usually running through the interlocking branches or leaping across intervening spaces from tree to tree instead of ascending a tall tree trunk. Occasionally they make their escape by running down a tree trunk and off along the ground. A few short, rather hoarse notes were heard from these squirrels, but they were usually silent. By the construction of the Gatun Dam the region of the type locality of *S. g. morulus* has nearly all been submerged, Lion Hill being now reduced to a tiny island in Gatun Lake.

Specimens examined: Lion Hill (type locality), 3; Gatun, 15[1]; Porto Bello, 1; Rio Indio (near Gatun), 6; Tabernilla, 2.

Genus MICROSCIURUS Allen. Pygmy Squirrels

The pygmy squirrels of the genus *Microsciurus* are mainly South American in distribution, but range northward through Panama to Costa Rica. *Microsciurus* is distinguished from *Sciurus* by diminutive size and the simpler molar cusp development already pointed out in the remarks on the latter genus, and from *Syntheosciurus* by the absence of grooved upper incisors.

MICROSCIURUS BOQUETENSIS Nelson

Chiriqui Pygmy Squirrel

Sciurus (Microsciurus) boquetensis, NELSON, Proc. Biol. Soc. Washington, Vol. 16, p. 121, September 30, 1903. Type from Boquete, Chiriqui, Panama (altitude 6,000 feet).

Several pygmy squirrels are now known to occur in Panama, from which this species is distinguished by the richer reddish coloration of the underparts. It is known only from the type locality on the slope of the Volcan de Chiriqui where specimens were collected for the British Museum by H. J. Watson.

In his recent revision of the genus Dr. Allen (1914, p. 152) regards *Microsciurus boquetensis* as "a strongly differentiated mountain form of the *alfari* group, with the soft fine pelage and strongly colored ventral surface of the *similis* group, in correlation with the altitude of its haunts. It seems entitled to rank as a species until its inter-

[1] Three in collection Amer. Mus. Nat. Hist.

gradation with other forms has been shown." As Dr. Allen remarks, specimens from Panama described by Alston (1878, p. 669) and referred by him to *Sciurus rufoniger* were doubtless some form of *Microsciurus*. These examples, collected by Enrique Arcé in western Panama, were later assigned by Alston (1879, p. 134) to *Sciurus chrysurus*. Arcé visited the Volcan de Chiriqui and Alston's description of the specimens applies fairly well to *Microsciurus boquetensis*. A specimen in the Museum of Comparative Zoology labelled "Panama, Gerrard, 1873," and probably collected by Arcé at Boquete seems clearly referable to this species.

Specimens examined: Boquete, 1 (topotype); "Panama" (probably Boquete), 1.

MICROSCIURUS ALFARI BROWNI Bangs

Brown's Pygmy Squirrel

Sciurus (Microsciurus) browni BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 24, April, 1902. Type from Bugaba, Chiriqui, Panama.

Brown's pygmy squirrel is paler in general color and the underparts are grayer than in the allied forms, *Microsciurus a. alfari* of Costa Rica and *Microsciurus a. venustulus* of the Canal Zone and eastern Panama. The tail is edged with grayish white instead of reddish as in *M. a. venustulus*.

This diminutive squirrel is known only from low elevations on the Pacific slope in the western part of the republic. Mr. Bangs in his original account of the animal says: "Mr. Brown [W. W. Brown, Jr.,] found this little squirrel in the forest about Bogaba [=Bugaba], at 600 feet altitude. It was rare and exceedingly hard to get, on account of its small size and dull coloring, and only by devoting much time and energy to the chase did he succeed in taking five specimens."

Specimens examined: Bugaba, 5.[1]

MICROSCIURUS ALFARI VENUSTULUS Goldman

Canal Zone Pygmy Squirrel

[Plate 30, figs. 2, 2*a*]

Microsciurus alfari venustulus GOLDMAN, Smiths. Misc. Coll., Vol. 56, No. 36, p. 4, February 19, 1912. Type from Gatun, Canal Zone, Panama.

The Canal Zone representative of the *Microsciurus alfari* group of pygmy squirrels differs from *M. a. alfari* of Costa Rica in less rufescent general coloration, and from its closely allied geographic neighbor, *M. a. browni* of western Panama, in the darker tone of the

[1] Four in collection Mus. Comp. Zool.

upper and under parts. The tail is edged with rusty reddish instead of grayish white as in the latter form.

These tiny tree squirrels are apparently not very numerous, or, owing to the density of the forest cover they inhabit, individuals easily escape observation. In allusion to rapid movements the animal has received the native name, in the Canal Zone, of *ardita voladora.* One of the specimens taken at Gatun was seen running rapidly down the trunk of a tree. I noticed that the tail seemed to extend behind rather stiffly in a straight line with the body. On the top of the hill near the west end of the Gatun Dam one, which had evidently become alarmed at my approach, was seen moving down the trunk of a small tree. When within four feet of the ground it slipped suddenly out of sight on the opposite side before I could shoot. I supposed it had jumped to the ground but found on searching that it had climbed the tree again and was watching me from a perch among some leaves in the extreme top, sitting motionless with its tail curved over the back in characteristic squirrel fashion.

From the Canal Zone *M. a. venustulus* ranges eastward to near the Colombian frontier. A specimen collected at Porto Bello was clinging head downward, about 20 feet from the ground, on the trunk of a large tree giving short squeaking sounds suggesting those of some North American chipmunks. A single example was obtained at 2,000 feet altitude on the mountains near Cana. The same mountain slope at 3,500 feet is inhabited by *Microsciurus isthmius vivatus* which here typifies another species. Anthony (1916, p. 366), who obtained specimens on Mount Tacarcuna, also noted their occurrence in the same general locality and apparently overlapping the range of *M. i. vivatus,* but he states that *venustulus* was taken at slightly higher elevations and on the crest and eastern slope of the mountains. His specimens agree closely in color with the type. *M. i. venustulus,* contrasted with *M. i. vivatus* has darker, much more finely grizzled upperparts. Specific distinction is, however, better shown in cranial details; in the skull of *M. a. venustulus* the interpterygoid fossa and basioccipital are narrower, the maxillae are less extended at the expense of the frontals between the lachrymals and the premaxillae, and the interparietal is rectangular instead of subtriangular in outline. The type of *M. a. venustulus,* an adult female, lacks the small upper premolars usually present in *Microsciurus.*

Specimens examined: Gatun (type locality), 2; Cana, 1; Mount Tacarcuna, 3[1]; Porto Bello, 1.

[1] Collection Amer. Mus. Nat. Hist.

MICROSCIURUS ISTHMIUS VIVATUS Goldman

Mount Pirre Pygmy Squirrel

[Plate 30, figs. 1, 1*a*]

Microsciurus isthmius vivatus GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, p. 4, September 20, 1912. Type from near Cana, eastern Panama (altitude 3,500 feet).

Comparatively little is known of the relationships of pygmy squirrels, most of the known forms being currently regarded as full species based on scant material from few localities. It was, therefore, with considerable interest that I noted the occurrence of two very distinct forms in close proximity on the Cana slope of the Pirre Mountains near the Colombian frontier. One of them proved to be *Microsciurus alfari venustulus,* previously known only from farther west, and the other an apparently new geographic race of *M. isthmius* whose general known range is in the valley of the Atrato River and the coast region of Colombia. Since *M. i. vivatus,* the new form, inhabits these mountains at 3,500 feet altitude, while *M. a. venustulus* was taken only 1,500 feet lower down on the steep slope, both will probably be found at the same elevations. *M. i. vivatus* is distinguished from *M. isthmius isthmius* by paler upperparts and orange buffy instead of deep ferruginous underparts. Anthony (1916, p. 366) records specimens of *M. i. vivatus* from 2,650 feet altitude near the village of Tacarcuna, which closely resemble specimens from the type locality, but have slightly richer-colored underparts. The examples of *M. i. vivatus* were obtained by me while hunting birds. They were all found among the lower branches or on the trunks of trees, where they were inconspicuous owing to masses of dense overhanging vegetation in the dimly lighted forest. In this forest, fog enshrouded during much of the time, one of these tiny squirrels moving along a tree trunk may easily be mistaken for one of the common Dendrocolaptine or Formicariinine birds of the region.

Specimens examined: Cana (type locality), 3; Mount Tacarcuna, 3.[1]

Genus SYNTHEOSCIURUS Bangs. Pygmy Squirrels

In this as yet monotypic genus of small tree squirrels an unusual departure in dental details is exhibited. The upper incisors are very slender and project outward and the outer surfaces, smooth in *Sciurus* and *Microsciurus,* each bear a longitudinal median groove.

[1] Collection Amer. Mus. Nat. Hist.

SYNTHEOSCIURUS BROCHUS Bangs

Groove-toothed Squirrel

Syntheosciurus brochus BANGS, Bull. Mus. Comp. Zool., Vol. 39, No. 2, p. 25, text figs. 1-4, April, 1902. Type from Boquete, Chiriqui, Panama (altitude 7,000 feet).

Concerning this peculiar squirrel nothing has been added to the full original account by Mr. Bangs. In general external appearance it is much like *Microsciurus,* but as the author states, is larger,[1] with "ear still smaller, hardly standing up above the fur, and very woolly; pelage very long, dense, and woolly. . . . . General coloration dark reddish olive, with under parts varying from orange rufous to ferruginous." Perhaps the most important as well as easily recognizable differential character is the grooved condition of the upper incisors.

Mr. Bangs further remarks: "Mr. Brown [W. W. Brown, Jr.] met with this remarkable squirrel but once, when he took the pair described. It was unknown to the native hunters who accompanied him, and who expressed much astonishment on being shown the two examples. Judging by the long, dense fur, even at this time of year—April 30—when the female was nursing young, it is evidently an animal of high elevations only.

"Among tree squirrels, *Syntheosciurus brochus* has no very near ally; its light, papery skull recalls that of *Sciuropterus,* but the audital bullae are much smaller. Its peculiarly straight, slender rostrum, weak, projecting, and grooved incisors at once distinguish the genus from any other."

Specimens examined: Boquete, 2 (including type).

Order LAGOMORPHA. Rabbits

Family LEPORIDAE.[2] Rabbits

The single genus *Sylvilagus* of the family Leporidae is known from Panama.

Genus SYLVILAGUS Gray

The only representative of this genus within the region under review is a forest rabbit of Middle America, easily distinguishable from its North American congeners by the short ears, dark color, and extremely short tail.

[1] Type: Total length 320 mm. (total length in Microsciurus less than 300 mm.); tail vertebrae, 150; hind foot, 46.

[2] The family Leporidae, formerly placed by authors in the order Rodentia, has recently been elevated, along with the family Ochotonidae, to a group of full ordinal rank (see Gidley, Science, N. S., Vol. 36, pp. 285-287, August 30, 1912).

Subgenus TAPETI Gray

SYLVILAGUS GABBI GABBI (Allen)

Costa Rica Forest Rabbit

Lepus brasiliensis var *gabbi* ALLEN, Monogr. N. Amer. Rodentia, p. 349, August, 1877. Type from Talamanca, Costa Rica. (Probably near Sipurio, in the valley of the Rio Sicsola.)

Forest rabbits doubtless inhabit nearly the whole of Panama, and range from sea level well up on the slopes of the higher mountains. The Costa Rican form reaches from the western boundary as far east, at least, as the Canal Zone. In extreme eastern Panama it is replaced by a closely allied subspecies, *Sylvilagus g. messorius,* which is less rusty reddish in general color, and darker on the back.

While these rabbits may be met with in the depths of the forest, they favor the dense undergrowth along the edges of the forest, or old clearings. They are shy and apparently feed mainly at night, remaining during the day well concealed on forms under logs or other cover. Even when their hiding places have been discovered they may remain motionless, making no effort to escape until finally dislodged by the very close approach of an intruder when they scurry to the nearest shelter, perhaps only a few feet away. The very short tail is dark colored like the body and one misses the flash of contrasting white seen when a northern rabbit leaves cover.

Specimens from the localities on both the Atlantic and Pacific sides of the Canal Zone agree with the type of *S. g. gabbi* and are regarded as typical. Bangs (1902, p. 48) recorded specimens collected by W. W. Brown, Jr., as follows: "Nine specimens, Divala, November and December; Boquete, 3,400 to 4,500 feet, March and April, and Bugaba, July. The seasonal differences in color are well shown by this series. July specimens are much redder, with but few black-tipped hairs in the back, than autumnal examples." Six individuals taken by J. H. Batty have been recorded by Thomas (1903*a*, p. 42) from Gobernador Island, and rabbits probably occur on other islands near the coast of western Panama. Examples from Boqueron, also obtained by J. H. Batty, were listed by Allen (1904, p. 70).

Specimens examined: Boqueron, 5[1]; Boquete, 2[2]; Bugaba, 2[2]; Divala, 2[2]; Corozal, 1; Gatun, 7; Lion Hill, 2.[2]

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[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

SYLVILAGUS GABBI MESSORIUS Goldman

Panama Forest Rabbit

[Plate 27, figs. 2, 2*a*]

Sylvilagus gabbi messorius GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 13-14, September 20, 1912. Type from Cana, eastern Panama (altitude 1,800 feet).

In the mountains of eastern Panama, *Sylvilagus gabbi gabbi* which ranges in western Panama and the Canal Zone is replaced by a closely allied subspecies lacking the strongly rufescent suffusion of color shown in the typical form, and with upperparts more obscured by the long black tips of the longer hairs. Anthony (1916, p. 371) lists specimens from Boca de Cupe, Tacarcuna, and Tapalisa and the darker form doubtless occurs throughout the general region, including adjacent Colombian territory.

In connection with the operation of the Darien gold mines considerable land on the small plateau near Cana has been cleared at different times and planted to sugar-cane and other crops. In these clearings, partly marshy and neglected for years, an exuberant growth of coarse grasses, shrubs, and small trees now form nearly impenetrable thickets in which the rabbits, as shown by their number, find conditions much more favorable for existence than in the unbroken forest. In places, well-trodden paths mark their general routes through dense cover. During the dry season small areas are sometimes burned over and the fresh new verdure springing up affords an attractive food supply. The rabbits visit these open spaces to feed at night and are easily shot, their eyes giving off reddish reflections in the glare of a hunting lamp. In the field of reflected light they sit motionless and if no noise is made one may approach to within a few feet, before they take alarm and dash off into the darkness.

Specimens examined: Boca de Cupe, 3[1]; Cana (type locality), 10; Tacarcuna, 2[1]; Tapalisa, 4.[1]

SYLVILAGUS GABBI INCITATUS (Bangs)

San Miguel Island Rabbit

Lepus (*Tapeti*) *incitatus* BANGS, Amer. Nat., Vol. 35, p. 633, August 22, 1901. Type from San Miguel Island, Panama.

Greater general dimensions combined with shorter ears and paler color apparently distinguish this insular form from *Sylvilagus gabbi*

[1] Collection Amer. Mus. Nat. Hist.

gabbi of the adjacent mainland. The braincase is also narrower, and the rostral portion of the skull heavier than usual in the group. The animal was one of those discovered by W. W. Brown, Jr., during his collecting trip to San Miguel Island for Mr. Bangs in the spring of 1900.

Regarding its occurrence, Mr. Bangs in his original account says: "The hare was not at all common in San Miguel Island, and Mr. Brown saw but one other during his stay. Mr. Brown tells me that *Lepus gabbi* and *L. incitatus* [=*Sylvilagus gabbi incitatus*] are extraordinarily swift of foot and are seldom seen except for an instant as they dart like a flash through the undergrowth."

Specimens examined: The type and only known example.

SYLVILAGUS GABBI CONSOBRINUS Anthony

Savanna Rabbit

Sylvilagus gabbi consobrinus ANTHONY, Bull. Amer. Mus. Nat. Hist., Vol. 37, p. 335, May 28, 1917. Type from Old Panama (near City of Panama), Panama.

An unusually light-colored rabbit taken by Mr. H. E. Anthony near the savanna at Old Panama on the Shiras Expedition of 1914 was recorded by him (1916, p. 371) as *Sylvilagus gabbi gabbi.* More recently this specimen has been described by him and made the type of *Sylvilagus gabbi consobrinus,* an apparently pale form which may range at low elevations throughout the savanna regions of southern Panama. The few specimens of *Sylvilagus* available from Boqueron, Bugaba, and Divala appear somewhat intermediate in color between typical *S. g. gabbi* and the type of *S. g. consobrinus,* and might with similar propriety be referred to either subspecies. They are listed as *S. g. gabbi,* but future increments of material from the general region may indicate the desirability of transferring them to the paler form.

Specimens examined: The type.

Order CARNIVORA. Carnivores

Family CANIDAE. Wolves, Foxes, Bush Dogs

None of the familiar North American members of the family to which our domestic dog belongs are known from the region under consideration. The single genus occurring represents the intrusive South American element of the fauna.

Genus ICTICYON Lund. Bush Dogs

The somewhat aberrant genus *Icticyon* was not until the present survey known to enter Panama. It is a robust animal with short ears, limbs, and tail and at first glance is scarcely recognized as a member of the Canine family. The general proportions and long hair give the bush dog a badger-like appearance.

ICTICYON PANAMENSIS Goldman

Panama Bush Dog

[Plate 31, figs. 1, 1*a*]

Icticyon panamensis GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 14-15, September 20, 1912. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 5,000 feet).

One afternoon while in camp near the summit of Mount Pirre several short dog-like barks were heard not far away. Cautiously stalking in that direction I saw the whitish shoulders of an old female bush dog suddenly appear through a small opening, presenting a conspicuous target in the dimly lighted forest. A quick shot brought her down. Three nearly full-grown young were soon sighted, two of which were secured while the other escaped. Tracks led to a burrow a few yards away on a steep hillside covered with tall forest. Fresh earth had been thrown out of a tunnel directed downward at an angle of about 45 degrees. The ground was trampled and the place showed other signs of habitation for a considerable period. Many bones and fragments scattered about the entrance to the burrow had been carried from a heap of camp refuse; the bush dogs had evidently been our very near neighbors for two weeks before the barking, probably of the young, led to detection.

The discovery of a bush dog in Panama materially extends the known range of the genus northward. The Panama animal apparently differs from *Icticyon venaticus* of Brazil in the whitish color of the anterior part of the body and in cranial details.

Specimens examined: Three, an old female (the type) and her offspring, two nearly full-grown young, from Mount Pirre.

Family PROCYONIDAE. Raccoons, Cacomistles, Coatis, and Kinkajous, etc.

The family includes the familiar "coon," the less familiar "cacomistle," representatives of which reach the United States, the rare *Bassaricyon,* and the common coatis and kinkajous of the American tropics. They are all medium-sized carnivores with plantigrade feet, naked soles, and curved non-retractile claws. The tail is moderately long, somewhat bushy, and usually more or less distinctly annulated.

Genus **BASSARISCUS** Coues. Cacomistles

The cacomistles are more slender in form than the related genera of the region. They have short, rounded heads with larger ears than *Potos* or *Bassaricyon*. The tail, flattened and long-haired to the tip like that of *Bassaricyon*, is ringed in strongly contrasting colors throughout its length.

BASSARISCUS SUMICHRASTI NOTINUS Thomas

Panama Bassariscus; Cacomistle

Bassariscus sumichrasti notinus THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 11, p. 379, April, 1903. Type from Boquete, Chiriqui, Panama (altitude 6,000 feet).

The only record of the occurrence of *Bassariscus* in Panama seems to be that of the type of *B. s. notinus*, from Boquete, at 6,000 feet altitude on the southern slope of the Volcan de Chiriqui. It is described as paler in color, with smaller skull and teeth, and longer palate in contrast with *B. s. variabilis* of Guatemala.

The various forms of the genus *Bassariscus* are all slender, short-legged animals, grayish in general color and with fox-like faces. Perhaps the most distinctive external character, however, is the tail which is about as long or longer than the body, with alternate black and white or gray rings. The general range of the genus *Bassariscus* is to the northward, one form reaching Oregon. Except in parts of Mexico where *B. astutus* is very common these animals are rather scarce, or of local occurrence only, and owing to retiring habits are little known. All of the forms are expert climbers. *B. astutus* commonly lives in caves or crevices in cliffs, but the forms of the more southern species, *B. sumichrasti,* seem to be more arboreal in habits. *B. sumichrasti* also differs notably from *B. astutus* in the longer tail, the more extensively naked soles of feet, and in dental details, the cutting edges of the first and second upper incisors of the permanent series being finely but distinctly trifid, while in the latter species they are smooth. In very young examples of *B. astutus,* however, a tendency to similar division of the edges in these teeth is sometimes shown. The Mexicans use the native name *cacomistle,* but no English vernacular name for animals of this group has met with general acceptance.

Genus **PROCYON** Storr. Raccoons

The raccoons are distinguished externally by robust form, short ears and nose, and rather short, somewhat bushy, ringed tail. Two species, recognized as subgenerically distinct, inhabit parts of the Isthmian region.

Subgenus **PROCYON** Storr

PROCYON LOTOR PUMILUS Miller

Little Panama Raccoon; Mapachin

[Plate 32, figs. 1, 1*a*]

Procyon pumilus MILLER, Proc. Biol. Soc. Washington, Vol. 24, p. 3, January 28, 1911. Type from Ancon, Panama.

The mapachin or common raccoon closely resembles its congener, the crab-eating species, but is recognizable externally by the normal inclination backward of the pelage of the nape.

Material now available, including a series of six topotypes, shows that this raccoon, while small, is not so diminutive as the type, a rather unusually under-sized and not fully adult individual, seemed to indicate. General comparisons point to intergradation with the common raccoon of North America, through *Procyon lotor crassidens* of Costa Rica, the next geographic race to the north, and *P. l. hernandezii* of Mexico. The animal inhabiting the Canal Zone, and differing essentially from the more northern continental forms only in size, marks in this region the southern known limit of the range of the *P. lotor* group.

These raccoons are more numerous in the Canal Zone than the larger so-called crab-eating species, *Procyon cancrivorus panamensis,* which inhabits the same region. While generally distributed they favor the vicinity of swamps and streams and share the crab-eating habit with *P. c. panamensis,* as shown by stomachs examined. They are more arboreal in habits, however, as evidenced by their sharper claws and the fact that they were commonly found in trees while the latter species was encountered on the ground. Several were shot at night as they climbed about among the mangroves along the Moré River near Porto Bello. They were located by their eyes which give off deep red reflections under the glare of a hunting lamp. On one occasion two were found close together in a tree, and when shot both at once came tumbling with a great splash into the water near the canoe.

Bangs (1902, p. 49) notes the species from Pedregal, Chiriqui, where it was taken by W. W. Brown, Jr. Allen (1904, p. 77) recorded a specimen taken by J. H. Batty at Boqueron.

Specimens examined: Balboa, 6[1]; Boqueron, 1[2]; Gatun, 4; Pedregal, 1[3]; Porto Bello, 2.

Subgenus EUPROCYON Gray

PROCYON CANCRIVORUS PANAMENSIS (Goldman)

Panama Crab-eating Raccoon: Mapachin

[Plate 33, figs. 1, 1*a*]

Euprocyon cancrivorus panamensis GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 15-16, February 28, 1913. Type from Gatun, Canal Zone, Panama.

The Panama crab-eating raccoon differs from its North American relative, of the subgenus *Procyon,* in the reversed direction of the pelage of the nape; from a hair-whorl between the shoulders the pelage is inclined forward, meeting the opposing pelage of the head along a V-shaped line between the ears. It differs also in cranial and dental characters, especially the more rounded molariform cusps which are better adapted for crushing hard substances. The general non-sectorial character of the dentition is shown in the upper carnassial where the trenchant commissure of the median outer cusp and the postero-internal cusp present in the more northern species is absent.

The crab-eating raccoon is mainly South American in distribution, but is represented as far north as the Canal Zone where it meets the range of a southern form of the *Procyon lotor* group. In Panama the altitudinal range is from sea level to 2,000 feet, as determined by the capture of a specimen near Cana, on the slope of the Pirre Mountains.

Several were shot at night along the banks of the Chagres River, their eyes appearing deep red under the light of a hunting lamp. Another specimen obtained was killed as it emerged from some tall grass near the edge of a swamp whence it had been driven by a pack of hounds. Stomachs examined contained fragments of fish and crabs.

The so-called crab-eating raccoon is apparently less arboreal in habits than *Procyon lotor,* the Panama representative of which is, however, also a crab eater. Adaptation for a terrestrial life is shown in the bluntness of the claws as compared with those of *Procyon.* All of the specimens obtained were found upon the ground while those of *Procyon* were usually located in trees.

[1] Collection Field Mus. Nat. Hist.

[2] Collection Amer. Mus. Nat. Hist.

[3] Collection Mus. Comp. Zool.

The species was noted from as far north as Colon by Sclater (1875, p. 421). Alston (1879, p. 69) probably referred to the same material as Sclater in stating that "The Crab-eating Raccoon is found as far north as Panama, whence living specimens have more than once been received by the Zoological Society, and Veragua, whence it has been obtained by M. Boucard."

The native name *mapachin* is also applied to *Procyon lotor pumilus.*

Specimens examined: Cana, 1; Gatun, 3; Panama, 1[1]; Porto Bello, 1.

Genus NASUA Storr. Coatis

The coatis are remarkable for the length and mobility of the snout which projects forward well beyond the lower lip. The claws are long and rather straight and blunt for such arboreal animals. The ears are short and the tail long and tapering. The muzzle is whitish or grayish, and two narrow whitish lines usually extend backward along the face diverging gradually to enclose the eyes.

NASUA NARICA PANAMENSIS Allen

Panama Coati; Pisote

Nasua narica panamensis Allen, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 51, February 29, 1904. Type from Boqueron, Chiriqui, Panama.

The long projecting snout of the coati fully distinguishes it from the other members of the general group to which it belongs.

Nasua narica, represented by several closely allied continental forms, ranges throughout the tropical portions of Middle America and ascends from sea level well up on the slopes of the higher mountains. Variation in color and cranial details is remarkable and to *N. n. panamensis* I provisionally refer the animal inhabiting the region as far east as Cana. The material available is insufficient to satisfactorily determine the exact status and relationships of this subspecies, but it seems doubtfully recognizable from *N. n. bullata* of Costa Rica.

Dr. Allen (*l. c.*) in describing the Panama form says that in coloration it is "not readily distinguishable from *N. narica bullata,* being very dark and highly colored, but much smaller, and with the bullae of the usual size for the *narica* group." He adds: "*N. narica panamensis* probably differs very little in average coloration from *N. n. bullata,* both forms presenting the usual wide individual range of color-variation seen in all the forms of *Nasua,* but it

[1] Collection Mus. Comp. Zool.

is apparently very much smaller, with the audital bullae nearly one-half less. From *N. narica* it differs markedly through its much darker general coloration, and still more so in this respect from the forms of the more arid portions of Mexico."

The coatis are largely arboreal in habits, but they appear to be equally at home upon the ground. They are sociable animals and commonly range about in parties or troops consisting of several old females and younger animals of both sexes. The old males are met with alone, and from their solitary habits are in many localities supposed to be of a different species. They are referred to in Panama as *pisote solo* to distinguish them from the more gregarious *pisote de manada*. Under other native names the same distinction is made in other parts of Middle America.

The coatis are less strictly nocturnal in their activity than some of the other members of the family. At Gatun several parties of from five or six to a dozen individuals were seen roaming through the forest during the morning and evening hours. During the heat of the day they were occasionally startled from a resting place in the trees, from which they tried to escape by running along large branches and passing across into other trees, or came bounding down and off along the ground. When searching for food they carry their long tails high in the air and move at a rather rapid pace, running here and there, pausing a moment to paw up the ground or poke their long noses into likely places and then hurrying on to overtake more advanced members of the troop. They also ascend trees in quest of food. Stomachs examined by me contained fruit pulp only, but they probably have a diversified diet.

Belt[1] in Nicaragua observed a solitary pisote climb trees in pursuit of iguanas, the large tree lizards of the region, but they made their escape by dropping to the ground and rushing off to another tree. The pisote, " however, seemed to take all his disappointments with the greatest coolness, and continued the pursuit unflaggingly. Doubtless experience had taught him that his perserverance would ultimately be rewarded; that sooner or later he would surprise a corpulent iguana fast asleep on some branch, and too late to drop from his resting-place." In Panama the iguanas congregate in numbers to feed on the flowers of certain trees, especially an *Erythrina*-like species at Gatun; at such times some of them would not be likely to escape the sudden attack of a party of pisotes.

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[1] The Naturalist in Nicaragua, p. 339, 1888.

They are easily tamed and make entertaining pets. Their sense of smell is keen as shown by one at Gatun that without offering to bite would force his long snout into the spaces between my fingers in order to reach a nut held in my clenched hand; but if I extended my empty hand, clenched as before, he merely sniffed at it. When hunted with dogs a whole party will quickly climb trees and pass across from one tree to another until they reach a point where they can go no farther in that direction. If one or more are shot the others usually attempt to escape by running down the tree trunks; reaching the earth with a bound, they frequently avoid the waiting dogs and go scampering off to another tree. If caught by the dogs, they fight savagely, and slashing with their long, sharp tusks, often inflict serious wounds.

Alston (1879, p. 75) notes the species as collected by M. Boucard in Panama. Under the name *Nasua narica* specimens collected at Boquete by W. W. Brown, Jr., were listed by Bangs (1902, p. 49) who says: "The nasuas separate naturally into many geographic races. These, as proper material accumulates, are gradually coming to be understood; the name *narica* is used here provisionally." These specimens were referred to *N. n. panamensis* by Allen (1904, p. 77) who says of them "while they agree in color with *bullata*, they lack the excessive development of the audital bullæ seen in that form." All of the specimens from Panama are provisionally referred to *N. n. panamensis*, but the audital bullæ are very variable in size, in some examples closely approaching those of *N. n. bullata*, and *N. n. panamensis* may prove to be based on an unstable character. Anthony (1916, p. 372) lists specimens from Boca de Cupe; Real de Santa Maria, Tacarcuna and Tapalisa.

Specimens examined: Boca de Cupe, 1[1]; Boquete, 6[2]; Boqueron, 1[1]; Cana, 1; Gatun, 2; Real de Santa Maria, 1[1]; Tacarcuna, 2[1]; Tapalisa, 4[1]; Volcan de Chiriqui, 1.

Genus BASSARICYON Allen

In external appearance *Bassaricyon* closely resembles *Potos*, the short ears, short face, rounded head and general proportions being about the same. The tail, however, unlike that of *Potos*, is non-prehensile, somewhat flattened like that of a squirrel, and instead of tapering is long-haired to the tip. In cranial characters *Bassaricyon* and *Potos* are widely different. The known range of the genus is

[1] Collection Amer. Mus. Nat. Hist.
[2] Collection Mus. Comp. Zool.

from Ecuador to Nicaragua, and in Panama it ascends from sea level to 5,000 feet altitude. Two closely allied forms occur within our limits.

BASSARICYON GABBII GABBII Allen

Bushy-tailed Olingo

[*Bassaricyon*] *gabbii* Allen, Proc. Acad. Nat. Sci., Philadelphia, p. 23, April 18, 1876. Type from Talamanca, Costa Rica.

The known forms of the genus agree closely in essential characters and may prove to be geographic races all assignable subspecifically to *Bassaricyon gabbii.* The distinguishing characteristics of the species are the same as those given for the genus, but the grayer color of the face when contrasted with that of *Potos* may be pointed out as an additional aid in avoiding confusion with that genus.

Bassaricyon has been regarded as a rare animal, but the fact that it was met with at several localities and on several occasions at a single locality in Panama leads me to believe that it is rather common. While much less abundant than *Potos* its apparent rarity may have been due to failure in some instances to distinguish it from that animal when specimens were chosen, and to a lack of knowledge of its habits.

As in many other groups cranial modifications furnish more reliable differential characters than color. No material showing the color of *B. gabbii* at the type locality is available, but a specimen from near Gatun agrees very closely in cranial details with the type and coming, as it does, from within the same general faunal area may be regarded as typical. In this specimen the face is gray as usual in the genus, and not at all like Huet's (1883, pl. I) figure of the animal from "Caimito, dans la province de Correo, un peu au nord de Panama" (=the vicinity of Chorrera, about 17 miles southwest of Panama) and only about 30 miles from Gatun. Huet's figures of the skull, on the other hand, agree well with the type of *B. gabbii* and on geographic grounds might be expected to represent that species. Since the skulls from Gatun and near Chorrera agree closely with that of the type, typical *B. gabbii* is assumed to range from Costa Rica eastward to the Canal Zone. In eastern Panama typical *B. gabbii* is replaced by subspecies *B. gabbii orinomus* from which it differs in more brownish color, shorter postorbital processes, larger audital bullæ, and correspondingly narrower basioccipital.

The species seems to be arboreal and owing to nocturnal activity is likely to be overlooked unless special search is made for it. While using a hunting lamp one night in the forest along the lower course of the Chagres River near Gatun one of these animals was located by the glare of its eyes in a tree top. When it was shot and dropped to the ground short muffled squeaking sounds and rustling branches were heard as several others, assumed to be of the same species, climbed rapidly away through the trees. The stomach of the example taken contained a small quantity of the pulp of some unidentifiable fruit. Several native hunters readily identified the specimen as an *olingo,* a name they apply also to *Potos,* and I found that they made no distinction between the two animals.

Specimens examined: Near Gatun, 1; Corozal, 1.

BASSARICYON GABBII ORINOMUS Goldman

Panama Bushy-tailed Olingo

[Plate 34, figs. 1, 1*a*]

Bassariscyon [sic] *gabbi orinomus* GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 2, pp. 16-17, September 20, 1912. Type from Cana, eastern Panama (altitude 1,800 feet).

The form of *Bassaricyon gabbii* inhabiting the mountains of eastern Panama differs from typical *B. g. gabbii* of Costa Rica, western Panama and the Canal Zone in more tawny or paler fulvous, less brownish, coloration. It differs also in combination of cranial characters, the basioccipital being broader, the postorbital processes longer, more projecting, and the audital bullæ decidedly smaller.

It was met with on several occasions while hunting at night in the forest at about 2,000 feet near Cana, always among the upper branches of trees, its eyes appearing in the narrow field of light projected by the acetylene gas burner like those of *Potos.* In fact I rarely knew what animal I fired at until it came tumbling to the ground. The eyes are of course visible only when the animal has an unobstructed view toward the hunter, and unless a quick and effective shot is fired the game is apt to be lost. Like *Potos* these animals climb about in small parties; two were shot in the same tree and several others were heard making off. On one occasion a *Bassaricyon* was killed and another shot fired a moment later at a pair of eyes in the same tree brought down an example of *Potos.* Both species had, as the contents of their stomachs showed, been attracted by the ripening fruit in the top of the tree, a tall species unknown to me. A *Bassaricyon* shot at 5,000 feet near the summit of Mount Pirre was in the act of passing from the top of one tall tree to another.

Specimens examined: Cana, 5; Mount Pirre, 1.

Genus POTOS Geoffroy and Cuvier. Kinkajous

The kinkajous have short ears, short faces, rounded heads and bear a remarkable external resemblance to *Bassaricyon,* but are distinguishable by the round tapering, short-haired, prehensile tail. The tail perhaps furnishes the most convenient differential characters, but others are revealed by close inspection. The general color and proportions are similar, but *Potos* is a larger, more robust animal, and the face similar to the back in color; in *Bassaricyon* the face is grayish. The genus, a preëminently arboreal one, ranges northward in Middle America to the tropical portions of southern Mexico. Two forms are represented in Panama.

POTOS FLAVUS ISTHMICUS Goldman

Isthmian Kinkajou; Cusimbí

[Plate 34, figs. 2, *2a*]

Potos flavus isthmicus GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 14-15, February 28, 1913. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 5,200 feet).

The Isthmian kinkajou is a rather common animal in the mountains of eastern Panama, being replaced farther west by the Chiriqui form of the group. Its known altitudinal range is from at least 1,000 feet on the slope to 5,200 feet near the summit of Mount Pirre. Contrasted with *P. f. chiriquensis* the present subspecies differs in the possession of a distinct black dorsal stripe; the skull is narrower interorbitally, the postorbital processes stouter, broader and more gradually tapering toward the base, instead of peg-like. The Isthmian race combines the color pattern of some of the South American forms with the heavier dentition of the Middle American forms.

The specimens obtained were all shot in trees at night, their eyes appearing reddish in color under the glare of the hunting lamp. Small parties or family groups are attracted by fruit and apparently revisit the same trees to feed night after night. This habit seemed to be shown by my meeting with them in the same vicinity on several occasions, and fallen fragments of fruit seen early in the morning indicated that frequent visits, presumably of these animals, were made. On approaching trees in which they were working a squeaking noise was commonly heard, coupled more rarely with short peculiar barks.

Under the name *Potos flavus chiriquensis* Anthony (1916, p. 372) lists specimens from Tapalisa (altitude 1,000 feet), and Tacarcuna (altitude 2,650 to 5,200 feet). Concerning them, he says: "Two were taken from a hollow tree at Tacarcuna, two were shot by moonlight and with the jack light at the upper camp on Tacarcuna, and others were secured from the natives. At the upper camp this species came nightly to feed on what seemed to be a variety of wild fig, a fruit about the size of a man's thumb, with a pink center. Shortly after sun down, a small band of probably eight to a dozen individuals would be heard coming into the fruit trees. They travelled entirely through the trees and did not descend to the ground. Quantities of dead twigs and debris were shaken down by their weight, and their progress could be thus noted when the moving branches could not be seen.

"The eyes of the Kinkajou ('Cusumbi' or 'Manteja,' native names) shine strongly red under the jack light. One was eaten and its flesh proved to be quite palatable. A nasal, grunting sound was the only call heard."

Specimens examined: Cana, 4; Mount Pirre (type locality), 4; Tacarcuna, 4[1]; Tapalisa, 3.[1]

POTOS FLAVUS CHIRIQUENSIS Allen

Chiriqui Kinkajou; Olingo

Potos flavus chiriquensis Allen, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 72, February 29, 1904. Type from Boqueron, Chiriqui, Panama.

The Chiriqui kinkajou inhabits the western part of the republic and ranges as far east at least as the Canal Zone. It is replaced in eastern Panama by *P. f. isthmicus* which is distinguished by the possession of a distinct black dorsal stripe and a different combination of cranial characters, especially the narrower interorbital region and stouter more gradually tapering, less peg-like postorbital processes. The striking general resemblance of the species of *Potos* to those of *Bassaricyon* has been mentioned in the remarks on the genus.

A series of specimens from the vicinity of Gatun includes adults and young of both sexes showing a wide range of variation in the intensity of the general yellowish tawny color. A trace of the dark median dorsal stripe, which is more distinct in *Potos flavus isthmicus,* seems to indicate gradation toward that form.

The Chiriqui kinkajou seems to be one of the more common mammals of the region, but owing to nocturnal habits it is little known. Examples were obtained by shooting them from trees in the heavy forest where by the light of a hunting lamp their eyes were

[1] Collection Amer. Mus. Nat. Hist.

seen flashing among the branches. They hunt in small parties and several may sometimes be killed in a single tree. When approached a short, rather hoarse barking sound is sometimes given and a rustling noise may be heard as they climb or leap from branch to branch. Several kinds of wild fruits were found in the stomachs examined, including a common leguminous species known as "guava." Fruit seems to be their principal diet, but they doubtless feed on many other things. One partially filled stomach contained mainly fragments of large insects, but included small Coleopterous species swallowed entire. These kinkajous are easily tamed and often kept as pets, although they are inactive and remain curled up in a corner during the day, and are inclined to be mischievous at night. A rather young individual, which had recently been caught in the forest, climbed to my shoulder and sat with its long tail coiled about my neck.

Bangs (1902, p. 49) listed specimens collected by W. W. Brown, Jr., at Bogava and remarks: "I do not think the Central American form is the same as true *P. caudivolvulus* of Surinam, but I have not sufficient material to decide the question." Under the name *Potos flavus megalotis,* Thomas (1903*a*, p. 40) recorded specimens probably referable to *P. f. chiriquensis* from Parida, Sevilla, and Almijas, all small islands near the southern coast of western Panama.

The name applied to the animal by natives of the Canal Zone is "olingo."

Specimens examined: Boqueron, 6[1]; Bogava, 3[2]; Gatun, 15.

Family MUSTELIDAE. Weasels, Tayras, Grisons, Skunks, Otters, etc.

The family, as restricted within our limits, includes a weasel of the familiar type, the tayra and grison, large powerful weasel-like animals, a long-nosed skunk, and an otter.

Subfamily MUSTELINAE. Weasels

Genus MUSTELA Linnaeus. Weasels

The weasels, mainly boreal in distribution, are represented in the region by a single form which ranges well into South America. Its small size, elongated body, short limbs, and hairy soles of hind feet distinguish it from the other carnivores of the region. The white facial markings present in the northern forms are absent or barely indicated by a few white hairs in front of the ears.

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

Subgenus MUSTELA Linnæus

MUSTELA AFFINIS COSTARICENSIS Goldman

Costa Rican Bridled Weasel

Mustela costaricensis GOLDMAN, Proc. Biol. Soc. Washington, Vol. 25, p. 9, January 23, 1912. Type from San José, Costa Rica.

The weasel of Panama may be referred to the Costa Rican subspecies of *Mustela affinis,* but is somewhat darker than the typical form and in the smaller skull, with less elongated braincase and relatively smaller, more flattened audital bullae, approaches *M. f. affinis* of Colombia. It seems to be distributed nearly throughout the republic, and the localities for specimens show an altitudinal range from sea level to over 5,000 feet.

Specimens were taken by me in traps. At Gatun one was attracted to a trap baited with the feathered body of a dead bird. Near the summit of Mount Pirre, on visiting a spot where I had placed a trap for small rodents under shelter of the wide spreading aerial roots of a tree, I found that some animal had carried off the trap; but bristles and some viscera of *Heteromys* left on the ground showed that some carnivorous species had anticipated me. A steel trap was set in the same place, and next morning held a weasel which bit savagely at the toe of my shoe when extended to within reach.

Under the name *Mustela brasiliensis,* Alston (1879, p. 78) records the species as obtained in Panama by M. Boucard. Bangs (1902, p. 49) referred to *Putorius affinis* three specimens collected at 4,000 to 5,800 feet near Boquete by W. W. Brown, Jr. He found that the examples agreed very well with Gray's description, but varied somewhat among themselves in color; a young individual had a wholly black head while the two adults had small irregular (not the same on both sides) white patches, behind the eye, in front of the ear, and above the corner of the mouth. The chins were white in all three, and the rest of the under parts varying shades of orange rufous. A specimen also from Boquete, taken by J. H. Batty, was assigned to *P. affinis* by Allen (1904, p. 72) who noted a similar irregularity of the white markings. He says " on the right side of the head are a few white hairs, scattered singly over the whole side of the head from eye to ear; on the left is a very small oblong white spot just behind the eye, and another somewhat larger white spot in front of the lower base of the ear."

Partial or complete obliteration of the white facial markings usually present in weasels of this group is also shown in the specimens collected by me, in one of which the face is entirely black while in the other there are small, very narrow elongated patches of white hairs in front of the ears.

Specimens examined: Boquete, 4[1]; Mount Pirre, 1; Rio Indio (near Gatun), 1.

Subfamily MELINAE. Tayras, Skunks

Genus TAYRA Oken. Tayras

The genus *Tayra,* as represented in Panama, is a large weasel-like animal, black in general color, but with the head and neck brown. The single form known from the region is a link in a chain of subspecies extending from South America north to southern Mexico.

TAYRA BARBARA BIOLOGIAE (Thomas)

Panama Tayra

Galictis barbara biologiae Thomas, Ann. Mag. Nat. Hist., Ser. 7, Vol. 5, p. 146, January, 1900. Type from Calovevora, Veragua, Panama.

The tayra is the largest and most powerful Middle American member of the family. In its several forms it ranges uninterruptedly from South America north to southern Mexico. The Panama race was based on a female from Calovevora which Thomas (*l. c.*) regarded as a smaller animal than *T. b. senex* of Mexico. Comparison of fully adult males, however, seems to indicate that the reverse is true. *T. b. biologiæ* differs otherwise from *T. b. senex* in the brownish instead of grayish head and neck. An adult male from Chunchumayo, Peru, assumed to represent *T. b. peruana* Tschudi seems to differ from *T. b. biologiæ* in the lighter color of the head and neck and somewhat smaller skull with noticeably smaller teeth.

A fine male, without a breast spot, obtained at Gatun, was shot one day as it slowly descended the trunk of a tree in the forest. No others were observed by me, but the species is not infrequently killed by hunters. I saw several skins taken by American hunters at Gatun who, for lack of a better vernacular name, referred to the animals as "black cats."

Under the specific name *Galictis barbara,* Alston (1879, p. 80) mentions specimens received by the Zoological Society of London from Panama. Bangs (1902, p. 49) in noting a specimen collected for him at Bugaba by W. W. Brown, Jr., says: "The black-headed Central American form is a very strongly marked subspecies." Anthony (1916, p. 372) lists specimens from Tacarcuna and Tapalisa, exhibiting considerable range of individual variation, especially in

[1] Three in collection Mus. Comp. Zool.; one in Amer. Mus. Nat. Hist.

the color of the head. He says: "Upon the one occasion when this animal was encountered by our party, I found it to be most interesting, it having marked resemblance in behavior to our northern weasels and martens. It was exceedingly curious and unafraid."

Specimens examined: Bugaba, 1[1]; Gatun, 1; Tacarcuna, 3[2]; Tapalisa, 3.[2]

Genus GRISON Oken. Grisons

The genus *Grison* includes a large, weasel-like animal, smaller, however, than *Tayra* and differing conspicuously in color. A broad white line extends across the forehead, over the ears and on to the sides of the neck; the limbs and the face to above the eyes are black; the back is mixed black and gray, producing a grizzled effect. The line across the forehead suggests the white facial markings commonly present in the weasels. The soles of the hind feet, unlike those of the weasels, are naked.

GRISON CANASTER (Nelson)

Yucatan Grison

Galictis canaster Nelson, Proc. Biol. Soc. Washington, Vol. 14, p. 129, August 9, 1901. Type from near Tunkas, Yucatan.

A grison was shot one night on or near the ground in the forest at 1,800 feet altitude near Cana. It was located by the glare of its eyes in the field of light projected from a hunting lamp, but the identity of the animal was not suspected until it was picked up. The example, a female, is provisionally referred to *G. canaster*, the type of which is now in the collection of the Biological Survey. It closely resembles *G. canaster* except that the dark element of the pelage is nearly pure black instead of dark brown; but the type of *G. canaster* was mounted and probably exposed to the light for several years during which time it may have faded. In comparing the skull of this female specimen with that of the type of *G. canaster*, a male, differences noted in the size of the teeth are those usually found when Mustelidæ of opposite sexes are examined. A specimen in the National Museum from Talamanca, Costa Rica, agrees closely in all essential respects with the one from Panama and may be referred to the same form. While the Middle American specimens may conditionally be assigned to *G. canaster* of Yucatan, the relationship of that form to typical *G. allamandi* Bell and to *G. crassidens* Nehring[3] of Brazil is some-

[1] Collection Mus. Comp. Zool.

[2] Collection Amer. Mus. Nat. Hist.

[3] For discussion of these forms see Nehring, Sitzungsber. der Gesellsch. naturforsch. Freunde zu Berlin, pp. 209-216, Nov. 19, 1901.

what problematical owing to the absence of adequate material for comparison. The Middle American animal is much grayer above than *G. allamandi,* as shown in the figure accompanying the description,[1] and the white of the frontal region passes rather gradually into the grayish color of the top of the head, there being no sharp line of demarcation as indicated in the figure of *G. allamandi*

Specimens examined: Cana, 1.

Genus CONEPATUS Gray. Skunks

In this genus of skunk the snout is very long, projecting well beyond the lower jaw, with a large naked pad on the upper side. The claws of the front feet are long and stout and the soles of the hind feet are naked to the heels. The tail is rather short. The skunks of the genus *Conepatus* are by their structure better fitted for rooting in the ground than are the members of the more boreal genera *Mephitis* and *Spilogale.*

Subgenus MARPUTIUS Gray

CONEPATUS TROPICALIS TRICHURUS Thomas

Panama Skunk

Conepatus tropicalis trichurus Thomas, Ann. Mag. Nat. Hist., Ser. 7, Vol. 15, p. 585, June, 1905. Type from Boquete, Chiriqui, Panama (altitude 4,000 feet).

The Panama skunk is described as apparently similar to *Conepatus tropicalis tropicalis* of Mexico, but with a decidedly longer tail, the black element of which is restricted to a shorter area at the base. The white dorsal stripes are also represented as shorter. The fur of the back is coarse, sparse, not very long and "less mixed with wool-hairs than in *C. mapurito*" of South America.

The species was based on five specimens from western Panama and Costa Rica, of which the type was collected by H. J. Watson on the Volcan de Chiriqui.

Two specimens collected by W. W. Brown, Jr., at Boquete were recorded by Bangs (1902, p. 48) as *Conepatus mapurito.* Under the same name Allen (1904, p. 72) noted an example taken by J. H. Batty at Boqueron.

No skunks were met with by me in the Darien region of eastern Panama, but native hunters reported their rare occurrence in the vicinity of Cana.

Specimens examined: Boqueron, 1[2]; Boquete (type locality), 2.[3]

[1] Trans. Zool. Soc. Lond., Vol. 2, pp. 204-205, pl. 35, 1837. (Also described in Proc. Zool. Soc. Lond., 1837, pp. 47-49.)

[2] Collection Amer. Mus. Nat. Hist.

[3] Collection Mus. Comp. Zool.

Subfamily LUTRINAE. Otters

Genus LUTRA Brisson. Otters

The otter is aquatic in habits and differs conspicuously in appearance from all the other mammals of the region. The body is elongated and supple and the limbs are short as usual in the family; the ears are very short, the tail is rather long, tapering, and somewhat flattened. The otter is much prized for its beautiful fur. Unlike the forms of the more northern *L. canadensis* group the otters of Middle America have the nose pad haired to near the upper border of the nostrils; the soles of the feet are entirely naked; the tufts of hair under the toes and the granular tubercles present on the soles of the hind feet in *L. canadensis* are absent.

LUTRA REPANDA Goldman

Panama Otter; Nutria

[Plate 35, figs. 1, 1*a*]

Lutra repanda GOLDMAN, Smiths. Misc. Coll., Vol. 63, No. 5, p. 3, March 14, 1914. Type from Cana, eastern Panama (altitude 2,000 feet).

The otters inhabiting the general region as far west at least as the Canal Zone and from sea level to 2,000 feet altitude or higher belong to a rather small species much more closely allied to *L. colombiana* of Colombia than to the other known Middle American forms. It apparently differs from *L. colombiana* in a number of cranial details, the rostrum and interorbital space being narrower; the lachrymal eminence more prominent, projecting as a distinct process on the anterior border of the orbit; the jugal less expanded vertically; the palate reaching farther posteriorly beyond the molars; the upper carnassial narrower, with the inner lobe less produced posteriorly, leaving a gap which is absent in the type of *L. colombiana;* the upper molar narrower, with the posteroexternal cusp set inward giving the crown a less evenly rectangular outline. Contrasted with that of *L. latidens* of Nicaragua, the skull is very much smaller and the two appear to be specifically distinct.

The specimens secured were brought to me by hunters who reported seeing them in small streams where they were shot during the day. According to the natives otters occur rather sparingly along small streams throughout the region. Near the mouth of the Chagres River they live along the banks of creeks up which the tide runs for some distance.

Under the name *Lutra felina,* Alston (1879, p. 86) records the otter as received through M. Boucard from Panama. Anthony

(1916, p. 372) in listing specimens from Tapalisa says: "I shot one near the junction of the Rio Tapalisa and the Rio Tacarcuna, but the wounded animal was lost in the rapid stream. Indian hunters brought in two." The animal is known as *nutria* to natives of the Canal Zone.

Specimens examined: Cana, 1; Gatun, 1; Tapalisa, 2.[1]

Family FELIDAE. Cats

The cats of the region under review are comprised in two genera; the genus *Felis,* which is well represented by the jaguar, the puma, the ocelot, and the long-tailed spotted cat; and the genus *Herpailurus* including only the yagouaroundi.

Genus FELIS Linnaeus. Cats

The cats assigned to the genus *Felis* vary considerably in size and color. The jaguar, the ocelot, and the long-tailed spotted cat are recognizable by their profusely spotted color pattern; the puma is fairly familiar as a big plain colored animal.

FELIS ONCA CENTRALIS Mearns

Central American Jaguar; Tigre

Felis centralis Mearns, Proc. Biol. Soc. Washington, Vol. 14, p. 139, August 9, 1901. Type from Talamanca, Costa Rica.

The jaguar, the largest of American cats, ranges from far south in South America north through the tropical parts of Middle America and occasionally reaches the southern United States. Several forms, apparently geographic races assignable to a single species, have been described, but their exact relationships are imperfectly known. *F. o. centralis* seems to be a comparatively small subspecies.

No specimens were obtained by me, but tracks probably of this subspecies were seen along the forested banks of the Rio Tuyra a few miles above Real de Santa Maria. Anthony (1916, p. 371) records a specimen killed by an Indian hunter at Boca de Cupe. The jaguar is well known as "tigre" to native hunters and is said by them to occur here and there throughout the region, favoring districts where deer and peccaries are abundant. Imperfect skins from indefinite localities were seen in the market in the city of Panama. Black individuals, doubtless melanistic examples, are to be found occasionally in the Darien region. They are supposed by some to be a distinct species known as "tigre negro."

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[1] Collection Amer. Mus. Nat. Hist.

While the jaguar is large and powerful enough to be very dangerous, I was unable to learn of an authentic case of an unprovoked attack on man. When surrounded it is said to fight stubbornly and sometimes kills dogs used in the chase. But even when harried by hounds it prefers to keep moving, seeking to escape to the densest parts of the forest. In order to avoid dogs the jaguar may climb into trees where it is easily approached and shot. At Chepo I learned that wandering jaguars periodically kill cattle ranging on the savannas between that point and the city of Panama.

The occurrence of the species in the Canal Zone was noted by Maack (1874, p. 171) who in the course of his extended journey saw one only, near the railway between Buenavista and Bohio. He says: "I came to within about twelve paces of it, but as soon as the animal saw me it ran away. It seems that these larger cats (referring in part to the ocelot) are very shy and cowardly, and prefer the most concealed life in the very middle of the forests."

Specimens examined: Boca de Cupe, 1.[1]

FELIS PARDALIS MEARNSI Allen

Mearns' Ocelot; Manigordo; Tigre Chico

Felis mearnsi ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 71, February 29, 1904. (Substitute for *F. costaricensis* Mearns, which is preoccupied by *F. bangsi costaricensis* Merriam.) Type from Talamanca, Costa Rica. (Probably from near Sipurio in the valley of the Rio Sicsola.)

The ocelot is the most abundant of the spotted cats of Middle America. *F. p. mearnsi* is a large southern form of the *F. pardalis* group easily distinguished from the jaguar by much smaller size and the presence of about four parallel black stripes on the nape and oblique stripes near the shoulders. In the jaguar these areas are black spotted instead of striped. While the two animals are widely different in size large ocelot skins represented to be those of the jaguar are sometimes sold at high prices to unsuspecting purchasers who may by noting the above markings avoid deception. The ocelot of Panama closely resembles the long-tailed spotted cat of the same region in profusely spotted and striped coloration, but is a much larger more robust animal with a shorter tail; the tail of the ocelot measures about 350 millimeters while that of the long-tailed spotted cat as represented by the type is 440 millimeters in length.

Several ocelots were seen during the day resting among the branches of trees. When approached they usually tried to escape by climbing slowly and stealthily out of sight, but when discovery

[1] Collection Amer. Mus. Nat. Hist.

became certain they ran down the trunks of the trees to the ground and, unless killed by a quick shot, promptly disappeared in the forest. On several occasions while hunting in the forest I had glimpses of ocelots crossing small openings among the trees, but none were encountered while using a hunting lamp at night.

Bangs (1902, p. 48) records the collection of a fine adult male at 4,000 feet altitude near Boquete by W. W. Brown, Jr. Under the name *Felis mearnsi,* proposed as a substitute for *Felis costaricensis* Mearns (which proved to be preoccupied by *F. bangsi costaricensis* Merriam for the puma), Allen (1904, p. 71) notes a specimen obtained by J. H. Batty at Boqueron. Anthony (1916, p. 371) lists a specimen from Real de Santa Maria.

Native names for the ocelot in the Canal Zone are "manigordo" and "tigre chico," the former also used in Costa Rica for the same animal and meaning literally thick paws, in allusion to its large feet.

Specimens examined: Boqueron, 1[1]; Boquete, 1[2]; Gatun, 3; Mount Pirre, 1; Punta de Peña (near Bocas del Toro), 1; Real de Santa Maria, 1.[1]

FELIS PIRRENSIS Goldman

Panama Long-tailed Spotted Cat

[Plate 36, figs. 1, 1*a*]

Felis pirrensis GOLDMAN, Smiths. Misc. Coll., Vol. 63, No. 5, p. 4, March 14, 1914. Type from Cana, eastern Panama (altitude 2,000 feet).

This species closely resembles the ocelot in heavily spotted and striped coloration, but differs in more slender form and longer tail; the tail of the type measures 440 millimeters in length (nearly 100 millimeters more than is usual in the ocelot).

In the original description I provisionally referred this animal to the little-known *F. pardinoides* group, with the remark that "in size it seems nearer to the *F. wiedii* group, but it lacks the reversed pelage of nape commonly ascribed to that group." I have since become convinced that the direction taken by the pelage of the nape is apt to be untrustworthy as a distinctive character; the animal is more probably a large member of the *F. wiedii* group which is represented farther north in Middle America by *F. glaucula,* a smaller, grayer colored animal. It is to this group of spotted cats that the name *Felis tigrina* seems to have been applied by writers on the cats of Middle America, a name which in the light of present knowledge

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

scarcely seems entitled to a place in our faunal lists. Although inhabiting the same region as the ocelots, the spotted cats of this group are rather rare as evinced by the small number of specimens that have found their way into collections.

The specimen on which the species is based was brought to me by a hunter who shot it in the forest near Cana. It had been disemboweled and the hunter reported finding its stomach well filled with undigested pieces of a large opossum, *Didelphis marsupialis etensis.*

Specimens examined: Cana, 1 (type).

FELIS BANGSI COSTARICENSIS Merriam

Central American Puma; León

Felis bangsi costaricensis MERRIAM, Proc. Washington Acad. Sci., Vol. 3, p. 596, December 11, 1901. Type from Boquete, Chiriqui, Panama.

Among American cats the pumas or mountain lions are second only to the jaguars in point of size. They are easily distinguished by large size, and the absence of body markings, except in very young individuals.

A number of forms have been described, but their relationships are little known. Collectively they range from southern Patagonia to southern Canada and ascend from sea level to the upper slopes of high mountains. While the forms vary considerably in general size and cranial details, no two appear to inhabit the same area and many facts point to the probability that all are geographic races of *Felis concolor* Linnæus. The animal has figured prominently in stories of adventure in many regions, but is much less dangerous than is commonly believed. Some popular misconception in regard to it is due to the various vernacular names, such as puma, cougar, panther and mountain lion which are supposed by many to apply to distinct species which may occur at the same localities. Throughout Middle America the animal is generally known to the natives as "león."

The Central American puma is characterized by rather small size and rich reddish coloration. It occurs here and there throughout Panama, but is rarely seen. On the stock ranges of the savanna region near the Pacific coast horses and calves are said to be attacked and killed by pumas, but such incidents are apparently of rare occurrence. Like the jaguar the puma is said to follow the deer and peccaries and is most likely to be found in localities where these animals are abundant.

The type of *F. b. costaricensis* was collected by W. W. Brown, Jr., for Outram Bangs at 4,000 feet altitude near Boquete on the southern slope of the Volcan de Chiriqui. An example from the bank of the Bayano River, 10 miles above the mouth of the Mamoní River, was shot by H. B. Johnson of the Canal Zone police, who reported finding it crouched on the ground and in the act of stalking a deer. The specimen is similar to the type in rich reddish color. A skin without skull obtained by J. H. Batty at Boquete is recorded by Allen (1904, p. 70), who says of it: "This specimen agrees with Dr. Merriam's description of the type, from Boquete. The sides are bright reddish; the median dorsal region is much darker—or dark reddish chestnut—as is also the dorsal area of the tail; the tail darkens apically, so that the apical half is decidedly blackish, the tip being wholly black for the terminal two inches. The inguinal region is pure white, a small pectoral area whitish, and the intervening region is like the flanks but much paler. Fur between toe pads black; ears almost wholly black, the usual lighter areas being brownish black and the rest deep black."

Specimens examined: Bayano River, 1; Boqueron, 1[1]; Boquete, 1.[2]

Genus HERPAILURUS Severtzow

The single species referable to this genus, commonly accorded subgeneric rank only, is a small, slender, long-tailed cat, with variable but unspotted coloration, ranging from Paraguay northward through the warmer parts of middle America to southern Texas. Generic distinction seems well shown in the skull. Contrasted with *Felis* the more differential characters are the elongation and lateral compression of the cranium, accompanied by the greater elevation of the rostrum in combination with the relatively short canines, the height of the latter being less than that of the anterior nares. Unlike normal *Felis* the outer instead of the inner side of the upper sectorial is longest owing to the suppressed or vestigial condition of the protocone. The foramen ovale is placed well behind the level of the glenoid cavity, a position unusual among cats, and apparently associated with the elongation of the braincase.

HERPAILURUS YAGOUAROUNDI PANAMENSIS (Allen)

Yagouaroundi; Panama Gray and Red Cat

Felis panamensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 71, February 29, 1904. Type from Boqueron, Chiriqui, Panama.

Herpailurus yagouaroundi seems to be a dichromatic species presenting gray and red color phases of varying tone. *H. y. panamensis* is a dark geographic race of which the only known specimens are

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zoöl.

in the grayish phase, the dark brown or black and the buffy gray elements of the pelage being finely mixed and producing a grizzled effect; but individuals of the less common reddish phase may be expected to occur in the region.

A specimen obtained in the forest near Cana was shot by one of my assistants who found it in a tree. Alfaro[1] states that in Costa Rica this animal is called "león miquero" because of its fondness for travelling over the branches of large forest trees. Alston (1879, p. 63) states that "M. Boucard has received the Yaguarundi from Veragua."

Specimens examined: Boqueron, 1[2] (type); Cana, 1; Empire, 1; Lion Hill, 1.[3]

Order INSECTIVORA. Insectivores

Family SORICIDAE. Shrews

The shrews are small mouse-like creatures, distinguished externally by short, dense, very dark colored fur, long, pointed noses, tiny feet, and in our southern groups, inconspicuous ears. In America the family reaches its greatest development in more northerly latitudes and a single genus is known from Panama.

Subfamily SORICINAE. Shrews

Genus CRYPTOTIS Pomel. Shrews

The shrews of this genus inhabit mainly the mountains of middle America, but at least one species ranges at low elevations in the southern United States and several have been described from northwestern South America. The single species found in Panama is perhaps the smallest four-footed mammal of the region. The skull is low and flat, without zygomata or audital bullae; the teeth are 30 in number.

CRYPTOTIS MERUS Goldman

Mount Pirre Shrew

[Plate 37, figs. 1, 1*a*]

Cryptotis merus Goldman, Smiths. Misc. Coll., Vol. 60, No. 2, p. 17, September 20, 1912. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 4,500 feet).

The discovery of this small black shrew close to the Colombian frontier materially extends the known range of the *Cryptotis mexi-*

[1] Mamiferos de Costa Rica, 1897, p. 17.
[2] Collection Amer. Mus. Nat. Hist.
[3] Collection Mus. Comp. Zool.

cana group eastward from Costa Rica. The group is represented in Costa Rica by *C. orophila* Allen, which differs from *C. merus* in somewhat larger size, decidedly larger claws, paler color, and in cranial details. No shrews are known from western Panama, but one or more species doubtless inhabit the Volcan de Chiriqui.

Three specimens of the present species were trapped under logs on steep banks at from 4,500 to 5,000 feet altitude near the headwaters of the Rio Limon. The banks of streams in this vicinity are very wet and heavily overgrown with ferns.

Specimens examined: Three, from the type locality.

Order CHIROPTERA. Bats

Family EMBALLONURIDAE. Sac-winged Bats; White Bats

The bats of this family are slender species, with large interfemoral membrane perforated by the tail which appears on the upper surface a short distance from the edge. The limbs are very slender, the forearm strongly curved. Most of the genera have glandular sacs or recesses in the antebrachial membranes. These sacs are well developed and conspicuous in the males, but are more rudimentary and inconspicuous in the females and for this sex do not, therefore, always furnish satisfactory distinguishing characters. Some of the genera are marked by two parallel whitish dorsal stripes; others are plain, dark colored, and the genus *Diclidurus* is white. The postorbital processes are long and curved, except in the genus *Diclidurus*, in which they are very short and straight. There is no nose leaf.

Subfamily EMBALLONURINAE

Genus RHYNCHISCUS Miller

The genus *Rhynchiscus* includes diminutive, butterfly-like bats with remarkably long, projecting noses. As in the genus *Saccopteryx* there are whitish dorsal stripes, but unlike the other genera of the subfamily inhabiting the region, there are no wing sacs. Perhaps the most readily distinctive characters are the haired tibia and tufts of grayish fur placed at intervals along the outer side of the forearm. The teeth are 32 in number. A single known species ranges from Brazil to Mexico.

RHYNCHISCUS NASO PRISCUS G. M. Allen

Mexican Long-nosed Bat

Rhynchiscus naso priscus G. M. Allen, Proc. Biol. Soc. Washington, Vol. 27, p. 109, July 10, 1914. Type from Xcopen, Quintana Roo, Mexico.

The Mexican long-nosed bat is a small species (forearm about 38.5) with two whitish stripes extending along the back much as in the species of *Saccopteryx*. It is smaller than the latter, however, and easily distinguished by the buffy gray instead of glossy brown general color, and the characters given for the genus.

FIG. 1.—Rhynchiscus naso priscus.
No. 179843, U. S. Nat. Mus. About nat. size.

Specimens from Panama are apparently somewhat intermediate in characters, but referable to this recently described subspecies, which differs from typical *R. naso* of Brazil most notably in the form of the anterior upper premolar.

A colony of 13 individuals was found suspended from the under side of a concrete bridge on the Panama Railroad about half a mile north of Corozal. They occupied a strongly lighted space about two feet in diameter, and were conspicuous against the light-colored background of masonry. Ten specimens, now in the Field Museum of Natural History, were collected at Lagartera on the Rio Trinidad by Dr. S. E. Meek.

Specimens examined: Corozal, 13; Lagartera, 10.

Genus SACCOPTERYX Illiger

The sac-winged bats usually encountered belong to this genus. Whitish dorsal stripes are present as in *Rhynchiscus,* but the tibia and forearm are naked instead of clothed with grayish tufts of fur as in that genus. Glandular sacs are conspicuous in the wings of the males, but are less easily detected in those of the females. The genus is similar to *Centronycteris,* but more robust in general structure and the skull differs in the greater lateral expansion of the lower border of the orbit, which overhangs and hides the toothrow when viewed from above. The ears are moderately long, narrow and pointed. The teeth are 32 in number. Two species of the genus range in Panama.

SACCOPTERYX BILINEATA BILINEATA (Temminck)

Greater White-lined Bat

Urocryptus bilineatus TEMMINCK, Vander Hoeven's Tijdsch. Natuurlij. Gesch., Vol. 5, p. 33, pl. 2, figs. 3-4, 1838-1839. Type from Surinam, Dutch Guiana.

Like the still smaller species *Saccopteryx leptura,* which it very closely resembles, this small bat has two white longitudinal stripes near the center of the back. It is not unlike *Rhynchiscus naso* in the arrangement of the stripes, but is larger (forearm about 47.5 mm.) and the general color glossy brown or black instead of buffy gray. The males possess a well-developed glandular sac in the antebrachial membrane near the inner side of the forearm; in the females this sac may be difficult to find. Specimens from Panama appear to represent typical *S. bilineata* and differ in larger size from examples of *S. b. centralis* from Mexico. This difference seems most noticeable in the skulls.

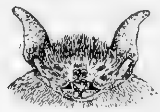

FIG. 2.—Saccopteryx bilineata bilineata.
No. 179849, U. S. Nat. Mus. About nat. size.

Near Gatun a colony of 15 of these bats was found in the space between the projecting buttresses on the trunk of a large tree in the forest. They were clinging to the bark about 10 feet from the ground and in plain view. At Tabernilla half a dozen were located in the open smokestack of an old French dredge which had beeen abandoned and was lying in second growth forest near the railroad. They were irregularly distributed over the smooth inner surface and hanging motionless with their muzzles somewhat elevated or pointing outward, beyond the plane of their backs. Bats of this species were discovered under shelter of the high arch of the natural bridge over the Rio del Puente, a few miles north of Alhajuela. Here they were grouped in dark recesses from which they were dislodged by shooting. A specimen picked up from the ground where it had fallen with the others proved to be *Peropteryx canina.* A few greater white-lined bats were also obtained from crevices in a small well-lighted cave in the cliff forming the coast line a short distance west of the entrance to the Panama Canal at Balboa. Clinging in or near the same crevices in the cave walls were a few *Hemiderma p. aztecum* and *Glossophaga soricina leachii.*

On Taboga Island August Busck met with *S. b. bilineata* clinging to sun-exposed rocks at the entrance to a cave. None were found beyond the entrance. Anthony (1916, p. 373) records a specimen taken by W. B. Richardson at Cituro.

Specimens examined: Alhajuela, 2; Balboa, 1; Cana, 1; Cerro Azul, 1; Cituro, 1 [1]; Gatun, 5; Rio del Puente (natural bridge north of Alhajuela), 6; Tabernilla, 1; Taboga Island, 10.

[1] Collection Amer. Mus. Nat. Hist.

SACCOPTERYX LEPTURA (Schreber)

Lesser White-lined Bat

Vespertilio lepturus SCHREBER, Saugethiere, Vol. 1, p. 173, pl. 57, 1774. Type from Surinam.

The lesser white-lined bat closely approaches *Saccopteryx bilineata* in general appearance, the glossy dark brown or blackish color and two white dorsal lines being about the same. It is a distinct species, however, differing in decidedly smaller size (forearm about 42.3 millimeters).

Two of these bats shot as they circled at dusk over the bank of the Chagres River at Alhajuela, January 29, 1912, were the only examples secured. This South American species has not previously been recorded from Middle America.

Specimens examined: Alhajuela, 2.

Genus PEROPTERYX Peters

In general structure this genus is similar to *Saccopteryx,* but the skull exhibits a much more inflated and generally rotund condition of the rostrum, the back lacks dorsal stripes and the wing sacs are smaller and advanced to near the anterior border of the antebrachial membranes. The teeth are 32 in number. A single species is known.

PEROPTERYX CANINA CANINA (Wied)

Dog-like Bat

Vespertilio caninus WIED, Schinz's Theirreich, Vol. 1, p. 179, 1821. Type from east coast of Brazil.

There is nothing especially dog-like about this bat as the name "canina" might be taken to indicate. It is a small species much like those of the genus *Saccopteryx* in external appearance except that, as indicated under the genus, the dorsal lines present in the latter are absent.

One was picked up from the ground where it had fallen along with a small number of *Saccopteryx bilineata* that were dislodged by shooting into dark recesses under the high arch of the natural bridge over the Rio del Puente, a few miles north of Alhajuela. Ten specimens in the Field Museum of Natural History were collected at Balboa by Messrs. Osgood and Anderson. This bat, originally described from Brazil and ranging to southern Mexico, is one of the few species that apparently maintain the same characters throughout this wide interval and on the continent show no tendency toward subspecific division. A subspecies, *Peropteryx canina phæa,* G. M. Allen, has been described from the Lesser Antilles.

Specimens examined: Balboa, 10; Gatun, 1; Rio del Puente, 1.

Genus CENTRONYCTERIS Gray

Similar to *Saccopteryx,* but more slender in general structure. Skull with the lower border of the orbit so slightly projecting that the toothrow is visible from above, instead of hidden as in *Saccopteryx.* The teeth are 32 in number. The genus, mainly South American in distribution, is represented in Panama by a single species.

CENTRONYCTERIS CENTRALIS Thomas

Thomas' Bat

Centronycteris centralis THOMAS, Ann. Mag. Nat. Hist., Ser. 8, Vol. 10, p. 638, December, 1912. Type from Bugaba, Chiriqui, Panama (altitude 800 feet).

The only record of this bat is the description of the type, and only known specimen, which was collected in western Panama, at the locality given above, by H. J. Watson.

The species is " Nearly allied to *C. maximiliani,* but slightly larger, colour rather darker, and basi-sphenoid pits of skull markedly shorter.

" Fur long and loose; hairs of back about 6.5 mm. in length. General colour above dark tawny brown, that of a Para example of *C. maximiliani* somewhat paler. Basal third of interfemoral well clothed with long hairs." The forearm measurement given is 45 millimeters. The species is said to be mainly distinguishable from *C. maximiliani* by the much shorter basi-sphenoid pits which do not extend forward between the pterygoids as in *C. maximiliani* of South America.

Subfamily DICLIDURINAE

Genus DICLIDURUS Wied

The species of the genus *Diclidurus* are white, a color very unusual among bats. The ears, unlike those of other genera of the family known to occur in Panama, are short and rounded. The skull presents remarkable features, the braincase, flattened anteriorly, descending abruptly to the rostrum which is very broad and depressed, with elevated lateral margins. There is no wing sac. The teeth are 32 in number.

DICLIDURUS VIRGO Thomas

Costa Rican White Bat

Diclidurus virgo THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 11, p. 377, April, 1903. Type from Escazu, Costa Rica.

The Costa Rican white bat was not met with by me, but in the original account of the species Mr. Oldfield Thomas records specimens from "Pueblo Nuevo, N. W. Panama," and from Boquete, Chiriqui.

The color of the upper parts, described as pure white or gray-mixed, should render this species conspicuous among the bats of the general region. The length of the forearm is 66 millimeters. The species is said to agree in general character with *Diclidurus albus* of Brazil, but has differently shaped incisors and premolars.

Family NOCTILIONIDAE. Bull Dog Bats

The bats of this family are rather large, with narrow, sharp-pointed ears which, when laid forward, reach about to the end of the nose. The short tail protrudes from the upper side of the inter-femoral membrane. The pelage is short and on the lower part of the back confined to the median portion. There is no nose leaf. The upper canine teeth curve widely apart and project conspicuously over the lower jaws. The elongated middle pair of upper incisors are in contact near the middle, but diverge leaving a deep emargination between their conical points. The outer pair of upper incisors are very short, barely reaching the cingulum of the inner pair behind which they are partially hidden. Two genera are recognized, the typical one, *Noctilio,* including a large, long-legged, ochraceous-tawny species not yet recorded from Panama, although it probably occurs there. This species is noted for its alleged fish-eating habits. The family is represented on the Isthmus by the genus *Dirias*.

Genus DIRIAS Miller

The genus *Dirias* is very similar to *Noctilio* in general structure, but differs considerably in appearance owing to smaller size, dark coloration and relatively short legs. The skull closely resembles that of *Noctilio,* but the teeth are more delicate in sculpture and differ in detail. The upper molars are more closely crowded; instead of forming prominent cusps with distinct commissures the hypocones of the first and second are shelf-like, with trenchant lateral margins connecting with ridges extending upward to protocone and metastyle. The teeth are 28 in number.

DIRIAS ALBIVENTER MINOR (Osgood)

Little Bull Dog Bat

Noctilio minor Osgood, Field Mus. Nat. Hist., Publ. 149, zool. ser., Vol. 10, p. 30, October 20, 1910. Type from Encontrados, Zulia, Venezuela.

A Panama specimen of this bat is a very dark shade of brown, or near bone brown (Ridgway, 1912) above, with a faint grayish median stripe down the posterior part of the back; the underparts are whitish. It is a robust animal with large feet, and narrow ears tapering to slender points. The fur is short. The forearm measures about 60 millimeters.

The form was known only from Venezuela until recorded from Empire, Panama, by E. W. Nelson (1912, p. 93). The record was based on an individual shot flying across an old pineapple field near Culebra Cut just at dusk, February 2, 1912. Several others appeared at the same time and all had doubtless just come from some hiding

Fig. 3.—Dirias albiventer minor.
No. 179848, U. S. Nat. Mus. About nat. size.

place in the vicinity. They flew with rapid wing strokes, passing at a height of about 30 feet from the ground and so near that the erect ears were noted. Another example secured flew into my quarters at Empire during the evening of February 16, 1912. The two individuals secured have been compared with the type and another example from Venezuela and found to agree essentially with them. A dry skin is darker than the Venezuela specimens, but in all probability merely represents a darker color phase.

Specimens examined: Empire, 2.

Family PHYLLOSTOMIDAE. Leaf-nosed Bats

By far the greater number of American bats are comprised in this rather heterogeneous family under which a number of subfamilies are recognized. The family includes the largest of American bats, but the range in size is extraordinary, some of the species being very small. The members are usually distinguishable by the presence of "nose leaves" or naked cutaneous folds which rise prominently over the nostrils, but in the *Chilonycterinæ* these are absent. The ears, moderately developed in most genera, are variable in form, but usually rather narrow and tending to be pointed; in certain members of the family, as *Vampyrus* and *Lonchorina,* however, they are greatly elongated. The tail is also variable in length, but except in such examples as *Macrophyllum, Lonchorina,* and *Chilonycteris* does not extend far into the interfemoral membrane; in various genera no external tail is discernible and its absence may be associated with a deep emargination of the posterior border of the interfemoral membrane. Among structural details distinguishing the family are the presence of three completely ossified phalanges in the third finger and the entire premaxilla. The molar teeth are well developed, but exhibit wide diversity of form in the various subfamily divisions.

Subfamily CHILONYCTERINAE

Genus CHILONYCTERIS Gray

Unlike most members of the family, Phyllostomidæ, the genus *Chilonycteris* lacks a nose leaf and the well-developed tail projects through and overlaps the upper surface of the interfemoral membrane. The ears are long with pointed tips directed slightly backward. The braincase is subglobose, owing largely to the very narrow interorbital constriction. The rostrum is depressed above near base, and somewhat upturned anteriorly, the nasal opening circular and directed forward. The teeth are 34 in number.

CHILONYCTERIS RUBIGINOSA RUBIGINOSA Wagner

Dark Brown Bat

Chilonycteris rubiginosa WAGNER, Weigmann's Arch. f. Naturg., IX, Vol. 1, p. 367. Type from Caiçara, Matto Grosso, Brazil.

In general color this bat is dark brown, or warm sepia (Ridgway, 1912). The pelage is rather long and directed forward over the

FIG. 4.—Chilonycteris rubiginosa rubiginosa.
No. 179754, U. S. Nat. Mus. About nat. size.

head from a hair-whorl on the back of the neck. The face is well haired and elongated tufts project from the sides of the muzzle. The forearm measures about 62 millimeters. Typical *Chilonycteris rubiginosa* is replaced in southern Mexico by the smaller form, *C. r. mexicana*.

Specimens collected by August Busck in the Chilibrillo caves, near Alhajuela, in April or May, 1911, have been recorded by G. S. Miller, Jr. (1912, p. 23); examples from the same place are recorded by

Anthony (1916, p. 373). A few were found by me January 30, 1912, in one of the larger caves of the same series in which Mr. Busck and Mr. Anthony obtained their specimens. They were located near the entrance and seemed rather shy and quick to leave cavities near the roof in which they were resting. Twenty-three were shot, along with a large number of *Hemiderma perspicillatum aztecum,* in a French diversion tunnel near Bas Obispo, January 27, 1912. Here they left the high-vaulted roof and began flying back and forth, in company with the more abundant species, as soon as my boat entered the dimly lighted tunnel which was driven through a hill to turn aside the flow of a small river.

Specimens examined: Bas Obispo, 23; Rio Chilibrillo (Chilibrillo caves), 25[1]; Vijia, 2.

Subfamily PHYLLOSTOMINAE

Genus MICRONYCTERIS Gray

The members of the genus *Micronycteris* are small, slenderly formed bats with very large, thin, papery interfemoral membrane. The thin delicate ears are variable in size and are connected by a concealed band across the forehead. The long pelage of upperparts is rusty brownish in color, becoming white basally; rather long hairs cover the lower inner sides and conspicuously fringe the anterior margins of the ears. Similar in structure and external appearance to *Macrophyllum,* but hind limbs shorter; interfemoral membrane similarly extensive, but perforated by the short tail for about half its expanse instead of to near the posterior border as in *Macrophyllum;* color rusty instead of dark brownish; nose leaf prominent, but much narrower than in *Macrophyllum.* Skull much more slender than that of *Macrophyllum,* the anterior nares opening upward as well as forward close behind the base of the incisors. Dentition much as in *Macrophyllum,* but premolars all well developed. The teeth are 34 in number.

MICRONYCTERIS MICROTIS Miller

Nicaraguan Small-eared Bat

Micronycteris microtis Miller, Proc. Acad. Nat. Sci., Philadelphia, p. 328, July 27, 1898. Type from Greytown, Nicaragua.

The ears of this bat can be regarded as small only when contrasted with those of its large-eared congener *Micronycteris megalotis.* The species is rusty brown in general color. The ears when laid forward

[1] Six in collection Amer. Mus. Nat. Hist.

reach just beyond the muzzle. The forearm measures about 32 millimeters.

The small number of specimens of *Micronycteris* available from Panama are referred to this form, whose exact relationship to the larger-eared but otherwise similar form *M. megalotis* of South America and *M. m. mexicana* of Mexico is not very clear. The ears in these specimens are short but rather variable in width and

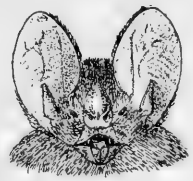

FIG. 5.—Micronycteris microtis.
No. 198338, U. S. Nat. Mus. About nat. size.

the skulls, with one exception, are about like those of *M. megalotis* and *M. m. mexicana*. A single individual, apparently like the others externally, has a skull so small that I doubtfully refer it to the same species. This aberrant specimen was collected by R. E. B. McKenney at Bocas del Toro, whence additional material is, therefore, especially desirable.

M. microtis ranges in Panama from sea level well up on the slopes of the mountains. An example was taken at Boquete on the southern slope of the Volcan de Chiriqui by W. R. Maxon. In a note accompanying specimens from Pinogana, at sea level in the Darien region, H. Pittier says: "A fire was made at the base of a hollow tree showing signs of being inhabited. Unfortunately all the bats fell in the fire, so that only two could be saved."

Specimens examined: Bocas del Toro, 1; Boquete, 1; Pinogana, 2.

Genus LONCHORINA Tomes

The very long nose leaf and large ears are among the external characters distinctive of the genus *Lonchorina*. The elongated posterior limbs, and tail reaching posterior border of large interfemoral membrane, approximate the arrangement of these parts in *Macrophyllum*. The skull and teeth, however, somewhat suggest those of *Chilonycteris* with differential details. The interorbital region is deeply depressed on the median line, the nasals, curving upward and over anteriorly, project above the nasal opening; the molars are similar to those of *Chilonycteris* in general sculpture, the anterior upper premolars are more reduced in size, and the median lower premolars are relatively small as in that genus. The teeth are 34 in number.

LONCHORINA AURITA Tomes

Tomes' Long-eared Bat

Lonchorina aurita TOMES, Proc. Zool. Soc. London, 1863, p. 83. Type from West Indies.

The distinguishing characters of the species have been given under the genus. The forearm measures about 53 millimeters.

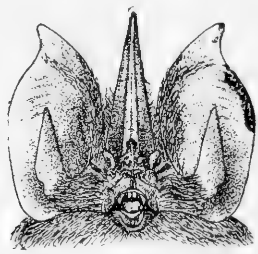

FIG. 6.—Lonchorina aurita.
No. 174904, U. S. Nat. Mus. About nat. size.

Mr. Miller (1912, p. 23) has published detailed measurements of two adults, a male and a female, collected in the Chilibrillo cave, near Alhajuela, by August Busck, April 14, 1911. Mr. Busck obtained five additional specimens at the same locality in March, 1912. The species is mainly West Indian in known distribution and has not been recorded from elsewhere in Middle America.

Specimens examined: Rio Chilibrillo (Chilibrillo cave near Alhajuela), 7.

Genus TONATIA Gray

In general external characters *Tonatia* is similar to *Micronycteris*, but the single species known to occur in Panama is decidedly larger (forearm about 53 mm.) than the regional representative of the latter genus (forearm about 32 mm.). The skull is more massive in general structure, but has a narrower palate and more constricted interorbital region than *Micronycteris*. More important differential characters are exhibited by the teeth. The upper canines are relatively larger and nearly in contact with the median incisors, thus forcing the outer incisors out of line; the large lower canines meet behind the incisors, which are reduced to two in number; the median lower premolar is obsolescent, its crown reaching about the level of the anterior premolar, instead of being a well-developed functional tooth as in *Micronycteris*. The teeth are 32 in number.

TONATIA AMBLYOTIS (Wagner)

Round-eared Bat

Phyllostoma amblyotis Wagner, Wiegmann's Archiv. f. Naturg., p. 365, 1843. Type from Matto Grosso, Brazil.

Characters distinguishing the round-eared bat from the other species of the region are given under the genus. The forearm measures about 53 millimeters.

The only record I have of its occurrence in Panama, or any part of Middle America, is that of Thomas (1902*a*, p. 54) based on specimens collected at Bugaba, Chiriqui, by H. J. Watson. The species is said to be rare.

Genus MACROPHYLLUM Gray

The unusual elongation of the hind limbs and corresponding posterior extension of the interfemoral membrane inclosing the long tail to border, together with the large nose leaf and slender general form externally distinguish this monotypic genus. The skull is short with high, anteriorly arched braincase and very short, broad rostrum. The nasal opening is directed forward from a point far back leaving a shelf-like projection of the jaw between the opening and the base of the incisors. The dentition is similar to that of *Micronycteris,* but the anterior upper premolar is very small and the middle lower premolar notably minute, crowded inward out of line and nearly hidden by the other premolars. The reduced condition of these teeth is probably associated with the general shortness of the skull. The upper incisors completely fill the space between the canines, the middle pair being much larger than the outer, with somewhat oblique cutting edges. The teeth are 34 in number.

MACROPHYLLUM MACROPHYLLUM (Wied)

Long-legged Bat

Phyllostoma macrophyllum Wied, Beitr. zur Naturg. Brasilien, Vol. 2, 1826, p. 188. Type from Mucuri River, Minas Geræs, Brazil.

Features distinctive of this rare bat have been given under the genus. The forearm measures about 38 mm. The only record of the occurrence of the species in Panama or any part of Middle America is that recently published by E. W. Nelson (1912, p. 93), based on specimens taken by me in the ruins of old Panama about five miles east of the modern city. Accompanied by W. H. Osgood I visited the ruins February 7, 1912. On entering a vaulted cellar behind one of the principal ruins along the beach path a short distance west of the old church tower we found ourselves in the midst of a large colony of *Hemiderma perspicillatum aztecum* and a smaller colony of *Glossophaga soricina leachii,* many individuals of the mingled species fluttering close about our heads. Among a few specimens of the common species knocked down we discovered a *Macrophyllum* and immediately began searching the flying swarm

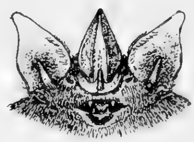

FIG. 7.—Macrophyllum macrophyllum.
No. 179724, U. S. Nat. Mus. About nat. size.

about us for others. We soon learned to distinguish the rare species from the common ones by the long hind limbs and corresponding posterior extension of the interfemoral membrane. Six specimens, altogether, were secured, three of which are in the U. S. National Museum and the others, collected by Mr. Osgood, are in the Field Museum of Natural History. No material from the type region of the species is available for comparison, but the specimens agree closely with the published descriptions and are assumed to represent the monotypic genus.

Specimens examined: Old Panama, 6.

Genus PHYLLOSTOMUS Lacépède

The distinguishing features of the members of this genus are the large robust form, well-developed nose leaf, rather small, narrow, pointed ears, short tail and large interfemoral membrane combined with short, massive skull and the possession of two lower incisors and two lower premolars on each side. There are no facial stripes. The skull in general angularity, especially the prominent sagittal crest and outstanding paroccipital processes suggests that of *Vampyrus,* but the much shorter rostrum exceeds the interorbital area in width, the teeth differ notably in structure and the lower premolars in number. The teeth are 32 in number.

PHYLLOSTOMUS HASTATUS PANAMENSIS Allen

Panama Spear-nosed Bat

Phyllostomus hastatus panamensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 233, June 29, 1904. Type from Boqueron, Chiriqui, Panama.

With the exception of the false vampire (*Vampyrus spectrum*) this is the largest American bat. The forearm measures about 90 millimeters. It is a robust animal, very dark brown or blackish brown in color above, except a lighter brown area across the shoulders. A gland on the under side of the neck is conspicuous in the males, but rudimentary in the females.

FIG. 8.—Phyllostomus nastatus panamensis. No. 179732, U. S. Nat. Mus. About nat. size.

The Panama race apparently differs from *Phyllostomus hastatus hastatus*[1] of Trinidad and eastern Venezuela in larger size. Specimens from Panama and as far north as Patuca, Honduras, are, however, equalled by examples from the Amazon and from southern Brazil.[2]

Common, at least at low elevations, throughout Panama. In one of the Chilibrillo caves, near Alhajuela, I found thousands suspended from various parts of the vaulted roof in the total darkness of the principal chamber. More than 100 were seen in a single spot over which they were so densely massed that their bodies seemed to be touching. There was much loud squeaking, but I was allowed to approach to within 12 or 15 feet when they vacated the place almost in a body. In flying through the resounding passages of the cave the noise of their wings resembled the thunderous roar of a heavy

[1] Type region fixed as Surinam by Allen, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 233-234, June 29, 1904.

[2] *Phyllostomus hastatus caucæ* Allen measures about the same and seems otherwise indistinguishable from *P. h. panamensis* which was given page priority when the two were published.

waterfall when heard at a distance. The cave contained several tons of guano, mainly the product of this species. Several smaller colonies of these bats were encountered in neighboring caves.

An aggregation of perhaps 100 of the same species was located in a small cave on the rocky sea shore a short distance west of the Pacific entrance to the Panama Canal at Balboa. Here the bats were clinging in clusters in dimly lighted cavities from which, when dislodged by shooting, some fell into the sea. One of the latter, bobbing about in the rough water, was only partially disabled as I learned when, on reaching for it from a boat, a canine tooth was instantly driven through the middle of the nail of my index finger. In other parts of the same cave were a few *Hemiderma perspicillatum aztecum* and *Glossophaga soricina leachii.*

The original description of the Panama form by Dr. Allen (*l. c.*) was based on six specimens from Boqueron, western Panama. Under the name *Phyllostomus hastatus* Mr. Miller (1912) has published detailed measurements of an adult male collected at Cabina by August Busck. Anthony (1916, p. 373) records examples from Boca de Cupe, Capeti, Real de Santa Maria and Rio Chilibrillo. Mr. Alston (1879, p. 42) has shown how this species has shared with *Vampyrus spectrum* the false accusation of being a blood sucker, the real culprits being the true vampires, *Desmodus* and other genera.

Specimens examined: Balboa, 20; Boca de Cupe, 4[1]; Boqueron, 6[1]; Cabima, 1; Capeti, 4[1]; Panama (city), 1; Real de Santa Maria, 8[1]; Rio Chilibrillo (Chilibrillo cave, near Alhajuela), 42.[2]

Genus TRACHOPS Gray

In the genus *Trachops* the lips and chin are conspicuously studded with conical or cylindrical wart-like protuberances, which distinguish it at a glance. The short tail projects from the large interfemoral membrane. The skull in general form is somewhat similar to that of *Vampyrus,* but less angular. The median lower premolars are very small and crowded inward out of line much as in *Macrophyllum.* The teeth are 34 in number.

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[1] Collection Amer. Mus. Nat. Hist.

[2] Nine in collection Amer. Mus. Nat. Hist.

TRACHOPS CIRRHOSUS (Spix)

Fringe-lipped Bat

Vampyrus cirrhosus SPIX, Simiar. et Vespert. Brasil, 1823, p. 64, pl. 36, fig. 3. Type from Brazil.

The fringe-lipped bat is large, dark-colored, and has large ears. The peculiar condition of the lips and chin have been described under the genus. The forearm measures about 62.5 millimeters.

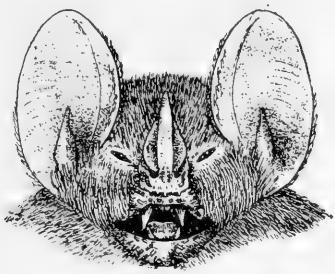

FIG. 9.—Trachops cirrhosus.
No. 174884, U. S. Nat. Mus. About nat. size.

A specimen of this species was taken by August Busck in the Chilibrillo cave near Alhajuela, in March, 1912.

Specimens examined: Rio Chilibrillo (Chilibrillo cave), 1.

Genus VAMPYRUS Leach

Very large general size, the forearm over 100 millimeters or four and one-fourth inches long and wing expanse about 760 millimeters or two and one-half feet, alone distinguishes the genus *Vampyrus* among American bats. The ears are long, relatively narrow and round-pointed, and the interfemoral membrane is large, but there is no external tail. In the form of the braincase the skull closely resembles that of *Phyllostomus,* but the sagittal crest is much higher and projects farther posteriorly; the rostrum and mandible are much longer; the latter affording space for an additional premolar; the nasal opening is slightly extended backward by a V-shaped emargination. Dental peculiarities are numerous, including the deep emargination of the lateral borders of the first and second upper molars, owing to displacement inward or greatly reduced size of mesostyle. The teeth are 34 in number.

VAMPYRUS SPECTRUM NELSONI Goldman

Nelson's False Vampire Bat

Vampyrus spectrum nelsoni GOLDMAN, Proc. Biol. Soc. Washington, Vol. 30, p. 115, May 23, 1917. Type from Coatzacoalcos, Vera Cruz, Mexico.

Nelson's false vampire, the largest North American bat, differs from the typical form of South America in somewhat smaller size and cranial details, especially the reduction of the hypocone of the posterior upper premolar. It is reddish-brown in color.

The general range of the species is from the Amazonian region northward through Middle America to southern Mexico. In Middle America it seems to be much less abundant than farther south, or at

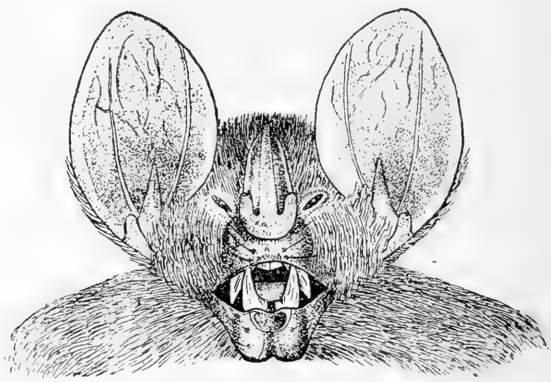

FIG. 10.—Vampyrus spectrum nelsoni.
No. 78127, U. S. Nat. Mus. About nat. size.

least few examples from that region have found their way into museum collections. A very large bat that I saw one evening in rather slow butterfly-like flight along the bank of the Chagres at Alhajuela I took to be of this species, but throughout the period covered by my work in Panama I was unsuccessful in securing specimens. Alston (1879, p. 39) notes the species collected in Panama by McLeannan, probably at some point along the line of the Panama railroad. More recently (Allen, 1904, p. 78) has recorded a pair taken by J. H. Batty at Boqueron in western Panama.

This bat, now known to be harmless, was formerly believed to be a bloodsucker, and the unfortunate name attached to it, together with its large size and repugnant general appearance, have doubtless fostered this misconception of its real character. The true vampires belong to the genera *Desmodus, Diphylla* and *Diaemus* which constitute a separate family, the *Desmodontidæ*. The false vampire is so little known in Middle America that the observations of Bates,[1] made at Ega on the upper Amazon many years ago seem worth quoting. He says: "The vampire was here by far the most abundant of the family of leaf-nosed bats. . . . . Nothing in animal physiognomy can be more hideous than the countenance of this creature when viewed from the front; the large leathery ears standing out from the sides and top of the head, the erect spear-shaped appendage on the tip of the nose, the grin and the glistening black eye all combining to make up a figure that reminds one of some mocking imp of fable. No wonder that imaginative people have inferred diabolical instincts on the part of so ugly an animal. The vampire, however, is the most harmless of all bats, and its inoffensive character is well known to residents on the banks of the Amazon." He found that the church at Ega was the headquarters of these bats and adds: "I used to see them, as I sat at my door during the short evening twilights, trooping forth by scores from a large open window at the back of the altar, twittering cheerfully as they sped off to the borders of the forest. They sometimes enter houses; the first time I saw one in my chamber, wheeling heavily round and round, I mistook it for a pigeon, thinking that a tame one had escaped from the premises of one of my neighbors. I opened the stomachs of several of these bats, and found them to contain a mass of pulp and seeds of fruits, mingled with a few remains of insects." The insects were species of Coleoptera.

Specimens examined: Boqueron, 2.[2]

Subfamily GLOSSOPHAGINAE

Genus GLOSSOPHAGA Geoffroy

The genus *Glossophaga* typifies the subfamily *Glossophaginæ* which includes six other genera, mainly tropical in distribution. The members of the group are small bats characterized externally by elongated muzzle, small nose leaf, short, rounded ears, notched lower lip, and short tail protruding slightly from the upper side of the moderately developed interfemoral membrane. In external appearance *Glossophaga* bears a striking resemblance to *Lonchophylla*, a member of the same subfamily, and accurate determinations must be based on the examination of skulls. The skull is shorter than in *Lonchophylla*, and differs most notably in the possession of complete zygomata. The median upper incisors are about as wide as high, and

[1] The Naturalist on the River Amazons, Vol. 2, pp. 332-333, 1863.

[2] Collection Amer. Mus. Nat. Hist.

project less prominently forward than in *Lonchophylla*. The teeth are 34 in number.

GLOSSOPHAGA SORICINA LEACHII (Gray)

Leach's Long-tongued Bat

Monophyllus leachii GRAY, Voyage of the *Sulphur*, Zool., Vol. 1, p. 18, 1844. Type from Realejo, Nicaragua.

As may be inferred from the remarks on the genus, Leach's long-tongued bat closely resembles species of *Lonchophylla*. It most closely approaches *Lonchophylla concava* in appearance, the dark brown color and proportions being nearly identical, but the ears are slightly more rounded, the forearm slightly longer and the lower, less protruding upper incisors also aid in its determination. The length of the forearm is about 35 millimeters.

In point of numbers *Glossophaga soricina leachii* seems to be exceeded in Panama only by *Hemiderma perspicillatum aztecum*. It passes the day in similar situations, often resting in close proximity to the latter species in tunnels, caves, or other darkened places, but smaller colonies seem to be the rule.

FIG. 11.—Glossophaga soricina leachii.
No. 179871, U. S. Nat. Mus. About nat. size.

At Corozal a few were located in a partly dark tunnel roofed with smooth concrete. The tunnel received daylight at both ends and the bats could be clearly seen by looking toward the light. They were irregularly distributed, one only in a place, clinging by their claws to the edges of roughened spots in the concrete, some with their bodies swinging free from the middle of the roof, but most of them on the side walls or in corners, their stomachs lying against the concrete and their nose leaves standing out rather conspicuously at right angles. All were females and several carried a small young attached to a teat. The same tunnel was inhabited by *Hemiderma p. aztecum*.

In a half-dark cellar behind a prominent ruin a short distance west of the cathedral tower at the old city of Panama, W. H. Osgood and I found these bats very near neighbors of *Hemiderma p. aztecum* and the exceedingly rare species *Macrophyllum macrophyllum*. They were clinging singly in the vicinity of massed clusters of the *Hemiderma*. We were allowed to approach quite near, the bats watching us suspiciously, their frequent squeaks and quivering ears showing their alertness. One was seen to extend its long tongue the full length and then retract it much as a dog does when stretching.

Small colonies were located in two shallow caves along the rocky coast a short distance west of the Pacific entrance to the Panama Canal. In these caves scattered individuals were hanging along crevices in half-lighted places. One cave was shared with *Phyllostomus hastatus panamensis* and *Hemiderma p. aztecum*, the other with the *Hemiderma* and *Saccopteryx bilineata*. Others were clinging to the roof of a limestone cave on the mountain side several miles below the Darien gold mines at Cana. In other parts of the same cave were colonies of *Hemiderma p. aztecum, Hemiderma castaneum, Lonchophylla robusta, Lonchophylla concava* and *Desmodus rotundus murinus*.

At Bohio a few of these bats were suspended from the vaulted roof of the old French powder house. At Porto Bello several individuals were located in a dark corner of an old Spanish fort.

As *Glossophaga soricina*, 13 specimens from Boqueron, collected by J. H. Batty, have been recorded by Allen (1904, p. 78). Under the same name, Bangs (1902, p. 50) listed a specimen collected by W. W. Brown, Jr., at Bugaba. Thomas (1903*a*, p. 39) in recording examples from small islands off the coast of western Panama, lists the following localities: Gobernador, Insolita, Jicaron, Palenque, Brava, Parida, Boqueron (island), and Cebaco.

In a recent revision of the genus, Miller (1913*a*, p. 419) lists specimens examined from the following localities in Panama: Balboa, Canal Zone, Colon, and Paraiso.

The feeding habits of this bat are little known, but are probably similar to those of a Glossophagine species, of Jamaica, which were described in considerable detail by W. Osburn [1] many years ago. His interesting account well illustrates the manner of using the very long protractile tongue in licking away the juice and pulp of soft fruits.

Specimens examined: Agua Clara, 1; Ancon, 1; Balboa, 3; Bohio, 3; Boqueron, 32 [2]; Bugaba, 1 [3]; Cana, 1; Colon, 3; Corozal, 24; Empire, 1; Old Panama, 16; Panama (city), 37 [1]; Paraiso, 44; Porto Bello, 1; San Pablo, 12; Vigia, 1.

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[1] Proc. Zool. Soc. Lond., 1865, pp. 81-85.

[2] Collection Amer. Mus. Nat. Hist.

[3] Collection Mus. Comp. Zool.

Genus LONCHOPHYLLA Thomas

The striking external resemblance of *Lonchophylla* to *Glossophaga* has been pointed out in remarks on that genus. The skull is longer and easily distinguishable from that of *Glossophaga,* by the incomplete zygomatic arch, and the differing form of the incisors, the upper median pair being relatively narrower, higher and more projecting forward, and the lower series having trifid cutting edges. The teeth are 34 in number. Two species inhabit the region under review.

LONCHOPHYLLA ROBUSTA Miller

Rusty Long-tongued Bat

[Plate 37, figs. 5, 5*a*]

Lonchophylla robusta MILLER, Proc. U. S. Nat. Mus., Vol. 42, No. 1882, p. 23, March 6, 1912. Type from cave on Chilibrillo River, Panama.

The rusty color and large size distinguish *Lonchophylla robusta* from the other Glossophagine bats known to inhabit Panama. The forearm measures about 45 millimeters.

FIG. 12.—Lonchophylla robusta.
No. 179847, U. S. Nat. Mus. About nat. size.

The species was first collected by August Busck in a cave on the Chilibrillo River near Alhajuela, in 1911. In the following year specimens were obtained by me in a limestone cave at about 2,000 feet altitude on the slope of the Pirre Mountains near Cana. The same cave was inhabited by *Lonchophylla concava, Glossophaga soricina leachii, Hemiderma perspicillatum aztecum, Hemiderma castaneum* and *Desmodus rotundus murinus.*

Lonchophylla robusta approaches the much smaller species *L. mordax* Thomas in the more important cranial and dental details and departs widely from its large congener *L. hesperia* G. M. Allen. No close comparison with *L. concava,* the only other species of the genus known to occur in Panama, is necessary.

Specimens examined: Cana, 6; Chilibrillo River (Chilibrillo cave near Alhajuela), 4 (including type).

LONCHOPHYLLA CONCAVA Goldman

Panama Long-tongued Bat

[Plate 37, figs. 5, 5a]

Lonchophylla concava GOLDMAN, Smiths. Misc. Coll., Vol. 63, No. 5, p. 2, March 14, 1914. Type from Cana, eastern Panama (altitude 2,000 feet).

In size, color and general external appearance *Lonchophylla concava* very closely resembles *Glossophaga soricina leachii* and examination of the skull is necessary to determine it with certainty. The ears are more pointed, however, and the longer more protruding upper incisors may distinguish it from the *Glossophaga* in specimens with the skulls in place. The forearm of the type measures 33.9 millimeters.

A single specimen of this species was obtained in a limestone cave at about 2,000 feet altitude on the slope of the Pirre Mountains near Cana. The cave was also inhabited by *Lonchophylla robusta, Glossophaga soricina leachii, Hemiderma perspicillatum aztecum, Hemiderma castaneum,* and *Desmodus robustus murinus.* Owing to the remarkable resemblance to *Glossophaga s. leachii* the specimen was at first referred to that species.

In the general form of the skull *L. concava* closely approaches *L. mordax* Thomas, the type species of the genus, and exhibits a corresponding departure from *L. hesperia* G. M. Allen in which the skull is relatively much narrower and more elongated. The greater attenuation of the rostrum in *L. hesperia* leaves the third upper molar implanted well in front of the maxillary processes of the zygoma as in the genus *Chœronycteris,* instead of in the same horizontal plane with these processes as in *L. mordax.* On the other hand *L. concava* approaches *L. hesperia* in the narrowness of the second upper premolar, the conspicuous inner lobe present in *L. mordax* being reduced to a slight swelling bearing a small cusp. The aberrant character of *L. hesperia* has been pointed out by Miller (1912, p. 24) who remarks: "The animal is so different from the other known forms of *Lonchophylla* that it can hardly be regarded as a member of the same genus." Although widely different from *L. hesperia, L. concava* combines characters which tend to bridge the gap between that species and the more typical forms of the genus.

Specimens examined: One, the type.

Subfamily HEMIDERMINAE

Genus HEMIDERMA Gervais

The bats of this genus are small or medium-sized species with small nose leaves, rather short, somewhat pointed ears and tails reaching to about the middle of the naked, moderately developed interfemoral membrane. The forearm is distinctly furred along outer side near base. No facial stripes are present. The skull is massive, with short rostrum and moderately developed sagittal crest; in the incomplete zygomatic arches it resembles that of *Lonchophylla,* but differs widely in other respects. The teeth are 32 in number.

HEMIDERMA PERSPICILLATUM AZTECUM (Saussure)

Short-tailed Bat

Carollia azteca Saussure, Rev. et Mag. Zool., Ser. 2, Vol. 12, pl. 20, fig. 1, p. 480, 1860. Type from southern Mexico.

The short-tailed bat is robust, medium sized, and has rather large feet. It varies from dark brown to rusty in color. The forearm measures about 42 millimeters. A much rarer species, *Hemiderma castaneum,* sometimes inhabiting the same places, is distinguished by smaller size, the forearm being about 5 millimeters shorter.

Fig. 13.—Hemiderma perspicillatum aztecum
No. 179811, U. S. Nat. Mus. About nat. size.

Hemiderma p. aztecum is the bat most frequently met with in Panama. Numbers may be found resting during the day in almost any dark sheltered places, such as caves, tunnels, or the darkened corners of old buildings.

Near Bas Obispo a colony of several thousand short-tailed bats was located in a tunnel driven by the French for the diversion of a small river. Here they hung in massed clusters from hollowed places in the rock roof about 15 feet above the water. Near the entrances to the same tunnel were smaller numbers of *Chilonycteris rubiginosa.*

At Corozal these bats were associated with *Glossophaga soricina leachii* in a half-dark concrete tunnel roofed squarely over. They were attached to roughened places in the concrete, their bodies in contact with the wall, and their heads turned partly outward.

Following directions given me by Col. D. D. Gailliard, and accompanied by W. H. Osgood, I visited the ruins of old Panama in quest of bats February 7, 1912. We entered a vaulted cellar behind high walls overgrown with wild fig trees near the beach path a short distance west of the old cathedral tower and found a large colony of *H. p. aztecum* suspended in masses from the ceiling. These bats shared the cellar with a smaller colony of *Glossophaga s. leachii* and a few individuals of *Macrophyllum macrophyllum*, which on being disturbed became mingled and fluttered close about us squeaking incessantly. When we remained quiet a few minutes many of the bats resumed their resting places, quietly attaching themselves only a few feet away. The short-tailed bats clung with heads twisting about, watchful eyes upon us, and ears trembling or turning nervously this way and that.

Another large colony was located in an old powder house on the bank of the Cascajal River about five miles above Porto Bello. Here the bats hung in apparently solid clusters from the ceiling of a half-darkened room.

At Bohio a few were detected clinging heads downward in half-darkness along the ridge pole of an abandoned palm-thatched house. When the door was opened and more light admitted they worked their way along the pole by short shuffling steps, into a darker corner where several disappeared in a crevice.

In the Chilibrillo caves near Alhajuela, whence a specimen has been recorded by Miller (1912, p. 25), a few were found by me roosting in the total darkness of the same large interior chamber occupied by a huge colony of *Phyllostomus hastatus panamensis*, but they were restricted to shallow cavities in the lower side walls while the *Phyllostomus* was massed on the walls and roof above them. Anthony (1916, p. 374), however, lists this form as the "most abundant bat of the caves." Besides the Rio Chilibrillo specimen he records specimens from El Real, Tacarcuna and Tapalisa.

These bats were clustered in shallow crevices of two small caves in the bluff forming the coast line a short distance west of the Pacific entrance to the Panama Canal at Balboa. One of these caves was also inhabited by *Phyllostomus h. panamensis* and *Glossophaga s. leachii*, and the other by *Glossophaga s. leachii* and *Saccopteryx bilineata*.

My quarters in an old French building at Empire were shared with these bats, numbers of which seemed to come tumbling out of crevices in the upper story just at dusk every evening. Near the same locality a few spent the day attached so that their bodies hung free in a rather well-lighted place under a railroad bridge.

They are common in most of the caves and old tunnels in the vicinity of the Darien gold mines at Cana; a limestone cave close to the railroad line several miles below the mines contains hundreds during the day, and is also inhabited by *Desmodus rotundus murinus, Glossophaga soricina leachii, Lonchophylla robusta, Lonchophylla concava* and *Hemiderma castaneum.*

Specimens collected by W. W. Brown, Jr., on San Miguel Island and at Bugaba, Chiriqui, have been recorded by Bangs (1901, p. 644, 1902, p. 50) who remarks that the series of 13 specimens from the latter locality "presents a wide range in the color of the upper parts, varying from hair-brown to russet, with every intermediate shade." Seventeen specimens obtained at Boqueron by J. H. Batty are listed by Allen (1904, p. 78). Examples taken by the same collector are recorded by Thomas (1903*a*, p. 39) from the following small islands off the south coast of western Panama; Sevilla, Jicaron, Gobernador, Brava, Insolita, and Cebaco. Hahn (1907) in his revision of the genus, published records of specimens examined by him from Panama (city), Boqueron, and Colon. Seven examples from Panama (city), as shown by Hahn (1907, p. 112) had been erroneously assigned by Bangs (1906, p. 213) to *Hemiderma castaneum.*

Specimens examined: Balboa, 1; Bas Obispo, 12; Boqueron, 3[1]; Bugaba, 13[2]; Cana, 23; Corozal, 13; Empire, 8; Old Panama, 20; Panama (city), 9[2]; Porto Bello, 6; Real de Santa Maria, 1[1]; Rio Chilibrillo (Chilibrillo cave, near Alhajuela), 10[3]; Rio Trinidad (Agua Clara), 4; Rio Indio, 1; San Miguel Island, 1; Tacarcuna, 4[1]; Tapalisa, 1.[1]

HEMIDERMA CASTANEUM (H. Allen)

Chestnut Short-tailed Bat

Carollia castanea H. Allen, Proc. Amer. Philos. Soc., Vol. 18, p. 19, February 25, 1890. Type from Costa Rica.

The chestnut short-tailed bat resembles *Hemiderma perspicillatum aztecum* very closely, but is distinguished by smaller size, the forearm measuring about 37 millimeters instead of about 42 millimeters, as in the latter species. The difference in size seems still more apparent when skulls of the two species are compared. The smaller *Hemiderma* is rare while the larger is probably the most abundant bat throughout the region under consideration.

In a limestone cave at about 1,500 feet altitude on the mountain side near Cana two of these bats were knocked down along with numerous examples of *Hemiderma p. aztecum.* Although they occu-

[1] Collection Amer. Mus. Nat. Hist.
[2] Collection Mus. Comp. Zool.
[3] Five in collection Amer. Mus. Nat. Hist.

pied the same cave and are indistinguishable from the latter species in color their specific distinctness seems clear. They agree with the type from Costa Rica in decidedly smaller size, as compared with *H. p. aztecum.* Others were found inhabiting the tunnel of an old mine at 2,000 feet near Cana.

Under the name *Hemiderma castaneum* seven specimens collected by W. W. Brown, Jr., at Calidonia, near Panama, were recorded by Bangs (1906, p. 213). Hahn (1907, p. 112), in reviewing the group, has shown that these specimens were erroneously identified; they are referred by him to *H. p. aztecum.* The type of *H. castaneum* has, therefore, remained unique until the present time.

Specimens examined: Cana, 4.

Subfamily STURNIRINAE

Genus STURNIRA Gray

Owing to peculiar and highly specialized tooth structure the genus *Sturnira* has been placed in a separate subfamily. Externally it is not very unlike some of the other Phyllostomidæ, one of the best distinguishing characters being the conspicuous tufts of stiff yellowish or rusty reddish hairs present in males near the front of the shoulder. There are no facial stripes. The nose leaf is small and the ears short and pointed. There is no external tail and the calcar is very small. The interfemoral membrane is reduced to a narrow fringe densely furred to the margin. The toes are haired to the base of the claws. In general form the skull resembles those of *Vampyressa* and *Vampyrops,* but the dentition is widely different. A cranial feature shared with *Vampyressa* is the extension of the nasal opening backward at the expense of the nasals. The teeth are 32 in number.

STURNIRA LILIUM PARVIDENS Goldman

Northern Yellow-shouldered Bat

Sturnira lilium parvidens GOLDMAN, Proc. Biol. Soc. Washington, Vol. 30, p. 116, May 23, 1917. Type from Papayo (about 25 miles northwest of Acapulco), Guerrero, Mexico.

The distinguishing characters of the yellow-shouldered bat in Panama are the same as those of the genus. The dark tips of the pelage give the back a dark brown tone, but the under color of the fur is gray. The forearm measures about 44 millimeters.

This bat has been accorded a range as a species from Paraguay, where it was observed by Azara, north to Mexico. It is one of the rarer ones in collections, and the only record from Panama is that of

Fig. 14.—Sturnira lilium parvidens.
No. 8209, U. S. Nat. Mus. About nat. size.

Bangs (1902, p. 51) of a single specimen taken at 7,500 feet on the Volcan de Chiriqui by W. W. Brown, Jr. The specimen exhibits the narrow braincase and molars characterizing the northern subspecies.

Specimens examined: Volcan de Chiriqui, 1.[1]

Subfamily STENODERMINAE

Genus URODERMA Peters

In general appearance, including the arrangement of the white facial and dorsal stripes, *Uroderma* much resembles *Vampyrops, Vampyrodes* and *Chiroderma*. In these genera a pair of white stripes extend upward from the sides of the nose leaf to the inner base of the ears; another pair less distinct reaches from the corners of the mouth toward the ears, and a median dorsal line is usually prominent. But the single species of *Uroderma* may be distinguished by the naked or minutely haired posterior margin of the interfemoral membrane in combination with the length of the forearm (about 45 millimeters). The skull is very similar in general to that of *Vampyrops,* but is easily recognizable by the bifid upper incisors. The teeth are 32 in number.

URODERMA BILOBATUM

Yellow-eared Bat

Uroderma bilobatum Peters, Monatsber. k. Preuss. Akad. Wissensch. Berlin, p. 587, 1866. Type from São Paulo, Brazil.

Uroderma convexum Lyon, Proc. Biol. Soc. Washington, Vol. 15, p. 83, April 25, 1902. Type from Colon, Panama.

In addition to and in combination with recognition characters given under the genus the yellowish color of the ear margins of

[1] Collection Mus. Comp. Zool.

Uroderma bilobatum, distinct in fresh specimens and fading in dry skins, might be mentioned. The species ranges from southern Brazil north at least to Costa Rica.

FIG. 15.—Uroderma bilobatum.
No. 153563, U. S. Nat. Mus. About nat. size.

In the forest near Gatun *Uroderma bilobatum* was located several times, a few in a place, clinging during the day in clusters to the midribs on the under sides of large palm leaves. They usually choose darkened spots where the leaf was folded over, or overhanging pinnæ shut out much of the light.

Andersen (1908, p. 220) in a revision of the genus places *Uroderma convexum* Lyon in synonymy. Comparisons made by me seem to justify this disposition of the name. Andersen records Panama specimens from Colon, Brava Island, Cebaco Island, Jicaron Island, Insolita Island, and Gobernador Island. With the exception of Colon the same localities for specimens in the British Museum had been listed by Thomas (1903*a,* p. 40), who also questioned the validity of *Uroderma convexum* Lyon.

A specimen erroneously referred by Bangs (1901, p. 644) to *Vampyrops helleri* was collected by W. W. Brown, Jr., on San Miguel Island. The same mistake in identification applies to specimens recorded by Bangs (1902, p. 50) from Bugaba, and by Allen (1904, p. 79) from Boqueron.

Anthony (1916, p. 373) records examples from Capeti, Chepigana and Real de Santa Maria.

Specimens examined: Boqueron, 6[1]; Bugaba, 6[2]; Capeti, 7[1]; Chepigana, 1[1]; Chorrera, 4[1]; Puente de Piña (near Bocas del Toro), 3; Rio Indio (near Gatun), 15; San Miguel Island, 1.[2]

Genus VAMPYROPS Peters

The approach in outward appearance of *Vampyrops* to *Uroderma* has been referred to in the treatment of that genus. *Vampyrops* is, however, easily separable from *Uroderma* by the densely furred

[1] Collection Amer. Mus. Nat. Hist.
[2] Collection Mus. Comp. Zool.

posterior border of the interfemoral membrane, and simple, oblique, instead of bifid, transverse cutting edge of upper incisors. The teeth are 32 in number.

VAMPYROPS HELLERI Peters

Heller's Bat

Vampyrops helleri PETERS, Monatsber. k. preuss. Akad. Wissensch. Berlin, 1866, p. 392. Type from Mexico.

Vampyrops zarhinus H. ALLEN, Proc. Acad. Nat. Sci. Philadelphia, 1891, p. 400. Type from Bas Obispo, Canal Zone.[1]

Heller's bat is little known and its status not entirely clear, no specimens from the type region being available for comparison. But the original account applies so well to the Panama animal that its identification seems certain. *Vampyrops zarhinus,* a name also applicable to the Isthmian species, is therefore placed in synonymy.

Heller's bat has white face stripes and a white median dorsal line arranged about as in *Vampyrodes, Chiroderma* and *Uroderma.* It may usually be distinguished from the Isthmian representatives of these genera, however, by smaller size. The forearm measures about 39 millimeters. The edges of the ears are distinctly yellowish in life, as in *Uroderma bilobatum,* which it approaches in size and general appearance, but the densely furred, instead of naked, border of the interfemoral membrane is distinctive.

The species as now understood ranges from southern Mexico at least as far south as Cana in eastern Panama, where a single specimen was obtained by me near the entrance to the tunnel of an old mine. Specimens from northern Venezuela are apparently indistinguishable from Panama examples and the species probably reaches Brazil. As *Vampyrops zarhinus,* Thomas (1903*a*, p. 40) listed a specimen from Sevilla Island, off the southern coast of western Panama where it was collected by J. H. Batty. In regard to the record Mr. Thomas in a recent letter says: "The specimen is certainly what I always look upon as *zarhinus,* but not having the type for comparison I cannot be absolutely sure I am right. The skull quite agrees with examples from Ecuador and Para." Among the bats collected in Panama by August Busck were two immature males of *Vampyrops helleri* from Cabima, of which forearm measurements, 39 and 39.6 millimeters, respectively, were published by Miller (1912, p. 25).

Specimens examined: Cabima, 2; Cana, 1.

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[1] The type specimen in the Museum of Comparative Zoology bears on the label "Obispo, Panama, Hassler Expedition, 1872," and the original assignment of the species to Brazil appears to have been an error.

Genus VAMPYRODES Thomas

The genus *Vampyrodes* is very similar to the genus *Vampyrops,* but has two instead of three molars in each upper jaw, the small last molar present in the latter genus being absent. A more important character, however, is the suppression of the metacone in the second upper molar. The genus *Vampyrodes* outwardly somewhat resembles the genera *Uroderma* and *Chiroderma,* but the differences in size of the Panama representatives of these genera suffice to separate them. The teeth are 30 in number.

VAMPYRODES MAJOR G. M. Allen

San Pablo Bat

Vampyrodes major G. M. Allen, Bull. Mus. Comp. Zool., Vol. 52, No. 3, p. 38, July, 1908. Type from San Pablo, Isthmus of Panama.

Vampyrodes major is a rather large bat with a pair of broad white face stripes extending from the nose backward, one on each side, over the eye to above the ear, and with a white line extending from the top of the head down the middle of the back. Another white mark extends from near the corner of the mouth to the ear. These stripes are shared with *Uroderma bilobatum* and *Vampyrops helleri,* but the greater forearm measurement, about 55.5 millimeters, is distinctive.

V. major is known in Panama only from the type locality, a place now covered by the waters of Gatun Lake. A specimen also in the Museum of Comparative Zoology was collected at Cerro Santa Maria, Costa Rica, by C. F. Underwood, January 5, 1908, and the species may be expected to occur anywhere in the general region.

Specimens examined: San Pablo, 1 (type).[1]

Genus VAMPYRESSA Thomas

The genus *Vampyressa* includes very small species with the white facial markings of *Artibeus;* it agrees further with that genus in the absence of a dorsal stripe, but the ears are shorter and more rounded. There is no external tail and the narrow interfemoral membrane is densely furred to the margin as in *Vampyrops.* The skull is similar in general contour to that of *Vampyrops,* but the molars are reduced to two on each side above and below. As in that genus the median upper incisors are separated by a distinct gap, but the cutting edge is bifid instead of smooth. The teeth are 28 in number.

[1] Collection Mus. Comp. Zool.

VAMPYRESSA MINUTA Miller

Little Yellow-eared Bat

[Plate 37, figs. 3, 3*a*]

Vampyressa minuta Miller, Proc. U. S. Nat. Mus., Vol. 42, No. 1882, p. 25, March 6, 1912. Type from Cabima, Panama.

This recently described species bears a rather close general resemblance to some of the small forms of *Artibeus*, but is smaller than any of them. The arrangement of white facial stripes is the same—a supraorbital pair reaching upward from the nose pad to the inner sides of the ears, and the cheek stripes extending from the angle of the mouth toward the ears. The short rounded ears have yellow margins. The forearm measures about 32 millimeters.

Vampyressa minuta is very closely allied to *Vampyressa thyone* Thomas. It apparently differs from that species only in rather slight cranial details as shown by comparison with an Ecuadorean specimen which has been determined as *V. thyone* by Thomas. The skull is slightly smaller, the difference in size being most noticeable in the braincase. The nasals are less developed anteriorly between the maxillae, the resulting gap or rounded excision constituting a distinct posterior extension of the anterior nares. The palate seems relatively narrower behind the posterior molars. The dentition is about the same.

The type was collected at Cabima by August Busck in May, 1911. The only other known specimen flew into my room at Cana where it was captured during the evening of June 6, 1912. The bright, yellow edges of the ears and tragus attracted my attention at once. This color, most intense on the lower part of the ears, was somewhat duller toward the tips. It is still shown in the dry skin, but is much less conspicuous than when fresh.

Specimens examined: Cabima, 1 (type); Cana, 1.

Genus CHIRODERMA Peters

The alliance of the genus *Chiroderma* seems to be most nearly with *Vampyrops* which it resembles in external markings; but the nose leaf is broader and the forearm and interfemoral membrane are more heavily furred than in that genus. The skull is similar to those of *Vampyrops* and *Vampyressa*, the dental formula being the same, but the teeth differ in detail. A striking contrast is presented, however, by the apparent absence of nasals, their excision foreshadowed in *Vampyressa* having progressed to the extreme degree. The teeth are 28 in number.

CHIRODERMA ISTHMICUM Miller

Isthmian Bat

[Plate 37, figs. 2, 2*a*]

Chiroderma isthmicum MILLER, Proc. U. S. Nat. Mus., Vol. 42, No. 1882, p. 25, March 6, 1912. Type from Cabima, Panama.

The Isthmian chiroderma is a rather small, brownish bat with the outer side of the forearm and the upper side of the interfemoral membrane well clothed with fur. A white dorsal stripe which is conspicuous in *Chiroderma salvini* seems to be indistinct or obsolete in this species. The forearm measures about 45 millimeters.

Chiroderma isthmicum was based on two specimens obtained by August Busck at Cabima. An individual flew into my room at Cana during the evening of May 21, 1912, and alighted on the wall where it was captured and one presented by Mr. George A. Brown was secured by him at Culebra.

Specimens examined: Cabima, 2 (including type); Cana, 1; Culebra, 1.

CHIRODERMA SALVINI Dobson

Salvin's Bat

Chiroderma salvini DOBSON, Catal. Chiropt. Brit. Mus., p. 532, 1878, pl. 29, fig. 3. Type from Costa Rica.

Salvin's bat is a handsome species, dark brown above, the face marked with white stripes, a pair of which extend from the outer edges of the nose leaf upward diverging gradually to near the inner sides of the ears. Another pair of short stripes reach backward, one on each side, from the angles of the mouth. A distinct white median dorsal stripe is also present. The forearm measures about 53 millimeters. Contrasted with *C. isthmicum* this bat is recognizable by larger size, and apparently by the conspicuous white facial and dorsal markings. The latter character may be unreliable, however, as it is known to be variable in some species of bats belonging to this general group.

A single individual was knocked down as it flew through a lighted corridor at the Darien gold mines at Cana, May 7, 1912. No others appear to have been taken in Panama, but the species was recorded from Colombia by Alston (1879, p. 207).

Specimens examined: Cana, 1.

Genus ARTIBEUS Leach

The genus *Artibeus* includes species varying in size from rather large to small, some of which range far north in Middle America. A pair of white facial stripes arising from the sides of the nose extend to near the inner base of the ears and a shorter lateral pair normally reach upward from near the corners of the mouth. In the possession of these markings and the absence of a dorsal stripe *Artibeus* agrees with *Vampyressa,* but the ears are more pointed and the disparity in size externally distinguishes the two genera. Moreover, the skulls differ rather widely in detail; the upper incisors are bifid in both genera, but while about as broad as high in *Artibeus* they are much higher than broad in *Vampyressa.* Some of the teeth are vestigial and may be absent in certain species, the number for the genus varying from 28 to 30 or 32.

ARTIBEUS WATSONI Thomas

Watson's Bat

Artibeus watsoni THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 7, p. 542, June, 1901. Type from Bugaba, Chiriqui, Panama.

Watson's bat may be distinguished from its Panama congeners by much smaller size and more distinct white facial stripes. The forearm measures about 40 millimeters. The edges of the ears are yellowish, much as in *Uroderma bilobatum* and *Vampyrops helleri.* The known range of the species is Panama and Nicaragua. Several similarly small and apparently not very distinctly related species inhabit northern South America.

At Gatun a single individual was found clinging to the under side of a banana leaf in an old field. The only other specimen obtained by me was knocked down near the entrance to the tunnel of an old mine at Cana.

Thomas (1903*a,* p. 40), the original describer of the species, recorded additional specimens from Sevilla and Cebaco, both small islands off the southern coast of western Panama. The same material was examined by Andersen (1908, p. 289) and listed in his monograph of the genus. Six specimens, collected by J. H. Batty at Boqueron, were recorded by Allen (1904, p. 79); six specimens from Chepigana are listed by Anthony (1916, p. 373).

Specimens examined: Boqueron, 6[1]; Cana, 1; Chepigana, 6[1]; Gatun, 1.

ARTIBEUS JAMAICENSIS JAMAICENSIS Leach

Jamaican Bat

Artibeus jamaicensis LEACH, Trans. Linn. Soc., Vol. 13, 1821, p. 75. Type from Jamaica.

The Jamaican bat is doubtless common at the lower elevations throughout Panama. It is a large robust species with rather indis-

[1] Collection Amer. Mus. Nat. Hist.

tinct whitish facial stripes of which a supraorbital pair usually extend from the nose pad to near the inner sides of the ears, and a pair, faintly indicated (or absent), reach from near the angle of the mouth toward the ears. The forearm measures about 62 millimeters. Examination of the skull is necessary in order to distinguish this bat with certainty from *Artibeus planirostris planirostris*. It lacks the tiny third upper molar present at the posterior end of the series in the latter form.

FIG. 16.—Artibeus jamaicensis jamaicensis.
No. 203082, U. S. Nat. Mus. About nat. size.

Dr. Knud Andersen (1908) in a revision of the genus states (p. 266) that "to prevent wrong identification it is important to emphasize that *Central America is inhabited by two races,* which ought not to be (but hitherto have always been) confused, viz., the smaller (truly indigenous) *A. j. jamaicensis* and the larger *A. j. palmarum* (an immigrant from south)." In similar language he reiterates (p. 278) that "in Central America and S. Mexico *A. j. palmarum* meets the considerably smaller *A. j. jamaicensis*. There is no doubt whatever that the latter race is the truly indigenous form in the region north of Panama, and that *A. j. palmarum* is a late intruder from the south into the same region." Dr. Andersen's positive assertions, made after a careful study of the group, should be given considerable weight; but since the forms as recognized by him appear to be characterized by average differences only, his interesting conclusions in regard to their geographic ranges seem open to serious question. The Middle American material recorded by him includes four specimens from Bugaba, Chiriqui, referred to *A. p. palmarum,* and a single example from Colon referred to *A. j. jamaicensis.*

Most of the specimens from Panama examined by me are indistinguishable from typical *A. j. jamaicensis,* having about the same general dimensions (forearm rarely reaching 65 millimeters) and degree of posterointernal emargination of the second upper molar, and the same dark color, including indistinct facial stripes. Although Bugaba examples are somewhat larger, I assign them, along with the others, to the typical form.

A colony, comprising 50 or more of these bats, was located in a shallow recess in the side of the high rock forming the center of the islet known as San José Rock in the Bay of Panama. W. H. Osgood and I visited the place together and obtained specimens, a part of which are now in the Field Museum of Natural History. The bats were suspended in crevices.

At Gatun several were caught in traps placed about a bunch of ripening bananas that had been left uncut in an old field, and to which the bats came to feed at night. At the same locality a single individual was found clinging within a curled fragment of dead banana leaf which still adhered to the plant at a point about six feet from the ground. The colors of the bat blended well with those of the leaf. Several were dislodged by firing into cavities in the arch of the natural bridge over the Rio del Puente a few miles north of Alhajuela, but one only was secured as a specimen.

A specimen obtained by W. W. Brown, Jr., at Bugaba, Chiriqui, was listed by Bangs (1902, p. 50) as *Artibeus intermedius.* Under the same name, Bangs (1906, p. 213) recorded an individual taken by the same collector at Calidonia (near Panama). The specimen from Bugaba, measuring 77 millimeters in length of forearm, was subsequently referred by G. M. Allen (1908, p. 42) to *Artibeus palmarum,* and Knud Andersen (*l. c.*) in the same year recorded material from the same locality as subspecies *palmarum.* Miller (1912, p. 26) assigned to *A. j. jamaicensis* three specimens collected by August Busck on Taboga Island.

An interesting and rather detailed account of the habits of this bat, as observed by W. Osburn in Jamaica, was published many years ago.[1] Osburn found them inhabiting caves in great numbers. While they sometimes lived in places from which the light was wholly excluded, they particularly haunted the entrances of caves, or caves of shallow depth, which led him to remark that " it certainly does not seem such a lover of darkness as the generality of the family." He also found them " clustering under the fronds of the cocoanut palm, so thickly and in such numbers that at a single shot I brought down twenty-two, while many flew off and took refuge in neighboring trees."

Specimens examined: Bugaba, 1 [2]; Boquete, 1 [2]; Calidonia, 1; Culebra, 1; Gatun, 6; Rio del Puente (natural bridge near Alhajuela), 1; San José Rock (Bay of Panama), 11; Taboga Island, 34.[3]

[1] Proc. Zool. Soc. London, 1865, pp. 64-67.

[2] Collection Mus. Comp. Zool.

[3] Ten in collection Museum Comp. Zool.

ARTIBEUS PLANIROSTRIS PLANIROSTRIS (Spix)

Flat-nosed Bat

Phyllostoma planirostre SPIX, Simiar. et Vespert. Brasil, 1823, p. 66, pl. 36, fig. 1. Type from Bahia, Brazil.

The flat-nosed bat very closely resembles *Artibeus j. jamaicensis.* The two species are sometimes difficult to distinguish apart by any external character, but *A. p. planirostris* differs, normally, in the possession of a third upper molar, a tiny tooth appearing at the posterior end of the series. But in some skulls even this differential character partially fails as these small teeth may be lost on one or both sides. In such cases, however, the alveolus of the missing tooth persists at least for a time.

A. planirostris appears to be a rare bat in Panama, while *A. j. jamaicensis* is one of the common species of the region. No specimens of the former were met with by me, but specimens from Bugaba and Boquete erroneously listed by Bangs (1902, p. 50) as *A. intermedius* were of this species as has been indicated by G. M. Allen (1908, p. 39). A bat collected by J. H. Batty at Boqueron, Chiriqui, and recorded by J. A. Allen (1904, p. 79) as *A. intermedius* proved on reexamination by him (1904, p. 233) to be an example of *A. planirostris* with the third molar on each side absent. Dr. Allen's later determination is evidently correct.

Specimens examined: Boqueron,[1] Boquete, 1,[2] Bugaba, 1.[2]

Family DESMODONTIDAE

The family Desmodontidæ includes the true vampire bats which subsist upon the blood of animals, probably to the exclusion of other food. Contrary to a popular conception they are not especially repugnant in appearance and are surpassed in size by many harmless species. The ears are short; the nose is bordered by cutaneous folds with a V-shaped notch in the middle above the nostrils. There is no external tail, and the interfemoral membrane is reduced to a narrow fringe. The general pelage is short and somewhat hispid, rusty brownish in color, rather coarse hairs extending the full length of the forearm and well down over the interfemoral membrane and hind limbs. The highly specialized dentition is distinctive, the median upper incisors consisting of greatly developed, trenchant, chisel-like teeth which exceed the canines in size and are largely instrumental in making the incision when blood is drawn. These bats often attack

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

horses and mules and rather rarely bite human beings, but since vast areas unoccupied by man are inhabited by them in considerable numbers, they doubtless prey normally upon native mammals or birds. Three genera are known, two of which, *Desmodus* and *Diphylla,* are represented in Panama.

Genus DESMODUS Wied

Blood-sucking bats met with throughout tropical Middle America usually belong to the genus *Desmodus,* the other Desmodont genus of the region, *Diphylla,* being exceedingly rare. *Desmodus* is distinguishable externally from *Diphylla* by the longer, more pointed ears, and the long thumb, equal to about one-fifth the length of the third finger, with two prominent pads on the inner side of the metacarpal. The calcar is short, stumpy, and supports no part of the interfemoral membrane. More important generic characters are lodged in the teeth, which differ notably in form and are reduced to 20 in number.

DESMODUS ROTUNDUS MURINUS Wagner

Mexican Vampire Bat

D[esmodus] murinus Wagner, Schreber's Säugthiere, Suppl., Vol. 1, p. 377 (1839), 1840. Type from Mexico.

Although few examples were met with by me the Mexican vampire bat is probably rather common at low elevations throughout Panama. Specimens of *Desmodus* from Mexico average smaller than those

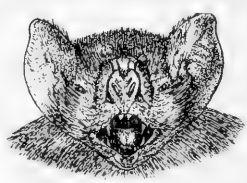

Fig. 17.—Desmodus rotundus murinus.
No. 179723, U. S. Nat. Mus. About nat. size.

from Paraguay, assumed to represent typical *D. rotundus,* and seem referable to a northern race for which the name *D. murinus* Wagner may be used, as has been shown by Osgood.[1]

The difference in size between the northern and southern forms is, however, rather less than might be inferred from measurements by Osgood (*l. c.*). He gives the length of the forearm in typical *D. rotundus* as 60-64 millimeters, as against a maximum of 55 millimeters in Mexican and Guatemalan specimens referred to the north-

[1] Pub. Field Mus. Nat. Hist., Zool. Ser., Vol. 10, No. 5, p. 63, Jan. 10, 1912.

ern subspecies. I find Mexican specimens that fully equal his measurements for typical *D. rotundus,* and Paraguayan examples that exceed those measured by him. But, while individuals are practically indistinguishable the southern race averages considerably larger, the difference in size seemingly more noticeable in the skulls than in external dimensions. The rather scanty material available from Panama indicates that the region is inhabited by a form somewhat intermediate in size but nearest to *D. r. murinus.*

A few vampires were found clinging in a recess of the high-vaulted roof of a limestone cave in the forest near Cana. Four secured as specimens had their stomachs distended with blood which had thickened and become very dark in color. One of these that had been knocked down was only partially disabled, and on being rather incautiously handled suddenly snapped at my finger. The canine teeth were not brought to bear, but the upper incisors neatly scooped out and completely removed a bit of skin leaving a wound from which blood flowed freely. In other parts of the same cave were colonies of *Hemiderma perspicillatum aztecum, Hemiderma castaneum, Glossophaga soricina leachii, Lonchophylla robusta,* and *Lonchophylla concava.*

Three specimens of this species collected by W. W. Brown, Jr., at Bogava were included by Bangs (1902, p. 51) in his list of "Chiriqui Mammalia," and a single example taken by J. H. Batty at Boqueron was recorded by Allen (1904, p. 79). Detailed measurements of an adult female obtained by August Busck on Taboga Island have been published by Miller (1912, p. 26).

Of this vampire bat Dr. Linnaeus Fussell (see Hale, 1903, p. 244), who had medical charge of a U. S. Government surveying party in eastern Panama in 1870, says in his report: "The bites of vampire bats should be referred to, as the stories told of them are by many deemed rather apochryphal. We were troubled with them more or less during the whole time we were out, but ordinarily they did not prove a serious annoyance; toward the latter part of our trip, however, some one was bitten almost every night; one night, the 13th of May, nine men were bitten. The men were rarely awakened by the bites, which, however, bled freely, sufficient blood being usually lost to saturate the clothing, and to show its effects very perceptibly in the loss of color and general feeling of weakness experienced."

While the fact that vampire bats, presumably of this species, attack man is fairly well established, such attacks seem to be rare in Panama. No instance came under my observation, and many people habitually sleep in the open air, unprotected by netting. I was told that in a few instances bats had been known to bite sleeping natives, usually choosing the ears or toes for their attacks. Horses and mules, however, frequently suffer from them. Streaks of blood-matted hair extending down from small incisions on the withers or sides of the neck are common evidence of their nocturnal visits. The wounds are usually slight and heal quickly without attention, but sometimes become infested with the larvæ of viviparous flies which may cause the death of the animal.

Specimens examined: Boqueron, 1[1]; Bogava, 3[2]; Çana, 4; Taboga Island, 2.

Genus DIPHYLLA Spix

The genus *Diphylla* is externally similar to *Desmodus,* but has shorter, more rounded ears; the thumb is reduced to about one-eighth instead of about one-fifth the length of the third finger, and its metacarpal lacks the distinct pads on the inner side in the latter genus. The corresponding teeth differ in important structural details from those of *Desmodus,* and are increased by a pair of minute outer incisors, and a pair of upper and lower molars, to 26 in number.

DIPHYLLA CENTRALIS Thomas

Central American Vampire Bat

Diphylla centralis Thomas, Ann. Mag. Nat. Hist., Ser. 7, Vol. 11, p. 378, April, 1903. Type from Boquete, Chiriqui, Panama.

The Central American vampire bat, whose general characters are those of the genus, is definitely known only from the type which was collected at Boquete, on the southern slope of the Volcan de Chiriqui, by H. J. Watson.

It is described as "externally quite similar to *D. ecaudata,* except that the legs are rather less heavily haired, and there is not so much white on the digits and tips of the wings. Colour of back and belly, where the hairs are dark to their bases, near 'seal brown'; anteriorly on the shoulders and neck the colour is markedly lighter, owing to the broad whitish bases to the hairs, *D. ecaudata* is rather darker throughout, with less white on the bases of the shoulder hairs.

"Skull rather rounder and less sharply arched above than in *D. ecaudata;* interorbital region narrower. Zygomata more widely and evenly spread. Bullæ larger and higher."

It is represented as differing from *D. ecaudata,* however, mainly in dental characters, the last three lower cheek teeth being subequal

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

in size, while in the latter species the fourth lower premolar is fully twice the size of the first lower molar, and half again as large as the third lower premolar. Thomas further remarks that "in spite of their general resemblance to each other the difference in the proportions of the lower teeth seems to necessitate the distinction of the Central-American *Diphylla* from that of Brazil." The forearm measurement given is 54 millimeters. Specimens of *Diphylla* from as far north as southern Mexico may prove to be referable to this species.

Family NATALIDAE

The members of the family are small, delicately formed bats, the continental representatives of which are recognizable by peculiar, low, somewhat funnel-shaped ears, long, slender limbs, large interfemoral membrane and the absence of nose leaves. The skull is long and narrow, with high subglobose braincase; the palate is excised anteriorly, but the premaxillæ meet in the median line in front of two well-developed foramina; postorbital processes are absent.

Genus NATALUS Gray

Salient characters of the only known continental genus of this restricted group have been given under the family. In addition, the long, thread-like tail crosses the interfemoral membrane, which is naked, except for a thin line of fringing hairs along the posterior margin. The teeth are 38 in number.

NATALUS MEXICANUS Miller

Mexican Straw-colored Bat

Natalus mexicanus MILLER, Proc. Acad. Sci. Philadelphia, p. 399, September 12, 1902. Type from Santa Anita, Lower California, Mexico.

Rich golden yellow appears to be the normal color of *Natalus mexicanus,* but individuals vary to dark brown. The color in con-

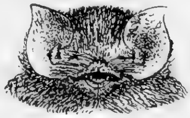

FIG. 18.—Natalus mexicanus.
No. 52117, U. S. Nat. Mus. About nat. size.

junction with the thin papery ears and flying membranes will aid in identification of the species. Its occurrence in Panama is known only from the record by Allen (1904, p. 78) of a single specimen collected by J. H. Batty on Coiba Island. In reduced size, most obvious in the length of the skull and toothrows, this example agrees closely with the Mexican form which is probably a small, geographic race of *Natalus stramineus*.[1] The forearm measures 38.4 and the upper toothrow (front of canine to back of posterior molar) 6.4 millimeters.

Specimens examined: Coiba Island, 1.[2]

Family VESPERTILIONIDAE. Common Bats

Most of the common bats of northern latitudes are included in the family Vespertilionidæ which, with several subfamily divisions, ranges over the greater part of the land surface in both the eastern and western hemispheres. The Isthmian members of the family are distinguishable externally by the combination of medium or small size, slender general structure, simple noses, narrow, usually pointed ears, slender tragus, long tail reaching to near posterior border of wide interfemoral membrane, and absence of adhesive disks on the soles and thumbs. A notable feature of the skull is a broad and deep U-shaped median, anterior emargination of the palate and the resultant obliteration of palatal branches of the premaxillæ. Five genera are now known to represent the family in Panama.

Genus MYOTIS Kaup

The bats of the genus *Myotis* superficially resemble those of several related genera and examination of skulls is often desirable in order to make positive determinations. The two known Panama representatives are, however, usually recognizable by the combination of color and size; the colors are dark brown or blackish and the length of the forearm 34 to 36.5 millimeters. They thus exceed the measurements of *Rhogeëssa* and do not attain the dimensions of the other Vespertilionine genera of the region. The skull of *Myotis* is slender and of rather delicate structure, the braincase rounded and usually rising high behind the narrow, depressed rostrum. Three upper premolars are normally present on each side, and the teeth are normally 38 in number. In certain species a pair of small obsolescent upper premolars may be present or absent.

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[1] In describing *Natalus mexicanus* Mr. Miller used for comparison specimens from Dominica as representing *N. stramineus*, whose exact type locality, however, remains undetermined.

[2] Collection Amer. Mus. Nat. Hist.

MYOTIS NIGRICANS (Wied)

Little Black Bat

V[espertilio] nigricans WIED, Beitrage zur Naturgesch, v. Brasilien, Vol. 2, p. 266, 1826. Type from Fazenda de Aga, near the Iritiba River, southeastern Brazil.

V[espertilio] exiguus H. Allen, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 281. Type from Aspinwall (now Colon), Panama.

Myotis chiriquensis Allen, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 77, February 29, 1904. Type from Boqueron, Chiriqui, Panama.

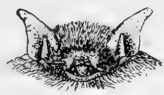

FIG. 19.—Myotis nigricans.
No. 179721, U. S. Nat. Mus. About nat. size.

The little black bat is a small, slender, blackish or brownish black species with a very small foot. In general appearance it is not very unlike *Eptesicus propinquus,* but is distinctly smaller. The forearm measures about 34 millimeters. Specimens from Panama seem indistinguishable in any way from a series from Sapucay, Paraguay, assumed to represent typical *M. nigricans.*

At Bohio a few of these bats were located in a vacant part of the old police station. They were clinging to the wall, several inches apart in an upper corner of a half-dark room. Others were found in an old tunnel formerly used for the storage of dynamite at the same locality. A specimen from Bugaba is recorded by Bangs (1902, p. 50), and two from Boqueron are listed by Allen (1904, p. 77). Anthony (1916, p. 373) notes the species from Chepigana, Cituro, Real de Santa Maria, Gatun, Tacarcuna, and Tapalisa as *Myotis chiriquensis.*

The type of *Vespertilio exiguus* H. Allen has been searched for in the U. S. National Museum, and Mr. James A. G. Rehn informs me that it cannot be found in the collection of the Academy of Natural Sciences of Philadelphia. It seems to have been lost. The description is of a small bat conforming closely in size and general characters with *Myotis nigricans* and it seems best to assign the name to the synonym of this species.

Examination of the type of *Myotis chiriquensis* shows that the forearm was broken off when the specimen was prepared and it is not, therefore, normally so short as Dr. Allen supposed. There seems to be no character by which it may be separated from *M. nigricans.*

Specimens examined: Boca de Cupe, 1; Bohio, 4; Boqueron, 3[1]; Bugaba, 1[2]; Cana, 1; Chepigana, 1[1]; Cituro, 1[1]; Culebra, 2[3]; Gatun, 1; Real de Santa Maria, 3[1]; San Pablo, 1; Tabernilla, 2; Taboga Island, 1; Tacarcuna, 2[1]; Tapalisa, 3.[1]

MYOTIS —— sp. indet.

An alcoholic specimen, with skull removed, in the Museum of Comparative Zoology, from San Pablo, Canal Zone, belongs to a widely ranging group which Mr. Gerrit S. Miller, Jr., informs me includes *Myotis yumanensis, Myotis albescens,* and other geographic races in both North and South America. The example differs from *M. yumanensis* in the dark color of its pelage, but the skull is not very obviously unlike those of several currently recognized species, and in the present unrevised condition of the genus the specimen cannot satisfactorily be determined. The forearm measures 36.4.

Genus EPTESICUS Rafinesque

The broad, naked membranes combined with larger size (forearm about 40 millimeters or more) suffice to distinguish members of the genus *Eptesicus* from other Panama representatives of the family. The skull is flatter with broader, heavier rostrum than that of *Myotis* and more nearly resembles that of *Rhogeëssa* in form. As in *Myotis,* and unlike *Rhogeëssa,* two pairs of upper incisors are present, but a departure from the *Myotis* formula results from the reduction of the upper premolars to the single pair present in *Rhogeëssa.* The teeth are 32 in number. Two species are known to occur within our limits.

EPTESICUS PROPINQUUS (Peters)

Peters' Black Bat

Vesperus propinquus PETERS, Monatsber. k. preuss. Akad. Wissensch. Berlin, 1872, p. 262. Type from Santa Isabel, Guatemala.

This rather small, dark brown, slenderly formed species bears a general external resemblance to *Myotis nigricans,* but is considerably larger. The forearm measures about 41 millimeters.

The specific distinctness of this bat from *Eptesicus fuscus* (Beauvois), with which it had been subspecifically associated, has been pointed out by Osgood.[4] It is smaller and differs otherwise

[1] Collection Amer. Mus. Nat. Hist.
[2] Collection Mus. Comp. Zool.
[3] One in collection Amer. Mus. Nat. Hist.
[4] Proc. Biol. Soc. Wash., Vol. 27, p. 101, May 11, 1914.

from the forms of *E. fuscus,* and the northern part of its range is overlapped by that of *Eptesicus fuscus miradorensis* (H. Allen). The exact relationship of *E. propinquus* to *Eptesicus hilarii* (Is. Geoffroy) and other South American species is, however, not so clear.

A small colony of *E. propinquus* was located in a dark corner of the attic of an old house at San Pablo, a locality now covered by Gatun Lake. The walls of the room had been white-washed and when a window was opened the dark color of the bats rendered them conspicuous. A few individuals of *Rhogeëssa tumida* were clinging to rafters nearby.

Specimens examined: San Pablo, 3.

EPTESICUS FUSCUS MIRADORENSIS (H. Allen)

Mirador Brown Bat

S[cotophilus] miradorensis H. ALLEN, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 287. Type from Mirador, Vera Cruz, Mexico.

The Mirador brown bat is one of the larger forms of Vespertilionidæ occurring in the region under consideration. It is externally similar to *Eptesicus propinquus,* but is decidedly larger, the forearm measuring about 50 millimeters in length. It also differs in dark brown instead of blackish color.

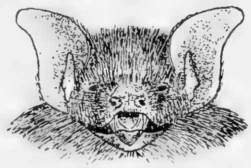

FIG. 20.—Eptesicus fuscus miradorensis.
No. 53784, U. S. Nat. Mus. About nat. size.

Eptesicus f. miradorensis was first made known from Panama by Bangs (1902, p. 50), who noted a single specimen collected by W. W. Brown, Jr., at Boquete, Chiriqui. Allen (1904, p. 78) lists examples taken at the same locality by J. H. Batty. This locality on the southern slope of the Volcan de Chiriqui, in the western part of the republic, marks the southern limit of the known range of *Eptesicus fuscus.* This species in its several forms is one of the most common in the area to the northward, including the entire United States and adjoining British territory. The skulls of examples from Boquete are slightly larger than in Mexican specimens with which they have been compared, but the external dimensions are about the same.

Specimens examined: Boquete, 4.[1]

Genus NYCTERIS Borkhausen

The genus *Nycteris* is easily recognizable by the continuation of the dense body fur over the hind limbs and the entire upper side of the wide interfemoral membrane. Distinctive tufts of fur appear also at the upper base of the thumb and along the basal portion of the fourth finger. In the allied genus *Dasypterus* the interfemoral membrane is much less extensively clothed. The skull of *Nycteris* is short and the rostrum broad and massive, very much as in *Dasypterus*, but a pair of minute upper premolars is not present in the latter genus. The teeth are 32 in number.

NYCTERIS BOREALIS MEXICANA (Saussure)

Mexican Red Bat

A[talapha] mexicana SAUSSURE, Rev. et Mag. de Zool., Ser. 2, Vol. 13, p. 97, March, 1861. Type from southern Mexico.

The rich reddish brown color of the upperparts, including the fur covering the hind limbs and the entire upper side of the wide inter-

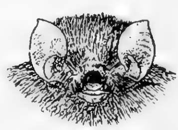

FIG. 21.—Nycteris borealis mexicana.
No. 122663, U. S. Nat. Mus. About nat. size.

femoral membrane distinguishes this bat from the otherwise similar form, *Dasypterus ega panamensis*, and all others of the general region. The ears are short and rounded as in *Dasypterus*. The forearm measures about 41 millimeters.

Bangs (1902, p. 50) records a specimen collected by W. W. Brown, Jr., at 4,800 feet near Boquete on the southern slope of the Volcan de Chiriqui, where the species reaches the extreme southern known limit of its distribution.

Specimens examined: Boquete, 1.[2]

[1] Three in collection Amer. Mus. Nat. Hist.; one in Mus. Comp. Zool.

[2] Collection Mus. Comp. Zool.

Genus DASYPTERUS Peters

The genus *Dasypterus* is similar externally to *Nycteris,* but the hind limbs and the posterior part of the interfemoral membrane are naked. The skull indicates alliance to *Nycteris,* but the absence of the small anterior upper premolars still appearing in that genus is distinctive. The teeth are 30 in number.

DASYPTERUS EGA PANAMENSIS Thomas

Panama Short-eared Bat

Dasypterus ega panamensis Thomas, Ann. Mag. Nat. Hist., Ser. 7, Vol. 8, p. 246, September, 1901. Type from Bugaba, Chiriqui, Panama (altitude 800 feet).

The type in the British Museum is the only known specimen of this bat. It was collected at Bugaba in western Panama by H. J Watson, October 8, 1898. It is described as dark brownish clay color in general tone above, instead of buffy white as in typical *Dasypterus ega* of Brazil. The forearm measurement given is 46.5 millimeters.

Bats of the genus *Dasypterus* appear to be rare in Middle America. They may be recognized by the rather unusual color among bats, together with the short rounded ears, and the long tail which supports the gradually narrowing interfemoral membrane to a point well beyond the feet. Another Middle American form, *D. ega xanthinus* Thomas has been described from Lower California.

Genus RHOGEËSSA H. Allen

The genus *Rhogeëssa* is similar externally to *Myotis,* but the yellowish brown color and small size sufficiently distinguish the Isthmian representative. The skull more nearly resembles that of *Eptesicus* in form, but the single pair of upper incisors and other details are distinctive. The teeth are 30 in number.

RHOGEËSSA TUMIDA H. Allen

Little Yellow Bat

Rhogeëssa tumida H. Allen, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 286. Type from Mirador, Vera Cruz, Mexico.

The small size, slender form, tiny foot, and naked interfemoral membrane together with rich yellowish brown color characterize this species, one of the smallest bats occurring in Panama. The forearm measures about 31.5 millimeters.

A few of these bats were found clinging from the rafters in the half dark attic of an old house at San Pablo, April 21, 1911. A corner of the same attic was inhabited by *Eptesicus propinquus.* Henry Pittier took a specimen of *Rhogeëssa tumida* at La Palma de Darien in January, 1912. Bangs (1902, p. 50) records a specimen

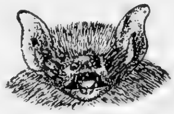

FIG. 22.—Rhogeëssa tumida.
No. 52065, U. S. Nat. Mus. About nat. size.

collected by W. W. Brown, Jr., at Bugaba, which was rather doubtfully referred to this species by G. S. Miller, Jr.

Specimens examined: Bugaba, 1 [1]; La Palma de Darien, 1; San Pablo, 3.

Family MOLOSSIDAE

The family Molossidæ includes large, medium and small bats with short, thick, leathery ears, broader than high, and projecting far forward over the eyes. The short thick muzzle is not provided with a nose leaf, the legs are short and the long tail projects prominently beyond the posterior border of the short interfemoral membrane. The general pelage is short and velvety; very short hairs with thickened and more or less distinctly spoon-shaped tips are present on the upper lip, and similarly modified hairs form a fringe along the under and outer sides of the lateral digits of the foot; more conspicuous but slender hairs with recurved tips project beyond the claws. The wings are very narrow, and together with the peculiar shape of the ears give bats of this group an angular appearance in flight.

Genus MOLOSSOPS Peters

The genus *Molossops* closely resembles *Molossus* in external appearance, but more conspicuous lines of fur diverging from the angle in the bend of the wing along the forearms and fourth finger are usually distinctive. The skull is distinguishable from those of *Molossus* and *Eumops* by the high, but broad, flattened rostrum with conspicuous, laterally projecting lachrymal ridges. Distinct basispenoid depressions are absent. In the species reaching Panama the teeth are 28 in number, but vary in the genus to 26.

[1] Collection Mus. Comp. Zool.

MOLOSSOPS PLANIROSTRIS (Peters)

Flat-nosed Mastiff Bat

M[olossus] planirostris PETERS, Monatsber. k. preuss. Akad. Wissensch. Berlin, 1865, p. 575. Type from British Guiana.

Molossops planirostris appears to be mainly South American in distribution, but G. M. Allen (1908, p. 56) directs attention to a specimen collected near the City of Panama by W. W. Brown, Jr., and erroneously referred to *Promops nanus* by Bangs (1906, p. 212). As Dr. Allen states, " the presence of this species within the limits of Middle America " is thus established.

Specimens examined: Panama (near city), 1.[1]

Genus EUMOPS Miller

Among the known Panama Molossine bats the genus *Eumops* is readily recognizable externally by the connection of the ears across the forehead. The skull is similar in general outline to that of *Molossus,* but the rostrum is narrower and dental differences are various. The upper incisors project forward far beyond the plane of the canines and an additional pair of outer incisors is present. The basisphenoid depressions are distinct as in *Molossus.* The teeth are variable in number, 30 being present in the two Panama species.

EUMOPS NANUS (Miller)

Dwarf Mastiff Bat

Promops nanus MILLER, Ann. Mag. Nat. Hist., Ser. 7, Vol. 6, p. 470, November, 1900. Type from Bugaba, Chiriqui, Panama.

The dwarf mastiff bat, originally described from western Panama, was not met with by me in the eastern part of the republic. A specimen collected near the city of Panama by W. W. Brown, Jr., and recorded as *Promops nanus* by Bangs (1906, p. 212) is referable to *Molossops planirostris* as pointed out by G. M. Allen (1908, p. 56). As Miller aptly remarked, the species is essentially a miniature of *Eumops glaucinus.* The forearm measures about 39 millimeters, instead of 59 millimeters as in the latter animal.

Specimens examined: Bugaba, 1.

EUMOPS GLAUCINUS (Wagner)

Chestnut Mastiff Bat

Dysopes glaucinus WAGNER, Wiegmann's Archiv. f. Naturg., 1843, p. 368. Type from Cuyaba, Matto Grosso, Brazil.

This rather large bat, mainly South American in distribution, was not until recently known to occur in Middle America. It is one of

[1] Collection in Mus. Comp. Zool.

the largest of the *Molossidae* of the region, and in general external appearance is not very unlike the typical genus *Molossus,* the short thick leathery ears projecting forward and overhanging the eyes in the same way. The forearm measures about 59 millimeters.

A large colony was found inhabiting the roof of the old police station at Bohio. The bats remained during the day between the corrugated iron roof and the ceiling. Looking through crevices a considerable number could be seen ranged in rows with their heads upward, their backs close to the iron, and their bodies lying flat on the boards. They held on to some extent with their thumbs. The sun was shining and the bats were panting with the almost intolerable heat radiating from the iron. When disturbed they crawled about with lively shuffling motions, seeking always to keep out of sight in the crevices. They were finally dislodged by tearing off the

Fig. 23.—Eumops glaucinus.
No. 179856, U. S. Nat. Mus. About nat. size.

roof. Some of them, liberated in a room from which they could not escape, flew round and round and finally hung up by their feet in corners, swinging heads downward in the usual position of bats when at rest. The building was soon torn down and the locality is now submerged in Gatun Lake.

A specimen collected by August Busck, at Paraiso, was recorded by Miller (1912, p. 26).

Specimens examined: Bohio, 14; Empire, 1; Paraiso, 1.

Genus MOLOSSUS Geoffroy

Externally the genus *Molossus* is similar to *Molossops,* but the Panama forms are distinguishable by their smaller size in comparison with the only known regional representative of the latter. The absence of the conspicuously furred areas present on the upper side of the wing between the forearm and fourth finger in *Molossops* are distinctive. The skull differs notably from those of *Molossops* and *Eumops* in the anteriorly arched braincase and high, trenchant sagittal crest sloping down posteriorly to the low lambdoid ridge. The basispenoid depressions are distinct as in *Eumops.* The upper incisors are less conical than in the genera mentioned and scarcely project beyond the plane of the canines. One pair only of upper premolars and one of lower incisors are present. The teeth are 26 in number.

MOLOSSUS COIBENSIS Allen

Coiba Island Mastiff Bat

Molossus coibensis ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 227, June 29, 1904. Type from Coiba Island, Panama.

The Coiba Island mastiff bat is a small, short-haired, glossy species of a dark chestnut brown or rusty blackish general color. The short broad leathery ears hang far forward, and over-shadow the eyes. The long tail projects well beyond the interfemoral membrane. The forearm measures about 36.5 millimeters.

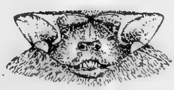

FIG. 24.—Molossus coibensis.
No. 202042, U. S. Nat. Mus. About nat. size.

This dark form was based by Dr. Allen on four specimens from Coiba Island, originally referred by him (1904, p. 78) to *Molossus obscurus.* It is nearly related to other forms of the *Molossus pygmaeus* group, at least some of which will no doubt eventually require reduction to subspecific rank.

In 1911 numbers of these bats inhabited the crevices between the corrugated iron roofs and the ceilings of old French buildings at Tabernilla and San Pablo. When a section of the iron roof of a building at San Pablo was lifted, the bats, finding themselves suddenly exposed to the full light of day, crawled rapidly over boards and plaster toward the cover of neighboring crevices. At Bohio a single individual was found clinging to the wall of a well-lighted room in the old police station. The windows were covered with mosquito netting and the bat had probably entered the room through a small hole in the ceiling, at night, and failed to find its way out again. Tabernilla, San Pablo, and Bohio are all localities now submerged in Gatun Lake.

A specimen probably assignable to *M. coibensis* was recorded by Thomas (1903*a*, p. 39) from Gobernador Island, under the name *Molossus obscurus.* Two examples of *M. coibensis* from San Pablo were referred to *M. crassicaudatus* by G. M. Allen (1908, p. 60).

Miller (1913, p. 92) in his review of the genus lists Panama specimens from Ancon, Chorrera, Culebra, Paraiso, and Tabernilla.

Specimens examined: Ancon, 1; Balboa, 4[1]; Bohio, 1; Chorrera, 3[2]; Coiba Island, 4[2] (including type); Culebra, 2; Panama City, 73[3]; Paraiso, 1; San Pablo, 18[4]; Tabernilla, 9; Boqueron, 2.[2]

MOLOSSUS SINALOAE Allen

Sinaloa Mastiff Bat

Molossus sinaloae ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 22, p. 236, July 25, 1906. Type from Escuinapa, Sinaloa, Mexico.

The Sinaloa mastiff bat is the largest species of the genus known to occur in Panama. It is similar to *Molossus bondae,* but larger and somewhat lighter in color, the upperparts being a dark brownish drab. The forearm measures about 47 millimeters.

The range of the species, as now understood, is from Sinaloa, Mexico, southward through Middle America to western Panama. Miller (1913, p. 89), in his revision of the genus, records specimens collected by R. E. B. McKenney at Punta de Peña.

Specimens examined: Punta de Peña (near Bocas del Toro), 2.

MOLOSSUS BONDAE Allen

Bonda Mastiff Bat

Molossus bondæ ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. 20, p. 228, June 29, 1904. Type from Bonda, Santa Marta, Colombia.

The Bonda mastiff bat is very similar to *Molossus sinaloæ,* but is smaller and seems to be darker colored. The forearm measures about 40 millimeters.

The recorded range of the species is from northern Colombia into Panama. Miller (1913, p. 89), in his revision of the genus, lists specimens from Chorrera, one of which I have seen.

Specimens examined: Chorrera, 1.[2]

Order PRIMATES. Primates

Suborder ANTHROPOIDEA. Monkeys, Apes, Man

Family SAIMIRIDAE. Titi Monkeys

This family is represented in the region by the single genus *Saimiri,* which includes species scarcely exceeding some squirrels in

[1] Collection Field Mus. Nat. Hist.
[2] Collection Amer. Mus. Nat. Hist.
[3] Seventy-two in collection Mus. Comp. Zool.
[4] Six in collection Mus. Comp. Zool

size. They are easily distinguished from the Callitrichidæ, another group of small, squirrel-like species, by the short, instead of much elongated pelage, especially of the nape and sides, and the absence of a narrow and conspicuous median frontal crest.

Genus SAIMIRI Voigt. Titi Monkeys

The members of the genus *Saimiri* are similar in size to those of the genus *Leontocebus,* family Callitrichidae, which also inhabits the general region; but they differ widely in more essential respects. The general pelage is rather short, harsh and of nearly uniform length, instead of being long and soft, with an elongated mane or mantle covering the nape and overhanging the sides as in *Leontocebus;* and the short hairs of the face pass rather gradually into the pelage covering the top of the head, there being no narrow, conspicuous median crest as in the latter genus. The long tail is hairy to the tip.

SAIMIRI ÖRSTEDII ÖRSTEDII (Reinhardt)

Örsted's Titi Monkey

Chrysothrix örstedii REINHARDT, Vidensk. Middel. Nat. For. Kjöbenhavn, 1872, p. 157. Type from Chiriqui, Panama.

Örsted's titi monkey is externally recognizable by its squirrel-like size together with the white face, sides of neck, throat and chest which contrast strongly with the black crown. The back, hands and feet are rusty reddish.

The species was named for the Danish traveller Andreas Sandøe Örsted, who secured a specimen in Chiriqui many years ago. A skeleton of an animal probably of this species was provisionally referred by Sclater (1856, p. 139) to *Saimiris sciurea* (Linnaeus). It was collected by Thomas Bridges in the forest near David. Sclater later (1872, p. 3) assigned the same material to *Saimiris entomophaga* (D'Orbigny) with the remarks: "In 1856 I recorded the existence of a species of Squirrel Monkey in Central America, Mr. Bridges having procured, near David in Veragua, a skeleton of a species of this genus. . . . . I have no doubt that the Central American form is the black-headed *S. entomophaga,* as there is a skin of this species in the British Museum from Veragua (Arcé)." Alston (1879, p. 16) also mentions the Bridges specimen and examples sent from Chiriqui by Enrique Arcé.

Recent collectors have met with the animal at various localities in western Panama. Bangs (1902, p. 51) lists five specimens collected by W. W. Brown, Jr., at Bugaba and says: "The squirrel monkey is common in the scrubby forest of the foothills of the Volcan de Chiriqui. It was very tame, and Mr. Brown states that often little parties of them, would follow him about in the underbrush, chattering, and allowing him to come so near that he could almost put his hand on them. It is a beautiful creature, with a long tasselled tail, and is admirably shown in Alston's plate in the Biologia Centrali-Americana. Mr. Brown states that he never saw a creature that he disliked so to kill, and after he had secured five specimens, nothing would induce him to molest the little troupes that accompanied him on his rambles over the foot-hills." Specimens taken by J. H. Batty for the Hon. Walter Rothschild are recorded by Thomas (1903*a*, p. 39) from Sevilla and Almijas, small islands near the southwestern coast of the republic. Examples obtained by the same collector at Boqueron were sent to the American Museum of Natural History, and included by Allen (1904, p. 80) in his annotated list of species. The animal is, so far as known, limited to western Panama. Another form, described by Thomas (1904, p. 250) as "*Saimiri oerstedi citrinellus*" with "head less blackened, and the limbs less yellow" inhabits adjacent parts of Costa Rica.

Specimens examined: Boqueron, 59[1]; Bugaba, 5.[2]

Family AOTIDAE. Night Monkeys

Among the monkeys of the region this aberrant family is characterized by nocturnal habits. The pelage is woolly, and in general appearance the members of the group are very unlike the other American monkeys; they bear a striking resemblance to some of the lemurs of the Old World.

Genus AOTUS Humboldt

The monkeys of the genus *Aotus* have very large and prominent eyes, which are doubtless correlated with their nocturnal habits. The face is marked by white frontal stripes, separated by a black median stripe. The tail is non-prehensile, and terminates in a small brush. One species is known from Panama.

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[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

AOTUS ZONALIS Goldman

Canal Zone Night Monkey

[Plate 38, figs. 1 1*a*]

Aotus zonalis GOLDMAN, Smiths. Misc. Coll., Vol. 63, No. 5, p. 6, March 14, 1914. Type from Gatun, Canal Zone, Panama (altitude 100 feet).

The night monkey of the Canal Zone and eastern Panama may be easily recognized among the monkeys of the region by the characters given for the genus. It is similar to *Aotus griseimembra* of the Santa Marta region of Colombia in external appearance, the principal difference being a more buffy suffusion of the body and limbs. The skull differs in numerous details, especially the broader braincase, and the more depressed interorbital region which materially alters the facial angle; the larger molariform teeth of the Panama animal would alone serve as a distinguishing character. A species differing in the reddish color of the feet, *Aotus rufipes* (Sclater), has been described from Nicaragua.

Owing to nocturnal habits the night monkeys are seldom seen, and are therefore little known. Near Cana an example was obtained by me while using a hunting lamp in the forest at night. Its large eyes glowed conspicuously in the field of light projected into a tree top. Rustling branches and low squeaking sounds indicated that others were hurrying away in alarm. I did not hear the voice of the animal, which was described to me by native hunters as *who-who* given in a low monotonous tone. While in the forest near Boca de Cupe one afternoon I heard a slight rustling sound, and looking up beheld several curious little faces peering out of a dark hole about 15 feet from the ground in the trunk of a tree. After backing away a few steps I fired a shot into the hole and on examining the tree found that three of these monkeys had dropped to the ground inside the trunk, whence they were extracted by enlarging another hole. A native hunter described finding an adult and several young under similar circumstances. Anthony (1916, p. 374) records examples from Boca de Cupe and Tapalisa of which he says: "Although my specimens were taken in southeastern Panama, no material differences between them and the type from Gatun are evident. The type is less richly suffused, but this difference is probably not outside the limits of individual variation."

Specimens examined: Boca de Cupe, 4[1]; Cana, 3; Gatun (type locality), 4; Tapalisa, 7.[2]

[1] One in Amer. Mus. Nat. Hist.

[2] Collection Amer. Mus. Nat. Hist.

Family CALLITRICHIDAE. Squirrel Monkeys

The family Callitrichidae includes small squirrel-like monkeys of which the single genus *Leontocebus* inhabits Panama.

Genus LEONTOCEBUS Wagner. Squirrel Monkeys

The smallest monkeys of the region are included in the genus *Leontocebus.* They are little larger than squirrels which they resemble in form, posture and activity. The general pelage is long and soft, that of the nape and sides especially elongated as a mane, or mantle. The face is thinly clothed with short grayish hairs through which the dark-colored skin is visible to a sharp line of demarcation along the narrow and conspicuous median frontal crest. The hands and feet, with the exception of the great toe, are armed with long, sharp, strongly curved and laterally compressed claws which doubtless facilitate rapid movement. The tail is long, slender and non-prehensile.

LEONTOCEBUS GEOFFROYI (Pucheran)

Geoffroy's Squirrel Monkey; Mono tití

Hapale geoffroyi PUCHERAN, Rev. Zool., Vol. 8, p. 336, September, 1845. Type from Panama.[1]

Small size, together with the chestnut color of the nape, white fore limbs and frontal crest distinguish the *mono tití,* as this little monkey is known to natives of the Canal Zone. In western Panama the species is largely or entirely replaced by the similarly small, but otherwise very different animal, *Saimiri örstedii,* which bears the same local designation.

In the Canal Zone and at localities visited in eastern Panama, Geoffroy's squirrel monkey seems to be the most abundant representative of the order, ranging from sea level to at least 2,000 feet altitude on the slopes of the mountains. They were usually met with in troops of four or five, which quickly became alarmed at sight of me and scattered like squirrels, scurrying along the branches and often leaping several feet in passing from tree to tree, giving meanwhile rather weak squeaking cries.

The species has been well known in the Canal Zone for many years. In his list of "Quadrumana found in America north of Panama," Sclater (1872, p. 8) says: "I have recently recorded the receipt by

[1] Locality given by Pucheran in account of *Hapale illigeri* on same page as that of *Hapale geoffroyi.*

the Society [Zoological Society of London] of a living example from Colon; and since that date other specimens have been received from the same port." Alston (1879, p. 17) records specimens from Panama, Colon, and Chepo, and mentions examples from Chiriqui formerly living in the gardens of the Zoological Society of London and believed by Sclater to be of this species. The animal is not represented in recent collections from western Panama and the latter record may be erroneous.

Anthony (1916, p. 374) in recording specimens from Boca de Cupe, Chepigana, Cituro, Maxon Ranch (Rio Trinidad), Tacarcuna and Tapalisa, says: "This small monkey was fairly common throughout the whole region where collecting was done, and specimens from the high mountains of the cordillera [vicinity of Mount Tacarcuna] are specifically the same as those of the Zone. In this series the yellowish underparts, which Elliot[1] made a character of his *salaquiensis,* a species which he withdrew[2] later upon the basis of additional material, occur frequently and show that this character is a variable one with no diagnostic value."

Specimens examined: Boca de Cupe, 1[3]; Cana, 2; Chepigana, 6[3]; Chepo, 1; Cituro, 4[3]; Maxon Ranch (Rio Trinidad), 1[3]; Tacarcuna, 12[3]; Rio Indio (near Gatun), 8; Tapalisa, 4.[3]

Family ALOUATTIDAE. Howling Monkeys

The howling monkeys, which alone compose this family, are remarkable mainly for their voices and the structural peculiarities that enable them to produce sounds that often reverberate for miles through the forest. The vertical expansion of the angle of the mandible, to a degree unusual among monkeys, is doubtless associated with the extraordinary inflation of the laryngeal apparatus which it partially protects.

Genus ALOUATTA Lacépède. Howling Monkeys

The members of the genus Alouatta are robust species, with rather long prehensile tails. They are similar in general appearance to those of the genus *Ateles,* but have shorter limbs and are distinguished by five instead of four fingers on the hands. One species only is known to inhabit the region.

[1] Elliot, Bull. Amer. Mus. Nat. Hist., 1912, p. 137.
[2] Elliot, Bull. Amer. Mus. Nat. Hist., 1914, p. 644.
[3] Collection Amer. Mus. Nat. Hist.

ALOUATTA PALLIATA INCONSONANS Goldman

Panama Howling Monkey; Mono Negro

[Plate 39, figs. 1, 1*a*]

Alouatta palliata inconsonans GOLDMAN, Smiths. Misc. Coll., Vol. 60, No. 22, pp. 17-20, February 28, 1913. Type from Cerro Azul, near the headwaters of the Chagres River, Panama (altitude 2,500 feet).

The Panama howling monkey is recognizable as a large black species with five fingers on the hands. It is closely allied to typical *A. p. palliata* of Nicaragua and Costa Rica, but the general color is clearer black, especially on the flanks, rump and posterior part of back. The skull differs in numerous details, the braincase being broader posteriorly, the frontal profile in the male rising more abruptly from the rostrum, the supraorbital protuberance being stouter, more projecting, the interpterygoid fossa broader, the audital bullæ flatter and the premolars narrower. It differs from the insular form, *A. p. coibensis,* in decidedly larger size.

Howling monkeys are generally distributed throughout the republic and range from near the coasts well up toward the summits of the higher mountains. The quaint account of monkeys in eastern Panama by Lionel Wafer (1729, p. 330) based on observations made in 1681, refers to several species apparently including the howler. It is quoted as follows:

"There are great Droves of Monkeys, ... most of them black; some have Beards, others are beardless. They are of a middle size, yet extraordinary fat at the dry Season, when the Fruits are ripe; and they are very good Meat, for we ate of them very plentifully. The *Indians* were shy of eating them for a while; but they soon were persuaded to it, by seeing us feed on them so heartily. In the rainy Season they have Worms in their Bowels. I have taken a handful of them out of one Monkey we cut open; and some of them 7 or 8 Foot long. They are a very waggish Kind of Monkey, and played a thousand antick Tricks as we marched at any Time through the Woods, skipping from Bough to Bough, with the young one's hanging at the old one's Back, making Faces at us, [and] chattering. . . . . To pass from Top to Top of high Trees, whose Branches are a little too far asunder for their Leaping, they will sometimes hang down by one another's Tails in a Chain; and swinging in that Manner, the lowermost catches hold of a Bough of the other Trees, and draws up the rest of them."

The habit of passing from tree to tree hanging by their tails in a chain is, of course, fictitious.

Howling monkeys occur in small numbers near Gatun in the northern end of the Canal Zone. Several parties were met with on the mountains near the headwaters of the Chagres River. On Cerro Azul a troop of about 12 was found in a group of very tall trees. The troop included several full grown males, females, and young. A very young individual was seen clinging to the lower part of its mother's back as she climbed into the topmost branches along with other females and the younger animals. The older males gave the usual roar when shots were fired, jumping about, looking down, and showing signs of anger rather than fear, as they made no effort to escape. After several of these monkeys were shot the others remained in the vicinity where they were seen on several subsequent occasions, being evidently permanent residents of that part of the forest. The so-called howling of these monkeys was heard soon after daylight nearly every morning not far from camp on the Cascajal River near Cerro Brujo, and at intervals during the day. Near the summit of the Pirre Range sudden showers of rain often brought forth deep-toned notes during the night. The voice of this animal as it reverberates through the forest, is wonderfully impressive, but seems better described as a series of deep growls, becoming a prolonged roar when given by several in unison, than as howling. Although the howler can pass rapidly through the tree tops, its movements seem sluggish when compared with those of *Ateles* or even *Cebus*. The flesh is eaten by the natives, but is less prized than that of *Ateles* and *Cebus*. It is commonly cut in strips and after being smoked over a fire may be kept for several days without salting. All of the specimens obtained carried numerous large larvae of flies, mainly in the skin on the throat, which added materially to their repugnant appearance. These larvae were not found on the spider monkeys taken in the same vicinity. Perhaps the greater activity of the latter may prevent the deposition of eggs.

Under the name *Alouatta palliata,* Bangs (1902, p. 51) lists three specimens collected by W. W. Brown, Jr., at 4,000 feet near Boquete. Specimens collected by J. H. Batty are recorded by Thomas (1903*a,* p. 39) from Sevilla, Almijas, and Insoleta, small islands near the southwestern coast of Panama. Regarding them he says: "Like mainland specimens these howlers are larger than the small insular form of Coiba Island, *A. p. coibensis* Thos." The same collector obtained a large series of specimens at Boqueron and Boquete for the American Museum of Natural History; measurements of selected individuals were published by Dr. Allen (1904, p. 79), who in the same connection points out the great range of individual variation in color. The howlers of the mainland of western Panama seem referable to *A. p. inconsonans,* but in cranial details indicate gradation toward typical *A. p. palliata.* Anthony (1916, p. 374) says: "This monkey was noted the oftenest because of its far-reaching call-note. It seemed to be everywhere common from the Zone up to the crests of the cordillera." He lists specimens from Cituro, Maxon Ranch (Rio Trinidad), Tacarcuna, and Tapalisa.

Specimens examined: Boqueron, 2[1]; Boquete, 5[2]; Cerro Azul, 9; Cituro, 1[1]; "Gulf of Panama," 1[3]; "Isthmus of Panama," 1[3]; Maxon Ranch (Rio Trinidad), 1[1]; Mount Tacarcuna, 1[1]; Tapalisa, 1.[1]

ALOUATTA COIBENSIS Thomas

Coiba Island Howling Monkey

Alouatta palliata coibensis THOMAS, Novitat. Zoologicæ, Vol. 9, p. 135, April 10, 1902. Type from Coiba Island, Panama.

The Coiba Island howling monkey was originally described as "a small insular race of the continental *A. palliata* Gray. The Howler Monkey of Coiba appears to have been reduced in size by its insular habitat in a way that the *Cebus* has not, for the latter is fully as large as its brethren on the mainland." The following remarks by Alston (1879, p. 4) doubtless apply to this form: "Mr. Salvin tells me that Captain Dow informed him that he once met with Howling Monkeys on the little island of Hicaron, which lies at the southern extremity of Quibo [Coiba] Island, off the coast of Veragua. The species would probably be *M. palliatus;* but it is difficult to understand how the founders of the colony could have reached this isolated spot from the mainland." Three specimens from Coiba Island collected by J. H. Batty indicate such disparity in size compared with the allied howler inhabiting the adjacent mainland that it seems best to regard it as a distinct species.

Specimens examined: Coiba Island, 3.[1]

Family CEBIDAE. Capuchin Monkeys

The restricted family includes the capuchin monkeys of the genus *Cebus,* some of whose distinguishing characters are given below.

Genus CEBUS Erxleben. Capuchin Monkeys

The monkeys of the genus *Cebus* are medium-sized species, readily distinguished in Panama by the white face, chest, and shoulders

[1] Collection Amer. Mus. Nat. Hist.

[2] Three in collection Mus. Comp. Zool.; two in Amer. Mus. Nat. Hist.

[3] Collection Mus. Comp. Zool.

The tail is long and curled under, but not naked near the tip. One species, represented by two subspecies, inhabits Panama.

CEBUS CAPUCINUS CAPUCINUS (Linnaeus)

Colombian White-throated Capuchin

S[*imia*] *capucina* LINNÆUS, Syst. Nat., ed. 10, Vol. 1, p. 29, 1758. Type region northern Colombia.[1]

The capuchins are recognizable by the extensive white area covering the entire face, sides of neck, throat, chest, and shoulders, in marked contrast with the glossy black remaining parts of the body. *C. capucinus* of recent authors is the animal which formerly was commonly referred to *C. hypoleucus* (Humboldt). The type locality of the latter is Rio Sinu, Colombia, and as the two are now regarded as identical the animal inhabiting eastern Panama and ranging as far southward as Paramba, Ecuador, is probably typical. In the vicinity of the Canal Zone *C. capucinus capucinus* is replaced by a northern geographic race, *C. c. imitator,* which is distinguished by the greater transverse extent of the premolars.

The white-throated capuchin was met with on several occasions, in the forests of eastern Panama, at localities ranging from 1,000 to 5,000 feet altitude. On Cerro Azul, near the headwaters of the Chagres River, a troop of eight or ten of these monkeys was found in the tops of tall trees on a steep hillside. When two were shot the others gave short cries of alarm and scampered off through the tree tops, showing great activity, but their progress seemed slower than that of *Ateles geoffroyi* under similar circumstances and I saw none of the tremendous flying leaps by which the latter species spans the distance between trees standing well apart. In the excessively humid forest covering the Atlantic slope of Cerro Brujo a small troop in the tops of tall trees remained quietly watching my party passing beneath. On Mount Pirre a lone male was heard giving hoarse barking sounds as he climbed rather slowly through the top of a tall tree in the heavy forest at 5,000 feet. The white area was conspicuous as he paused for a moment and looked down. Lionel Wafer (1729, p. 330) doubtless referred in part to this species when in describing the animals of eastern Panama he says: "There are great Droves of Monkeys, some of them white." Anthony (1916, p. 375) records specimens from Chepigana, Real de Santa Maria, and Tacarcuna (altitude 3,000 to 5,000 feet).

Specimens examined: Cerro Azul, 2; Cerro Brujo, 2; Chepigana, 1[2]; Mount Pirre, 3; Real de Santa Maria, 2[2]; Tacarcuna, 6.[2]

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[1] See Goldman, Proc. Biol. Soc., Washington, Vol. 27, p. 99, May 11, 1914.

[2] Collection Amer. Mus. Nat. Hist.

CEBUS CAPUCINUS IMITATOR Thomas

Panama White-throated Capuchin

Cebus imitator THOMAS, Ann. Mag. Nat. Hist., Ser. 7, Vol. 11, p. 376, April, 1903. Type from Boquete, Chiriqui, Panama.

The Panama white-throated capuchin inhabits the general region from the Canal Zone westward and northward to Costa Rica. No external character is known by which it may be distinguished from *C. capucinus capucinus* of eastern Panama, but the decidedly greater average transverse extent of the premolars above and below seem to entitle it to subspecific recognition. The upper premolars are usually broader than the first molar, while in typical *C. capucinus* the width of these teeth is about the same. In Central America the capuchins exhibit a progressive increase from south to north, in the width of the premolars, the maximum development noted being in specimens of *Cebus c. limitaneus* Hollister from Honduras.

An example of the Panama white-throated capuchin was obtained at Gatun, Canal Zone, which seems to be near the eastern limit of the range of the subspecies. Mr. Alston (1879, p. 13) mentions specimens in the British Museum obtained by Arcé in Veragua. Two topotypes collected by Mr. W. W. Brown, Jr., are recorded by Mr. Outram Bangs (1902, p.51) as *Cebus hypoleucus*. Under the same name five specimens of this species taken at Boqueron and one at Boquete by Mr. J. H. Batty are listed by Dr. J. A. Allen (1904, p. 80) who remarks that the males and females do not appear to differ in the relative elongation, or color, of the hair of the frontal region. In discussing six specimens of the capuchin of Coiba Island Mr. Oldfield Thomas (1902, p. 135) says: "I can find absolutely no difference, either in size or colour, between these and mainland specimens. Considering the small size of the island there is a noticeable amount of variation within the series, both with regard to the extension of the white on the arms and shoulders and in the skull in the height of the nasal bones." Skulls of specimens from Coiba Island in the American Museum of Natural History are rather small and in the narrowness of the premolars might, with nearly equal propriety, be referred to typical *C. c. capucinus*.

So little is known of the habits of the capuchins in Panama that the following observations on the same species by Belt[1] in Nicaragua seem worth quoting: "Sometimes . . . . we would fall in with a troop of the white-faced cebus monkey, rapidly running away, throwing themselves from tree to tree. This monkey feeds also partly on fruit, but is incessantly on the lookout for insects, examining the

[1] Naturalist in Nicaragua, p. 118, 1888.

crevices in trees and withered leaves, seizing the largest beetles and munching them up with great relish. It is also very fond of eggs and young birds, and must play havoc amongst the nestlings. Probably owing to its carnivorous habits, its flesh is not considered so good by monkey-eaters as that of the fruit-feeding spider-monkey. . . . . I kept one for a long time as a pet, and was much amused with its antics. . . . . I had it fastened with a light chain; but it managed to open the links and escape several times, and then made straight for the fowls' nests, breaking every egg it could get hold of . . . . Its chain allowed it to swing down below the verandah, but it could not reach to the ground. Sometimes, when there were broods of young ducks about, it would hold out a piece of bread in one hand, and, when it had tempted a duckling within reach, seize it by the other, and kill it with a bite in the breast."

Specimens examined: Boqueron, 6[1]; Boquete, 2[2]; Coiba Island, 12[1]; Gatun, 1; without definite locality, 9.[1]

Family ATELIDAE. Spider Monkeys

The Atelidæ form a surpassingly arboreal group of species. The great length and power of the tail as a grasping organ and the slenderness of the limbs, in allusion to which these animals are commonly called spider monkeys, permit a rapidity of progression through tree tops that is often marvelous.

Genus ATELES E. Geoffroy

This genus is composed of rather large, but slender, long-limbed species with very long, prehensile tails, naked on the under side near the tip. In general external appearance they are not very unlike the howling monkeys of the genus *Alouatta,* but are easily recognizable by the absence of the thumbs and consequent reduction of the number of fingers on the hands to four, instead of five as in all the other primates of the region. Two species are known to inhabit Panama.

ATELES GEOFFROYI Kuhl

Geoffroy's Spider Monkey; Mono Colorado

Ateles geoffroy [*sic*] KUHL, Beiträge z. Zoologie, 1820, p. 26. Type locality unknown.

Although somewhat variable in general color the "mono colorado" is usually reddish as the native name indicates, and by this character is distinguishable from the black spider monkey of Panama. Parts

[1] Collection Amer. Mus. Nat. Hist.

[2] Collection Mus. Comp. Zool.

of the early account of monkeys in Panama by Lionel Wafer (1729, p. 330) may have been based on observation of this species.

Geoffroy's spider monkey was not met with by me in the Canal Zone, but the species was recorded by Alston (1879, p. 8) from Colon, as living in the gardens of the Zoological Society of London. It is known to range in western Panama whence a specimen was referred by Sclater (1872, p. 4) to *Ateles melanochir.* He says: "There is also in the British Museum a skin of this Spider Monkey procured by Salvin's collector Arcé near Calovevora, in Veragua." Since the species is not included in the more recent and extensive collections made in Chiriqui by W. W. Brown, Jr., and J. H. Batty, it may not be very common there. It appears, however, to be better known throughout much of Costa Rica.

One was killed by a native hunter at about 2,000 feet altitude on Cerro Brujo near Porto Bello. A troop of 12 or 15 was seen by me near the Cascajal River, at the base of this mountain, but quickly escaped by climbing through the tall trees up a steep slope. At about 800 feet altitude on Cerro Azul, near the headwaters of the Chagres River, I came suddenly upon a small party the exact number of which I was unable to determine. Here I was especially impressed by the remarkable climbing powers of the animal. Some of them were seen to run along large horizontal limbs mainly on their hind feet, but holding on also with both hands and tails. Arriving at the end of a branch a tremendous flying leap carried one across an intervening space to another tree. The species was free from the larvæ of flies which infest the howling monkeys and the flesh is more highly prized as food by the natives.

Specimens examined: Cerro Azul, 2; Cerro Brujo, 1.

ATELES DARIENSIS Goldman

Darien Black Spider Monkey

[Plate 38, figs. 2, *2a*]

Ateles dariensis GOLDMAN, Proc. Biol. Soc. Washington, Vol. 28, p. 101, April 13, 1915. Type from near head of Rio Limon, Mount Pirre, eastern Panama (altitude 5,200 feet).

Eastern Panama is inhabited by a rather small spider monkey easily recognizable by its uniform black color from the "mono colorado" or reddish species, *Ateles geoffroyi.* The monkey appears to be a Darien representative of the *A. ater* group of South America. The type from the heavy forest near the summit of Mount Pirre was the only example taken by me. The species was not encountered in the course of my work in the Canal Zone, but Sclater (1872, p. 5) mentions several living specimens received by the Zoological Society of

London and said to have been procured at Colon. Anthony (1916, p. 375) records examples from Tapalisa and reports having once noted this species at 5,000 feet near Mount Tacarcuna in the Serrania del Darien northeast of the type locality. The exact relationship of *A. dariensis* to the little known *Ateles rufiventris* Sclater (1872, p. 688, pl. 57) is somewhat problematical. The latter species, which was described from the Rio Atrato and may range into Panama, seems, however, sufficiently distinguished by the bright rufous color of the underparts.

Specimens examined: Cituro, 1[1]; Mount Pirre (type locality), 1; Tapalisa, 1.[1]

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Original descriptions of *Marmosa isthmica* (=*Marmosa mexicana isthmica*), p. 1, *Metachirus nudicaudatus dentaneus*, p. 2, *Sciurus variegatoides helveolus*, p. 3, *Microsciurus alfari venustulus*, p. 4, *Oryzomys idoneus* (=*Oryzomys caliginosus idoneus*), p. 5, *Oryzomys frontalis* (=*Oryzomys tectus frontalis*), p. 6, *Oryzomys bombycinus*, p. 6, *Oryzomys gatunensis*, p. 7, *Zygodontomys cherriei ventriosus*, p. 8, *Heteromys panamensis* (=*Heteromys desmarestianus panamensis*), p. 9, *Heteromys zonalis* (=*Heteromys desmarestianus zonalis*), p. 9, and *Hoplomys goethalsi* (=*Hoplomys gymnurus goethalsi*), p. 10.

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Original descriptions of *Peramys melanops*, p. 2, *Marmosa invicta*, p. 3, *Microsciurus isthmius vivatus*, p. 4, *Peromyscus pirrensis*, p. 5, *Neacomys pictus*, p. 6, *Rheomys raptor*, p. 7, *Macrogeomys dariensis*, p. 8, *Heteromys crassirostris* (=*Heteromys desmarestianus crassirostris*), p. 10, *Hydrochœrus isthmius*, p. 11, *Isothrix darlingi* (=*Diplomys darlingi*), p. 12, *Sylvilagus gabbi messorius*, p. 13, *Icticyon panamensis*, p. 14, *Bassaricyon gabbi orinomus*, p. 16, and *Cryptotis merus*, p. 17.

1913. Descriptions of New Mammals from Panama and Mexico. Smiths. Misc. Coll., Vol. 60, No. 22, pp. 1-20, February 28, 1913.

Includes original descriptions of the following Panaman forms: *Bradypus ignavus*, p. 1, *Mazama tema reperticia* (=*Mazama sartorii reperticia*), p. 2, *Sciurus variabilis choco* (=*Sciurus gerrardi choco*), p. 4, *Oryzomys pirrensis*, p. 5, *Nectomys alfari efficax*, p. 7, *Rhipidomys scandens*, p. 8, *Heteromys australis conscius*, p. 8, *Dasyprocta punctata dariensis*, p. 11, *Potos flavus isthmicus*, p. 14, *Euprocyon cancrivorus panamensis* (=*Procyon cancrivorus panamensis*), p. 15, *Alouatta palliata inconsonans*, p. 17.

1914. Descriptions of Five New Mammals from Panama. Smiths. Misc. Coll., Vol. 63, No. 5, pp. 1-7, March 14, 1914.
Original descriptions of *Chironectes panamensis,* p. 1, *Lonchophylla concava,* p. 2, *Lutra repanda,* p. 3, *Felis pirrensis,* p. 4, and *Aotus zonalis,* p. 6.

1914a. The Status of *Cebus imitator* Thomas. Proc. Biol. Soc. Washington, Vol. 27, p. 99, May 11, 1914.
Type region of *Cebus capucinus capucinus* fixed as northern Colombia; *Cebus capucinus imitator* regarded as a valid subspecies.

1915. A New Spider Monkey from Panama. Proc. Biol. Soc. Washington, Vol. 28, pp. 101-102, April 13, 1915.
Original description of *Ateles dariensis,* p. 101.

1915a. Five New Rice Rats of the Genus *Oryzomys* from Middle America. Proc. Biol. Soc. Washington, Vol. 28, pp. 127-130, June 29, 1915.
Includes original description of *Oryzomys alfaroi dariensis,* p. 128.

1917. New Mammals from North and Middle America. Proc. Biol. Soc. Washington, Vol. 30, pp. 107-116, May 23, 1917.
Includes original descriptions of *Didelphis marsupialis particeps,* p. 107, *Marmosa mexicana savannarum,* p. 108, *Pecari angulatus bangsi,* p. 109, and *Dasyprocta punctata nuchalis,* p. 113.

GRAY, J. E.

1871. On a New Species of Three-toed Sloth from Costa Rica. Ann. Mag. Nat. Hist., Ser. 4, Vol. 7, p. 302, April, 1871.
Original description of *Arctopithecus griseus* (=*Bradypus griseus*), erroneously ascribed to Costa Rica; in reality from Cordillera del Chucu, western Panama.

1871a. Notes on the Species of Bradypodidæ in the British Museum. Proc. Zool. Soc. London, 1871, pp. 428-449, May 2.
Contains notes on *Arctopithecus griseus* (=*Bradypus griseus*), p. 446, from Panama.

1873. Notes on the Rats; with the Description of some new Species from Panama and the Aru Islands. Ann. Mag. Nat. Hist., Ser. 4, Vol. 12, pp. 416-419, November, 1873.
Includes original description of *Neomys panamensis* (=*Tylomys panamensis*), p. 417.

HAHN, WALTER L.

1907. A Review of the Bats of the Genus Hemiderma. Proc. U. S. Nat. Mus., Vol. 32, pp. 103-118, February 8, 1907.
Records *Hemiderma perspicillatum aztecum,* p. 112, from Panama (city), Boqueron, and Colon.

HALE, H. C.

1903. Notes on Panama, pp. 1-271, with maps and illustrations, November, 1903, Washington, Govt. Printing Office.
A compilation of general information relating to Panama, including very brief references to a few mammals.

HOWELL, ARTHUR H.

1914. Revision of the American Harvest Mice. North Amer. Fauna, No. 36, pp. 1-81, pls. 1-7, June 5, 1914.

Treats *Reithrodontomys creper,* p. 79, and records *Reithrodontomys australis australis,* p. 62, and *Reithrodontomys mexicanus cherrii,* p. 73, from Panama.

HUET, M.

1883. Note sur les Carnassiers du Genre Bassaricyon. Nouv. Arch. du Mus. d'Hist. Nat. de Paris, 2° sér., V, pp. 1-12, pls. i-iii., 1883.

Describes and figures two specimens from "Caïmito, province de Correo, un peu au nord de Panama."

MAACK, G. A.

1874. Report on the Geology and Natural History of the Isthmuses of Choco, of Darien, and of Panama, pp. 155-175, in Reports of Explorations and Surveys to Ascertain the Practicability of a Ship-Canal between the Atlantic and Pacific Oceans by Thomas Oliver Selfridge, Washington, 1874.

A few mammals of the general region are mentioned, usually no definite locality being given. A very small collection of mammals was sent by Maack to the Museum of Comparative Zoology, but labels bear only indefinite locality records, usually "Isthmus of Panama."

MERRIAM, C. HART.

1901. Preliminary Revision of the Pumas (*Felis concolor* group). Proc. Washington Acad. Sci., Vol. 3, pp. 577-600, December 11, 1901.

Includes original description of *Felis bangsi costaricensis,* p. 596, from Boquete, Panama.

MILLER, JR., GERRIT, S.

1900. A New Free-tailed Bat from Central America. Ann. Mag. Nat. Hist., Ser. 7, Vol. 6, pp. 470-471, November, 1900.

Original description of *Promops nanus* (=*Eumops nanus*), from Bugaba, Chiriqui.

1911. Descriptions of Two New Raccoons. Proc. Biol. Soc. Washington, Vol. 24, pp. 3-6, January 28, 1911.

Includes original description of *Procyon pumilus* (=*Procyon lotor pumilus*), p. 3.

1912. A Small Collection of Bats from Panama. Proc. U. S. Nat. Mus., Vol. 42, No. 1882, pp. 21-26, March 6, 1912.

An annotated list of 11 species including the three following which are described as new: *Lonchophylla robusta,* p. 23; *Vampyressa minuta;* p. 25, *Chiroderma isthmicum,* p. 25.

1913. Notes on the Bats of the Genus *Molossus.* Proc. U. S. Nat. Mus., Vol. 46, pp. 85-92, August 23, 1913.

A preliminary revision of the genus in which the following species are recorded from Panama: *Molossus sinaloæ,* p. 89, from Punta de Peña (near Bocas del Toro); *Molossus bondæ,* p. 89, from Chorrera; *Molossus coibensis,* p. 92, from Ancon, Chorrera, Culebra, Paraiso, San Pablo, and Tabernilla.

1913a. Revision of the Bats of the Genus *Glossophaga*. Proc. U. S. Nat. Mus., Vol. 46, pp. 413-429, December 31, 1913.

Records *Glossophaga soricina leachii*, p. 419, from Balboa, "Canal Zone," Colon, and Paraiso.

NELSON, E. W.

1903. A New Pygmy Squirrel from Central America. Proc. Biol. Soc. Washington, Vol. 16, p. 121-122, September 30, 1903.

Original description of *Sciurus* (*Microsciurus*) *boquetensis* (=*Microsciurus boquetensis*) from Boquete, Panama.

1909. The Rabbits of North America. North Amer. Fauna, No. 29, pp. 1-287, pls. 1-13, August 31, 1909.

A revision of the group including *Sylvilagus gabbi incitatus*, p. 261, and records of *Sylvilagus gabbi gabbi*, p. 261, from Panama.

1912. Two Genera of Bats New to Middle America. Proc. Biol. Soc. Washington, Vol. 25, p. 93, May 4, 1912.

Records *Dirias minor* (=*D. albiventer minor*) from Empire, and *Macrophyllum macrophyllum* from Old Panama.

OSGOOD, WILFRED H.

1909. Revision of the Mice of the American Genus *Peromyscus*. North Amer. Fauna, No. 28, pp. 1-267, pls. 1-8, April 17, 1909.

Recognizes *Peromyscus flavidus*, p. 221, and records *Peromyscus nudipes*, p. 195, from Panama.

PETERS, W.

1874. Hr. W. Peters las über die Taschenmäuse, Nager mit äusseren taschenförmigen Backentaschen, und eine neue Art derselben, *Heteromys adspersus*, aus Panama. Monatsber. k. preuss. Akad. Wissensch. Berlin, pp. 354-359.

Original description of *Heteromys adspersus* (=*Liomys adspersus*), p. 357, with pl.

PUCHERAN, J.

1845. Description de quelques Mammiferes Americains par le M. le Docteur Pucheran. Rev. Zool., pp. 335-337, September, 1845.

Contains original description of *Hapale geoffroyi* (=*Leontocebus geoffroyi*), p. 336, from Panama. Type locality given under *Hapale illigeri* Pucheran, on same page.

REINHARDT, J.

1872. Et Bidrag til Kundskab om Aberne i Mexiko og Central-amerika. Vidensk. Middel. Nat. For. Kjöbenhavn, pp. 150-158, 1872.

Description of a new species, *Chrysothrix örstedii* (=*Saimiri örstedii*), p. 157, from Chiriqui.

SCLATER, PHILIP LUTLEY.

1856. List of Mammals and Birds Collected by Mr. Bridges in the Vicinity of David in the Province of Chiriqui in the State of Panama. Proc. Zool. Soc., 1856, pp. 138-143.

Records the following species: *Saimiris sciurea* (Linn.) = (*Saimiri örstedii*), p. 139, *Sciurus* ———? (=*Sciurus variegatoides melania*), p. 139, *Sciurus æstuans* (=*Sciurus hoffmanni chiriquensis*), p. 139, *Cyclothurus didactylus* (=*Cyclopes didactylus dorsalis*), p. 139, *Cholœpus didactylus* (=*Cholœpus hoffmanni*), p. 139.

1872. On the Quadrumana found in America north of Panama. Proc. Zool. Soc. London, 1872, pp. 2-8.

Records the following species: *Saimiris entomophaga* (=*Saimiri örstedii*), p. 3, *Ateles melanochir* (=Ateles *geoffroyi*), p. 4, *Ateles ater* (=*Ateles dariensis*), p. 5, and *Midas geoffroii* (=*Leontocebus geoffroyi*, p. 8).

1875. On Several Rare or Little-known Mammals now or lately Living in the Society's Collection. Proc. Zool. Soc. London, pp. 417-423, 1875.

Records *Procyon cancrivorus* (=*Procyon cancrivorus panamensis*), p. 421, from Colon.

SHIRAS, GEORGE, 3RD.

1915. Nature's Transformation at Panama. Nat. Geog. Mag., Vol. 28, pp. 159-194, and 33 photographs, August, 1915.

An account of changes in faunal and physical conditions in the Gatun Lake region due to construction of Gatun Dam, including habitat notes and photographs of some of the mammals.

THAYER, JOHN E., and BANGS, OUTRAM.

1905. The Mammals and Birds of the Pearl Islands, Bay of Panama. Bull. Mus. Comp. Zool., Vol. 46, No. 8, pp. 137-160.

Literature cited, and a nominal list of 12 species of mammals, pp. 139-140, of which six are regarded as peculiar by Outram Bangs.

THOMAS, OLDFIELD.

1899. Descriptions of New Neotropical Mammals. Ann. Mag. Nat. Hist., Ser. 7, Vol. 4, pp. 278-288, October, 1899.

Contains original descriptions of *Tylomys watsoni*, p. 278, and *Philander laniger pallidus*, p. 286, both from Bugaba, Chiriqui.

1900. The Geographical Races of the Tayra (*Galictis barbara*), with Notes on Abnormally Coloured Individuals. Ann. Mag. Nat. Hist., Ser. 7, Vol. 5, pp. 145-148, January, 1900.

Original description of *Galictis barbara biologiæ* (=*Tayra barbara biologiæ*), p. 146, from Calovevora, Panama.

1900a. Descriptions of New Neotropical Mammals. Ann. Mag. Nat. Hist., Ser. 7, Vol. 5, pp. 217-222, February, 1900.

The following subspecies are described as new: *Proechimys centralis panamensis* (=*Proechimys semispinosus panamensis*), p. 220, and *Proechimys centralis chiriquinus* (=*Proechimys semispinosus panamensis*), p. 220.

1901. New Myotis, Artibeus, Sylvilagus, and Metachirus from Central and South America. Ann. Mag. Nat. Hist., Ser. 7, Vol. 7, pp. 541-545, June, 1901.

Original description of *Artibeus watsoni*, p. 542, from Bugaba, Chiriqui.

1901a. New Neotropical Mammals, with a Note on the Species of Reithrodon. Ann. Mag. Nat. Hist., Ser. 7, Vol. 8, pp. 246-255, September, 1901.

Original descriptions of *Dasypterus ega panamensis*, p. 246, *Oryzomys tectus*, p. 251, and *Oryzomys panamensis* (=*Oryzomys talamancæ*, p. 252.

1902. On Some Mammals from Coiba Island, off the West Coast of Panama. Novitates Zoologicæ, Vol. 9, pp. 135-137, April, 1902.

Cebus hypoleucus (= *Cebus capucinus capucinus*), p. 135, is recorded and the following are described as new: *Alouatta palliata coibensis,* p. 135, *Dasyprocta coibæ,* p. 136, *Dama rothschildi* (= *Odocoileus rothschildi*), p. 136, and *Didelphis marsupialis battyi,* p. 137.

1902a. Notes on the Phyllostomatous Genera Mimon and Tonatia. Ann. Mag. Nat. Hist., Ser. 7, Vol. 10, pp. 53-54, July, 1902.

Records *Tonatia amblyotis* (p. 54), from Bugaba, Chiriqui.

1902b. Diagnosis of a New Central-American Porcupine. Ann. Mag. Nat. Hist., Ser. 7, Vol. 10, p. 169, August, 1902.

Original description of *Coendou rothschildi* from Sevilla Island, off Chiriqui, Panama.

1903. New Mammals from Chiriqui. Ann. Mag. Nat. Hist., Ser. 7, Vol. 11, pp. 376-382, April, 1903.

Original descriptions of *Cebus imitator* (= *Cebus capucinus imitator*), p. 376, *Diphylla centralis,* p. 378, *Bassariscus sumichrasti notinus,* p. 379, and *Coendou lænatus,* p. 381, all from Boquete, Chiriqui, and of *Diclidurus virgo,* p. 377, the type of the latter from Escazu, Costa Rica, but Panama examples are recorded.

1903a. On a Collection of Mammals from the small Islands off the Coast of Western Panama. Novitates Zoologicæ, Vol. 10, pp. 39-42, April, 1903.

An annotated list of 23 species, including a second and fuller account of *Coendou rothschildi,* p. 41, from Sevilla Island.

1904. New Forms of *Saimiri, Saccopteryx, Balantiopteryx,* and *Thrichomys* from the Neotropical Region. Ann. Mag. Nat. Hist., Ser. 7, Vol. 13, pp. 250-255, April, 1904.

Original description of *Saimiri oerstedi citrinellus,* p. 250, from Costa Rica, referred to in text.

1905. New Neotropical Molossus, Conepatus, Nectomys, Proechimys, and Agouti, with a note on the Genus Mesomys. Ann. Mag. Nat. Hist., Ser. 7, Vol. 15, pp. 584-586, June, 1905.

Contains original description of *Conepatus tropicalis trichurus,* p. 585, from Boquete, Chiriqui.

1912. New *Centronycteris* and *Ctenomys* from S. America. Ann. Mag. Nat. Hist., Ser. 8, Vol. 10, p. 638, December, 1912.

Includes original description of *Centronycteris centralis* from Bugaba, Chiriqui.

1913. The Geographical Races of the Woolly Opossum (*Philander laniger*). Ann. Mag. Nat. Hist., Ser. 8, Vol. 12, pp. 358-361, October, 1913.

A list of geographic races, and original description of *Philander laniger nauticus,* p. 359, from Gobernador Island, Panama.

WAFER, LIONEL.
1729. A New Voyage and Description of the Isthmus of America, 3d ed., London, 1729. Published as pp. 263-460 of the third volume of Dampier's Voyages. The original edition was published separately under the same title in 1699.

Includes quaint and interesting accounts of mammals based on observations made in eastern Panama in 1681. Owing to an accident which prevented him from marching with the others, Wafer was left behind by Dampier's party at an Indian plantation on the Rio Congo in the early part of May. He and four companions remained among the Darien Indians until the latter part of August when Dampier's party was rejoined at the "Sambaloes" (= San Blas Islands).

PLATE 20

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Metachirus nudicaudatus dentaneus* Goldman. Type. Gatun, Panama. January 12, 1911. ♂ (172732).

2, 2*a*. *Chironectes panamensis* Goldman. Type. Cana, Panama. March 23, 1912. ♂ (179164).


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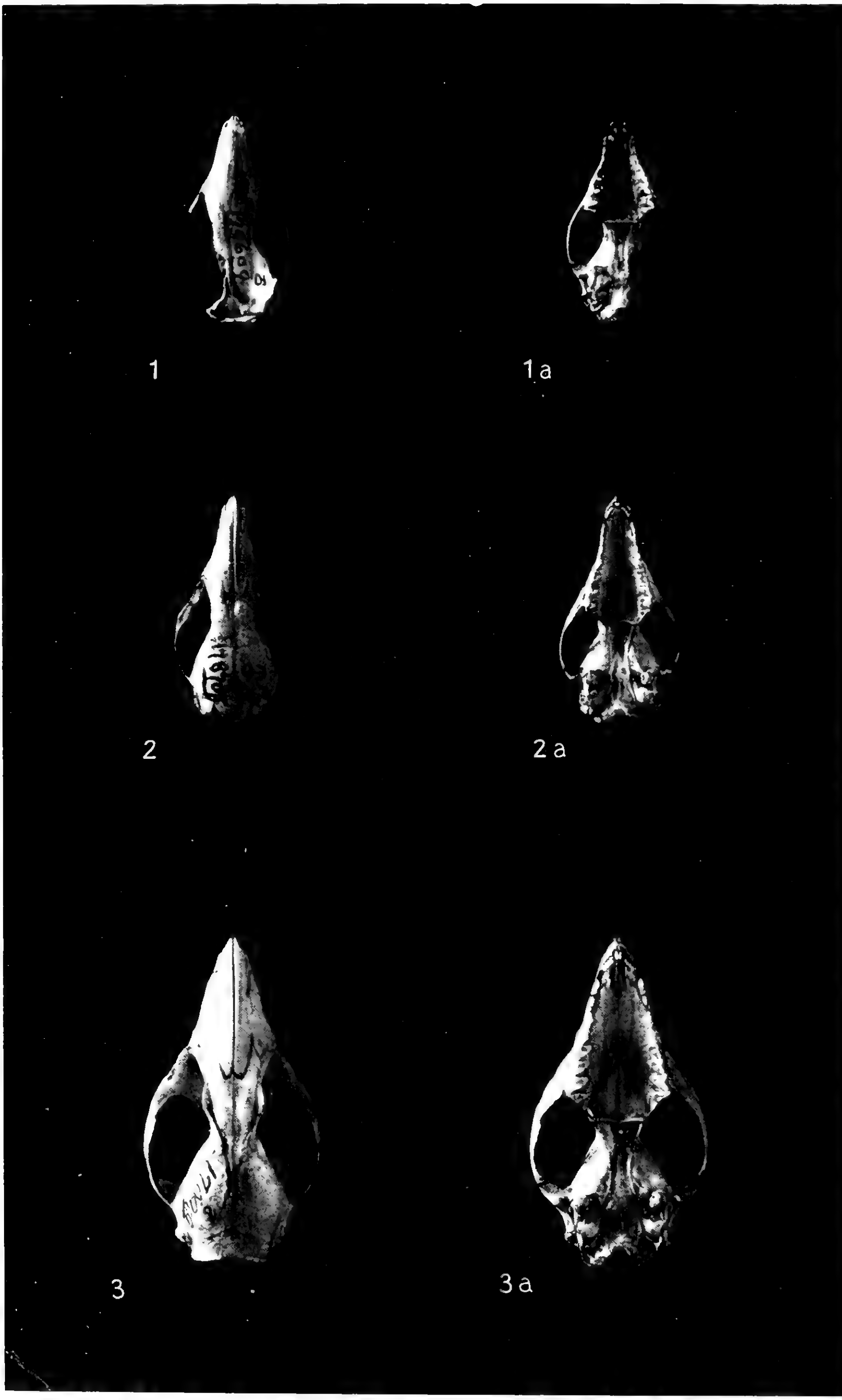
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PLATE 21

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Peramys melanops* Goldman. Type. Cana, Panama. May 23, 1912. ♂ (179609).

2, 2*a*. *Marmosa invicta* Goldman. Type. Cana, Panama. March 14, 1912. ♂ (178708).

3, 3*a*. *Marmosa mexicana isthmica* Goldman. Type. Rio Indio, near Gatun, Panama. February 16, 1911. ♂ (170969).

PLATE 22

[Natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Bradypus ignavus* Goldman. Type. Marraganti, Panama, April 6, 1912. ♀ (179551).

1

1a

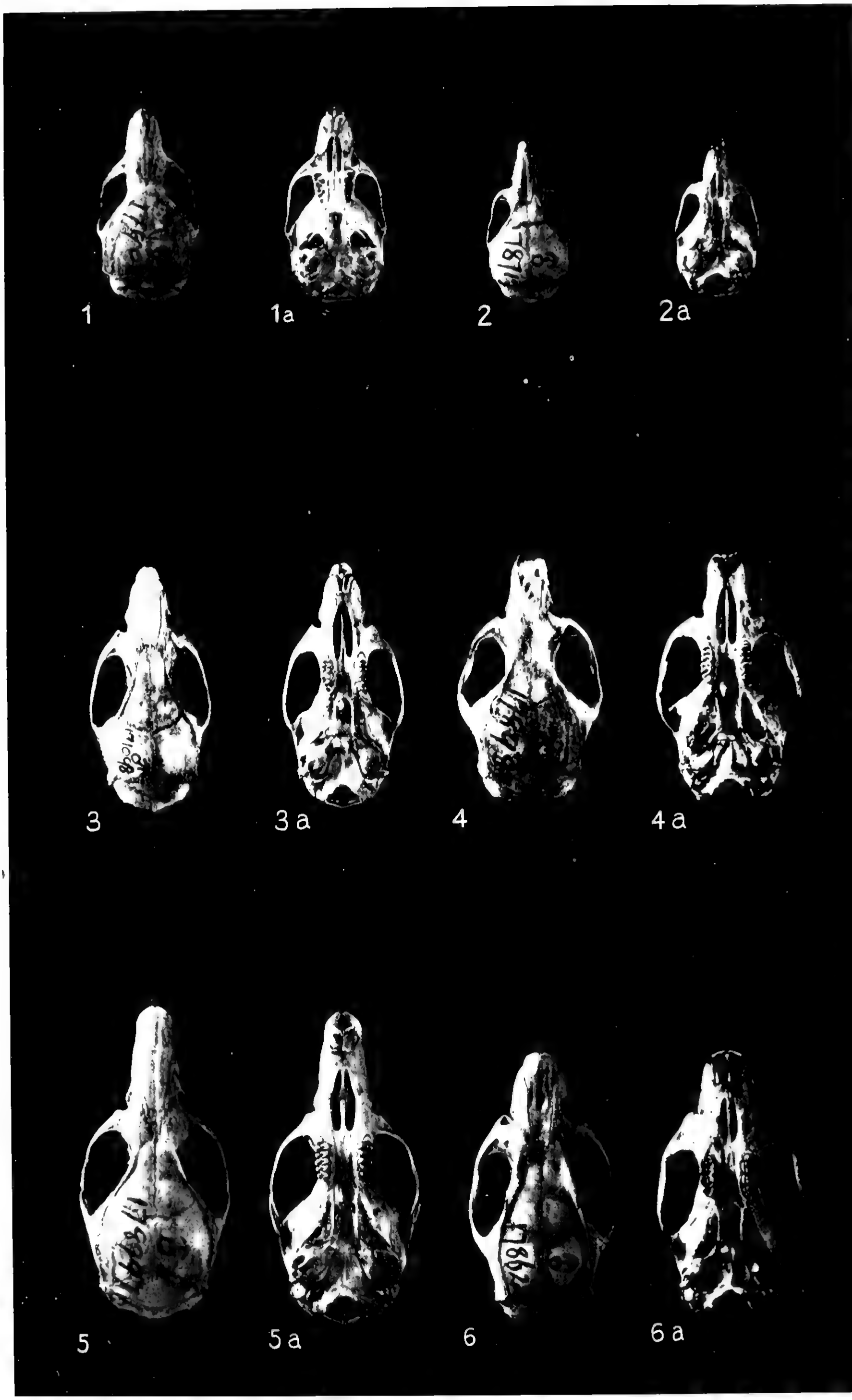
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PLATE 23

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Rheomys raptor* Goldman. Type. Mount Pirre, Panama. April 28, 1912. ♂ (179028).

2, 2a. *Neacomys pictus* Goldman. Type. Cana, Panama. March 13, 1912. ♂ (178717).

3, 3a. *Zygodontomys cherriei ventriosus* Goldman. Type. Tabernilla, Canal Zone, Panama. November 12, 1911. ♂ (171098).

4, 4a. *Rhipidomys scandens* Goldman. Type. Mount Pirre, Panama. April 25, 1912. ♀ (178987).

5, 5a. *Peromyscus pirrensis* Goldman. Type. Mount Pirre, Panama. May 3, 1912. ♂ (178997).

6, 6a. *Nectomys alfari efficax* Goldman. Type. Cana, Panama. March 12, 1912. ♂ (178627).

PLATE 24

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Oryzomys* (*Oryzomys*) *alfaroi dariensis* Goldman. Type. Cana, Panama. March 4, 1912. ♀ (178660).

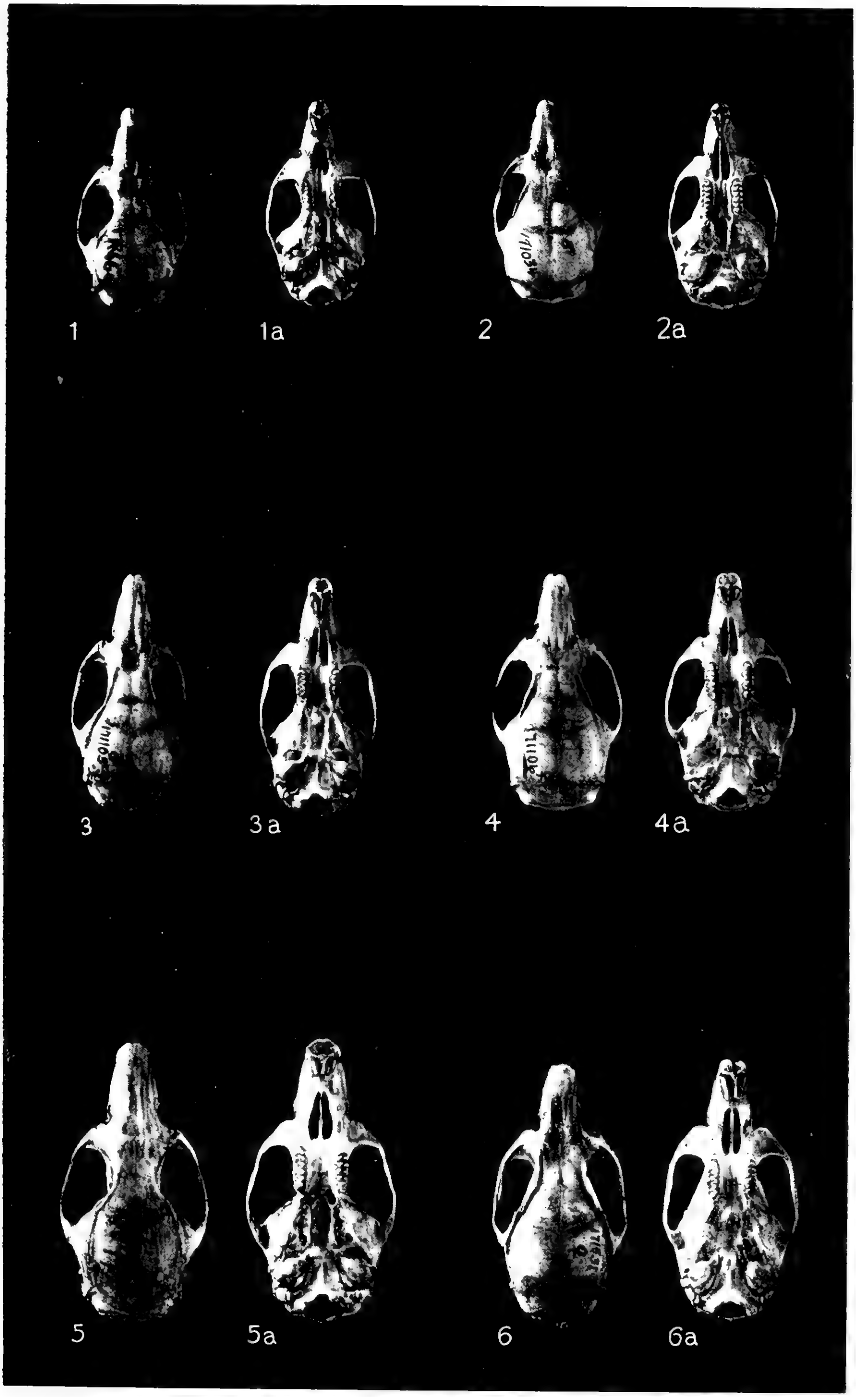
2, 2*a*. *Oryzomys* (*Oryzomys*) *gatunensis* Goldman. Type. Gatun, Canal Zone, Panama. March 7, 1911. ♂ (171034).

3, 3*a*. *Oryzomys* (*Oryzomys*) *bombycinus bombycinus* Goldman. Type. Cerro Azul, near head Chagres River, Panama. March 26, 1911. ♂ (171105).

4, 4*a*. *Oryzomys* (*Melanomys*) *caliginosus idoneus* Goldman. Type. Cerro Azul, near head Chagres River, Panama. March 26, 1911. ♀ (171106).

5, 5*a*. *Oryzomys* (*Oryzomys*) *pirrensis* Goldman. Mount Pirre, near head River Limon, Panama. April 29, 1912. ♂ adult (178993).

6, 6*a*. *Oryzomys* (*Oryzomys*) *tectus frontalis* Goldman. Type. Corozal, Canal Zone, Panama. June 20, 1911. ♂ adult (171531).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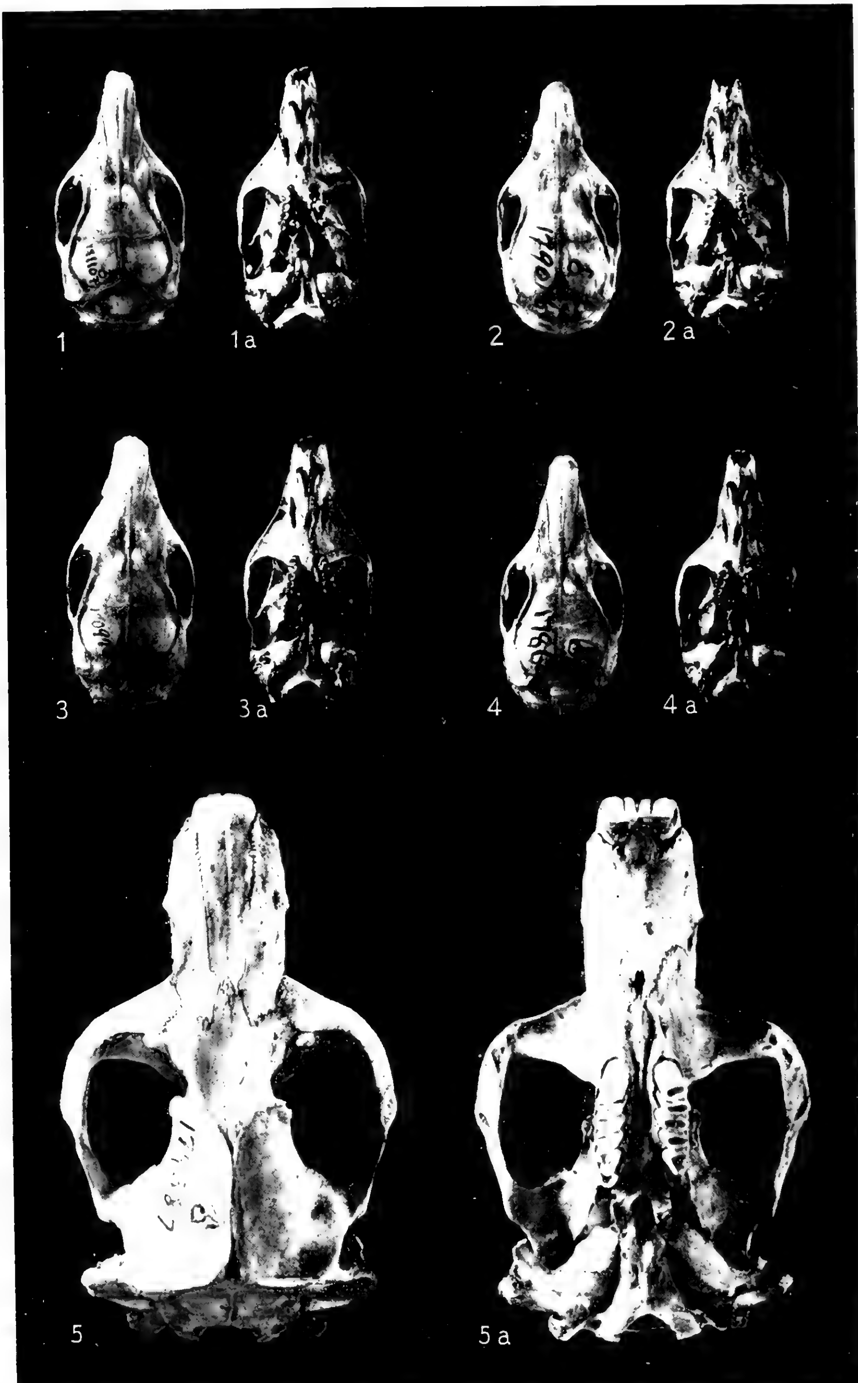
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PLATE 25

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Heteromys desmarestianus panamensis* Goldman. Type. Cerro Azul, near head Chagres River, Panama. March 23, 1911. ♂ adult (171107).

2, 2a. *Heteromys desmarestianus crassirostris* Goldman. Type. Mount Pirre, near head River Limon, Panama. April 26, 1912. ♂ adult (179016).

3, 3a. *Heteromys desmarestianus zonalis* Goldman. Type. Rio Indio, near Gatun, Canal Zone, Panama. February 15, 1911. ♀ adult (170976).

4, 4a. *Heteromys australis conscius* Goldman. Type. Cana, Panama. March 8, 1912. ♂ adult (178699).

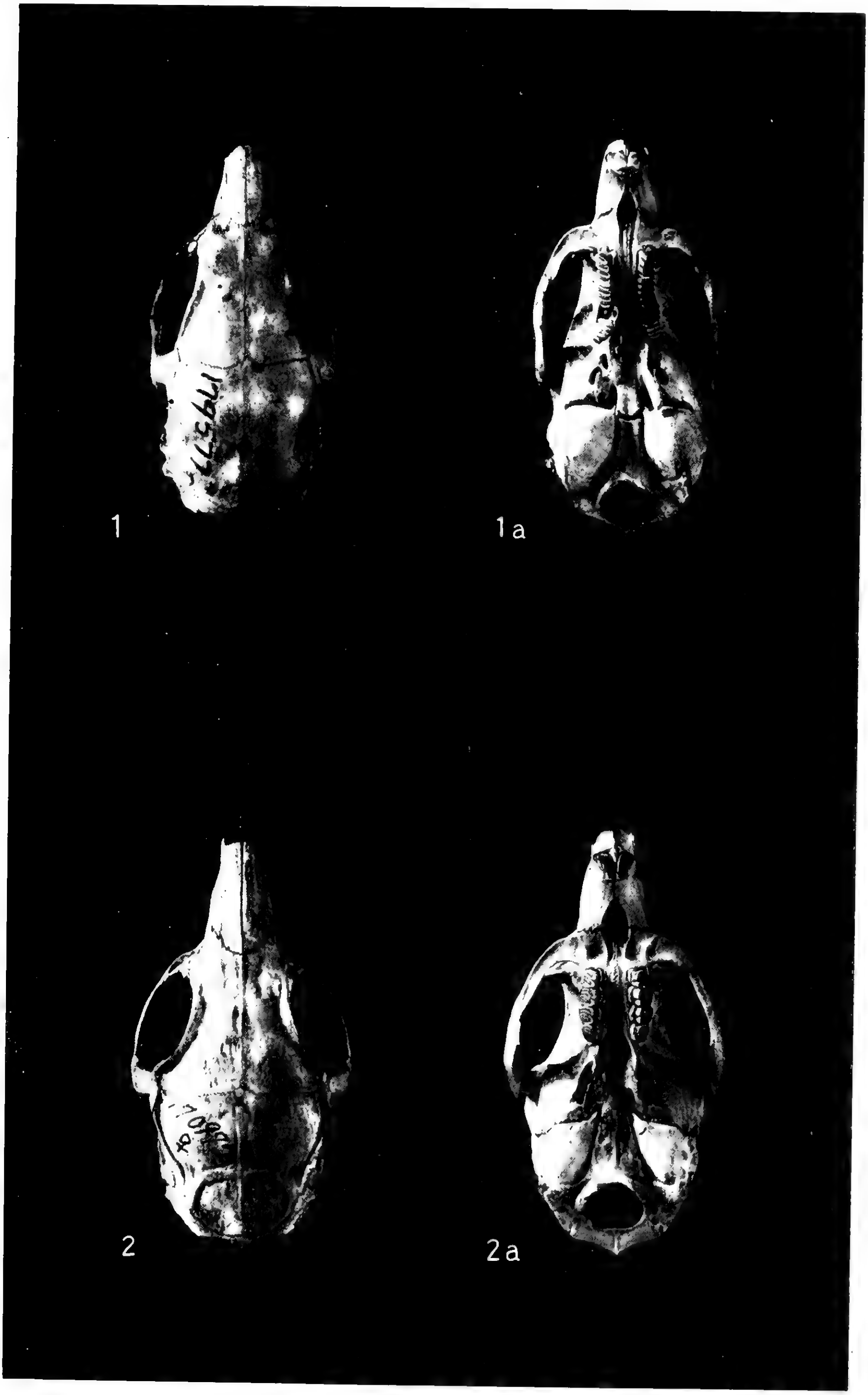
5, 5a. *Macrogeomys dariensis* Goldman. Type. Cana, Panama. May 31, 1912. ♂ adult (179587).

PLATE 26

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Diplomys darlingi* (Goldman). Type. Marragantí, Panama. May 11, 1912. Young ♀ (179577).

2, 2a. *Hoplomys gymnurus goethalsi* Goldman. Type. Rio Indio (near Gatun), Canal Zone, Panama. February 16, 1911. Young ♀ (170972).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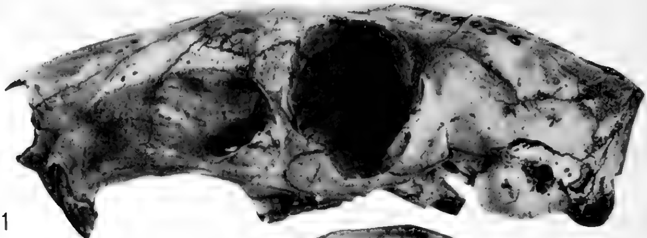

1

1a

1b

2

2a

PLATE 27

[Natural size, except figs. 1, 1a and 1b; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a, 1b. *Dasyprocta punctata dariensis* Goldman. Type. Mount Pirre, near head Rio Limon, Panama. April 24, 1912. ♀ adult (179056) (three-fourths natural size).

2, 2a. *Sylvilagus gabbi messorius* Goldman. Type. Cana, Panama. May 23, 1912. ♂ adult (179569) (natural size).

PLATE 28

[About one-half natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Hydrochoerus isthmius* Goldman. Type. Marragantí, Panama. April 4, 1912. ♂ adult (179703).

1

1a

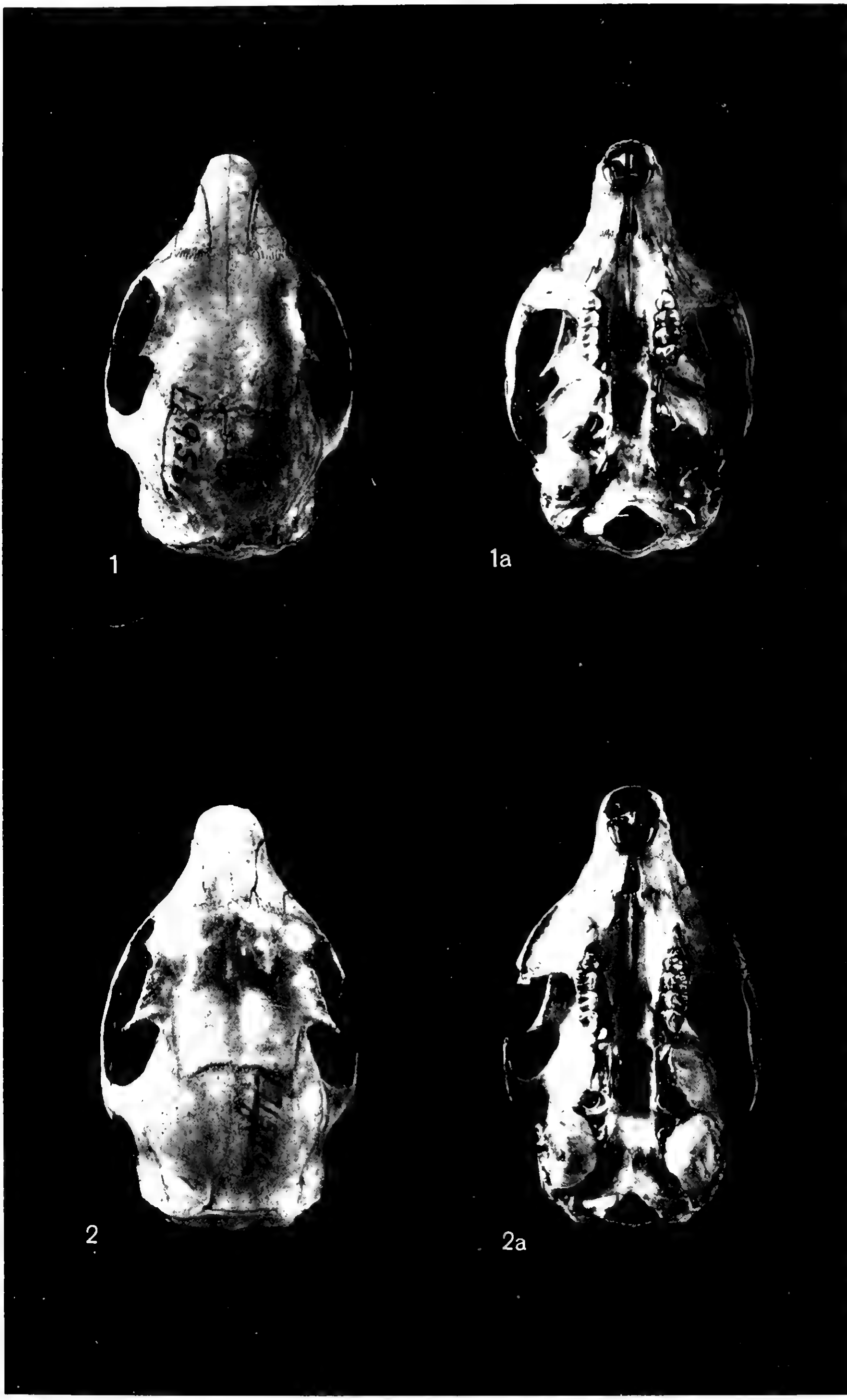
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PLATE 29

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Sciurus gerrardi choco* Goldman. Type. Cana, Panama. May 28, 1912. ♂ adult (179561).

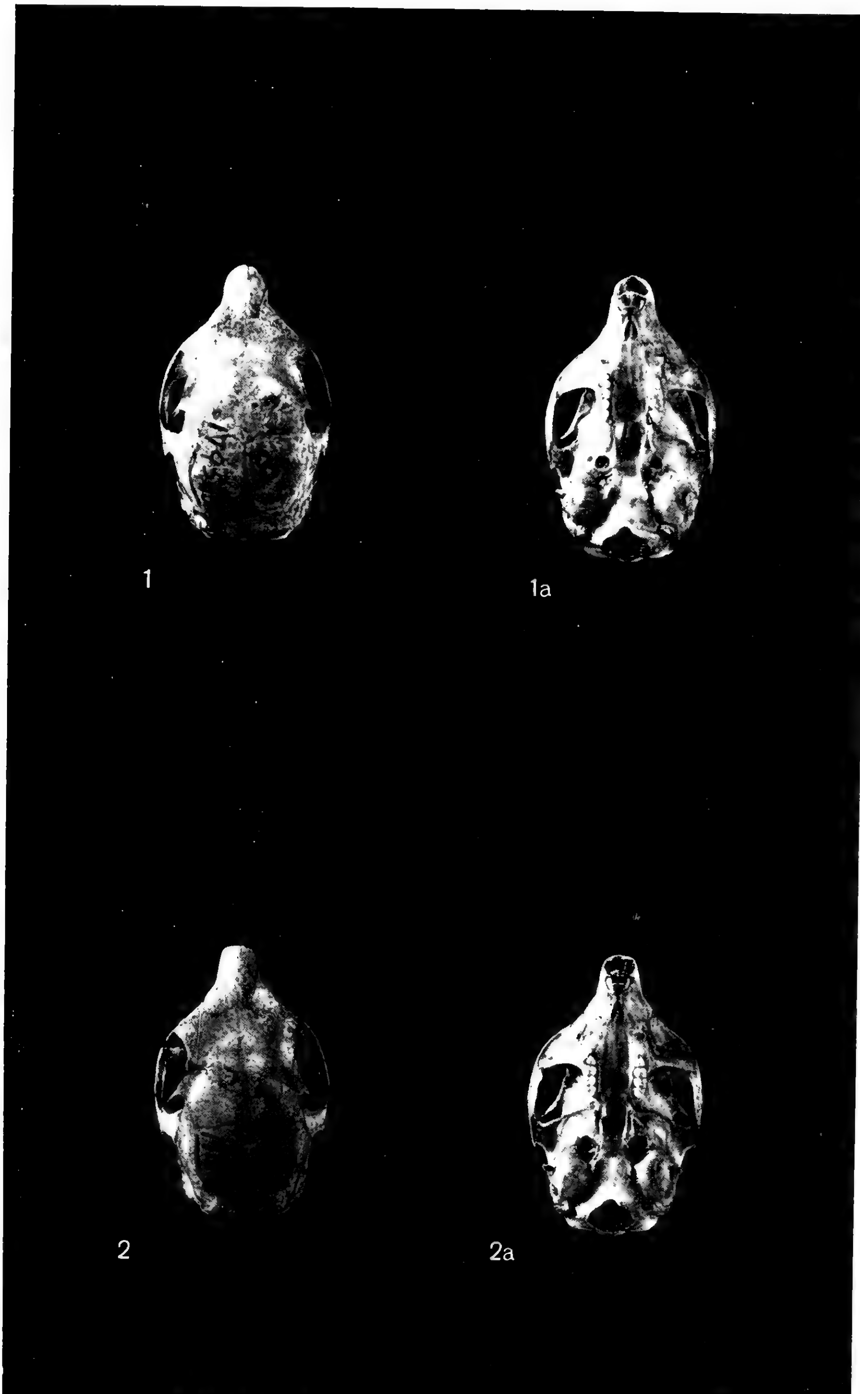
2, 2*a*. *Sciurus variegatoides helveolus* Goldman. Type. Corozal, Canal Zone, Panama. June 15, 1911. ♂ adult (171540).

PLATE 30

[Natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Microsciurus isthmius vivatus* Goldman. Type. Cana, Panama. June 5, 1912. ♀ adult (179565).

2, 2*a*. *Microsciurus alfari venustulus* Goldman. Type. Gatun, Canal Zone, Panama. March 1, 1911. ♀ (171030).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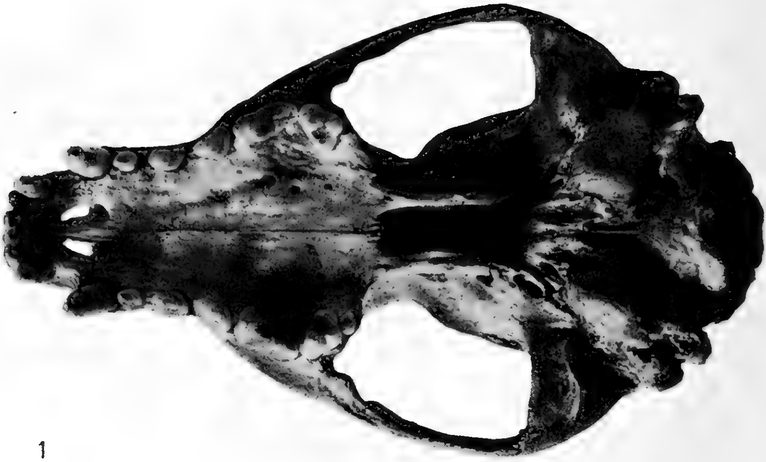
2
2a



1

1a

PLATE 31

[Three-fourths natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Icticyon panamensis* Goldman. Type. Mount Pirre, near head Rio Limon, Panama. April 28, 1912. ♀ adult (179046).

PLATE 32

[Three-fourths natural size; in U. S. Nat. Mus. collection.]

Figs. 1, 1*a*. *Procyon lotor pumilus* Miller. Type. Ancon, Panama. (171983, U. S. Nat. Museum collection).

1

1a

1

1a

PLATE 33

[Three-fourths natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Procyon* (*Euprocyon*) *cancrivorus panamensis* (Goldman). Type. Gatun, Panama. June 21, 1911. ♀ adult (171669).

PLATE 34

[Three-fourths natural size; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Bassaricyon gabbii orinomus* Goldman. Type. Cana, Panama. March 10, 1912. ♂ adult (179157).

2, 2*a*. *Potos flavus isthmicus* Goldman. Type. Mount Pirre, near head Rio Limon, Panama. April 21, 1912. ♀ adult (179042).

1

1a

2

2a

1

1a

PLATE 35

[Three-fourths natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Lutra repanda* Goldman. Type. Cana, Panama. May 30, 1912.
♂ adult (179974).

PLATE 36

[Natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1*a*. *Felis pirrensis* Goldman. Type. Cana, Panama. March 22, 1912. ♀ adult (179162).

1

1a


1
1a
2
2a
3
3a
4
4a
5
5a

PLATE 37

[Natural size; in U. S. Nat. Mus., Biological Survey collection, except figs. 2, 2*a*; 3, 3*a*; 4, 4*a*.]

FIGS. 1, 1*a*. *Cryptotis merus* Goldman. Type. Mount Pirre, near head Rio Limon, Panama. May 2, 1912. ♀ adult (178976).

2, 2*a*. *Chiroderma isthmicum* Miller. Type. Cabima, Panama. May, 1911. ♀ adult (173834, U. S. Nat. Mus. collection).

3, 3*a*. *Vampyressa minuta* Miller. Type. Cabima, Panama, May, 1911. ♀ imm. (173832, U. S. Nat. Mus. collection).

4, 4*a*. *Lonchophylla robusta* Miller. Type. Chilibrillo River, Panama. April 14, 1911. ♂ adult (173854, U. S. Nat. Mus. collection).

5, 5*a*. *Lonchophylla concava* Goldman. Type. Cana, Panama. May 20, 1912. ♂ adult (179621).

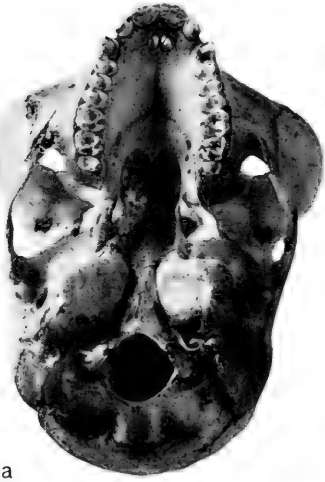
PLATE 38

[Natural size; except figs. 2, 2a; all in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Aotus zonalis* Goldman. Type. Gatun, Canal Zone, Panama. April 29, 1911. ♀ adult (171231).

2, 2a. *Ateles dariensis* Goldman. Type. Mount Pirre, Panama. April 29, 1912. ♀ adult (179044). (Three-fourths natural size.)

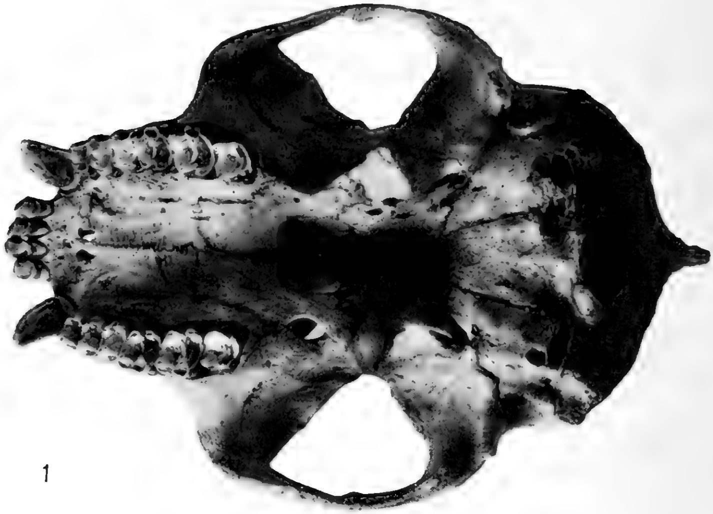
1



1a

2

2a



1

1a

PLATE 39

[Three-fourths natural size; in U. S. Nat. Mus., Biological Survey collection.]

FIGS. 1, 1a. *Alouatta palliata inconsonans* Goldman. Type. Cerro Azul, near head Chagres River, Panama. March 23, 1911. ♂ adult (171068).

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[Synonyms in *italics;* pages containing the principal reference to a species in **bold-face** figures.]

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 69, NUMBER 6

ON PERIODICITY IN SOLAR VARIATION

BY
C. G. ABBOT

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ON PERIODICITY IN SOLAR VARIATION

By C. G. ABBOT

Greatly interested by the paper of H. H. Clayton,[1] I directed Mr. Eisinger to make the necessary computations to determine by Clayton's method whether there occurred periodicities in the short interval solar variations in other years than 1913. I refer to those variations discovered by the Smithsonian Astrophysical Observatory, which often seem to run irregular courses of a week or ten days between maxima. Clayton's method is applied as follows:

All consecutive days are written down in a column from one end to the other of the observing season of each year. Opposite these days are written in a second column the corresponding values of the "solar constant" of radiation determined on Mount Wilson. As the observations are lacking on some days, vacancies exist in this column. In a third column the same "solar constant" values are written down, but raised one day on the scale of time. In succeeding columns up to 40 in all, the same "solar constant" values are written down, but each column is raised one day's interval as compared with the one before. Thus as we look along from column to column the values are so arranged horizontally that we compare the "solar constant" of each day with those of one, two, and subsequent days to forty days later. Owing to the lack of observations, not every day's value is thus compared with *all* the values of later days up to forty, but each day enters into some at least of these comparisons.

The observations being thus arranged, the usual computations are gone through with for obtaining coefficients of correlation between the "solar constant" of given days and those of 1 day, 2 days, and other intervals later. In selecting the groups required in correlation computations, the observations have been separated within ranges of 0.02 calories. To avoid giving undue weight to "wild" values, such as are probably affected by progressive obscuring or clearing of the atmosphere, all values over a certain reasonable maximum or under a certain reasonable minimum are put in with the highest and lowest 0.02 calory groups, and are regarded as falling in these ranges. Such high and low "wild" values seldom number more than 3 or 4 in a season.

[1] Smithsonian Misc. Coll., Vol. 68, No. 3, 1917.

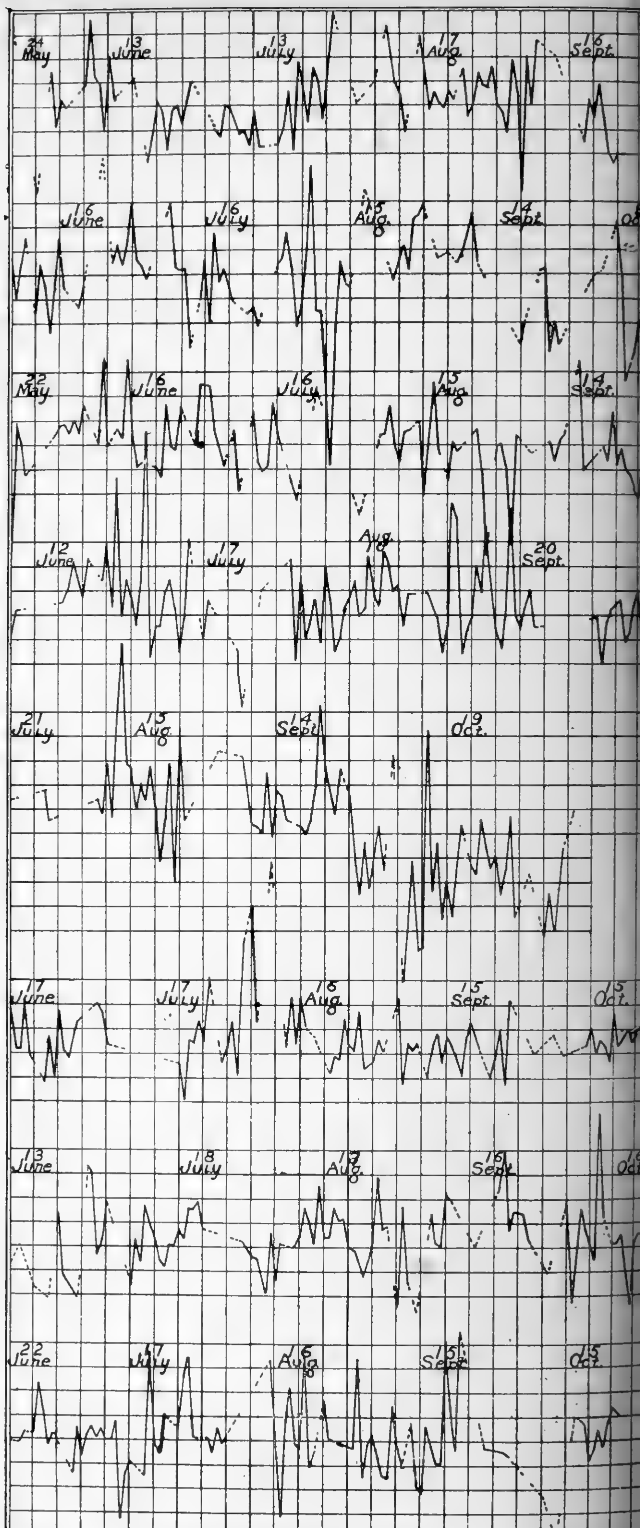
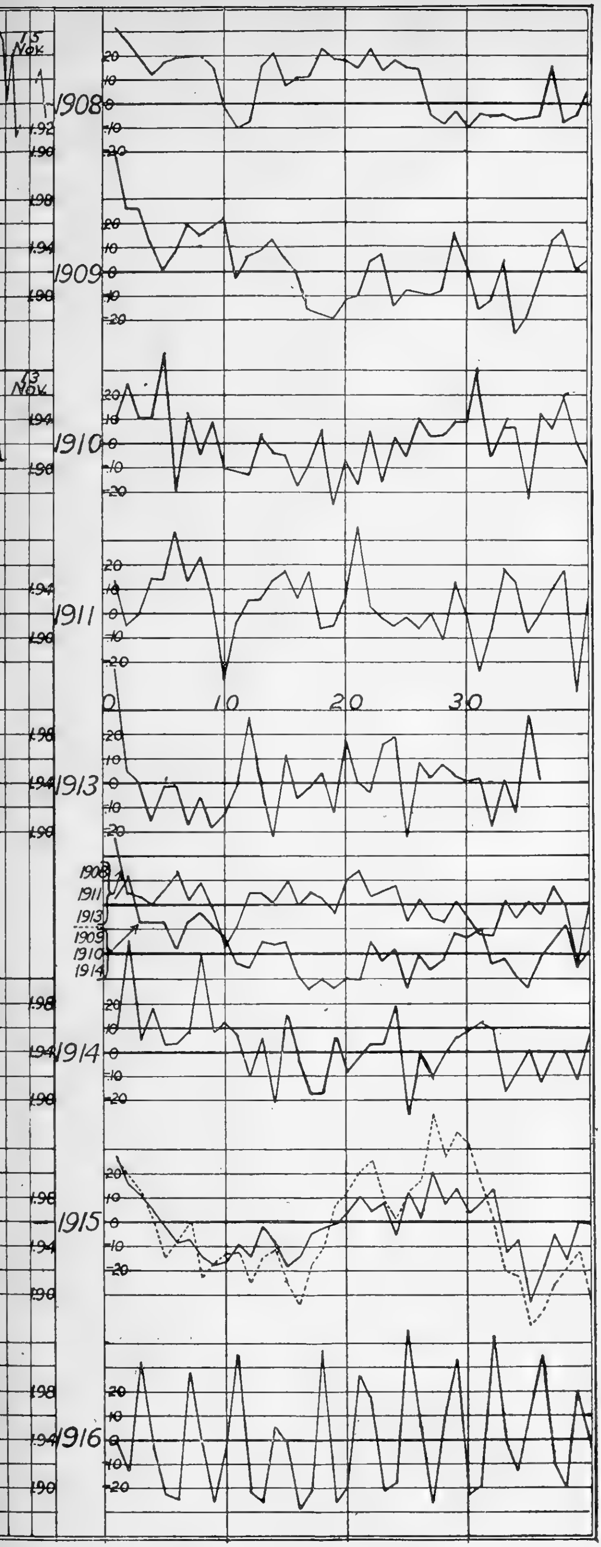


FIG. 1.—Solar Constant Values. Ordinates, Calories p
Abscissae, Time of Year.



Correlation Values. Ordinates, Correlation Coefficients, Abscissae, Days Elapsed.

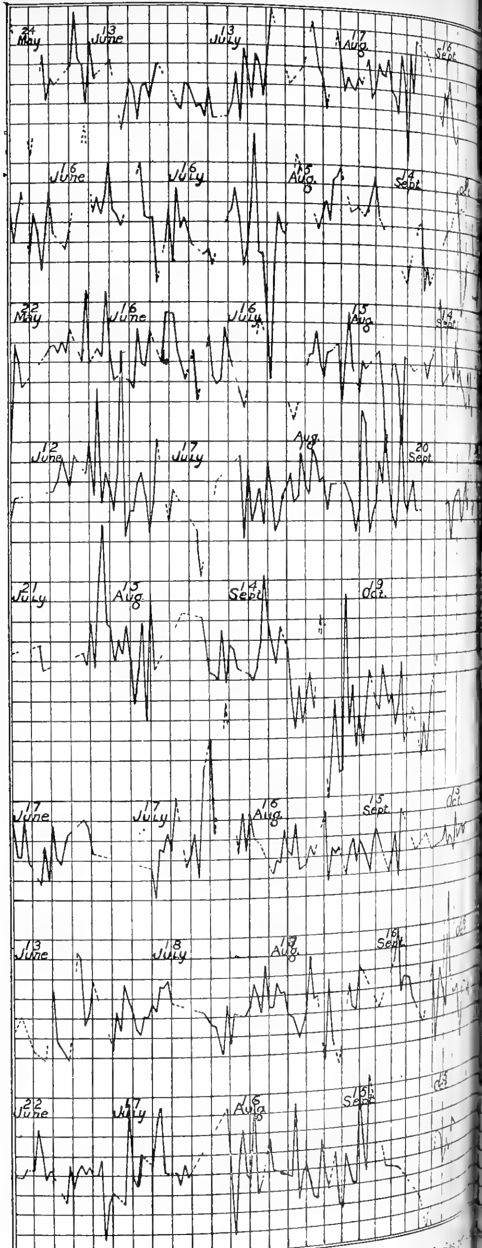
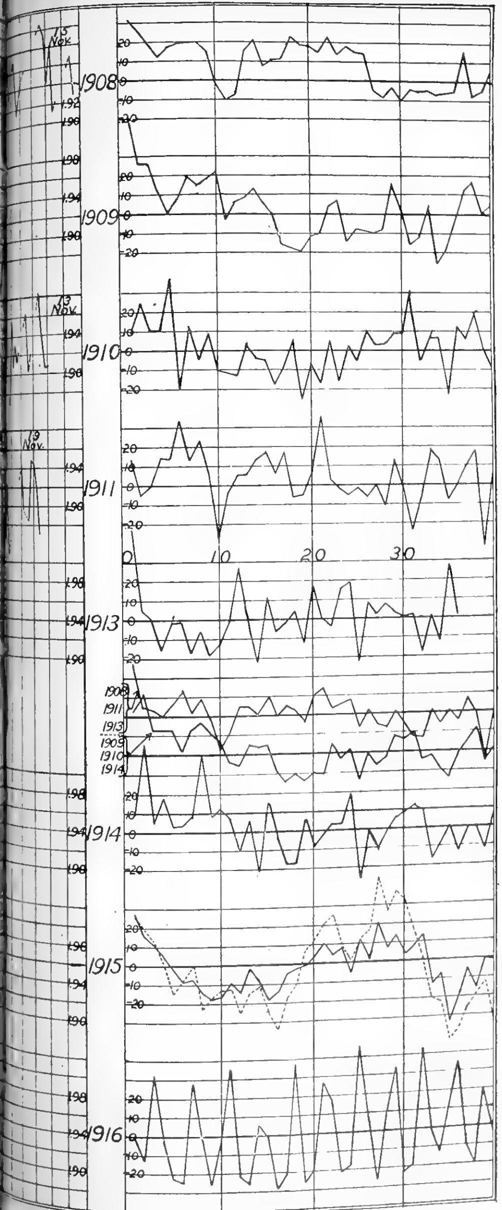


Fig. 1.—Solar Constant Values. Ordinates, Calories [illegible] Min., Abscissae, Time of Year.



Correlation Values. Ordinates, Correlation Coefficients, Abscissae, Days Elapsed.

As a result of these determinations of correlation coefficients, periodicities of solar variation would be exposed if they exist. For example, if the sun throughout an observing season was warmer on one hemisphere than the other, we should expect that high values of the "solar constant" would tend to be succeeded by high values after about 27 days, and low values would similarly tend to be succeeded by low values about 27 days later, whereas high values would follow low values after about 13½ days. These tendencies would express themselves in the coefficients of correlation. Positive correlation coefficients would continue for about one week, negative ones would succeed these for about two weeks more, and positive ones would follow these for the fourth and fifth week.

The results of the computations are shown graphically in the accompanying figure. On the left are plotted the "solar constant" values as obtained on Mount Wilson, and published as far as 1912 in volume 3 of the Annals of the Astrophysical Observatory. The observations of consecutive days have been connected in the plot. For the use of readers who may be interested, I give in Table 1 preliminary values of the "solar constant" for the years 1913-1916. It is possible that in the final publication of them in Vol. 4 of our Annals, some changes may be made as a result of checking, but in the main they will not be altered.

On the right of the illustration are given curves of correlation coefficients for each of the observing seasons 1908 to 1916, except 1912 when Mt. Kamai volcano was in eruption, and the "solar constant" values were less trustworthy. The curve for 1913 is taken from Clayton's paper. The others have been computed here. Two curves are given for 1915, of which the full curve represents the results of the whole year, and the dotted curve an independent computation from the results prior to September 12, which were first available. In Table 2 the correlation coefficients are printed. The probable error of individual values of these coefficients is about .08. For those unfamiliar with the correlation method it may be remarked that +1.00 or −1.00 are the outside limits of correlation coefficients, which both stand for perfect dependence between two variables. A value 0.00 indicates a complete absence of dependence.

(1) The first noticeable feature of the curves is their dissimilarity. No well marked periodicity of the solar variation persists through all of the eight years of the investigation. Each season is a law unto itself.

TABLE 1.—*Solar Constant Values*

Observations of the year 1913

Date	Solar Constant	Grade
July 16	1.928	Vg+
23	1.935	Vg−
24	1.911	Vg+
Aug. 3	1.928	E
4	1.916	E−
5	1.958	E
6	1.913	Vg−−
9	1.957	E−
10	1.954	Vg−
11	1.921	Vg−
12	1.940	Vg
13	1.927	Vg
14	1.955	E−−
15	1.922	E−
16	1.877	Vg+
17	1.913	E
18	1.958	Vg+
19	1.859	Vg+
20	1.987	Vg+
21	1.910	Vg−
28	1.968	G+
Sept. 2	1.963	G
3	1.933	E+
4	1.907	G−
5	1.905	Vg
6	1.901	Vg+
7	1.950	Vg++
8	1.897	Vg++
9	1.936	Vg+
10	1.930	E−
11	1.912	E
14	1.907	E−
15	1.899	Vg+?
16	1.912	Vg−
17	1.938	G+
18	2.000	Vg
19	1.954	Vg+
P. M. 21	1.915	Vg++
22	1.953	Vg
P. M. 24	1.928	E
25	1.881	Vg
26	1.849	E
27	1.894	E
28	1.855	E+
29	1.882	E+
30	1.907	G+
Oct. 1	1.869	Vg
3	1.966	Vg−
6	1.835	Vg
7	1.878	E
8	1.804	G+
9	1.806	G
11	1.852	E+
12	1.893	E+
13	.....	....
14	1.861	E
15	1.831	E
17	1.907	E−
19	1.873	E+
20	1.868	E
21	1.912	E−
22	1.893	Vg+
23	1.871	E
24	1.882	E
25	1.850	E
26	1.871	Vg+
27	1.914	G
28	1.830	E−
31	1.867	Vg+
Nov. 4	1.852	E+
5	1.818	E+
7	1.888	Vg+
8	1.902	E
9	1.918	Vg−

Observations of the year 1914

Date	Solar Constant	Grade
June 12	1.977	G+
13	1.943	E−
14	1.944	E−
15	1.979	E+
16	1.938	E
19	1.916	Vg
20	1.954	E−−
21	1.918	E
22	1.975	E−
23	1.943	E+
24	1.936	Vg−−
25	1.958	Vg
26	1.966	E
30	1.981	Vg+
July 1	1.973	E
2	1.947	E−
17	1.932	E
18	1.901	E
19	1.951	Vg+
20	1.949	Vg−
21	1.968	E
22	1.950	E+
23	2.004	Vg+
26	1.934	Vg++
P. M. 27	1.948	E−
28	1.968	Vg+
29	1.921	Vg−−
30	2.031	Disturbed
Aug. 1	2.062	weather
2	1.966	Sky streaked
P. M. 5	2.099	with cirri
7	1.989	Vg
8	1.945	Exceptional humidity
9	1.987	E−
10	1.949	E
11	1.987	E+
12	1.962	E−
14	1.952	Vg+
17	1.923	E−
18	1.937	Vg
19	1.935	E−
20	1.969	G
21	1.947	E+
22	1.942	E
23	1.975	E+
24	1.928	G−
26	1.934	E
27	1.951	Vg+
28	1.940	E
29	1.779	Disturbed weather
30	2.057	Sky streaked
31	1.987	with cirri
Sept. 1	1.915	E
2	1.948	E
3	1.942	E
4	1.949	E+
6	1.921	E+
7	1.944	G+
8	1.958	E−
9	1.932	Vg
10	1.954	E−
11	1.946	Vg
12	1.936	Vg
13	1.922	E+
14	1.954	E
15	1.965	E−
16	1.951	E+
19	1.921	Exceptional humidity
20	1.936	E
21	1.960	E
22	1.915	Vg+

Observations of the year 1914 (continued)

Date	Solar Constant	Grade
Sept. 23	1.985	E
28	1.941	E+
Oct. 2	1.956	G−
4	1.939	E (?)
9	1.947	E
10	1.961	G
11	1.940	E
12	1.951	Vg+
13	1.946	E+
14	1.933	Vg
15	1.973	Vg+
16	1.946	Vg
18	1.960	E−
19	1.949	E
20	1.955	E+

Observations of the year 1915

Date	Solar Constant	Grade
June 8	1.927	E
10	1.944	E
13	1.909	E−
16	1.899	G
18	1.969	Vg
19	1.920	G+
22	1.900	E−
24	2.010	E−
25	1.999	E
26	1.935	E
27	1.949	E−
28	1.980	E−
July 3	1.910	E−
4	1.949	E−
5	1.930	E
6	1.977	E
7	1.960	E+
8	1.948	E
9	1.931	E
10	1.925	E
11	1.944	E
12	1.945	Vg
13	1.957	G
14	1.949	Vg
15	1.975	E
16	1.974	E
17	1.980	E
18	1.958	Vg
26	1.948	E−
27	1.942	E
28	1.935	Vg+
29	1.933	E
30	1.920	Vg+
31	1.905	Vg
Aug. 1	1.954	Vg+
2	1.914	E+
3	1.946	E−
6	1.942	Vg+
7	1.950	E+
8	1.975	E
9	1.962	E+
10	1.945	E−
11	1.993	Vg
12	1.950	Vg+
13	1.950	E+
14	1.975	Vg+
15	1.964	Vg
16	1.966	Vg
17	1.944	E+
18	1.940	E
19	1.931	Vg
20	1.918	G
21	1.931	Vg+
22	1.946	E+
23	2.000	Vg−
24	1.956	E−

TABLE 1.—*Solar Constant Values* (*Continued*)

Observations of the year 1915 (continued)			Observations of the year 1916			Observations of the year 1916 (continued)		
Date	Solar Constant	Grade	Date	Solar Constant	Grade	Date	Solar Constant	Grade
Aug. 25	1.960	G+	June 17	1.941	Vg+	Aug. 18	1.920	Vg−
27	1.893	Vg−	19	1.940	E−	19	1.931	Vg
28	1.976	Vg−	20	1.949	Vg	20	1.955	Vg
29	1.915	Vg+	22	1.947	E−	21	1.976	G
31	1.887	Vg+	23	1.989	Vg+	22	1.944	Vg
Sept. 3	1.969	Vg+	24	1.966	E−	25	1.940	P
4	1.946	Vg−	25	1.938	Vg	27	1.936	G−
5	1.942	Vg	26	1.948	Vg−	28	2.011	G
6	1.987	E+	30	1.914	Vg−	29	1.911	G+
7	1.982	E	July 1	1.953	G+	30	1.937	G
12	1.942	Vg?	2	1.929	G	31	1.948	E−
17	1.990	E−	3	1.947	Vg−	Sept. 1	1.929	Vg+
18	2.020	E	4	1.954	Vg+	2	1.913	Vg−
19	1.956	E−	5	1.945	E−	3	1.911	P
20	1.971	E	6	1.951	Vg	4	1.970	Vg?
22	1.969	Vg	7	1.942	Vg+	5	1.936	Vg
23	1.949	E−	8	1.942	E−	6	1.921	Vg−
27	1.920	Vg	9	1.958	Vg+	7	1.940	G
28	1.934	Vg+	10	1.876	G+	8	1.957	Vg+
Oct. 1	1.977	E	11	1.914	Vg−	9	1.906	Vg
2	1.898	Vg	12	1.925	G+	10	1.899	E−
4	1.974	Vg	15	1.913	Vg	11	1.955	E−
5	1.956	Vg−	16	2.016	G	12	1.937	Vg+
6	1.943	Vg	17	1.940	E−	13	1.923	E
7	1.932	Vg+	18	1.931	Vg	14	1.923	E
8	2.052	G+	19	1.964	E+	15	2.025	G+?
9	1.967	Vg+	22	1.952	Vg−	16	1.968	Vg
11	1.944	P	23	1.992	Vg−	17	1.934	G
12	1.945	Vg+	24	2.011	Vg−	18	2.033	Vg
13	1.951	E−	25	1.944	E−	23	1.936	Vg
14	1.920	Vg+	28	1.945	E−	27	1.933	Vg+
15	1.893	Vg−	29	1.932	E−	28	1.929	G?
16	1.944	Vg+	30	1.953	E−	Oct. 5	1.897	P
17	1.952	E−	31	1.940	Vg−	8	1.860	E−
18	1.952	E−	Aug. 10	2.010	G+	12	1.962	Vg−
19	1.944	Vg	11	1.942	G	14	1.955	E
20	1.938	Vg−	12	1.879	Vg	15	1.923	E
21	1.950	E+	13	1.962	Vg	16	1.934	Vg−
22	1.931	Vg	14	1.987	Vg−	17	1.950	Vg+
			15	1.942	E−	18	1.934	E−
			16	1.935	E+	19	1.954	E−
			17	2.011	Vg	20	1.969	E
						22	1.962	G−

(2) In the second place we find positive correlations on the first day in all years except 1916. The lack of it in 1916 is explainable, as we shall see. Hence the supposedly solar variations are surely not due to mere accidental errors of observation, for this result shows that during several days in a group the solar constant values are apt to be affected in the same direction. This is not a certain proof that the variations are solar. The same thing would very likely be found if they were due to atmospheric causes.

However, the variability of the sun is now indicated[1] by (*a*) Mount Wilson observations of the solar constant, (b) comparison of

[1] See Annals of the Smithsonian Astrophysical Observatory, 3; Smithsonian Miscellaneous Collections, 65, Nos. 4 and 9; and 66, No. 5; Terrestrial Magnetism and Atmospheric Electricity, 20, 143, 1915.

TABLE 2.—*Correlation Solar Constant Coefficients*

Days later	Years								Mean	
	1908	1909	1910	1911	1913	1914	1915	1916	1908 1911 1913	1909 1910 1914
1.......	+.211	+.508	+.093	+.137	+.47	+.084	+.262	—.008	+.273	+.228
2.......	+.152	+.254	+.244	—.045	+.05	+.458	+.190	—.126	+.052	+.319
3.......	+.085	+.258	+.103	.000	.00	+.038	+.128	+.323	+.028	+.133
4.......	+.014	+.115	+.102	+.144	—.15	+.178	+.010	—.020	+.003	+.132
5.......	+.069	+.002	+.367	+.142	—.01	+.031	—.141	—.222	+.067	+.133
6.......	+.087	+.080	—.021	+.338	—.01	+.035	—.074	—.243	+.138	+.031
7.......	+.091	+.194	+.124	+.134	—.17	+.087	+.006	+.280	+.018	+.135
8.......	+.095	+.153	—.048	+.231	—.05	+.404	—.229	—.026	+.092	+.170
9.......	+.050	+.184	+.083	+.073	—.18	+.078	—.170	—.261	—.019	+.115
10.......	—.127	+.223	—.103	—.272	—.13	+.116	—.129	—.027	—.176	+.079
11.......	—.201	—.033	—.114	—.035	—.01	+.058	—.122	+.354	—.082	—.030
12.......	—.174	+.061	—.131	+.057	+.27	—.099	—.249	—.215	+.051	—.056
13.......	+.045	+.083	+.033	+.057	+.02	+.055	—.145	—.257	+.041	+.057
14.......	+.103	+.131	—.041	+.138	—.22	—.219	—.116	+.053	+.007	+.043
15.......	—.028	+.053	—.052	+.175	+.13	+.148	—.247	—.012	+.092	+.050
16.......	+.005	—.001	—.178	+.062	—.06	—.030	—.339	—.289	+.002	—.070
17.......	+.008	—.162	—.085	+.170	—.02	—.176	—.173	—.204	+.053	—.141
18.......	+.119	—.181	+.056	—.060	+.04	—.176	—.097	+.374	+.033	—.100
19.......	+.081	—.196	—.258	—.051	—.13	+.058	+.069	—.265	—.033	—.132
20.......	+.076	—.122	—.071	+.065	+.18	—.085	+.124	—.184	+.107	—.093
21.......	+.046	—.105	—.173	+.362	+.01	—.024	+.209	+.270	+.139	—.101
22.......	+.126	+.035	+.050	+.033	—.04	+.028	+.257	+.165	+.040	+.038
23.......	+.036	+.068	—.159	—.017	+.16	+.024	+.094	—.216	+.060	—.022
24.......	+.075	—.147	+.027	—.051	+.20	+.184	+.013	—.184	+.075	+.021
25.......	+.047	—.084	—.054	—.016	—.22	—.269	+.128	+.456	—.063	—.136
26.......	+.039	—.092	+.099	—.063	+.09	+.002	+.169	+.049	+.022	+.003
27.......	—.154	—.100	+.027	+.002	+.02	—.110	+.443	—.276	—.044	—.061
28.......	—.187	—.079	+.033	—.106	+.08	—.013	+.268	+.088	—.071	—.020
29.......	—.132	+.152	+.084	+.132	+.03	+.055	+.369	+.334	+.010	+.097
30.......	—.200	+.030	+.084	—.012	+.01	+.080	+.317	—.225	—.067	+.065
31.......	—.146	—.157	+.359	—.240	+.02	+.114	+.151	—.196	—.122	+.105
32.......	—.156	—.119	—.056	—.058	—.18	+.080	—.002	+.436	—.131	—.032
33.......	—.153	+.050	+.067	+.190	+.02	—.172	—.206	+.001	+.019	—.018
34.......	—.169	—.258	+.067	+.126	—.12	—.081	—.223	—.134	—.054	—.091
35.......	—.162	—.181	—.227	—.079	+.28	+.006	—.431	+.098	+.013	—.134
36.......	—.153	—.035	+.123	—.002	+.01	—.133	—.375	+.344	—.048	—.015
37.......	+.054	+.114	+.057	+.098	.....	—.014	—.255	—.097	+.076	+.052
38.......	—.180	+.169	+.195	+.174	.....	—.006	—.189	—.203	—.003	+.119
39.......	—.148	+.011	+.011	—.326	.....	—.121	—.126	+.189	—.237	—.033
40.......	—.037	+.047	—.094	+.052	.....	+.070	—.343	—.036	+.008	+.008

Mount Wilson and Bassour observations, (*c*) comparison of Mount Wilson and Arequipa observations, (*d*) comparison of Mount Wilson and magnetic observations, (*e*) comparison of Mount Wilson solar-constant work with Mount Wilson solar-contrast work. The cumulative effect of this evidence is overwhelming.

(3) We may next note the striking result for the year 1915. Two curves of correlation are given for 1915, of which the full line is computed from all observations of that year, the dotted curve from those prior to September 12. Both curves show strongly a periodicity of

about 27 days, no doubt associated with the solar rotation. There was evidently during this season a tendency toward a hot and cold side of the sun, which persisted during several solar rotations but diminished at the latter end of the season. Such a result is evidently a new proof that the variations we find are truly solar, for they have a well-known solar period in 1915.

(4) Not less extraordinary is the result for 1916. The 27-day periodicity seems to be no longer present, but $11\frac{1}{3}$ full periods, as regular as the time intervals of 24 hours between observations permit, occur in 40 days. This periodicity is then approximately 3.5 days. It is unique among the whole series of years. If the range of the correlation factors was smaller I would regard it as surely due to accidental error. But the range averages more than 50 per cent from crest to trough in correlation factors whose probable error is only about 8 per cent. It is really a most extraordinary result.

(5) The years 1909, 1910, and 1914 show a similarity in the march of correlation factors. From strongly marked positive values during the first week the coefficients fall to minimum negative values after about 18 days, and then, on the whole, tend to approach zero towards the end of our 40-day period of investigation. In the seventh curve of the figure, corresponding with the last column of Table II, I give the mean of correlation factors from all three years. This curve brings out in addition to the tendency just noted, a fairly well marked indication of a periodicity of $7\frac{1}{2}$ days.

(6) The results for the remaining years 1908, 1911, and 1913 differ from all the others and from each other, but on the whole if they stood alone would give less ground for a belief in the periodicity of solar variations than the group of three years we have been discussing, and much less than the years 1915 and 1916. In the sixth curve, corresponding to column 10 of Table II, I give the mean values for these three years.

(7) To sum up the investigation, we find in 1915 a well-marked hot and cold side of the sun persisting through several solar rotations. This occurred in a year near sun-spot maximum. The years 1909, 1910, 1914, either of moderating or of slowly increasing solar activity, show tendencies toward periodicities of solar variation, not very marked, but somewhat in common over the three seasons. The years 1908, 1911, and 1913 yield little of interest. The year 1916 yields a unique and extraordinary result. No definite periodicity in solar variations of short interval persists year after year.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 69, NUMBER 7

Hodgkins Fund

REPORT ON AIRCRAFT SUPPLY OF GREAT BRITAIN

AND DISCUSSION OF THE DIFFICULTIES INVOLVED IN PRODUCTION

(Publication 2500)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
JUNE, 1918

The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

Hodgkins Fund

ADVERTISEMENT

This pamphlet is an extract from the Report for the year 1917, of the War Cabinet of Great Britain relating to supply of aircraft. It is reprinted with the permission of Lord Reading, the British Ambassador.

The description given of the difficulties in the way of obtaining a supply of aircraft is so accurate and is so general in its application to all countries that it is believed it should be given as wide a circulation as possible in America. Its application to the American aircraft situation is evident if we remember that Great Britain has been at war since August, 1914, and that every resource of the country, famous for generations as the center of mechanical developments, has been applied to the problem of the production of aircraft. This enables us to appreciate more clearly the progress made by the United States in 1917-18.

THE WAR CABINET

REPORT

FOR THE YEAR 1917.

Presented to Parliament by Command of His Majesty.

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.

1918.

[Cd. 9005.] *Price One Shilling Net.*

SUPPLY OF AIRCRAFT

[The above recital indicates generally what steps have been taken in matters of administration and control.] It should be supplemented by some general account of the measures taken as regards supply of aircraft and the development of that supply.

In endeavouring to describe the measures taken to meet the aircraft needs of the Navy and Army, the writer is at once confronted by the fact that the information desired by the country is precisely the information desired by the enemy. What the country wants to know is what has been the expansion in our Air Services; whether we have met and are meeting all the demands of the Navy and of the Army, both for replacement of obsolete machines by the most modern types and for the increase of our fighting strength in the air; what proportion of the national resources in men, material and factories is being devoted to aviation; what the expansion is likely to be in the future. These are precisely the facts which we should like to know with regard to the German air service, and for that reason it would be inadmissable for us to supply Germany with corresponding information about ourselves by publishing a statement on the subject.

It can be said that the expansion of our Air Services is keeping pace generally with the growing needs of the Navy and the Army.

The brilliant part played by the Royal Flying Corps and the Royal Naval Air Service in the battles of the Somme, Vimy, Messines and Ypres has been described by the Commander-in-Chief, who has also borne frequent testimony to the inestimable value of the work performed daily and nightly by the two air services. It is fair to say that not even the well-known superiority of our airmen over those of the enemy would have enabled them to have earned the Commander-in-Chief's praise in so unstinted a measure unless they had been supplied with satisfactory machines and equipment from home. It is rather the fashion to criticise the quality of our machines. Most of the critics, however, are ignorant of the technical and manufacturing difficulties which have to be overcome in order to keep up a constant and increasing supply of the most up-to-date machines. Not only are the technical difficulties and the resultant research and experimental work formidable in themselves, but the task of building up in war time, without seriously affecting the requirements of other services, a new industry of a most highly skilled character necessarily puts a heavy strain upon the organising and manufacturing ability of the country. The growing realisation of the increasing importance of aviation as an artificer of victory has recently been reflected by the concession of first priority to labour and materials required for aircraft production.

The nature of the duties performed by the Royal Naval Air Service, both in conjunction with the fleet and from naval bases, makes secrecy essential to success. It is, unfortunately, inevitable, therefore, that the public should remain in the dark on this subject; but the Germans, who in this matter are perhaps the best judges, have good reason to know and to regret the great and growing activities of the Royal Naval Air Service. All that has been said regarding the difficulties of supplying the requirements of the Air Forces operating over the land applies equally to the supply of those which operate over the sea. In both cases difficulties are being overcome and the outlook is improving.

The science of aeronautics is in a state of constant and rapid development; improvements in engines, aeroplanes and their numerous accessories are constantly being worked out. But the interval between the discovery of an improvement and its introduction into the service is, owing to technical considerations, very much longer than is commonly supposed. Experience shows that, as a rule, from the date of the conception and design of an aero-engine to the delivery of the first engine in series by the manufacturer, more than a year elapses; the corresponding period for an aeroplane is about one half as long. Consequently, plans have to be laid for a long period ahead, and these plans are liable to be upset by many uncertain factors. The hopes based upon the promising results given by the first experimental engines of a new design are frequently disappointed owing to difficulties of bulk manufacture or to defects only developed after long trial in the air; new types of aeroplanes favourably reported on when first tried are found on longer experience not to give complete satisfaction, and yet it is impossible, if we are to keep ahead in the keen struggle for aerial superiority, to wait for full experience before placing orders. Risks must be run, and new types must be adopted at the earliest moment consistent with reasonable assurance that they will constitute a substantial improvement on what is already in use. Orders must be placed, moreover, for considerable numbers and for delivery over many months, as the large output required for our present flying services can only be obtained by bulk orders permitting a high degree of sub-division of work.

The next step in the problem is the balancing of the engine and the aeroplane programmes. Owing to the much longer period required for the production of engines than of aeroplanes, orders for the former must be placed for relatively long periods ahead, before it is known what types of aeroplanes will be required when the engines become available.

The problem is complicated by the fact that manufacture and delivery rarely if ever proceed in accordance with anticipation. The output of a particular type may be delayed for weeks or even months owing to some technical difficulty of manufacture. Moreover, as replacement of losses and expansion are proceeding simultaneously in the flying services, and the rate of wastage in different types of engines and of aeroplanes varies considerably according to circumstances, it is impossible to forecast with accuracy what engines will be available for the equipment of new types of aeroplanes after wastage has been made good. Nor is it possible to any great extent to adjust the programme by modifying orders once placed without disorganising supply. The problem does not end here. Whenever a new type is introduced provision must be made for accumulating a sufficient " head " of spare engines, spare aeroplanes and spare parts of innumerable kinds, to keep the squadron to be equipped with that type in a condition to make good the day-to-day wastage and carry out the constant repairs required.

Such being the nature of the problem, it is satisfactory to be able to record that during the year 1917 not only was the number of squadrons of aircraft on the various fronts increased in a notable degree, but there was a complete replacement of machines and engines of the older types. The very great increase in output which is being obtained has placed a considerable strain on the workers in the aircraft and aero-engine factories of the country, a strain which is being met on the whole in a satisfactory manner.

The difficulties in connection with production are aggravated by the competing claims of many different types of aero-engines. Standardization is the ideal but it is obviously difficult of attainment having in view the importance of not losing time in production and at the same time of keeping abreast with the very latest developments necessitated by the need for constant increase of horse-power and higher performance. The Air Council are most keenly impressed by the need for concentration on a few approved engines, and they have the whole question of the reduction of numbers of types under constant and careful consideration.

Attention was drawn, on more than one occasion, by manufacturers to the importance of maintaining the interest of workers in aircraft factories in the highly important but generally monotonous work on which they are employed. Engaged, as they frequently are, on the production by a repetition process of some small part of an aeroplane, these men and women find it difficult to realize that they are contributing effectively to one of our most valuable instruments of warfare. It was accordingly arranged that Captain Ewart, R.F.A., well known as a writer by the name of "Boyd Cable," should visit various squadrons at the front and gather materials and photographs for lectures concerning the exploits performed with various types of aircraft for delivery to the workpeople engaged on the manufacture of those particular types. Captain Ewart delivered several series of lectures which, judging from the reports received from the factories concerned, proved a very great success.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 69, NUMBER 8

UGANDA MOSSES COLLECTED BY R. DÜMMER AND OTHERS

(WITH ONE PLATE)

BY
H. N. DIXON, M. A., F. L. S.

(PUBLICATION 2522)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1918

The Lord Baltimore Press
BALTIMORE, MD., U. S. A.

UGANDA MOSSES COLLECTED BY R. DÜMMER AND OTHERS

By H. N. DIXON, M. A., F. L. S.

(With One Plate)

Mr. R. Dümmer, who has been collecting for some years in the Uganda Protectorate, has from time to time made gatherings of mosses. Some of these have been received by the United States National Museum, and these, which form the principal material of the present paper, have been entrusted to me for determination. A few others have been sent to me from the British Museum, to be incorporated in this report, and one or two I have received direct from Mr. Dümmer. I have included also a few plants collected recently in Uganda by Mr. J. D. Snowden, and sent to me by Mr. W. H. Pearson.

Although not numerous, Mr. Dümmer's mosses contained several novelties, the most interesting being a new species of *Cyathophorum*, a small and beautiful genus hitherto unknown to Africa, confined in fact to southern and eastern Asia and the Pacific and Australasian regions.

Unless otherwise specified the types of the new species described are in the United States National Herbarium.

DICRANACEAE

TREMATODON INTERMEDIUS Welw. & Dub.

Damp roadside, alt. 4,000 ft., Luga, July, 1914, *Dümmer* 971. Low grassland swamp, Nagoze, alt. 4,000 ft., Aug., 1916, *Dümmer* 2963. Both c. fr.

LEUCOBRYACEAE

OCTOBLEPHARUM ALBIDUM (L.) Hedw.

Rocky ledges, Jumbwa, alt. 4,000 ft., Jan.-Feb., 1917, *Dümmer* 3078; c. fr.

FISSIDENTACEAE

FISSIDENS SUBGLAUCISSIMUS Broth.

Moist ground in forest, near Kipayo, alt. 4,000 ft., Dec., 1914, *Dümmer* 1403; c. fr.

FISSIDENS EROSULUS (C. M.) Par.

Damp caverns, in rocks, Jumbwa, alt. 4,000 ft., July, 1916, *Dümmer* 2967; c. fr.

FISSIDENS SCIOPHYLLUS Mitt.

On *Erythrina* bark, grassland, Kijude, Nov., 1915, *Dümmer* 2645a; c. fr.

A few stems, mixed with *Fabronia angolensis*. The leaf apex varies greatly, being usually acute, but often obtuse and apiculate; the cells are a little larger and less obscure than in Mungo Park's specimen at Kew, named by Mitten, but this is the only difference I can detect, and I have little hesitation in referring it to that species.

POTTIACEAE

TORTULA ERUBESCENS (C. M.) Broth.

On trees, Chiko Forest, Busoga, alt. 3,500 ft., *Snowden* 1, 7b.

ORTHOTRICHACEAE

SCHLOTHEIMIA GREVILLEANA Mitt.

On bark of *Erythrina tomentosa,* grassland, Kipayo, alt. 4,000 ft., May, 1914, *Dümmer* 823; c. fr.

BYRACEAE

BRACHYMENIUM VARIABILE Dixon, sp. nov.

B. capitulato Mitt. affine sed foliis *brevioribus, latioribus, late ovatis, minus distincte marginatis,* longius cuspidatis. Seta *multo brevior,* circa 1.5 cm. longa. Theca *minor, horizontalis vel plerumque subpendula, angustior,* e collo brevi clavata; peristomium melius evolutum. Spori 30-40 μ. Folia siccitate plerumque valde torquata. Dioicum videtur.

Hab.: Tree trunk, savannah, Namonyungi, alt. 4,000 ft., June, 1915, *Dümmer* 2577; c. fr.

A perplexing plant, from its great variability. It belongs to the section *Orthocarpus,* but though the leaves are often strongly spirally twisted when dry, as in *B. nepalense* Hook., they are sometimes erect and appressed; the arista may be short and cuspidate or long and flexuose, the border well defined though narrow, or entirely wanting. The capsules may be pendulous, horizontal, or inclined. I supposed at first that there were two similar plants closely intermixed, distinguishable by the position of the leaves when dry, but the two forms appear to intergrade, and there seems to be no difference in the fruit.

It differs from *B. capitulatum,* apart from the characters distinguished above, in the peristome, the outer teeth of which are very densely barred with highly projecting lamellae on the outer surface, deep orange in color, strongly bordered, very finely and regularly papillose on the dorsal surface; the basal membrane of the endostome is about half the height of the outer teeth, with well developed, broad, obtuse segments, almost equal to the teeth, pale, and very delicately papillose.

These characters, the form and position of the capsule, and the very weakly bordered leaves, will separate *B. variable* from its other African near allies, almost all of which have the capsule suberect or only slightly inclined, and often or usually turgidly oval in form.

RHODOBRYUM ROSEUM (Weis) Limpr.

Rocky outcrops, Namonyungi, alt. 4,000 ft., June, 1915, *Dümmer* 2578.

NECKERACEAE

PILOTRICHELLA PILIFOLIA Dixon, sp. nov.

Ab omnibus congeneribus africanis facile distinguitur foliis caulinis *in pilum longum filiforme saepe undulatum* attenuatis.

Stirps pergracilis, ramis *flexuosis attenuatis,* foliis perindistincte seriatis, basi *minime auriculatis,* apice breviter cuspidatis. Seta flexuosa, circa 3 mm. longa; theca elliptico-cylindrica, fulva, operculo oblique longirostrato.

Hab.: Epiphytic; pendent in forest, Mabira, near Mubango, alt. 4,000 ft., July, 1916, *Dümmer* 2961; c. fr. Type in British Museum.

A distinct species, more slender than most of its African allies, with markedly attenuate branches, and a very conspicuous difference between the longly piliform stem leaves and the shortly mucronate turgid ones of the branches. Some species of the closely allied genus *Squamidium* have similarly piliferous stem leaves, but these have a distinct group of differentiated alar cells.

Pilotrichella tenellula (C. M.) and *P. capillicaulis* (C. M.) may be near it, but the author describes the leaves as shortly pointed, apparently in reference to the stem leaves. *P. pseudoimbricata* C. M. is also somewhat like it, but the stem leaves are more shortly and rigidly pointed, the branch leaves more erect, etc.

NECKEROPSIS TRUNCATA (P. Beauv.) Fleisch.

Tree trunks in forest, near Nagoye, alt. 4,000 ft., Dec., 1916, *Dümmer* 3028.

A sterile plant, probably referable here. *Neckeropsis subtruncata* Broth. from Togoland I do not know; but it appears to be an unpublished species.

NECKEROPSIS LEPINEANA (Mont.) Fleisch.

Epiphytic in forest, Mabira, near Mubango, alt. 4,000 ft., July, 1916, *Dümmer* 2962. Locally abundant.

POROTRICHUM LAURENTII Ren. & Card.

Tree trunks in forest, Kipayo, alt. 4,000 ft., Sept., 1915, *Dümmer* 1057; c. fr.

This agrees quite well with an original specimen of Laurent's gathering from the Belgian Congo, in Herb. Besch. at the British Museum. It has not hitherto been recorded in fruit. Sporophytic characters to be noted are as follows:

Perichaetia numerous; bracts rigid, subsquarrose, broadly acuminate, subentire, thinly nerved; vaginula and paraphyses somewhat exceeding the perichaetium. Seta 1.5 cm., yellowish, slender. Theca erect, symmetrical; lid rostrate. External peristome pale; teeth hyaline, very narrow, rather closely trabeculate, striolate only in the lowest segments, above finely papillose; internal orange brown, from a low basal membrane; processes nearly equal to the teeth, rather robust, rigidly linear, narrowly and interruptedly slit for the greater part of their length, finely papillose, nodose. Cilia apparently none.

PINNATELLA ENGLERI Broth.

In small quantity, associated with the last species. Also on trees, Chiko Forest, Busoga, alt. 3,500 ft., 1916, *Snowden* 6.

THAMNIUM PENNAEFORME (Hornsch.) Kindb.

Chiko Forest, Busoga, alt. 3,500 ft., 1916, *Snowden* 6a.

ENTODONTACEAE

ERYTHRODONTIUM SUBJULACEUM (C. M.) Par.

Chiko Forest, Busoga, alt. 3,500 ft., 1916, *Snowden* 3 p. p. and 7; c. fr. On bark of *Erythrina,* grassland, Kipayo, alt. 4,000 ft., May, 1914, *Dümmer* 820; c. fr.

FABRONIACEAE

FABRONIA ANGOLENSIS Welw. & Dub.

On *Erythrina,* grassland, Kijude, alt. 4,000 ft., Nov., 1915, *Dümmer* 2645b; c. fr. Tree trunk, savannah, Namonyungi, alt. 4,000 ft., June, 1915, *Dümmer* 2577b; c. fr.

HOOKERIACEAE

HOOKERIOPSIS PAPPEANA (Hampe) Jaeg.

A stem or two with one or two capsules, associated with *Rhacopilum marginatum* (*Dümmer* 984).

Mitten[1] records this species, with some uncertainty, from the Usagara Mountains.

HYPOPTERYGIACEAE

CYATHOPHORUM AFRICANUM Dixon, sp. nov.

§ *Cyathophorella.* Stirps *pergracilis;* caules 4-6 cm. alti, flexuosi, cum foliis 5 mm. lati, apice *haud flagelliformi desinentes.* Folia sat conferta, paullo recurvata, 3-4 mm. longa, valde asymmetrica, *latere inferiore plus minusve concavo, superiore valde convexo,* margine omnino plano, e basi fere minute, apicem versus magis magisque acute, subspinose dentato, valde indistincte marginato; costa pro more *valida,* tertiam partem folii longitudinis vel supra attingens. Areolatio sat densa, valde chlorophyllosa, superne e cellulis rhomboideis 40-50 μ longis, 14-18 μ latis, marginalibus 1-2 seriebus angustioribus limbum indistinctum efficientibus.

Amphigastria multo minora, *lanceolata, sensim anguste acuminata,* argute dentata, laxius areolata, minus chlorophyllosa, costa *unica, longa* 1/2-2/3 folii longitudinem aequante praedita.

Seta erecta, tenuiuscula, 1.5-2 mm. longa; theca erecta, breviter oblonga *valde leptodermica,* pallide fusca. Peristomium *pallidum,* externum e dentibus *angustis inaequalibus* articulatis dense *grosse*

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[1] Journ. Linn. Soc. Bot. **22**: 309. 1886.

papillosis instructum. Endostomium? Calyptram operculumque haud vidi.

Hab.: Tree trunk in forest, Kipayo, alt. 4,000 ft., March, 1914, *Dümmer* 721.

The first member of this beautiful genus to be found in Africa. Of a dozen or so stems none show any tendency to the gemmiparous, flagelliform attenuation of most of the section *Cyathophorella* (raised by Fleischer to the position of a genus); but the peristome undoubtedly belongs there. This is, however, of a very puzzling nature. Only two capsules show it in at all good condition. In the one case the teeth are all densely and coarsely papillose from top to bottom, very unequal in width, and somewhat irregular in form; and there appears to be no endostome. In the other the teeth, while approximately of the same build, equally irregular or more so, are absolutely smooth and pellucid; and again there is no indication of a second row. At first I supposed these to be the endostome; but if so, there is absolutely no trace of outer peristome left, which would be remarkable considering that the inner (if it so be) is fairly, if not altogether intact; and still more so as in that case we are to consider that in the first capsule described the *outer* peristome has remained more or less perfect while the *inner* has altogether disappeared. I am strongly inclined to suppose, therefore, that here too it is the outer peristome present, but entirely free from the dense coating of papillae shown in the former.

RHACOPILACEAE

RHACOPILUM SPELUNCAE C. M.

On trees, Chiko Forest, Busoga, alt. 3,500 ft., 1916, *Snowden* 3.

This agrees with Schweinfurth's plant in the Kew Herbarium. The leaves, convolute and often rigidly spreading when dry, not at all connivent, and the large stipular leaves, almost similar in form to the lateral leaves, seem to be features of this species.

RHACOPILUM MARGINATUM Dixon, sp. nov.

Species valde notatum, praecipue foliorum areolatione, e cellulis *magnis,* elliptico-hexagonis, 20-30 μ longis, 12-15 μ latis instructa, *marginalibus 1-2 seriebus perangustis, linearibus vel rhomboideo-linearibus, limbum sat notatum instruentibus;* basilaribus multo laxioribus, oblongis, superioribus plus minusve papillosis. Folia lateralia *valde asymmetrica,* majuscula, 2.5-3 mm. longa, obtusiuscula, supra medium sat argute denticulata; costa in cuspidem longiusculum rigidiusculum excurrens. Folia stipuliformia multo minora, late triangulari-hastata, subdenticulata, costa valida in aristam *strictam crassam aequilongam* excurrens. Seta *tenuiuscula,* 2.5-2.75 cm. longa, theca (operculata) 4-5 mm. longa. Operculum curvirostratum, circa 1/3 thecae longitudinem aequans.

Hab.: Tree trunk in forest, Kipayo, alt. 4,000 ft., Aug., 1914, *Dümmer* 984; c. fr.

The large-celled leaves with a more or less distinct border separate this from all the other African species. *R. macrocarpum* Broth. has a longer seta and rather longer (5 mm.) capsule. The capsules here are not quite mature, so that their ultimate form and direction is uncertain.

RHACOPILUM UGANDAE Broth. & Dixon, sp. nov.

R. Büttneri Broth. affine. Species nostra differt foliis apicem versus argutius serrulatis, cellulis (papillosis) paullo *minoribus, brevioribus,* 13-16 μ longis, 8 μ latis, foliis stipuliformibus valde crasse longe cuspidatis, foliis perichaetialibus marginibus *denticulatis;* seta *circa 2 cm. longa,* theca (nec perfecte matura) inclinata, *5-7 mm. longa,* operculo *breviter rostrato seu rostellato, vix 1/3 thecae longitudinem aequante.*

Hab.: Trunk of tree in forest, Kampala, Kyagwe Prov., Nov., 1913, *R. Dümmer.* Type in my herbarium.

Although scarcely differing vegetatively from *R. Büttneri,* the fruiting characters give adequate if not striking differences, as noted above. The seta in that species is 2.5 cm., the capsule only 2.5 to 4 mm. long, the lid with a beak half the length of the capsule, the perichaetial leaves entire. *R. crassicuspidatum* Corb. & Thér., which it resembles in the long, stout arista of the stipular leaves, has these not cordate or hastate at the base, while the leaf cells are smooth. *R. speluncae* has much larger stipular leaves; *R. macrocarpum* Broth. has more serrulate stipular leaves, entire perichaetial leaves, longer seta, and rather shorter capsule.

LESKEACEAE

LINDBERGIA PATENTIFOLIA Dixon, sp. nov.

Autoica. Caespites densi, saturate virides; caulis pro genere sat robustus, strictiusculus, irregulariter pinnato-ramosus, rami sicci *valde teretes, julacei,* obtusi. Folia valde conferta, *madida horizontaliter patentia, apice saepius leniter sursum incurvo, sicca arcte* *julaceo-appressa,* e basi rotundato-ovata *breviter* saepe oblique acute acuminata, marginibus planis vel uno latere ad basin angustissime reflexis, integris, costa inferne sat valida, *superne sensim angustata,* infra apicem evanida. Cellulae superiores *subrotundatae* seu brevissime ellipticae, parietibus subincrassatis, juxta-costales paullo elongatae, omnes fere basilares transverse ellipticae; omnes omnino laeves, *valde pellucidae.* Flores masculi numerosi, subfuscentes; perichaetia breviuscula, foliis internis suberectis, sat breviter acuminatis, superne subdenticulatis. Fructus ignotus.

Hab.: On trees, Chiko Forest, Busoga, alt. 3,500 ft., 1916, *Snowden* 7c. Type in my herbarium.

The generic position of this plant can not be considered definitely settled in the absence of fruit, but its close affinity to one or two other African species of *Lindbergia,* notably *L. haplocladioides* Dixon [1] and *L. viridis* Dixon & Wager (ined.), leaves no doubt in my mind of its belonging here. *L. haplocladioides* closely resembles it, but the leaves there are more longly acuminate, less widely spreading when moist, and not julaceously appressed when dry; the stems more slender and more curved. *L. viridis* has leaves less spreading and more gradually acuminate, longer and thinner-walled cells, stouter nerve, etc., and is a far more slender plant.

THUIDIUM LAEVIPES Mitt.

Chiko Forest, Busoga, 1916, *Snowden* 2b; c. fr. Tree trunk in forest, Kipayo, 4,000 ft., Dec., 1915, *Dümmer* 512, 720; c. fr.

Original specimens of Mitten's species appear to be unavailable; but these agree well with central African specimens so named, which agree with Mitten's description; it appears to be not infrequent in central Africa. The cilia on the inner perichaetial bracts are sometimes extremely long and conspicuous, but this character is not constant. The capsules are usually much contracted below the mouth.

THUIDIUM PALLIDISETUM Dixon, sp. nov.

T. pycnangiello C. M. affine, sed habitu multo alieno, laetevirens, ramulis *densius confertis,* foliisque *confertioribus;* cellulis foliorum ramulorum *multo minoribus,* chlorophyllosis, *magis obscuris.*

Caules elongati, *regulariter plumose bipinnati;* rami subaequales, circa 5 mm. longi, ramulis confertis, numerosis. Folia caulina *perminuta,* triangularia, breviter acuminata, falcato-squarrosa, levi-

[1] Bull. Torr. Bot. Club **43**: 75.

ter plicata, sicca flexuoso-incurva, integra, marginibus subplanis, costa infra apicem desinente. Folia ramulina *dense conferta,* madida subcomplanata, ovato-elliptica, subobtusa, costa *angusta, subpellucida,* longe infra apicem desinente; cellulis *minutis,* irregulariter hexagonis, 4-5 μ latis, humiliter papillosis; marginibus crenato-serrulatis.

Autoicum. Folia perichaetialia externa aristata, *rigide patentia vel subsquarrosa,* interna erecta, in acumen *loriforme rigidiusculum subintegrum* producta, intima ciliata. Seta 1.5 cm., tenuis, *pallide aurantiaca, laevis.* Theca *subpendula,* breviter ovato-elliptica, gibbosa, operculo e basi plano-convexa breviter recte rostellato.

Hab.: Tree trunk in forest, Kipayo, alt. 4,000 ft., March, 1914, *Dümmer* 719.

A very pretty and distinct species, with the dense plumose habit more nearly of *T. plumulosum* (Doz. & Molk.) than of any of its African allies; it is indeed very similar in appearance to the more slender forms of that species. *T. ramusculosum* (Mitt.) is of quite a different order.

HYPNACEAE

ECTROPOTHECIUM DÜMMERI Dixon, sp. nov.

Caespites densissimi, *sordide virides,* nitidiusculi. Caules dense intricati, densiuscule irregulariter subpinnatim ramosi, pergraciles, ramis circa 3-5 mm. longis, *complanatis.* Folia *complanata,* valde patentia, *nec falcata, parva,* caulina circa 0.5 mm. longa, ovato-lanceolata, sensim breviter acuminata; ramea minora, *ovata, breviter oblique acuminata, vel acuta;* marginibus planis, integris vel inconspicue denticulatis, costis nullis. Areolatio *sat laxa,* e cellulis lineari-rhomboideis, *valde prosenchymaticis,* 5-7 μ latis instructa, basilaribus unica serie latioribus, ellipticis, subvesiculosis, alaribus vix ullis.

Autoicum. Seta tenuis, *circa 1 cm. longa,* laevis. Folia perichaetialia *erecta,* sensim *longe rigidiuscule acuminata,* subdenticulata. Theca *minuta,* vix 1 mm. longa, turgide ovata, horizontalis, postea pendula; operculum conicum, siccitate conico-rostellatum.

Hab.: Damp soil in forest, Nagoye, alt. 4,000 ft., Jan., 1917, *Dümmer* 3050a; c. fr.

A distinct species, with much shorter and wider leaves, wider cells, and darker color than the allied African species, which for the most part have finely acuminate leaves and very narrow cells. The present plant is vegetatively much more like an *Isopterygium,* but the subglobose, pendulous capsule is quite ectropothecioid.

VESICULARIA SPHAEROCARPA (C. M.) Broth.

Chiko Forest, Busoga, 1916, *Snowden* 2; c. fr. Tree trunk in forest, Kipayo, May, 1914, *Dümmer* 826; c. fr.

Both these belong to a form with longly acuminate, falcate leaves and longer, narrower cells than in the type; it occurs in South African specimens mixed with the type form.

EXPLANATION OF PLATE

FIG. 1. *Brachymenium variabile* (type). *a*, Leaf apex, × 80. (The nerve is shown a little too stout.)

FIG. 2. *Pilotrichella pilifolia* (type). *a*, Part of stem, nat. size; *b*, stem leaf, × 20; *c*, branch leaf, × 20.

FIG. 3. *Cyathophorum africanum* (type). *a*, Stem, nat. size; *b*, leaf, × 10; *c*, amphigastrium, × 10; *d*, capsule, nat. size.

FIG. 4. *Rhacopilum marginatum* (type). *a*, Leaf, × 10; *b*, stipuliform leaf, × 10; *c*, upper marginal cells, × 200.

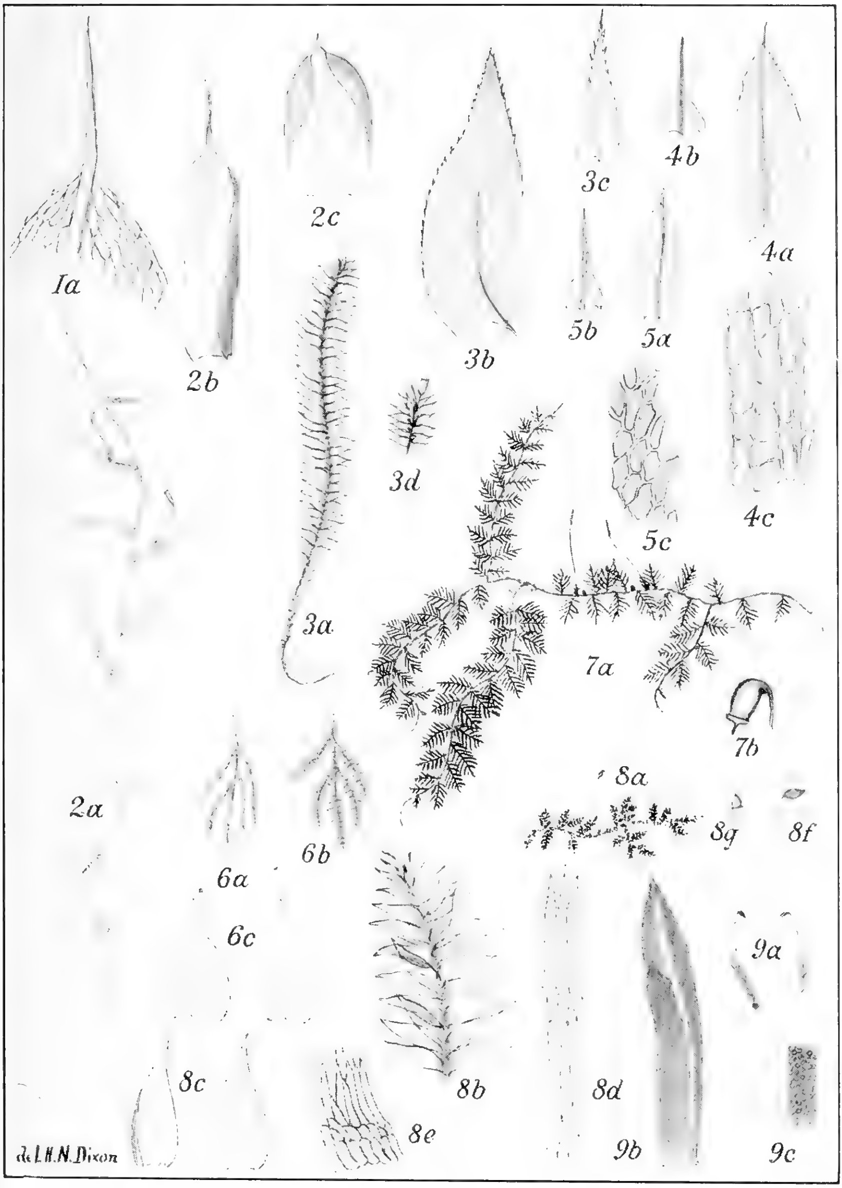
FIG. 5. *Rhacopilum ugandae* (type). *a*, Leaf, × 10; *b*, stipuliform leaf, × 10; *c*, upper marginal cells, × 200.

FIG. 6. *Lindbergia patentifolia* (type). *a*, Stem (dry), × 3; *b*, the same (moist), × 3; *c*, leaves, × 10.

FIG. 7. *Thuidium pallidisetum* (type). *a*, Stem, nat. size; *b*, capsule, × 5.

FIG. 8. *Ectropothecium Dümmeri* (type). *a*. Stem, nat. size; *b*, branch, × 10; *c*, branch leaves, × 20; *d*, upper cells, × 200; *e*, alar cells, × 200; *f*, *g*, capsules, × 2.

FIG. 9. *Fissidens subglaucissimus* (*Dümmer* 1403). *a*, Stems, × 1; *b*, leaf, × 20; *c*, marginal region of vaginant lamina near base, × 150.



UGANDA MOSSES

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THE SMITHSONIAN ECLIPSE EXPEDITION OF JUNE 8, 1918

(WITH FOUR PLATES)

BY
L. B. ALDRICH

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THE SMITHSONIAN ECLIPSE EXPEDITION OF JUNE 8, 1918

REPORT OF L. B. ALDRICH

(With Four Plates)

PREPARATION

Congress having made appropriation for an expedition from the Smithsonian Astrophysical Observatory to observe the total solar eclipse of June 8, 1918, plans were made according to which the director of the Observatory would personally accompany the expedition. But as the time approached, Dr. Abbot found other urgent matters requiring his attention, and though his advice and assistance were available at all times, he placed the expedition in charge of the writer.

It was early decided that a location in western Kansas be chosen, rather than to go farther west, chiefly for the reason that the line of observers would thus be more extended and the probable number of stations favored with good weather increased.

Besides the writer, the expedition included Mr. Andrew Kramer, instrument maker of the Observatory, and Rev. Clarence Woodman, C. S. P., of Berkeley, Cal., a volunteer observer whose large experience materially aided in the success of the expedition. Both Father Woodman and Mr. Kramer had assisted in the eclipse expedition of the Smithsonian Institution under Secretary Langley at Wadesboro, N. C., in 1900.

Because of transportation difficulties incident to the war, a minimum of apparatus was sent from the Institution. As far as possible the equipment was obtained and constructed at the station. Only two medium-sized boxes of apparatus were prepared, and these were taken as personal baggage by the expedition members.

OBJECTS

The objects in view were three-fold:

(1) Measurements with the pyranometer. This included—

(a) Measurements of sky brightness.

(b) Measurements of the total radiation from sun and sky.

(c) Measurements of the outgoing radiation from the earth during totality.

Similar observations for comparison were also planned for another day and at night.

(2) Direct photography of the solar corona, with two cameras of 335 cm. (11 feet) focus and 7.5 cm. (3 inches) aperture.

(3) Observations of the times of contact, and visual observations of the phenomena.

FIELD CONDITIONS

The station chosen was on the central eclipse line, about midway between the towns of Lakin and Hartland, Kansas, both of which are on the main line of the Santa Fé Railroad. Computations by Rev. Woodman gave the location of the station as follows:

Latitude	37°	53′	4″.2	N,
Longitude	101°	17′	51″.3	W.

The altitude at this place is 900 meters (3,000 feet) above sea level, with a mean barometer of 67 cm. (26.7 inches). There is little rainfall, and the land, which is flat and bears few large trees, is chiefly given to the cultivation of alfalfa, watered artificially.

Mr. Aldrich and Mr. Kramer arrived at Hartland on Monday morning, June 3, and were joined there by Rev. Woodman. An eclipse party from the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, under the direction of Dr. S. J. Mauchly, had chosen the same location and were already on the ground when the Smithsonian party arrived. This fact proved of decided value to our expedition, for, being familiar with local conditions, Dr. Mauchly and his party gave us valuable suggestions and assistance. Their interest and help is gratefully acknowledged.

Within a few hundred feet of the station of the Department of Terrestrial Magnetism, and in the same alfalfa field, there stood an unused barn which immediately suggested itself as an excellent windshield for our instruments. Permission to use the barn was given us by Mr. Jacob M. Hoss, lessee of the property. The thanks of the Institution are due him for granting this privilege entirely without charge. It is pleasant to record the universal interest and disposition to help among all with whom we came in contact. Especially we wish to acknowledge the kindness of Mr. and Mrs. P. C. Pittenger, the nearest neighbors, for furnishing two of our party room and board at great inconvenience to themselves.

Our location being settled, necessary equipment was obtained from Lakin by auto truck, and with the help of a local carpenter, the barn was altered to suit our needs, piers erected, and the instruments mounted as rapidly as possible.

From the time we arrived on Monday morning, up to an hour before the eclipse began on Saturday afternoon, the weather was very discouraging. Almost continuous cloudiness existed during this period. Thursday and Friday were completely overcast, with much lightning and thunder. We were unable to obtain any focus plates or to correct the rate of the driving mechanism of the photographic apparatus. Saturday morning, the day of the eclipse, the sky was more densely overcast than ever and the success of the expedition looked hopeless. At noon a few rifts appeared and by an hour before the eclipse began, the cumulus clouds had practically disappeared, leaving the sky covered with streaks of thin cirrus cloud. This condition continued the remainder of the day. While the sky was not ideal for our work, it enabled us to carry out the complete program with success.

APPARATUS

For the radiation work, Pyranometer A. P. O. No. 5[1] was used. To meet more adequately the eclipse requirements, it was partially rebuilt, as follows: A new thermopile, consisting of four tellurium-platinum thermo-elements, was inserted beneath the blackened manganin strip. (Pyranometer A. P. O. No. 5 is a single-strip type of instrument.) This made it more sensitive than any pyranometer yet constructed, and made easily measurable a radiation absorbed by the strip as small as .0005 calory (per square centimeter per minute). To avoid a small galvanometer drift found in measuring radiation from the sky alone, the sun shade[2] was increased in size so as to shade from direct sun rays the whole copper disk surrounding the absorbing strip. It was also raised to a distance of about 35 centimeters from the strip so as not to intercept too large a sky area.

[1] See Smithsonian Misc. Coll., Vol. 66, No. 7, p. 7.

[2] With the small sun shade, this galvanometer drift occurs in the single-strip type of instrument because, since the cold junctions of the thermopile are buried in the copper disk, part of which is exposed to direct solar radiation during the sky-alone measurements, the temperature of these junctions tends to increase. In the two-strip form of instrument this difficulty is obviated by placing the cold junctions beneath the second absorbing strip. The angular radius for the large shade was 7° 34′, the small strip shade, 3° 10′, and for the sun, 0° 16′. The corresponding solid angles subtended were, for the large shade .0547, small shade .00962, and sun .000068.

The galvanometer was of the D'Arsonval type furnished with the Ångström pyrheliometer and pyrgeometer. It also was modified, first, by adding a lever device giving means for setting the scale zero as desired; second, by removing the iron damping core, thus insuring a definite first swing under all conditions of use. All the pyranometer measurements were made according to the first-swing method described in detail in the paper "On the Use of the Pyranometer" (Smithsonian Misc. Coll., Vol. 66, No. 11).

Weston Milliammeter No. 8,244, reading to 1.5 amperes and previously calibrated at the Bureau of Standards, was used.

As a measure of precaution a duplicate pyranometer, galvanometer, and ammeter were brought from Washington, but by good fortune were not needed.

The pyranometer was mounted outside on a pier about 6 meters west of the shelter which enclosed all the auxiliary apparatus and at an altitude of 1.5 meters above the ground. The absorbing strip was horizontal and was exposed to almost a complete hemisphere of sky, only a small portion of the sky low in the east being cut off by the barn. Inside the barn, the galvanometer was hung on a solid wooden pier, well protected from wind or temperature changes. In front of the galvanometer another pier supported the ammeter, rheostats, and dry cells which furnished the calibrating current, and a dial resistance box. This box was inserted in the galvanometer circuit, enabling the observer at the galvanometer to keep the deflection always of suitable magnitude.

For the photographic work, a portion of the west wall and roof of the barn sufficient to expose the lenses to the sun during the duration of the eclipse was removed and the remainder of the barn was made a better protection by covering cracks with strips of batting. Two tubes of 8 inch (20 cm.) iron stove-pipe, riveted together in lengths 11 feet (335 cm.) long, formed the tubes for the double-barreled camera. These were mounted on a polar axis which itself was supported by two wooden posts embedded in cement and well braced. An arm 8 feet (2.5 meters) long, clamped to the polar axis, extended due west and moved downward over a roller, thus causing the camera tubes to follow the apparent solar motion. The rate of motion was regulated by a clockwork placed on a pier just above the end of the lever arm.

The photographic plates used were 8 by 10 inches (20 x 25 centimeters) Special Red Label brand, made by the Hammer Dry Plate Co.

For the determination of the times of contact, a small telescope of 2 inches (5 centimeters) aperture was mounted just outside the opening in the barn.

ASSIGNMENT OF OBSERVERS

The observers were assigned as follows:

Rev. Woodman,

(1) Determination of times of contacts and general observations with the 2 inch refractor.

(2) Giving of warning signals.

(3) Manipulation of the cap exposing the photographic plates.

Mr. Kramer,

(1) Manipulation of the pyranometer.

(2) Observations of general phenomena.

Mr. Aldrich,

(1) Observing at the galvanometer.

(2) Manipulation of the camera driving mechanism and plate-holder slides.

A number of practise eclipses were carried through on Saturday morning to familiarize each with his duties.

OBSERVATIONS

(1) PYRANOMETER

Observations with the pyranometer both of the brightness of the sky alone and of the total sky and sun, were made on the afternoon of the eclipse beginning at about one o'clock of local summer time and continuing until after ten o'clock at night. These were made about every 15 minutes up to the beginning of the eclipse, their frequency then increasing as totality approached and again decreasing after totality. An observation of the brightness of the sky was made 2 minutes before totality and 15 seconds after totality, and of the total sky and sun 2½ minutes before and 1 minute after. During totality the glass hemisphere covering the pyranometer strip was removed and two determinations made of the outgoing radiation to space. In the course of the observations frequent calibrations were made with heating currents sufficient to give deflections of the same size as those recorded by the exposures to the sky and to the sky and sun. Also, at intervals readings were made of the water vapor pressure with a sling psychrometer.

On the afternoon of June 9, with a sky considerably clearer than June 8, similar though not so frequent observations were made for comparison.

After the work of the expedition was concluded, the pyranometer and ammeter were taken by the writer to the Smithsonian station at Mt. Wilson, Cal., and there comparisons were made with Secondary Pyrheliometer A. P. O. No. IV on the sun alone, for the purpose of determining the constant of the eclipse pyranometer. Five comparisons were made on June 26, and six on June 28, the mean of these giving a value 23.8 as the constant of the eclipse pyranometer when glass covered, and 22.6 with glass off. The computed value of the constant (glass covered) is 25.9. The discrepancy is not surprising when one considers the vicissitudes of the instrument since the computation was made early in 1916. The value 23.8 was adopted in reducing the readings to calories.[1]

Note by C. G. Abbot.—The value 22.6 stated by Mr. Aldrich as the constant of pyranometer No. 5, as used for nocturnal work, without the glass cover is determined by multiplying the day value, 23.8, by the fractions $\frac{92}{100}$ and $\frac{98}{95}$. The former fraction corrects for removing the hindrance to rays caused by two reflecting surfaces of glass, the latter represents an attempt to take account of the fact that the blackening of the pyranometer strip is less completely absorbing for long wave rays, such as are proper to a body at ordinary terrestrial temperatures, than for sun rays. This latter assumption is quantitatively very uncertain.

Dr. A. K. Ångström has lately published a paper entitled "Determination of the Constants of Pyrgeometers" (Arkiv för Matematik Astronomi och Fysik, K. Svenska Vetenskaps akademien, Band 13, No. 8, 1918). In this paper he explains clearly the methods and results of his recent investigation to fix the scale of the Ångström nocturnal radiation instruments, and gives the constant of Pyrgeometer No. 22, now with the Smithsonian solar constant expedition to Chile as 13.4.

Messrs. Moore and L. H. Abbot of the Chilean expedition made careful comparisons of that pyrgeometer with pyranometer S. I. No. 3, at Hump Mt., N. C., on several nights of 1917 and 1918. They found that if the same conventions adopted by Mr. Aldrich in computing the nocturnal radiation constant of the pyranometer were employed, and if we assume that as so used the pyranometer truly reads in calories, then the constant of Ångström pyrgeometer No. 22 is 9.8. Their value differs by 36 per cent of itself from Angström's, so that Angström's results are therefore much higher than ours.

I call attention to this glaring discrepancy, not intending to imply that the Smithsonian pyranometer scale of nocturnal radiation is right or that Ångström's pyrgeometer scale is wrong, but rather to hinder readers from accepting either scale as yet verified. Nocturnal radiation measurements can-

[1] See Smithsonian Misc. Coll., Vol. 66, No. 7, p. 7.

not, I believe, be put on a sound basis until an instrument for nocturnal radiation is perfected which employs as the radiating and absorbing member a hollow chamber, or so-called "absolutely black body." I believe the discrepancy above mentioned results from the facts that both the radiation and absorption of the sensitive strips of the pyranometer and pyrgeometer, and the radiation and absorption of the terrestrial atmosphere differ widely from being "perfect" for wave lengths exceeding 10 microns.

The reader *should not infer* that it is admitted that the scale of the pyranometer for *daylight* measurements with *glass on* is doubtful. Sunbeams and the brightness of the sky embrace rays almost wholly transmissible by glass, and for which the absorption of lamp black paint is well known. Furthermore, as a check to its computed constant the pyranometer with glass on is calibrated against the pyrheliometer.

In Tables 1A and 1B are summarized the observations of June 8 and June 9. Columns 2 and 3 give the calories of radiant energy reaching a square centimeter of horizontal surface per minute from the whole sky (the sun being shaded), and from the total sky and sun, respectively. Table 1C, showing the brightness of the sky for a typical Mt. Wilson day made with the same pyranometer, is added for comparison. Table 1A also gives the values of the outgoing radiation to space during totality and at night.

Tables 2A and 2B give values of the air mass and corresponding solar radiation in calories per square centimeter of surface normal to the radiation per minute all during the eclipse of June 8, and on the afternoon of June 9. These values are obtained by subtracting the total sky brightness from the total sun and sky brightness and dividing by the cosine of the zenith distance of the sun. Table 2C, giving similar values (obtained by pyrheliometry) for a typical Mt. Wilson day, is added for comparison.

TABLE IA.—*June 8, 1918*

Hour angle (west)			Sky brightness	Sky and sun	Wet and dry bulb readings	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*Calories*)	(*F.°*)	(*mm. of mercury*)	
0	14	40	.349	....	....	....	Wind S. E.
	16	50	....	0.556	{65.2	13.10	Clouds breaking, especially in west. Sun shines intermittently.
	32	25	.388	....	76.0}	....	
	34	25	....	1.597	....	....	
	40	05	.378	....	....	....	
	41	25	....	1.540	....	....	
	44	15	.381	....	....	....	
	45	05	....	1.556	....	....	
1	12	40	.217	....	....	....	
	13	45	....	1.300	....	....	
	15	45	.232	....	{67.8	14.35	Cumulus clouds disappearing. Strati-cirri developing over whole sky.
	35	40	.250	....	79.5}	....	
	36	45	....	1.310	....	....	
	40	25	.235	....	....	....	
	41	25	....	1.333	....	....	
	46	05	.253	....	....	....	
	47	25	....	1.352	....	....	
2	13	45	.214	....	....	....	
	15	25	....	1.237	....	....	
	17	30	.218	....	{68.0	14.17	
	44	20	.250	....	81.0}	....	
	46	20	....	1.178	....	....	
3	14	10	.203	....	....	....	
	16	05	....	1.048	....	....	
	17	30	.203	....	{68.2	14.30	
	27	50	.215	....	81.1}	....	
	29	40	....	.972	....	....	Strati-cirri over whole sky. Cumuli low in west and east.
	30	55	.214	....	....	....	
	41	55	.195	....	....	....	
	44	05	....	.784	....	....	
	46	40	.177	....	....	....	First contact at $3^h\ 35^m\ 52^s$.
	54	55	.154	....	....	....	
	56	50	....	.682	....	....	
	58	0	.136	....	....	....	
4	06	55	.102	....	....	....	
	08	20	....	.502	....	....	
	08	55	.097	....	....	....	
	12	40	.0792	....	....	....	
	13	55	....	.397	....	....	
	15	10	.0742	....	{68.7	14.20	
	21	55	.0514	....	81.0}	....	
	23	10	....	.245	....	....	
	23	45	.0471	....	....	....	
	28	0	.0340	...	....	....	
	28	50	....	.163	....	....	
	29	35	.0302	....	....	....	
	33	45	.0188	....	....	....	
	34	10	....	.0864	....	....	
	34	45	.0181	....	....	....	
	35	10	.0140	....	....	....	
	40	25	.0031	....	....	....	
	40	55	....	.0167	....	....	
	41	10	.0017	....	....	....	
	43	30	—.145				Glass off. Eclipse total from $4^h\ 43^m\ 19^s$ to $4^h\ 44^m\ 41^s$.
	44	25	—.137				

TABLE IA.—*June 8, 1918* (Continued)

Hour angle (west)			Sky brightness	Sky and sun	Wet and dry bulb readings	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*Calories*)	(*F.°*)	(*mm. of mercury*)	
	44	55	.0006	....	....	....	
	45	25	....	.0031	....	....	
4	45	50	.0019	....	....	....	
	49	25	.0088	....	....	....	
	49	55	....	.0305	....	....	
	50	30	.0119	....	....	....	
	55	10	.0283	....	{65.0	13.43	
	55	50	....	.0871	74.0	....	
	56	10	.0333	....	....	....	
	59	25	.0493	....	....	....	
	59	55	....	.120	....	....	
5	0	25	.0528	....	....	....	Strati-cirri continue.
	04	50	.0721	....	....	....	
	05	25	....	.161	....	....	
	05	55	.0735	....	....	....	
	13	20	.1028	....	{65.7	13.84	
	13	45	....	.268	74.6	....	
	15	25	.1063	....	....	....	
	30	55	.145	....	....	....	
	31	30	....	.324	....	....	
	32	05	.144	....	....	....	
	43	40	.148	....	....	....	
	44	10	....	.298	....	....	
	44	55	.1485	....	....	....	Fourth contact at 5^h 45^m 49^s.
6	13	05	.1080	....	....	....	
	15	55	....	.131	{65.1	13.58	
	15	55	.1022	....	73.7	....	Thick strati-cirri around horizon (which obscured sun soon after 6.44). Also streaked over whole sky. Very little wind.
	42	40	.0559	....	....	....	
	43	40	....	.0554	....	....	
	44	40	.0512	....	....	....	
							Sun below horizon.
7	20	25	.00371		....	....	Sunset 7^h 17^m.
	21	10	.00295		....	....	
	22	55	.00231		....	....	
	24	25	—.0992		{64.0	13.74	Glass off.
	56	30	.00193		69.6	....	Glass on.
	59	0	—.1066		....	....	Glass off.
8	34	30	0		....	....	Glass on.
	37	0	—.0907		....	....	}Glass off.
9	19	0	—.0887		{62.0	13.31	
					65.2	....	
							Sky apparently clear overhead, but clouds around horizon.

NOTE.—The negative values are the outgoing radiation from the earth to space, in calories per sq. cm. per minute.

TABLE 1B.—*June 9, 1918*

Hour angle (west)			Sky brightness	Sky and sun	Wet and dry bulb readings	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*Calories*)	(*F.°*)	(*mm. of mercury*)	
0	23	0	.1378	....	....	....	Sky clear except of some cumuli around horizon. Little wind.
	24	50	....	1.587	....	....	
	27	40	.1338	....	{71.7	15.22	
	48	45	.1245	....	{89.8	....	
	49	35	....	1.462	....	....	
	50	35	.1278	....	....	....	
1	21	25	.1126	....	....	....	
	22	10	....	1.333	....	....	
	23	10	.1142	....	....	....	Cumuli increasing somewhat.
	52	25	.1262	....	....	....	
	52	55	....	1.349	....	....	
	53	35	.1262	....	{70.6	13.67	
2	21	0	.1228	....	{92.0	....	
	21	35	....	1.223	....	....	
	22	25	.1145	....	....	....	Wind increasing.
3	14	15	.1109	....	....	....	
	14	45	....	1.033	....	....	
	15	45	.1178	....	{70.0	13.89	
	45	30	.1145	....	{89.0	....	
	46	0	....	0.909	....	....	
	46	45	.1042	....	....	....	
4	23	15	.0924	....	....	....	
	24	0	....	.712	....	....	
	24	45	.0952	....	{67.7	12.42	
	36	30	.0895	....	{87.0	....	
	39	05	....	.642	....	....	
	39	55	.0905	....	....	....	
5	57	45	.0855	....	{67.8	12.85	Considerable cirri over whole sky.
	58	30	....	.311	{85.5	....	
	59	25	.0885	....	....	....	

TABLE 1C.—*Mt. Wilson, Cal., Aug. 9, 1918*

Hour angle (west)			Sky brightness	Wet and dry bulb	Vapor pressure	Remarks
h.	*m.*	*s.*	(*Calories*)	(*C.°*)	(*mm. of mercury*)	
2	10	20	.0957	....	....	Some cumuli low in east. A little wind.
	16	0	....	{13.8	7.17	
	38	10	.0928	{24.8	....	
3	25	40	.0938	....	....	
	31		....	{12.8	6.85	
4	18	0	.0826	{22.7	....	
	44	50	.0776	....	....	
	49		....	{11.2	6.30	
5	14	50	.0671	{19.9	....	
	54	50	.0455	....	....	No wind.
6	01		....	{9.0	4.33	
	20	50	.0281	{19.2	....	
	37	50	.0141	....	....	
	45	05	.0085	....	....	Sun close to horizon.
	54	20	.0026	....	....	Sun below horizon.
7	0		....	{6.6 {18.3	2.41	

TABLE 2A.—*June 8, 1918*

Hour angle (west) h.	m.	s.	Air mass (Sec. z.)	Sun alone (Calories, normal surface)
0	34	25	1.045	1.272
	41	25	.049	.217
	45	05	.051	.235
1	13	45	.078	.160
	36	45	.110	.185
	41	25	.117	.217
	47	25	.128	.241
2	15	25	.187	.211
	46	20	.279	.187
3	16	05	.398	.181
	29	40	.468	.112
(1st contact)				
	44	05	1.552	0.928
	56	50	.638	.880
4	08	20	.729	.695
	13	55	.777	.568
	23	10	.864	.3655
	28	50	.924	.2522
	34	10	.983	.1348
	40	55	2.065	.0295
(2d and 3d contacts)				0
	45	25	2.125	.0039
	49	55	.189	.0516
	55	50	.278	.1282
	59	55	.344	.1617
5	05	25	.440	.215
	13	45	.605	.427
	31	30	3.045	.548
	44	10	.467	.520
(4th contact)				
6	13	55	5.160	.129
	43	40	10.00	.019

TABLE 2B.—*June 9, 1918*

Hour angle (west) h.	m.	s.	Air mass (Sec. z.)	Sun alone (Calories, normal surface)
0	24	50	1.039	1.508
	49	35	.053	.407
1	22	10	.086	.325
	52	55	.137	.391
2	21	35	.202	.327
3	14	45	.390	.277
	46	0	.560	.248
4	24	0	.868	.154
	39	05	2.068	.141
5	58	30	4.095	0.918

TABLE 2C—*Mt. Wilson, Cal., September 21, 1914**

Hour angle (east) h.	m.	s.	Air mass	Sun alone (Calories, pyr. No. 4)	Wet and dry bulb readings (C.°)	Vapor pressure (mm. of mercury)
1	49	50	1.348	1.529	....	....
2	0	0	.381	....	13.2	7.49
	47	50	.606	1.492	22.2	....
	51	0	.625	....	10.9	5.74
3	35	50	2.022	1.419	20.3	....
	42	0	.097	....	10.3	5.92
4	5	50	.47	1.366	18.4	....
	15	0	.97	....	7.1	3.06
	26	50	.97	1.297	17.7	....
	41	50	3.46	1.248	....	....
	52	0	4.00	....	6.2	2.48
	58	50	4.32	1.148	17.1	....
5	11	50	5.34	1.061	....	....
	15	50	5.76	1.027	....	....
	20	0	....	....	8.0 17.2	4.12

* See Smithsonian Misc. Coll., Vol. 65, No. 4, p. 14.

TABLE 3

Place	Altitude	Temperature	Vapor pressure	Nocturnal radiation
	(Meters)	*(Centigrade)*	*(mm.)*	*(Calories)*
Bassour, Algeria	1160.	18.8	12.57	.146
Mt. Wilson, Cal.	1730.	18.9	12.37	.143
Indio, Cal.	0.	24.1	10.3	.177
Mousaia Valley, Algeria	540.	19.6	8.0	.174
Lakin, Kan., during totality	900.	about 24.0	13.8	{ .145 .137
Lakin, Kan.	900.	{ 20.9 18.4	13.7 13.3	.102 .090

(2) PHOTOGRAPHIC

Equal exposures of 70 seconds for each camera were made during totality by Father Woodman. The negatives were kindly developed, with Director Pickering's permission, by Mr. King at Harvard College Observatory. They show evidences of motion caused by the lack of opportunity to rate the driving clock accurately, but exhibit coronal streamers extending at least 2½ solar diameters. These are much shortened in the accompanying reproductions.

(3) TIMES OF CONTACT

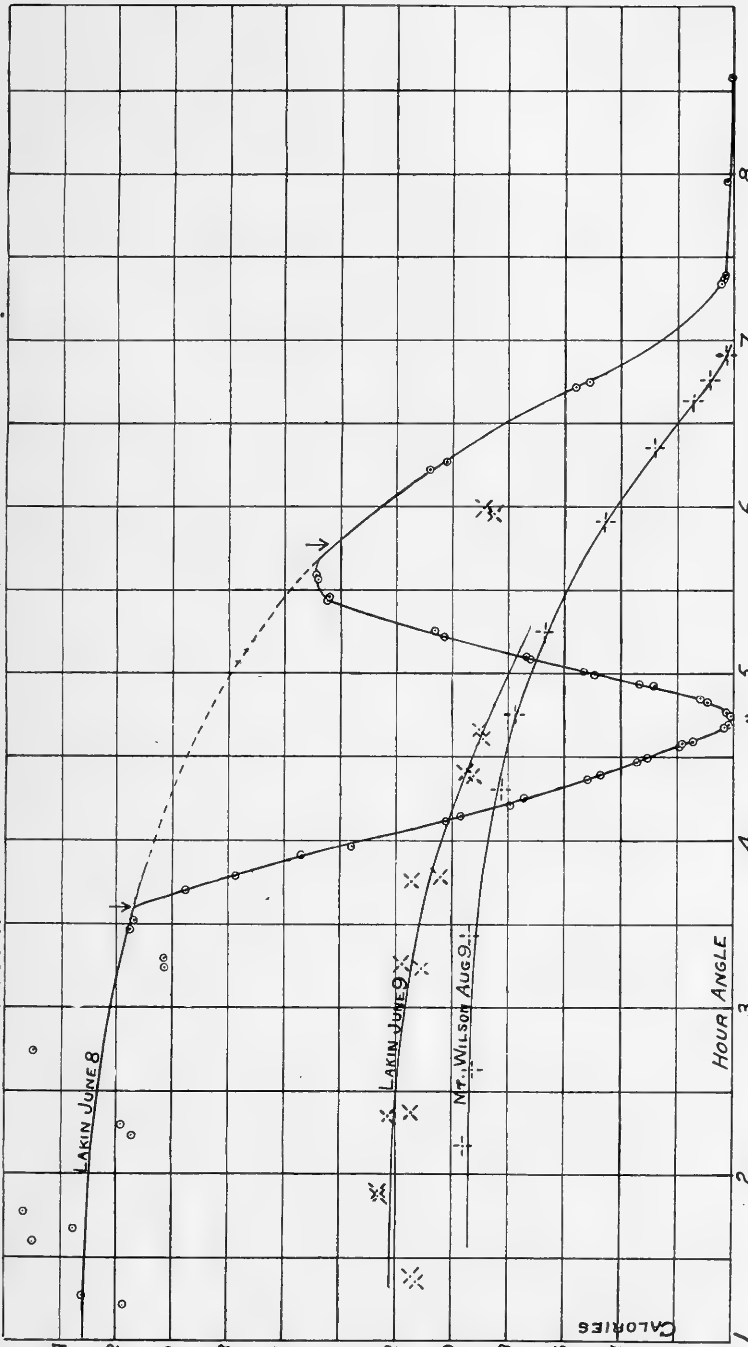
Rev. Woodman obtained an accurate rating of his watch from Western Union noon signals during the week preceding the eclipse and each day comparisons were made with an excellent Hamilton watch of the Smithsonian Institution. The times of contact determined by Rev. Woodman follow:

1st contact	$10^h 19^m 48.^s5$	G. M. T.
2d contact	11 27 15.1	
3d contact	11 28 37.3	
4th contact	12 29 45.4	

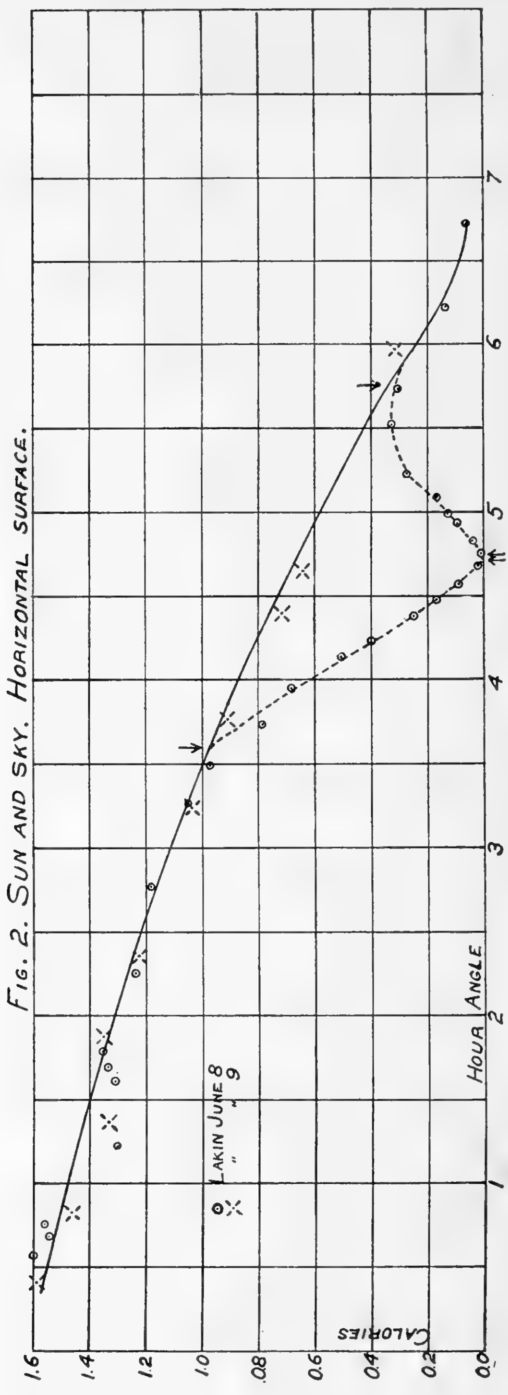
(4) GENERAL OBSERVATIONS

The writer obtained only one short look at the total eclipse through a small window in the barn. He was profoundly astonished at the weird grandeur of the sight. Rev. Woodman and Mr. Kramer, both stationed out of doors, were impressed with the unusual darkness which prevailed, it being markedly greater than that which they experienced at Wadesboro, N. C., in 1900. Miss A. L. Loving, of St. Joseph, Mo., a spectator, reported seeing shadow bands distinctly in the direction northeast to southwest.

FIG. 1. SKY ALONE. HORIZONTAL SURFACE.



SKY RADIATION. TOTAL SOLAR ECLIPSE. LAKIN, KAN., JUNE 8, 1918.



SUN AND SKY RADIATION. TOTAL SOLAR ECLIPSE. LAKIN, KAN., JUNE 8, 1918.

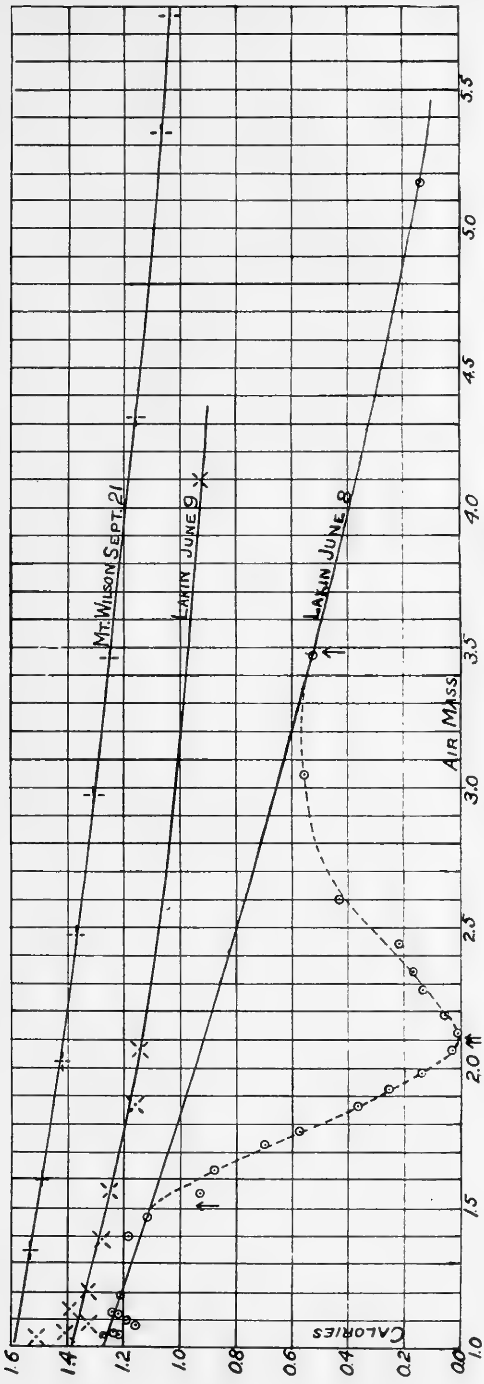


Fig. 3. Sun alone. Normal surface.

Solar Radiation. Total Solar Eclipse. Lakin, Kan., June 8, 1918.

RESULTS

The results summarized in the tables are graphically shown in figures 1, 2, and 3. Figure 1 shows the relation between sky brightness and hour angle, figure 2 the total sun and sky brightness and hour angle, and figure 3 the intensity of solar radiation and air mass (secant of the zenith distance). The intensity of sky brightness on June 8 was nearly double that of June 9 due to the streaks of cirrus cloud which prevailed on the former day. On June 9 the sky was clear and blue during the afternoon up to an hour angle of about five hours. At this time, cirri similar to June 8 spread over the whole sky. This explains the deviation of the last two points on the curve of June 9 (fig. 1). The great deviations in sky brightness early on the afternoon of June 8 arise from the presence of cumulus clouds scattered over the sky. By the time the eclipse began the cumuli had practically disappeared and the values for the remainder of the day yield a surprisingly smooth curve.

It is apparent from these data that the total brightness of the sky during totality was less than that of the twilight one hour after sunset of the same day. From first contact to second during the eclipse the decrease in sky brightness was almost linear. The curves of figures 1 and 2, showing the relationship of sky and total sun and sky brightness to hour angle, are in their general form in agreement with those computed from theoretical considerations by King.[1] However, the ratio of sky brightness at large zenith distances of the sun to that at high sun is much smaller in the observed values than the ratio obtained from King's computed curves. In other words, the falling off of sky brightness as the sun approaches the horizon is considerably more rapid in both the Mt. Wilson and Lakin curves than would be anticipated from his theoretical considerations. It is probable that the presence of clouds low in the west on June 8 behind which the sun set made the after-sunset sky brightness values of that day lower than a clear sky would have shown.

Of the two values of the outgoing radiation to space obtained during totality, the second is smaller than the first, due to the rapid cooling off of the instrument and surrounding air and consequent decrease in temperature difference between the instrument and the space to which it is radiating. This agrees with the values obtained by Ångström[2] at the total eclipse at Åviken, Sweden, in 1914. Both

[1] Phil. Trans. Roy. Soc. London, Series A, 212, p. 429.

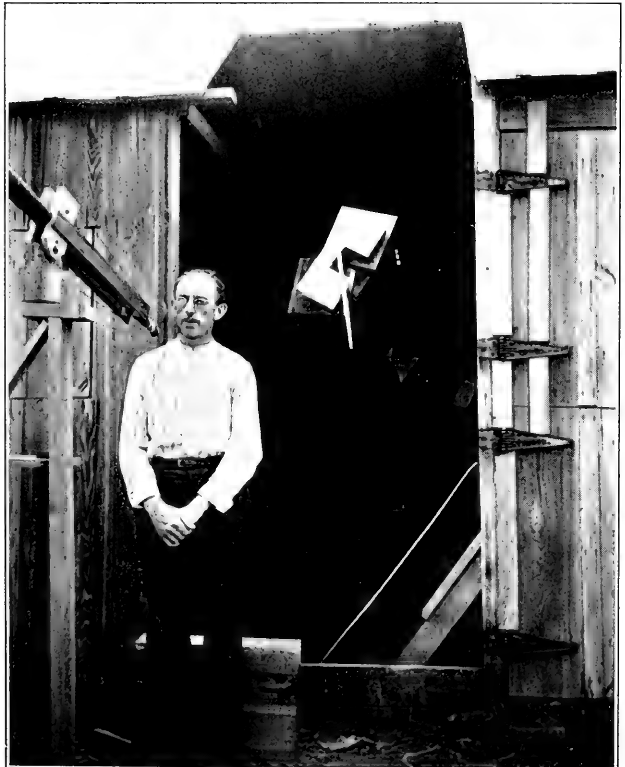
[2] "Radiation of the Atmosphere," A. Ångström, Smithsonian Misc. Coll., Vol. 65, No. 3, p. 74.

values are considerably in excess of the nocturnal radiation values obtained after dark the night following the eclipse, with humidity and sky conditions nearly identical. This was to be expected because of the higher temperature during totality. So far as can be seen from these values, they uphold the conclusion of Ångström that "the effective temperature radiation during the day follows the same laws as hold for the nocturnal radiation."

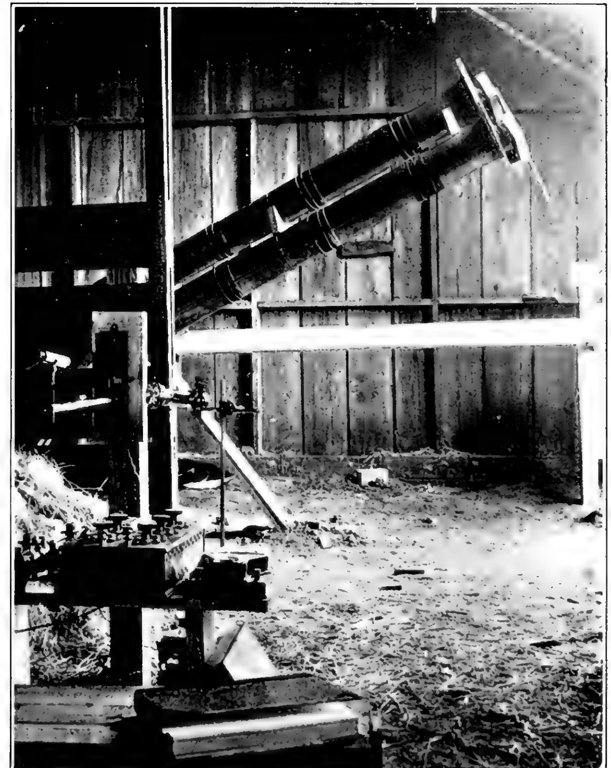
Table 3 is appended, showing values of nocturnal radiation found by Ångström with clear skies under varying conditions and comparing them with the Lakin values. That the latter are lower than Ångström's values may be due partly to the veiling effect of the thin cirrus clouds at Lakin, and partly to the difference in scales of nocturnal radiation above noted.

SMITHSONIAN OBSERVING SHELTER NEAR LAKIN, KANSAS.

EXTERIOR OF OBSERVING SHELTER SHOWING POSITION OF PYRANOMETER AND VISUAL TELESCOPE.

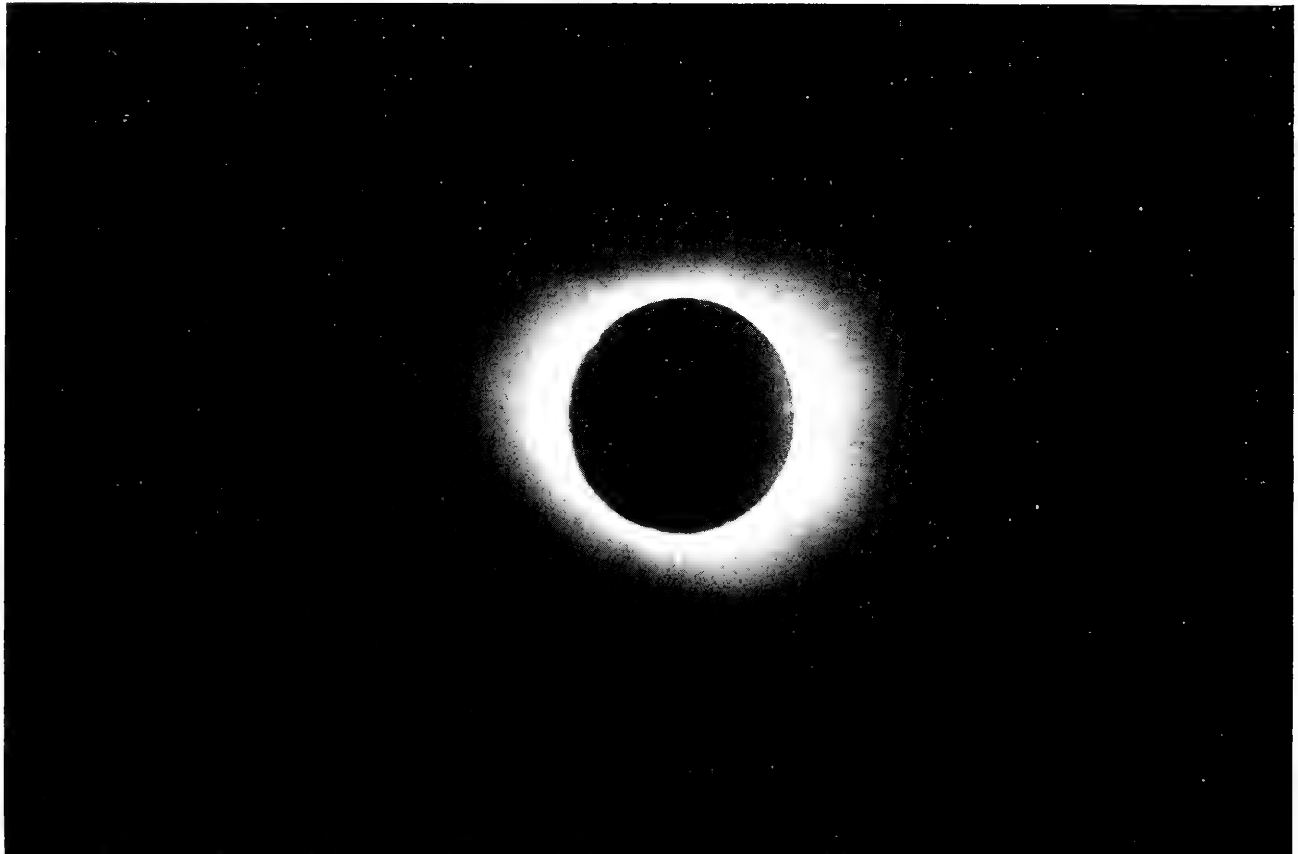


VISUAL AND PHOTOGRAPHIC TELESCOPES.



INTERIOR OF OBSERVING SHELTER.

TOTAL SOLAR ECLIPSE OF JUNE 8, 1918. 11-FOOT FOCUS CAMERA EXPOSURE 70 SECONDS. DEVELOPED TO SHOW EXTENSION OF CORONA.



TOTAL SOLAR ECLIPSE OF JUNE 8 1918. 11-FOOT FOCUS CAMERA; EXPOSURE 70 SECONDS. DEVELOPED TO SHOW PROMINENCES AND INNER CORONA.

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THE REFLECTING POWER OF CLOUDS

BY
L. B. ALDRICH

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THE REFLECTING POWER OF CLOUDS

By L. B. ALDRICH

INTRODUCTION

In the spring of 1918, the War Department established an observation balloon school at Arcadia, California. On clear days the balloons of this school are in full view from the Smithsonian Observing Station on Mt. Wilson. The valley to the south and west of Mt. Wilson is often filled in the early morning with dense fog, and from the mountain-top one looks down upon a surface of white, billowy clouds remarkably level and unbroken as a whole. Usually after several hours the fog is dissipated, but on rare occasions it lasts until noon or later. From this combination of circumstances it appeared evident that one of these observation balloons sent up through such a fog sea offered an unusual opportunity for determining the reflecting power of a cloud surface practically filling a hemisphere of solid angle. The top of the mountain, to be sure, would cut off a portion of the horizon, but being in the quarter opposite the sun, several miles distant and with intervening haze itself supplying nearly as much radiation as the small solid angle of cloud it took the place of, no correction would be needed to allow for the presence of the mountain. Accordingly Dr. Abbot obtained from the Director of Military Aeronautics, General Kenly, permission to use a balloon and detail of officers and men for cloud reflection work on the first favorable day. Preliminary arrangements were made with the Commanding Officer at Arcadia, and a favorable day awaited.

On September 16, 1918, a very heavy fog filled the valley, persisting all day and its top level almost reaching the summit of Mt. Wilson. Prospects seemed excellent for a similar heavy fog at a lower level on September 17, and final arrangements for the experiments were made. The sky conditions of September 17 more than fulfilled expectations. A dense, homogeneous fog, unusually level and even on top, filled the valley. Its upper surface was about 800 meters (2,600 feet) from the ground. It was 500 meters (1,600 feet) thick at the start and 180 meters (600 feet) thick at the close of the work.[1]

The sky above was cloudless and very clear. Under these conditions the following experiments were made.

OBJECT AND METHOD OF THE EXPERIMENTS

It was desired to determine what proportion of the rays of the sun, including sun rays scattered by the sky, is reflected upward from a level layer of cloud of indefinite extent. For this purpose a pyranometer[2] having a glass hemispherical cover was to be exposed in one series of experiments in its inverted position to measure the rays coming up from fog in the hemisphere below, and on a similar day in the usual position to measure the rays from the sun and sky in the hemisphere above. The glass cover served as a screen to sift out for observation rays lying between 0.3 microns and 3.0 microns in wave length. These rays comprise practically all rays of relatively appreciable intensity in the solar spectrum. The glass excludes rays of more than 3.0 microns in wave length such as the earth, the clouds, and the atmosphere emit by virtue of their proper temperatures. In order to determine whether the reflecting power of a wide sheet of cloud differs much with the angle of incidence of the rays, it was desirable to begin the experiments at low sun and continue them till the sun reached high altitude above the horizon. Experiments reported in Volume II of the Annals of the Smithsonian Astrophysical Observatory[3] of course show that the reflection varies in azimuth and nadir distance greatly with the angle of incidence. But it was not shown certainly whether the total intensity of the reflected rays summed up over all azimuths and nadir distances within a hemisphere would change much with the angle of incidence of the rays upon the cloud layer.

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[1] In passing up and down through the layer of fog the observer reported as follows:

Pacific standard time	6 hr. 55 min.	9 hr. 00 min.	10 hr. 00 min.	10 hr. 55 min.
Level of bottom (feet)	1,000	1,800	....	2,000
Level of top (feet)	2,600	2,600	2,600	2,600

Such a thinning of the fog from the bottom without much change in its upper level seems curious and is probably unusual.

[2] See Smith. Misc. Coll., Vol. 66, Nos. 7 and 11, 1916.

[3] For further discussion of the theory of the method of observing see the figure and explanation given in Addenda to Annals Vol II, entitled, "Note on Reflecting Power of Clouds."

ARRANGEMENTS

Pyranometer A. P. O. No. 5, modified for use in the eclipse expedition of June 8, 1918,[1] was somewhat further modified for this work. It was proposed to suspend the pyranometer, inverted, below the basket of the balloon, thus exposing the pyranometer strip to the radiation from a practically infinite cloud surface. The sun shade was removed and the glass hemisphere securely fastened in place with shellac. The pyranometer was suspended about one-half meter below the bottom of the balloon basket, and a flexible shaft, operating the shutter through miter gears, extended to within easy reach of the officer in the basket. For stability the galvanometer was necessarily mounted on the ground and connected to the pyranometer through a reel of special telephone wire. (Insulated piano wire was employed such as is used in ordinary balloon work for telephone communication with the ascending officer. This introduced probably over 1,000 ohms resistance into the galvanometer circuit, but the pyranometer was sufficiently sensitive to give deflections ranging from 1.50 to 4.0 cms. and could be read to 0.01 cm.). The galvanometer, ammeter, and accessories were the same as used on the eclipse expedition of last June, 1918.[1]

Observation Balloon No. 7, with its complement of officers and men, was assigned to aid in the work. The writer wishes to express his appreciation for their assistance, and particularly for the interest and efficient help of Lieut. E. W. Raeder, the ascending officer. Lieut. Raeder reported the sky conditions and manipulated the pyranometer shutter from the balloon basket, being in constant telephone communication with the ground through a second reel of telephone wire. His great zeal and gallantry are shown by the fact that, being alone in the basket, he tied his ankle by a bit of rope to the balloon and hung head downward for about 5 minutes to fix a defect in the exposing apparatus which developed near the end of the experiments, then climbed back and continued the observations.

OBSERVATIONS

The observations of cloud, sun, and sky, and of electric current for calibration of the pyranometer, are given in Table I. As the balloon was brought to earth between observations of groups 7 and 8 (see

[1] See Smithsonian Misc. Coll., Vol. 69, No. 9.

TABLE I

Group No.	Hour angle of sun (East) H.	Min.	Air mass of sun (Sec. Z)	Brightness of sky alone on horizontal surface (Calories)	Sun alone per sq. cm. normal to beam (Calories)	Sky and sun per sq. cm. of horizontal surface (Calories)	Calories per sq. cm. reflected from cloud	Altitude of instrument above cloud surface (Meters)	Wind velocity at balloon basket (Meters per sec.)	No. of individual determinations	Current calibration values of $\frac{C^2}{Dc}$	Mean deflections of galvanometer (cm.)	Per cent reflected from cloud surface	Probable error per cent	Maximum range of galv. zero drift (cm.)	Estimated grade based on zero drift
1	4	29	2.84	.064	1.250	.504	.401	30.	0.	10	.01085	1.532	79.6	1.2	0.16	Ex.
2		15	2.47	.070	1.303	.598	.460	120.	4.	10	.01089	1.752	76.9	0.5	0.54	V. G.
3		01	2.26	.073	1.337	.665	.530	210.	9.	11	.01093	2.014	79.7	1.4	2.56	P.
4	3	48	2.07	.077	1.367	.737	.567	120.	3.	10	.01097	2.144	77.0	0.8	0.57	V.G.
5		35	1.92	.080	1.390	.804	.615	25.	0.	11	.01100	2.317	76.5	0.7	0.22	Ex.
6		12	1.71	.083	1.424	.916	.824	25.	0.	11	.01104	3.098	90.0	1.5	1.25	Fair.
7	2	56	1.59	.086	1.442	.994	.868	105.	2.	10	.01108	3.251	87.4	0.8	0.67	G.
8	1	34	1.26	.092	1.493	1.278	1.019	60.	5.	9	.01114	3.787	79.8	2.2	1.19	Fair.
9		18	1.24	.093	1.497	1.300	1.145	60.	5.	10	.01115	4.265	88.1	3.0	2.80	V. P.
10		09	1.22	.094	1.500	1.324	1.051	50.	3.5	6	.01118	3.897	79.4	0.8	0.42	V. G.
11	0	59	1.20	.094	1.503	1.346	.945	50.	3.5	8	.01118	3.514	70.2	1.1	0.81	G.

Mean of all = 80.4 per cent. Mean of first five = 77.9 per cent. Mean of all with probable error 1.2 per cent or less (7 values) = 78.1 per cent. Adopted best value = 78.0 per cent ± 1.1 per cent.

table) three current calibrations[1] were made—just before the first ascension, between the first and second, and after the second ascension. The galvanometer circuit was unchanged throughout the observations, so that the calibrations were made under the same conditions as the cloud observations, save that the balloon was near the ground for the former and above the fog for the latter.

Column 5 in the table (total solar radiation per sq. cm. normal to the beam) was obtained as follows: On the morning of September 16, the usual solar constant observations, which include pyrheliometer measurements of the total solar radiation on normal surface, were made on Mt. Wilson. Then on September 17, simultaneously with the cloud reflection observations, Mr. H. Benioff of the Mt. Wilson Solar Observatory staff very kindly made pyrheliometer readings on Mt. Wilson with Pyrheliometers IV and VII. He made eight determinations, the mean of which gave for an air mass 1.5 the value 1.46 calories, total solar radiation received per square centimeter of normal surface. The plotted values of September 16 give for the same air mass the practically identical value, 1.452 calories. Furthermore the solar constants determined at the recently established Smithsonian station in Chile are:

September 16, 1918........................1.960
September 17, 1918........................1.951

As far as visual observations of the sky could indicate the two days were identical. Thus, since the two days show nearly identical solar constant values and nearly identical pyrheliometer values at a given air mass, it is to be assumed that the pyrheliometer values for the whole range of air masses would have been nearly identical. Values of column 5 are therefore taken from the pyrheliometer curve of September 16.

Column 4, the sky brightness, was not so easily obtained. Unfortunately, owing both to delay in the return of instruments and to an unprecedented amount of cloudy weather, sky brightness values on a day with sky conditions similar to September 17 were not available.[2] The pyranometer data of previous years was examined and

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[1] The first-swing method was used. See Smith. Misc. Coll., Vol. 66, No. 11, p. 8.

[2] It will be possible to obtain such values at some future time, however.

two days chosen, one of greater haziness and one of greater clearness than September 17, as follows:

Place	Date	Sky brightness at air mass		Kind of sky
		1.2	2.8	
Mt. Wilson, California.	Aug. 7, 1916 (A. M.)	.105 cal.	.065 cal.	Very hazy. Pyrheliometer 5% lower than Sept. 17, 1918.
Hump Mountain, N. C.	Nov. 17, 1917 (A. M.)	.085 "	.061 "	Very clear. Pyrheliometer values not obtained, but on neighboring days were several per cent above Mt. Wilson values of Sept. 17, 1918.

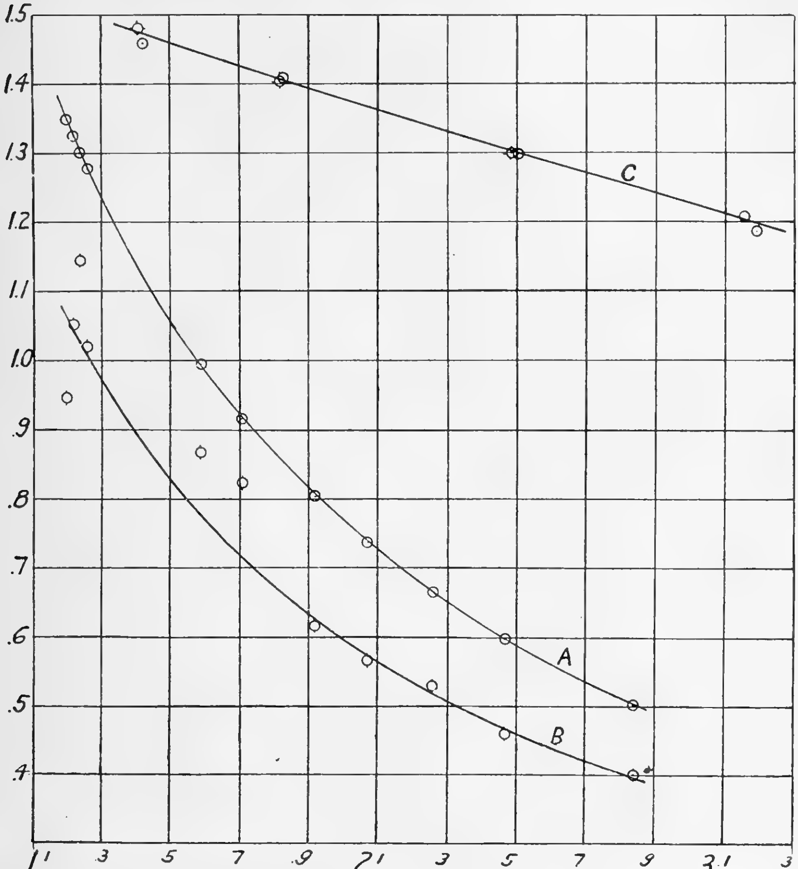
A mean between the values of sky brightness for these two days was adopted as the sky brightness for September 17, 1918. It is certain that on the first of these days the sky was brighter than on September 17, and on the second it was less bright than on September 17. If we were to adopt the values of either of these two days, the resulting values of total sky and sun brightness of September 17 would not be altered by so much as one per cent from those given in the table.

Comparisons of the pyranometer with Pyrheliometer IV on the sun alone were made before this work,[1] and again after the work on October 8 and October 9. A mean of 10 values on these last two days gave a constant 2½ per cent higher than the earlier comparisons. Taking a mean of all comparisons, the constant of the pyranometer was regarded as **24.1** instead of 23.8 as used for the eclipse reductions. The computed values originally obtained from measurements of dimensions, electrical resistances and assumed absorbing power of the pyranometer strips is 25.9. That recent observed values are so much lower is doubtless due to rough usage of the blackened surface necessary in fastening in new thermo-couples.

It is to be noted that a very considerable irregular galvanometer drift was present throughout the cloud observations. This seemed due mainly to the changing air currents as the balloon basket swung in the wind. Table I shows that in general the higher the wind velocity, the greater the range of zero drift. Inadequate protection of the galvanometer from vibrations caused by passing trains and auto trucks also contributed to the drift. However, since each individual determination required but five seconds and in each group

[1] See Report of Eclipse Expedition, Smith. Misc. Coll., Vol. 69, No. 9, p. 6.

the mean of a number is used, the error from irregular drift is minimized. The writer is inclined to place more weight in the observations of the first half of the morning, for the fog then was thicker and its top surface more level. As the sun rose higher there was not



Abscissae = Air masses. Ordinates = Calories.
Curve *A* = Total sky and sun per sq. cm. of horizontal surface.
Curve *B* = Calories reflected from cloud per sq. cm. of horizontal surface.
Curve *C* = Pyrheliometry of September 16, 1918. Total calories from sun alone per sq. cm. normal to beam.

only more boiling of the fog surface but the increased temperature differences tended to increase possible thermo-electric disturbances.

RESULTS

The mean value is 78 per cent. No evidence of a change of reflecting power with a change in solar altitude is evident for the range of air masses in Table I. This is of importance in deducing a value of the albedo of the earth from these results, for it tends to show not only that fog layers near the boundaries of the earth's surface differ little in reflecting power from those directly under the sun, but also that rough clouds do not differ very much from smooth ones in reflecting power. This latter point of course should not be urged too far, for it is obvious that clouds with very deep holes and furrows must reflect less than smooth ones.

Referring to the discussion of cloud reflecting power in Volume II, Annals of the Smithsonian Astrophysical Observatory, page 145, we find that using 65 per cent as the reflecting power of a cloud surface a value of 33.7 per cent is obtained as the total amount of the incoming solar radiation over the whole earth reflected to space by clouds. Substituting 78 per cent for 65 per cent this value becomes 40.4 per cent. It seems probable that the low cloud reflection value of the early Mt. Wilson work (65 per cent for cloud reflecting power) can be attributed largely to the uncertainty of the extrapolations necessary, since the observations were limited to a small range of nadir distance. Moreover, the contribution from the very bright area near the angle of specular reflection was perhaps minimized.

Following the method of pages 162 and 163 (Annals, Vol. II), a new value of the albedo of the earth is derived. Using 78 per cent as the cloud reflecting power, the albedo of the earth (as defined by Bond, see article by Russell, Astrophysical Journal, 43, p. 175) becomes 43 per cent. Russell (Astrophysical Journal, 43, p. 190) derives for it a value of 45 per cent from a consideration of Very's visual observations on Venus and the moon.

It will be clear that the method here adopted to get the cloud reflecting power (i. e., taking the ratio of the total radiation received by the pyranometer per square centimeter of horizontal surface from the cloud, to the total radiation received from sky and sun by a square centimeter of horizontal cloud surface) may give different results from measurements by visual or photographic methods as employed in photometry. Although even in the present work part of the solar rays is missing, owing to water vapor absorption, the results are more clearly applicable to considerations of the earth's temperature than photometric results would be. Still it is probable that the difference is small.

The planet Venus according to Russell's discussion of Müller's observations, has a Bond albedo of 59 per cent for visual rays. Because of its high reflecting power and the absence of telescopic markings Venus is usually regarded as altogether cloudy. If this is the case, unless the clouds are very deeply broken up by pits and billows an albedo for total radiation of 78 per cent (or even a little more considering the specular reflection near the edges of the sunlit surface) would be expected. Young notes that the limb of the planet is always much brighter than the central parts. This may indicate that the clouds while general are not thick enough to give full cloud reflection except for rays received obliquely.

SUMMARY

A pyranometer suspended below the basket of an army observation balloon was used to measure the reflecting power of a level cloud surface practically filling a hemisphere of solid angle. Over one hundred determinations were made. The solar air masses ranged from 2.8 to 1.2, and the sky above was cloudless and very clear. A mean value of 78 per cent is obtained. No change of total reflection depending on solar zenith distance is apparent within a range of zenith distance from 33° to 69°. A value of 43 per cent for the albedo of the earth is obtained by revision of the earlier value of Abbot and Fowle (Annals, Vol. II, p. 162) which depended on a lower value of cloud reflection based on observations over but a small part of a hemisphere.

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THE RACES OF RUSSIA

(WITH 1 MAP)

BY
ALEŠ HRDLIČKA

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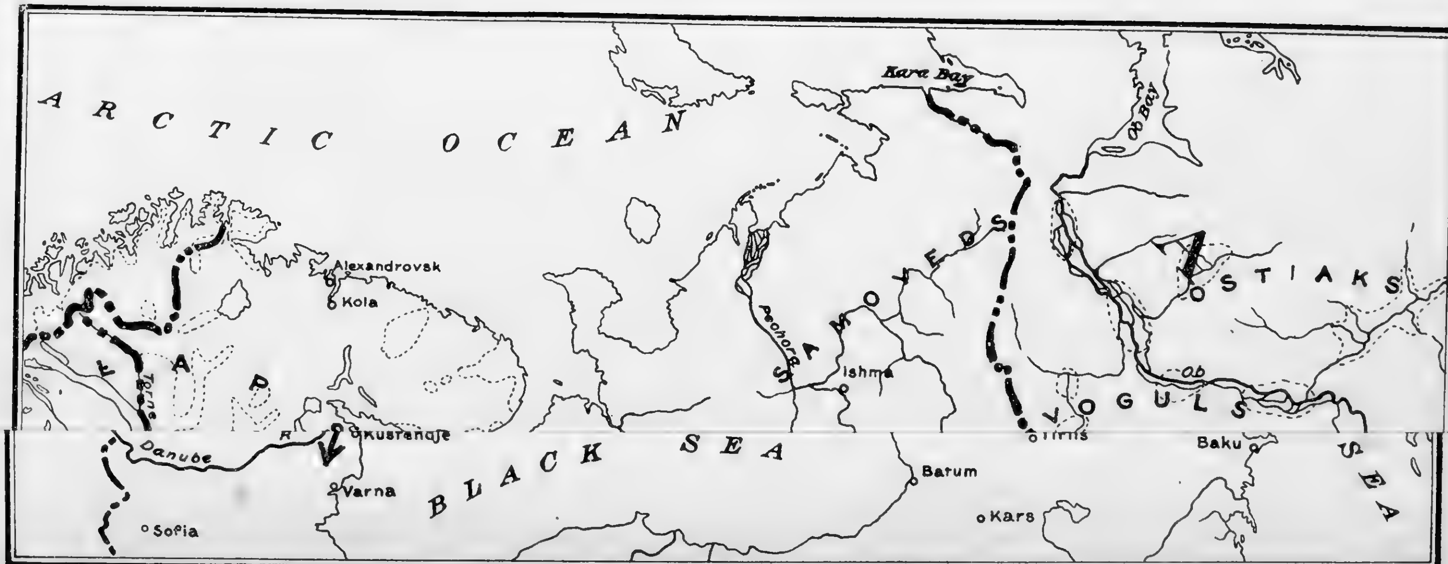


HISTORIC MOVEMENTS OF POPULATIONS IN EUROPEAN RUSSIA.

———— Spread of the Slavs.
— — — — Invasions by Asiatics.
- • - - • - Invasions by Nordic tribes.

THE RACES OF RUSSIA

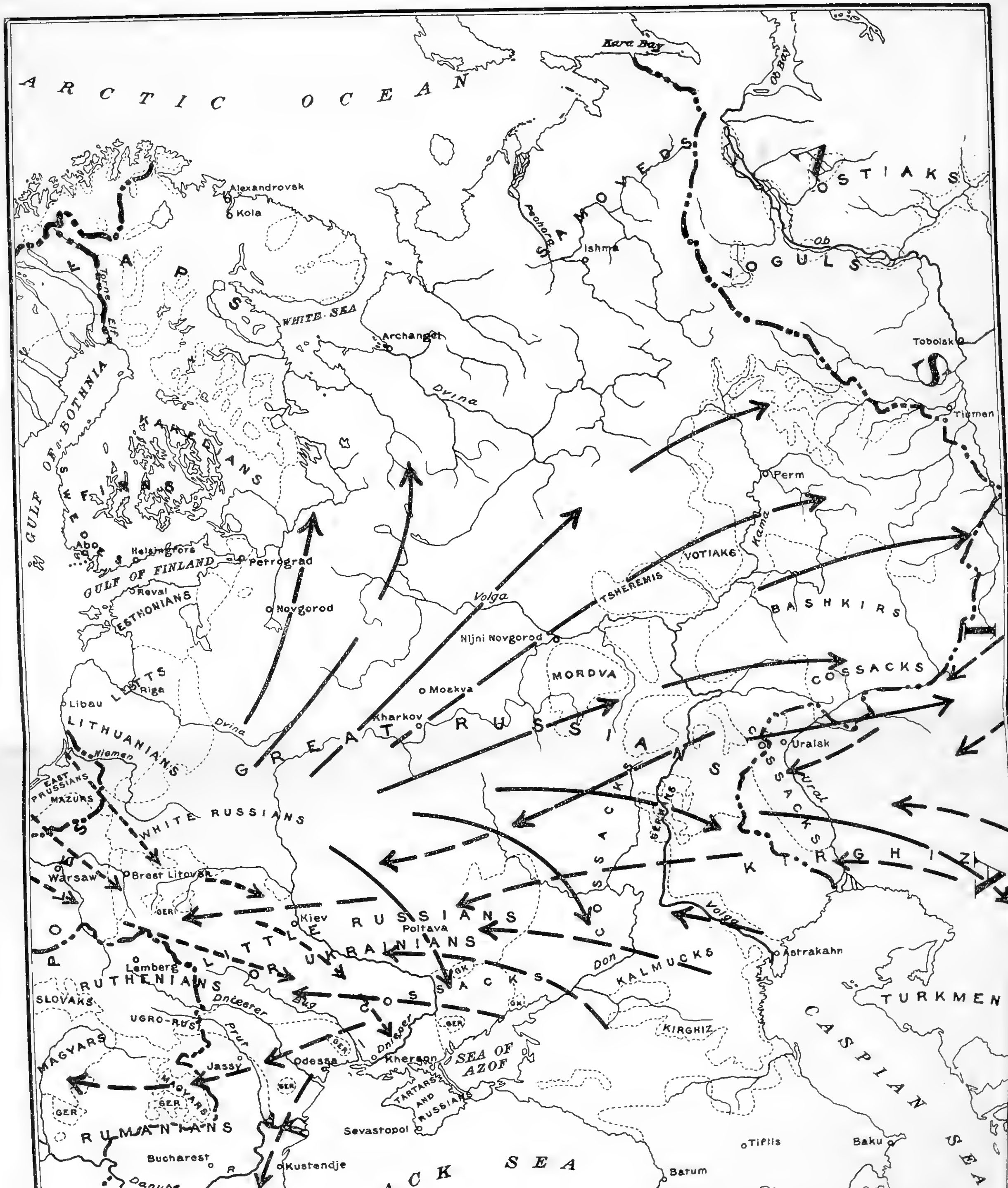
By DR. ALEŠ HRDLIČKA,

CURATOR, DIVISION OF PHYSICAL ANTHROPOLOGY, U. S. NATIONAL MUSEUM

The subject of the races of Russia—the great Russia that was yesterday and that must be again if the world is to know any peace—seems very baffling, and is in fact far from simple. Yet if the field is viewed from a higher horizon, with due historical and anthropological perspective, many of its irregularities disappear, and where at first there seemed to be an almost hopelessly involved mosaic of ethnic differences there are seen great areas of fairly uniform racial color.

So far as known to science, European Russia began to be peopled during the latter phases of the paleolithic epoch and the following neolithic times. Some skulls found in Russian Poland and southwestern Russia show features that still remind the anthropologist quite strongly of those of the Neanderthal man, but on the whole the type is already fairly modern. The remains from these earlier times are, however, still rare and limited to territories into which extension from the more southern and western parts of Europe was easily practicable.

A much more important peopling of European Russia took place during the latest neolithic, and the bronze and iron periods; and it proceeded, as far as is now discernible, not only from the adjacent regions in Europe, but also over Caucasus and from the great steppes of Asia. The western Asiatic or Ural-Altaic elements, evidently quite early and numerous, overran and sparsely settled or roamed over perhaps as much as two-thirds of the great region of what is now European Russia, reaching in the north to the limits of the land, in the west as far as Finland, Esthonia, Livonia, and approximately the thirtieth meridian, and in the south below the latitude of Moscow. At about the same time the southeastern and southern parts of Russia became peopled by Turanian and Iranian tribes, spreading over the Caucasus and from beyond the Caspian. Only the western and southwestern parts of the great territory received



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the overflow from the adjoining countries of Europe. The southern grassy plains became then a broad and important avenue for a long series of movements of populations, directed principally from east to west, and the territory was gradually covered with remnants of these populations. This much is known, though the details of these earlier ethnic movements in Russia are lost in the haze of antiquity, or preserved merely in historical fragments.

The first tribes occupying part of the territory which is now Russia, with whose specific name we meet in ancient chronicles, are the Cimmerians, the people whose name is perpetuated in that of Crimea; and the Tauri, from whose name was derived that of "Taurica," the other old name for the Crimean peninsula. Our actual knowledge of these peoples is, however, very limited. Neither reached great importance. The Cimmerians, who probably antedated the Tauri, occupied a part of Crimea and the territory north and northeastward, extending to and about the Palus Maeotis (Sea of Azov); they eventually came into contact with the Thracians and possibly other European groups; but their affinities seem to have been with the Caucasus and the Asiatic countries to the southward, rather than with Europe. They are said to have eventually disappeared into the regions south of Caucasus, being replaced, possibly before 1000 B. C., by the Scythians. The Tauri, probably of the Turanian stock and reputedly very barbarous, occupied the peninsula up to the time of the Greek colonization, after which their name gradually disappears.

This brings us to the more strictly protohistoric times of the region under consideration, the period of the Greek voyages and colonization along the shores of the Euxine (Black Sea). At this time the whole vast territory had already been subdivided among various tribes.

These protohistoric populations first became better known as a result of the famous march into their country of Darius Hystaspes—the first Napoleon—about 512 B. C., and more especially through the writings of Herodotus, about 450 B. C. Of those populations that were mainly of Asiatic origin, by far the most prominent were the "Scythians," whose territory embraced practically the whole present southern Russia below about 50° of latitude. Peoples of related origin covered the country from the Urals to Finland and from the Volga to Esthonia. They were subdivided into numerous tribes and differed somewhat in blood, but all belonged to the Turkish, Tartaric, Finno-Ugrian, and Laplandic subdivisions of the great Ural-Altaic stock of Asia. All these peoples, including the Scythians proper, had in common a greater or lesser admixture of Mongolian blood, many were nomadic or semi-nomadic, none being strictly agricultural, and except where in prolonged contact with other peoples, such as in the case of the Scythians with the Greeks, the Bulgars with the Khazars, or the Finns with the Scandinavians, their culture was of a low order.

The more northern and less hospitable regions were only sparsely settled, developed no native political units of importance, and played but a secondary part in the history of European Russia. The more southern of these populations, on the other hand, were much more numerous, showed greater virility, and, possibly under Iranian influence, greater powers of organization. They gave rise to the old Scythia; they constituted for two thousand years the dread southeastern background to the European peoples of Russia; and they were the sources, under one name or another (such as Huns, Avars, Turks, Tartars, etc.), of many disastrous invasions of southern Russia and even central Europe from the third to the thirteenth centuries of our era.

The term "Scythians" deserves a few remarks. Due to their warlike qualities and the direct intercourse with them by the earlier Greeks, few "barbaric" nations of the pre-Christian era have been more mentioned, and few peoples since have given rise to more speculation as to their racial identity. On the basis of our present historical and archeological knowledge it may, however, be safely said that the early Greeks applied the term Scythians not to a race, but to a mass or conglomerate of peoples, partly nomadic and partly agricultural, who occupied the southern part of Russia when the Greeks began to explore and colonize the coasts of the Black Sea.[1] The main strain of the more eastern Scythians was undoubtedly Tartar or Turkish, but probably tinged with Iranian. To the west of the Borysthenes (Dnieper), however, and particularly in present Volhynia, Bukovina, and Galicia, the principal strain and possibly exclusive element of the population from the earliest times was evidently of European extraction, and this stock could have been in the main no other than Slav. To it belonged tribes such as the "Neuri" (Nestor, the earliest Russian historian, mentions "Norici, who are the same with the Slavs"); the Alazones or Halizones (which in Russian would be Galitshani, after which Galicia); and possibly the Borysthenitae husbandmen.

[1] Compare Ellis H. Minns—Scythians and Greeks, 4°, Cambridge (Engl.), 1913.

The true Scythians claimed to have occupied the country in which they were found by the Greeks for many centuries. As shown by their customs described by the Greeks, and by the remains of their culture uncovered by archeological exploration, they were not wholly a barbaric people; and contrary to what may be observed with later Tartar tribes, their war-like activities were directed mainly toward Persia and Asia Minor rather than toward Europe. It was to avenge their invasion of Medea and Persia that Darius undertook his memorable incursion into their country. Proceeding over Hellespont and the Danube he reached as far as the "Oarus" (supposed to have been the Volga, but more probably the Dnieper), only to find his great effort against the nomads quite futile. He finally barely escaped back across the Danube with the famished remnants of his army.

Scythia, which never formed a highly organized, cohesive political or national unit comparable to that of Persia or Greece, existed, with waning vigor, until the early part of the Christian era, when it gave way before the Gothic, Hun and Khazar invasions; but the name, as applied both to the country and to its inhabitants, persisted for many centuries afterward.

Scythia itself was subject to invasions, which deserve some consideration. Shortly after the commencement of the present era, there are noted in Europe, and between Europe and Asia, movements of peoples which are commonly referred to as "the migrations of races," but which in the main were invasions for conquest or plunder, or were the results of displacements, not seldom forcible, of tribal groups in regions where the density of population had surpassed the resources and the struggle for existence had become acute. They doubtless succeeded older movements of similar nature, of which we have little or no knowledge. They followed two main directions—from the north southward and from the east westward. Russia that was to be, was in a large measure the avenue over which these migrations took place.

The first of these invasions into what is now Russian territory of which we have better knowledge is that of the Goths, though some indications make it possible that these were preceded by less important offshoots from the same stock of people. The Goths were of Scandinavian origin, coming originally perhaps from or over the large island in the Baltic which still bears their name (Gothland). From this they easily traversed the Baltic, known in the early Russian annals as the "sea of the Variags" or Scandinavians, and landed somewhere on what is now the Prussian coast, in the vicinity of the

Vandals and probably not far from the Vistula River. There they remained for a time; but when the number of people increased greatly, Filimer, their king, " decided that the army of the Goths with their families should move from that region," and " in search of suitable homes and pleasant places they came to the land of Scythia." (Jordanes, Getica, 551 A. D.) Whatever the details of their invasion, it is certain that by the beginning of the third century A. D., the Goths reached as far as the western parts of Scythia, to the Black Sea and the Danube, as well as to the south of the Carpathians. They then became known as the western and the eastern Goths, or Visigoths and Ostrogoths; and the latter, with whom alone we are here concerned, were found at the beginning of the fourth century ruling over the territory from the Carpathians to the Sea of Azov. This rule they kept up until 375 A. D., when their state under Hermanric, together with the remainder of Scythia, was broken up by the invasion of the Huns. Most of the Ostrogoths who survived sought refuge in the southwestern part of Europe; while those who remained were subject to the Huns until after Attila's death, or about 460, when they moved bodily into Pannonia, granted to them by the Romans.

However, the Goth sovereignty in southwestern Russia should not be viewed as an occupancy of a waste or depopulated region by a new race. The territories in question were peopled before, and remained so after the period of Goth domination. And their population was not Goth but in all probability Vendic or Slav, though there are also mentioned the Callipidae (Gepidae), the Alans, and the Heruli, who may have been some of Alpine and some of Nordic extraction. The Goths were warlike northerners, who forcibly invaded Scythia in considerable force for the time, and brought with them their families. Due to their favorable original geographical position and their sea activities they, much like the Germans of to-day, were more advanced in culture and especially in military art and equipment, than the inland populations that so far were relatively only slightly affected by the rest of the world. As a consequence the northmen found little difficulty in overrunning great areas occupied by the sedentary as well as the nomadic primitive tribes, which had little political unity and no adequate power of resistance. Some such tribes could even be employed against others, though of their own blood, and the invader finished by becoming the ruler. We have excellent illustrations of similar processes elsewhere, such as many centuries later on the American continent, in

Mexico and Peru. But the invaders, though they may create a state under their own banners, are seldom strong enough to give the conquered people their language, and though their name may remain, as has happened later in Bulgaria, the conquerors themselves disappear, either by being driven out or through rapid amalgamation. Thus the Ostrogoths who gave way eventually before the Huns were in all probability merely the usurping and ruling class, together with their military; and when they were driven westward they left little, if anything, behind them that would permanently affect the type of the indigenous populations. Moreover, they doubtless carried with them, in their families, households, and the army, many elements and perhaps even whole groups of these populations.

The great Hun invasion which overcame and finally drove out the Ostrogoths, and which was one of the most sustained and serious of the Asiatic invasions of all times, still further obliterated Scythia and disorganized the whole region of the present Ukraina and Bessarabia. Some of the Scythians possibly remained under other names, while others may have receded to Asia; at all events they vanished as a power and entity. They left thousands of kourgans or burial mounds over southern Russia, but probably also, like the Goths, affected in no great way its future population.

The Hun swarm came from beyond the lower Don and Volga. In blood they were of "Tartar" or Ugrian derivation, and partly—perhaps largely—Mongolic.[1] Their language, like that of all the native population east of the Slav Russia, belonged to the Ural-Altaic. From southern Russia they extended their incursions over most of western Europe, reaching finally as far as northern France, where on the Catalaunian plain they met their Marne. Soon after this defeat, in 455, their dread chief Attila died, the power which they established in Pannonia and Central Europe rapidly crumbled, their confederates, among whom were some of the Germans and even Ostrogoths, broke loose, and what remained of the horde, no longer able to hold its ground, retraced their steps eastward beyond the Dnieper and were lost to sight. Exactly what effect the Hun invasion and prolonged occupation had on the population of southern Russia is difficult to gauge, but it was probably more that of destruc-

[1] It seems almost superfluous to state that racially the Germans have nothing in common with the Huns. The only present European relations of the Huns are the Magyars and Turks, the blood of both of whom, however, is now so much mixed with that of European or Asia Minor populations that the original types are submerged.

tion and dispersion than blood admixture. Yet remnants of the Huns may have remained in what was once Scythia for a long time after their original name disappeared.

The Scythians, together with the problematical Sauromatae, the Goths, the Huns, and other early groups, became now gradually replaced in southern Russia by a new ethnic unit, the Khazars. The Khazars were, according to many indications, of Caucasus or Asia Minor extraction, and related to the Georgians and Armenians. There were with them, however, also the so-called "Black Khazars," who may have been Huns. Their history in Russia extends over a very considerable period of time—from the end of the second to the eleventh centuries. Between 600 and 950 their territory spread from the Caspian Sea to the Don and later even into Crimea. They were relatively civilized people, who built towns and engaged extensively in sea trade, which earned them the name ot the "Phoenicians" or "Venetians" of the Caspian and Black Seas. In the earlier part of the seventh century their power was such that they compelled the agricultural Slavs of the Dnieper and even those of more northern regions to pay tribute. About 740 they accepted Judaism. But during the ninth and tenth centuries they were gradually overwhelmed by the Russians, and in the eleventh century they practically disappeared from the stage. Remnants of the Khazars probably still exist in the Caucasus. What effect this interesting ethnic unit had on the blood of the Russian population it is hard to estimate, but at most it was not extensive.

The Khazar occupation of the regions which now form southeastern Russia was, however, far from uniform and continuously peaceful. The waves of invasion of the Turkish and Tartar tribes from farther east followed one another with greater or shorter intervals and over approximately the same roads, the broad open steppes, traversed before by the Huns. Some of these invasions it is not necessary to enumerate in detail. The more important ones were those of the Bolgars, in 482,[1] of the Avars, in 557, and those of the Polovtsi (Kumans), Ugri (Magyars), Pechenegs, and related tribes, in the ninth and tenth centuries. Whatever the name under which they came, they were, so far as can at present be discerned, all of Tartar or Turkish or Ugro-Finnic extraction, which means mixtures in differing proportions of the white (western Asiatic) and

[1] These were the non-Slavic Bolgars from the Volga, who eventually left their name to the Slavonic state south of the Danube.

yellow-brown (Tungusic or Mongolic) racial elements. All were more or less nomadic and destructive, bent on spoliation, and on penetration toward the richer more southern and central parts of Europe, rather than on the conquest of Russia and the establishment there of a permanent new home; though some, such as the Polovtsi, Pechenegs, and others, became for a greater or less period settled in Russian territory before they disappeared. Taken collectively, these invasions resulted in a great retardation of the settlement of the southern parts of Russia by the Slav people, as well as in seriously hindering the cultural advance of the Russians; but the hordes did not colonize or mix readily, except through captives, and while some remnants of them and mixtures were doubtless left scattered over the territory, they made no great impression on the eventual Russian population.

Meanwhile, since as early as the times of Herodotus, we began to hear of tribes such as the "Budini," which reached far eastward in Russia, and may have been Slavonic. In the fourth century, according to Jordanes,[1] the historian of the Goths, Hermanric conquered the Veneti, or Vends, which was the earlier generic name for the Slavs, the term "Slav" not appearing even in the Byzantine chronicles until after the close of the fifth century. In Jordanes' time, or about the middle of the sixth century, the "populous race of the Veneti dwell near the left ridge of the Alps (Carpathians) which inclines toward the north and beginning at the source of the Vistula, occupying a great expanse of land. Though their names are now dispersed amid various clans and places, yet they are chiefly called Sclaveni and Antes. The abode of the Sclaveni extends from the city of Noviodunum and the lake called Mursianus to the Danaster, and northward along the Vistula. The Antes, who are the bravest of these peoples dwelling in the curve of the sea of Pontus, spread from the Danaster to the Danaper, rivers that are many days' journey apart." In another part of the work of the same author we read that these new people "though off-shoots from one stock, have now three names, that is, Veneti, Antes and Sclaveni." And "they now rage in war far and wide, in punishment for our (*i. e.*, Goth) sins," though once "all were obedient to Hermanric's commands."

During the ninth and tenth centuries many Slav settlements or outposts are mentioned in Russia as far north already as the Tchoud

[1] Mierow's version, Princeton, 1908.

country (Esthonia), and as far west as the region between the Don and the Volga. Since the sixth and seventh centuries, also, we have historical data indicating extensive and in a large measure solid Slavic population reaching from the Balkans to Pomerania, and from Bohemia and the Elbe over Poland, Galicia and western Russia. This population, the vital center of which seems to have been the territory about and north of the Carpathians, is subdivided into numerous "families," tribes, or nations, which form as yet no great units. The term Slavs (probably from slavit, to praise, to glorify) as applied to these people may possibly have originated from their frequent usage in personal names of the terminal "slav," as in Jaroslav, glorifying the spring, Mstislav, extolling revenge, Boguslav, praising God, etc., which at that time was common to the whole people. Their earlier history and origin were lost in the mists of uncertainty, and their western contingents were not always clearly differentiated from the Germanic tribes. Also, they bore as yet none of those names under which they later became distinguished.

The political unit of Russia did not come into existence until the ninth century. At that time, according to the "Ancient Chronicle" of Nestor, the first Russian historian, there lived in the regions along and west of the Dnieper and farther northward, the following Slav tribes: On the Ilmen, the Novgorodci; on the upper Dnieper, Dvina and Volga, the Krivitchi (who may, however, have been partly of Lithuanian origin); between Dvina and Pripet, the Dregovitchi; southeast of these, the Dierevliane (the woodsmen); from Teterev to Kiev, the Poliane (those of the flatlands); on the Bug, the Duliebi and Buzhane; on the Dniester and Bug, the Tivertsi and Ulitchi; in Volhynia, the Voliniane; on the Sozha, the Radimitchi; on the Oka, the Viatitchi; and on the Desna and Seim, the Severiane (the northerners).

These tribes or local groups, however, were not yet united, and, according to Nestor, their dissensions finally led an influential elder to propose that they call some prince of foreign blood, of whom none would be jealous, and under whom, in consequence, it might be possible to merge all the subdivisions into one strong Slav state. The wisdom of this advice was acknowledged and the envoys called on certain princes of the Variags or Varangians, of Scandinavian origin. These were three brothers, the oldest of whom was named Rurik. They were offered the privilege of becoming the rulers of the tribes and, accepting, the Slav territories were divided among them; and the two younger brothers dying, perhaps not by natural means, shortly afterward, the entire nation became united under Rurik. But in the opinion of some modern Russian historians the real facts were that the Slav and Tchoud tribes, suffering from repeated incursions of the much better armed and trained Scandinavians, hired other "Variags" for their protection and these ended by usurping the ruling power over the tribes. Such was the birth of Russia. The term "Rus" appears at about the same time. It is probably derived from "rusij," fair-haired, blond, and was applied at first to blond non-Slavic elements, but after a time came to be used by foreigners and then by natives for the whole new nation. The Variags played a prolonged but subordinate and steadily diminishing rôle in the Russian annals until they eventually disappeared, leaving little behind except some of their given names such as Oleg, Olga, etc., which are in frequent use among the Russians to this day.

After Rurik the bulk of Russian history consists of internal accommodations, not seldom violent; of defensive or retaliatory external wars; of endless, fluctuating life-and-death struggle in the south and southeast with the Asiatic hordes; and of unceasing extension of the prolific Slav element in all directions where resistance was not insurmountable. This was particularly toward the northeast and northwest, where gradually the Meria, Mordva and other primitive Finnic tribes were replaced or in a large measure absorbed.

Notwithstanding the many internal and external vicissitudes of the country, its elementary spread continued until 1226, when all southern Russia fell under the greatest plight that has yet afflicted it, through the final and overwhelming Tartar or "Mongol" invasion. This invasion covered all present Ukraina and beyond, and thence extended over parts of Poland, Galicia, and Hungary. The southern Russians were slaughtered in large numbers and subjected to the Tartar yoke, or forced to flee. The southern and southwestern parts of Russia became seriously depopulated and were occupied by the roaming Tartars of the "Golden Horde"; and Russia as a whole suffered from the effects of the invasion for over two centuries. The invaders established themselves over much of the southern part of the country, particularly in Crimea, where they became a fixed element and developed a political unity of their own, which remained ruled by their Khans until 1783, the year of their final submission to the Russians. To this day, however, a large part of the population of Crimea is more or less Tartar.

Long before this, however, the Russians spread over all the more northern regions of their present European domain, to and beyond the Urals, and even over Siberia. Expansion into the latter deserves a few words by itself.

Up to the sixteenth century the vast region now known as Siberia was peopled exclusively by native tribes, of Ural-Altaic or Mongolian extraction or with Mongolian admixture. They were all more or less nomadic and in a primitive state of culture. There was never any political unity; and many of the tribes whose forefathers had probably participated in the westward invasions lapsed gradually into a numerically and otherwise weakened condition. It was such a state of affairs which awaited the ever progressing Russian tide.

The first Russians crossed the Urals as early as the eleventh century, but this led to no consequences of importance. The conquest of Siberia took place in 1580. Yermak, a Don Cossack in disgrace, invaded the vast territory with 1,636 followers, and this handful of men practically secured the conquest of a territory considerably more than twice as large as the whole of Russia in Europe. Within eighty years after that the Russians reached the Amur and the Pacific; and the rest is merely a history of a gradual disappearance of the natives and of Russian immigration.

The cultural progress as well as the racial aspects of southern Russia was affected more by the great Tartar invasion of the thirteenth century than by any or perhaps all the previous ones. The descendants of the Tartars, together with other remnants, are found to this day in numbers along the Volga and some of its tributaries, and north of the Sea of Azov, as well as in Crimea and the Caucasus; while some Tartar blood can be traced in not a few Russian families. The effects of the resulting ethnographic changes are felt even now and have been utilized by the enemies of Russia against the interest of the country. This relates especially to the region now known as Ukraina (the "border province") or Little Russia. No such subdivision existed before this last Tartar invasion, and the region of Kiev, now the capital of Ukraine, was the old center and heart of Russia. The Tartar massacres in part depopulated the region, and created a terror which resulted in large numbers of the people fleeing westward into Galicia and Polish territory. There are differences of opinion as to how great the depopulation really was, but that it was severe, though perhaps not complete, is indisputable. As all this is of particular importance at the present time it may be best to quote here from one of the foremost modern Russian historians who gave this question particular attention[1]:

The exodus from Kievan Rus took two different directions, and flowed in two different streams. Of these streams, one tended towards the West—towards the region of the Western Bug, the upper portions of the Dniester and Vistula, and the interior districts of Galicia and Poland . . . This westward movement had a marked effect upon the fortunes of the two most outlying Russian provinces in that direction—namely, Galicia and Volhynia. Hitherto their position in the political hierarchy of Russian territories had always caused them to rank as lesser provinces, but now Galicia—one of the remote districts allotted only to *izgoi* princes of the house of Yaroslav—rose to be one of the strongest and most influential in all the southwestern region. The "*Slovo o Polku Igorově*" even speaks of the Galician Prince of its day (Yaroslav the Prudent) as "rolling back the gates of Kiev," while, with the end of the twelfth century, when Roman, son of Mstislav, had added the province to his own principality of Volhynia, the combined state waxed so great in population and importance that its princes became sufficiently rich and powerful to gather into their hands the direction of the whole southwestern region, and even of Kiev itself. In fact, the Ancient Chronicle goes so far as to describe Prince Roman as "the Autocrat of all the Russian land." Probably, also, this inrush of Russian refugees into Galicia and Poland explains the fact that annals of the thirteenth and fourteenth centuries frequently refer to Orthodox churches as then existing in the province of Cracow and other portions of the Southwest.

The same migratory movement may serve to throw light upon a phenomenon of great importance in Russian ethnography—namely, the formation of the Little Russian stock. The depopulation of Dnieprian Rus which began in the twelfth century was completed during the thirteenth by the Tartar invasions which took place between the years 1229 and 1240. For a long period after the latter date the provinces of ancient Rus, once so thickly peopled, remained in a state of desolation. A Catholic missionary named Plano Carpini, who traversed Kievan Rus in 1246, on his way from Poland to the Volga to preach the Gospel to the Tartars, has recorded in his memoirs that, although the road between Vladimir in Volhynia and Kiev was beset with perils, owing to the frequency with which the Lithuanians raided that region, he met with no obstacle at the hands of Russians—for the very good reason that few of them were left alive in the country after the raids and massacres of the Tartars. Throughout the whole of his journey across the ancient provinces of Kiev and Periaslavl, he saw countless bones and skulls lying by the wayside or scattered over the neighbouring fields, while in Kiev itself—once a populous and spacious city—he counted only two hundred houses, each of which sheltered but a few sorry inmates. During the following two or three centuries Kiev underwent still further vicissitudes. Hardly had she recovered from the Tartar attacks delivered prior to the year 1240 when (in 1299) she was ravaged afresh by some of the scattered bands of Polovtsi, Pechenegs, Turks, and other bar-

[1] A History of Russia, by V. O. Kluchevsky, late professor of Russian History of the University of Moscow, 3 vol., 8°, Lond., 1911-13; I, 194-196.

barians who roamed her desolate frontiers. In that more or less grievous plight the southern provinces of Rus remained until well-nigh the middle of the fifteenth century. Meanwhile Southwestern Rus (now beginning to be called in documents of the period "Malaia Rossia" or "Little Russia") had been annexed to the combined state of Poland-Lithuania; so that of the Empire thus formed the region of the Middle Dnieper—*i. e.*, old Kievan Rus—had now become the southeasternmost province or Ukraine. With the fifteenth century a new colonisation of the Middle Dnieper region began, to which two circumstances in particular contributed: namely, (1) the fact that the Steppes of the South were becoming less dangerous, owing to the dispersal of the Golden Horde and the rise of Muscovite Rus, and (2) the fact that the Polish Empire was beginning to abolish her old system of peasant tenure by quit-rent in favour of the *barstchina* system, which tended towards serfdom and therefore filled the oppressed rural population with a desire to escape from the masters' yoke to a region where they might live more freely. These two factors combined to set on foot an active *reflex* exodus from Galicia and the central provinces of Poland towards the southeasternmost borders of the Polish Empire—*i. e.*, towards the region of the Dnieper and old Kievan Rus. The chief directors of this movement were the rich Polish magnates, who had acquired enormous estates in that part of the world, and now desired to people and reclaim them. The combined efforts of the immigrants soon succeeded in studding these seignorial domains with towns, villages, hamlets, and detached homesteads; with the result that we find Polish writers of the sixteenth century at once exclaiming at the surprisingly rapid movement of colonists towards the Dnieper, the Dniester, and the Eastern Bug, and lamenting the depopulation of the central provinces of Poland to which that movement had given rise. All things considered, there can be little doubt that the bulk of the settlers who took part in the recolonising of Southern Rus were of purely Russian origin—that, in fact, they were the descendants of those very Russians who had fled westwards from the Dnieper during the twelfth and thirteenth centuries, and who, though dwelling since among a Polish and Lithuanian population, had, throughout the two or three intervening centuries, retained their nationality intact.

The language of the new population of Ukraina developed certain dialectical differences, while in other parts of Russia it was being gradually affected in other ways by association with the Lekhs (Poles), Lithuanians, and the Finnish tribes. In addition there arose in the course of time, as could hardly be otherwise when the great territories over which the Russian people were spread are taken into consideration, some differences in the richness and nature of folk tales, folk poetry, dress, etc.; differences the perception of which by the Ukrainians has for long before the present war been assiduously fostered by the Germans and Austrians, on the basis of their cherished, old "*divide et impera*" principle. Finally this region has received, together with Bessarabia, the mass of the Jewish immigration into Russia, which could not but add to its separatism, for which anthropologically and outside of the Jews there is no substantial reason.

At about the same time that the terms of Ukraina and Mala Rossia (" smaller Russia ") came into vogue, there also began to appear those of Velika and Biela Rossia ("Greater, and White Russia"), and those of Malorusi, Velikorusi and Bielorusi, which are applied to their respective populations. These terms, like those of Ugro-Rusi, Rutheni, Gorali, etc., are partly conventional, partly environmental or geographical. The language and habits of the Bielorusi, who occupy the westernmost part of Russia north of Ukraina, were gradually affected, though on the whole to but a moderate extent, by their relations with the Poles and Lithuanians; while those of the Velikorusi or " Moskvali " (Muscovites) who spread over central, northern and eastern Russia, were modified somewhat in turn by their associations with the Tchouds, Finns, and various other people of the Finno-Ugrian stock with whom they mingled and whom they freely absorbed.

Such were in very brief the origin and nature of the three great subdivisions of the Russian people with which we meet to-day. The resulting differences between them, both cultural and somatological, are smaller than those between some of the tribes of Germany, and had it not been for Russia's enemies in whose interest it was to foment dissensions in the population, they would have remained harmless and with growing culture would have disappeared. But powerful united Russia, such as it could have been and with the help of the Allies may yet be, was an insupportable nightmare to both Austria-Hungary and Germany.

From the purely anthropological standpoint, the Russians belong overwhelmingly to the great type of Slavs in general, which in turn can hardly be distinguished from the Alpine type. But, like all large nationalities, the Russians show in various localities more or less marked traces of admixture with the Nordic peoples on the one hand, and on the other with the Finnish, Turkish, Tartar, and Iranian tribes.

The modern Russian population represents a physically strong and very prolific stock, freer as yet from degenerative conditions than perhaps any other of the larger European groups. The total population of European and Asiatic Russia counted collectively at the commencement of the war 178,000,000, living in a continuous mass and increasing yearly, through the natural excess of births over deaths by over 1.67%, the highest rate of any more important white population. The Slavs constitute approximately 75% of this population—81% in European Russia and Poland, 40% in Caucasus, and 85% in Siberia. As to the proportion of the separate Slav and other racial elements, we have the following interesting and trustworthy estimates by Professor Niederle[1] of Prague, the foremost authority on Slav matters in general:

ETHNOGRAPHIC DISTRIBUTION OF THE POPULATION OF RUSSIA

	European Russia	Russian Poland	Finland	Caucasus	Siberia	Central Asia
	per cent.	*per cent.*	*per cent.*	*per cent.*	*per cent.*	*per cent.*
Russians (Slavs)	80.0	6.7	0.2	34.0	81.0	8.9
Poles	1.2	71.8	....	0.3	0.5	0.1
Lithuanians	3.0	3.3	....	0.1	0.2	....
Finns	3.6	0.1	86.7	0.1	1.1	0.2
Germans	1.4	4.3	13.0	0.6	0.1	0.1
Jews	4.0	13.5	....	0.4	0.5	0.1
Caucassians	....	....	....	26.2	....	....
Armenians	0.1	....	....	12.0	....	0.1
Turko-Tartars	4.9	0.1	....	20.2	8.3	85.5
Mongols	0.2	....	....	0.2	6.2	0.2
Others	1.6	0.2	0.1	5.9	2.1	4.8

THE NON-RUSSIAN RACES OF EUROPEAN RUSSIA

These include the Poles, the Lithuanians, the Tchouds and Finns, the remnants of the Finno-Ugrian tribes of the interior, the Laps and the Samoyeds, the Tartars, the tribes of the Caucasus, and finally the immigrant Jews and Germans. In the first place, however, a few remarks may be appropriate here regarding the Cossacks.

The Cossacks.—The term Cossack has in the course of time become surrounded, even in Russia itself, with a semi-romantic and heroic halo, which is not wholly undeserved; but the term itself is seldom properly understood. The Cossacks of the present day may be defined as a special class of irregular, privileged cavalry. The Kazaki (the Russian form of the term) of the fifteenth and sixteenth centuries were in part a class of irregular agricultural help "who possessed neither a definite avocation nor a settled domicile," in part frontiersmen and adventurers, along the southern boundaries of the Russian settlements. The word Cossack came to signify, in Kirghiz, a cavalier, in Tartar a freebooter, in Turkish a light-armed soldier; they were all this and more. They were

[1] Lubor Niederle: Slovanský Svět, 8°, Praha, 1910; abstr. in Smithson. Rep. for 1910, pp. 599-612, with a map.

of Russian origin; but being always settled on the outskirts of the advancing empire and continuously in struggle or contact with the Turkish and Tartaric hordes, their blood has received in the course of time more or less admixture. Some of the Cossacks now are recruited in the main from non-Russians.

The fighting Cossacks as far as traceable originated during the fourteenth or fifteenth century from among the Russian refugees before the invading Tartars. They settled on certain islands in the Dnieper River, were hunters, fishermen, and Tartar fighters, and gradually developed into a strong, bold, and resistant group, loving the hard frontier life with its liberties and dangers. Similar bodies developed all along the border of the steppes and became the terror of the Tartars and Turks, though frequently also a trouble to the Poles and even Russians. Their military value was, however, generally recognized in time and led to the regulation and extension of the Cossack system over southern Russia, Caucasus, Central Asia, and Siberia, until the Cossack became the regular forerunner, scout, and protector of the Russian armies and Russian colonies from the Danube to the Pacific Ocean.

There exist to-day about twelve subdivisions of the Cossacks, the best known of which are those of the Don, Orenburg, Ural, and Siberia. Their free institutions, interesting customs, and especially their exploits in the conquest of Siberia, the Napoleonic invasion, etc., made their name justly famous.

The Poles.—The Poles, the old "Lekhi" and "Poliane," are Slavs derived in prehistoric times, like the Russians, Czechs, etc., from the common autochthonous Slav nucleus north of the Carpathians. They are admixed somewhat with the Russians and to some extent also with the Lithuanians; slightly, perhaps, also with nordic and other elements. At the commencement of the war they numbered in European and Asiatic Russia approximately eleven millions, almost nine-tenths of which were in Russian Poland.[1] Notwithstanding their thousand years of agitated history, they are still a "young" stock, full of energy, ability and spirits, and as prolific as the Russians.

The Lithuanians.—The Lithuanian territory lay originally along the Baltic, between the Visla (Vistula) and Dvina, and at the time of their maximum power their influence reached from the Gulf of Riga to Ukraina. They extend at present from Poland and east Prussia to near Riga.

[1] Those of Austrian-Poland counted in 1914 approximately 4,500,000; those of German-Poland approximately 4,000,000.

The Lithuanians are a strain of people whose racial identity has been a matter of considerable controversy. Through their ancient tongue, which has many similarities with the Sanscrit and with the Slav, they are related most closely to the latter, but in physical type while resembling the Poles and Great Russians they also approximate in part the Scandinavians on account of more frequent blondness. In all probability they have an admixture of all these elements. They are subdivided into three main branches, the Borussians (Prussians), the Latvis or Letts, and the Litvini or Lithuanians proper. Their total number at present is slightly over four millions, about equally divided among the Letts and Lithuanians. The Borussians, whose home was in eastern Prussia, were almost destroyed by the Germans in the thirteenth century, under the pretext of Christianization. In the words of one of the German writers himself (Schleicher, 1852), " Never has a pagan people, good, brave and generous, been maltreated in a more cruel manner than the eastern Prussians . . . . The history of their death struggle against the Teutonic order must be mentioned as one of the most sinister episodes of mankind." A few remnants of them still exist in Eastern Prussia.

The Lithuanians, whose ethnographic limits are ill-defined, have been connected with Russia since 1797.

The Livonians.—The true Livonians are practically extinct. Their country lies east of the Gulf of Riga and is now occupied partly by Letts and partly by Esthonians. Their language belonged to the Finnish or Finno-Ugrian family, and they were doubtless closely related to the Esthonians.

The Tchouds or Esthonians are a Finnish tribe occupying a larger part of the territory between the Gulf of Riga and the Gulf of Finland. They have been united with Russia since 1030, but were tributary to the Russians much earlier. They number at present only between five and six hundred thousand persons. Efforts by the Germans since the thirteenth century at " Christianizing " Livonia and Esthonia, as they did Prussia, have been a failure, and " the Ehsts and Letts openly display their traditional hatred against the invaders."

The Finns.—The Grand duchy of Finland was ceded by Sweden to Russia in 1809. Its population consists at present of approximately 2,700,000 Finns, 350,000 Swedes, 8,000 Russians, 2,000 Germans, and 1,700 Laps. The Finns represent the westernmost extension of the Finno-Ugrian Asiatic stock; but while retaining their language their blood, especially in the south, has become much mixed with that of the Scandinavians. The more northeastern subdivision of the Finns, known as the Karelians, are better preserved.

The Laps and Samoyeds.—These are the most Mongolic-like natives of European Russia and are undoubtedly of Asiatic origin. Their numbers are insignificant—collectively less than 20,000 individuals. They occupy the northernmost limits of the Russian territory, the Laps extending into Scandinavia.

Finno-Ugrian tribes of the interior.—These are located principally on the middle Volga and the Kama, and represent the dwindling remnants of the primitive native populations that once covered much of central and eastern Russia. They have long been without any political individuality and are in a more or less advanced stage of absorption into the Russian population. They are known principally as the Mordva, Tcheremis, Voguls and Votiaks.

The Turko-Tartars.—Of these there are approximately seven millions in European Russia and the Caucasus. They are divided into the Crimean Tartars, Kazan Tartars, the Bashkirs, the Tchuvash and the Kirghiz, with many minor units. They still occupy or wander over a large portion of southeastern Russia and except within the diverse groups have no political or racial cohesion.

Caucasus.—This region since ancient times has been the eddy and refuge of remnants of nations, and there are in its fastnesses many interesting units which it is difficult to classify. By far the strongest element of the Caucassian population to-day, however, is the Slav (approximately 40% of the total), which is followed by the Turco-Tartar, Georgian, and Armenian. The total population of Cis- and Trans-Caucasia may be estimated at present at something over 13,000,000.

Siberian Natives.—To-day Siberia or more properly Asiatic Russia, possesses nearly eleven million inhabitants, considerably less than one-tenth of whom are non-Russians. Of these approximately 500,000 are Turko-Tartars, 300,000 Mongols, 70,000 Tungus, and 35,000 Ghiliaks, Chukchis, Koriaks, Yukaghirs, Kamchadals, Eskimo, and other smaller units; but all these groups are more or less mixed with the Russians,[1] and with the exception perhaps of those in Turkestan have no individualistic aspirations.

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[1] An excellent ethnographic map of Siberia has been published, together with two large volumes of descriptive text, by the Dept. of Agriculture of the Russian government in 1914 ("Etnograficheskaia Karta Asiatskoi Rossii").

THE JEWS

The Russian Jews are in the main, if not entirely, tne descendants of refugees driven out of Germany during the persecution of the race in the middle ages. Some Jews penetrated into Poland and Lithuania as early as the middle of the eleventh century, but by far the larger number came later, particularly under the Polish king, Casimir the Great, whose wife was of Jewish extraction. From Poland they spread to Lithuania, Courland, and what is now Ukraina and Bessarabia. Peter the Great, and particularly Catherine II, opened to them the door of Russia.

A small branch of the Russian Jews are known as the Karaites. They differ in many respects from the remainder, are settled in Crimea where they speak Tartar and in western Russia where they speak Polish, and are principally agricultural. Their origin is still in dispute.

The total present number of Jews in European Russia before the war approximated 4,000,000, in Russian Poland 1,300,000, and in Caucasus 50,000. In addition there were about 50,000 in Siberia and Central Asia.

It is very interesting to note that physically the Russian Jews of to-day resemble to a considerable extent the Russians themselves (compare Maurice Fishberg, The Jews, N. Y., 1911). In Poland the approximation of the two types of population is much less apparent. The Karaites, whom some suppose to be the descendants of the Khazars, show anthropologically some affinity with the Tartars.

THE GERMANS

The total number of Germans in the lands under Russian dominion amounted at the beginning of the present war to a little over 1,800,-000. They were scattered over practically all except the poorest parts of the empire, especially in the cities. In the Baltic provinces they were the privileged landed proprietors. In southern Russia and other agriculturally rich regions there were German agricultural colonies, some recent, some of older formation.

The German influx into Russia started in the sixteenth century and was especially active during the reign of Peter the Great. They came as artisans and merchants, frequently on invitation; and in 1762 they were invited to settle in some parts of southern Russia in agricultural colonies, which gradually and in a scattered way extended to the Don and the Caucasus. These colonies received special privileges, were practically self-governing, and fused but little with the Russians. During the latter half of the nineteenth century German colonization in important parts of Russia was, there are valid reasons to believe, favored if not directed by the German Government for economic and perhaps strategic reasons.

The German nobles and landed proprietors in the Baltic provinces date in the main from the time of the attempts by the German Knights to forcibly "Christianize" the natives of these provinces, though some were brought there later by the guileless Russians.

A study of the German relations with Russia shows that the latter has ever been a field for advancement and exploitation by Germany. By most Germans at home, the Russians, together with the rest of the Slavs, were looked upon as a desirable "fertilizer" for the German stock; but every care was taken that the Germans in Russia should not disappear in the Russian mass and thus weaken Germany to the advantage of her neighbor, the dreaded sleeping Samson, the Russian Slav.

CONCLUDING REMARKS

Leaving aside all details and localized ethnic peculiarities, we find that the racial problems of European as well as of Asiatic Russia, are relatively fairly simple. (1) We find over a large portion of the vast territory a thin substratum of Finno-Ugrians, who are of western Asiatic origin and carry with them varying traces of Mongolian admixture. (2) The southern portions of Russia from remote time constitute a broad avenue for the movement of Asiatic peoples in a westerly direction. These peoples are partly of Iranian, but in the main of Turko-Tartar derivation; and the Turko-Tartars like the Finno-Ugrians are mixed peoples, partly white and partly Mongolian. Their influence, both racial and cultural, on the country and its people is marked and in a measure persists even to the present day. (3) Along the Baltic we find Finnish tribes in the north and the Lithuanians, probably of mixed Slavic and Scandinavian composition, farther southward and westward. (4) All the rest of the great region is Slav, Polish in the west, Russian in the center and eastward.

It is eminently true that Russia is essentially a Slav country, which to-day is equally true of Siberia and in a large measure even of the Caucasus. In Central Asia the Russian element is still considerably exceeded by the Turco-Tartars.

From the anthropological standpoint, the Russian stock is well developed, virile, resistant, and full of potential force. It may truly be said to be the great human reserve of the European population. If it has not advanced in culture as much as the western and southern European nations, the causes if contemplated impartially are seen to have been not inherent or racial, but geographic and circumstantial. It must not be forgotten that Russia by acting from its inception as the buffer between the rest of Europe and Asia, and by becoming later the principal check of the Turk, has deserved a deep gratitude of the more western and more favorably situated nations.

What will be Russia's future? Perhaps the anthropologist may attempt to predict where others would hesitate.

The Russian Slavs taken collectively, count to-day over one hundred millions,[1] and they are increasing yearly, by the excess of births over deaths by 1,700,000. This rate of increase is greater than that of any other people in Europe except some of the other branches of the Slavs, and with the mass of the people belonging to the conservative simple-lived rural population, cannot be expected to become much reduced in the near future. Such a rate of increase of this otherwise strong and able portion of the white stock, means a biological momentum which in the end must prevail over all opposition. The Russian giant may have his Delilahs, internally as well as externally, but these will not be able to hold him forever. Russia cannot but have a future commensurate with her potential powers.

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[1] See author's article on "The Slavs" in the Nov., 1918, number of the Czechoslovak Review, II, Chicago, 180-187.

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BEGONIACEAE CENTRALI-AMERICANAE ET ECUADORENSES

BY
CASIMIR DE CANDOLLE

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BEGONIACEAE CENTRALI-AMERICANAE ET ECUADORENSES[1]

CASIMIR DE CANDOLLE

1. BEGONIA KELLERMANII C. DC., n. sp.

Caule erecto lignoso crasso; foliis peltatis modice petiolatis, limbo ovato sinuato-integro basi rotundato apice acuminato, 7-nervio, utrinque petioloque incano-tomentosis, stipulis lanceolatis basi truncatis apice subulatis dorso pilosis; pedunculo apice cymam pauci-floram gerente incano-tomentoso, bracteis obovato-oblongis basi et apice truncatis dorso et apice villosis; floris masc. sepalis 2 rotundatis glabris integris, petalis oblongo-ellipticis integris glabris, antheris liberis filamenta superantibus obovato-oblongis basi acutis apice obtusis; floris fem. 3-lobi lobis glabris integris externis rotundatis, interno multo minore; capsulae ellipticae basi ima pilosae 3-alatae 3-locularis pedicello incano-tomentoso, stilis 3 persistentibus basi connatis superne 3-fidis laciniis spiraliter papilliferis, placentis 2-partitis lamellis utrinque ovuliferis.

Caulis in sicco fuscescens 1 cm. crassus; ramuli floriferi fere 3 mm. crassi incano-tomentosi. Folia alterna. Limbi adulti 5 cm. longi et 3 cm. lati. Petioli circiter 3 cm. longi. Pedunculi circiter 5 cm. longi. Floris masc, pedicellus 4 mm. longus; sepala 5 mm., petala 4 mm. longa; stamina 12 toro convexo inserta, antherae 2.5 mm. longae rimis dehiscentes; capsulae pedicellus 12 mm. longus; capsulae 11 mm. longae ala maxima 7 mm. longa.—Species sectionis *Rachia* A. DC., a *B. incana* Lindl. foliis multo minoribus, limbo magis ovato et longius acuminato ac capsulis minoribus floribusque glabris discrepans.

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[1] The plants of the family Begoniaceae collected during the biological exploration of Panama, undertaken a number of years ago under the auspices of the Smithsonian Institution, were placed in the hands of Mr. Casimir de Candolle, of Geneva, for determination, together with unidentified specimens from other parts of tropical America. The present paper, manuscript of which was received some time before Mr. de Candolle's death, contains description of new species based upon a part of this material. Of the species described as new, 14 are from Panama, and one each from Guatemala, Costa Rica, and Ecuador.—FREDERICK V. COVILLE.

GUATEMALA: Prope Patulul, Depart. Sololá, Februario, *W. A. Kellerman* 5694.

2. BEGONIA FISSURARUM C. DC., n. nom.

Begonia leptophylla C. DC. Bull. Herb. Boiss. ser. 2. **8:** 319. 1908.

Nomen mutandum quia prius (1896) a cl. Taubertio usitatum.

3. BEGONIA STENOPTERA C. DC., n. sp.

Ramulis sat dense pilosis; foliis sat longe petiolatis, limbo ovato basi valide inaequilatera, latere breviore subrotundato, longiore rotundato, apice longe et acute palmati-septemnervio, utrinque petioloque sat dense pilosis; pedunculis quam petioli brevioribus apice cymam paucifloram gerentibus, ut cymae ramuli pedicellique pilosis; floris masc. sepalis 2 rotundatis integris subtus breviter haud dense pilosis, antheris quam filamenta brevioribus numerosis subovato-ellipticis; floris fem. 3-lobi lobis integris externis rotundatis subtus dense breviterque pilosis, interno elliptico multo minore; capsulae ellipticae basi et apice attenuatae trialatae alis subaequalibus marginiformibus dorso pilosis, stilis caducis basi ima connatis bifidis, laciniis spiraliter papilliferis.

Ramuli in sicco atro-rubescentes, pilis ferrugineis crispulis. Folia alterna. Limbi in sicco rigido-membranacei usque ad 10 cm. longi et 6.5 cm. lati. Petioli usque ad 7 cm. longi. Cymarum pedunculi circiter 2 cm., capsularum pedicelli 12 mm. longi. Floris masc. sepala 5 mm. longa et lata, antherae 0.5 mm. longae rimis dehiscentes, filamenta 1 mm. longa. Capsula 10 mm. longa, 5 mm. lata, placentae bifidae, lamellae utrinque ovuliferae.

COSTA RICA: Santa Elena de Turrialba, Januario, *H. Pittier*, sine numero.

4. BEGONIA GARAGARANA C. DC., n. sp.

Omnino glabra; foliis e rhizomate longissime petiolatis, limbo oblique rotundato-ovato basi inaequilatera subcordato apice breviter acuminato margine integro, palmatinervio, scapo e rhizomate surgente folium aequante, superne cymifero; floris masc. sepalis 2 subobovatis integris, petalis 2 obovato-lanceolatis, staminibus liberis, filamentis brevissimis, antheris linearibus apice connectivo brevissime producto apiculatis; stilis caducis, capsulae ovato-rotundae ala maxima horizontaliter dolabriformi, placentis bipartitis lamellis undique seminiferis.

Folia alterna. Limbi in sicco membranacei oblique 17 cm. longi et usque ad 19 cm. lati, stomata sparsa, cellulae spiculares et cystosphaeria crebra. Petioli 2-5 cm. longi. Scapus usque ad 54 cm. longus, floris masc. sepala 9 mm. longa et 6 mm. lata, antherae 2.5 mm. longae, capsulae 8 mm. longae, ala maxima 2.5 cm. longa et 1.2 cm. lata, semina elliptica.

PANAMA: Cerro de Garagará, Sambú Basin, southern Darién, alt. 500-974 m., *H. Pittier* 5672.

5. BEGONIA BREVICYMA C. DC., n. sp.

Omnino glabra; foliis e rhizomate longe petiolatis, limbo rotundato basi cordato apice acuminato superne utrinque 1-2-dentato caeterum margine integro, palmatinervio; scapo e rhizomate surgente folia superante apice breviter cymifero, cyma pauciflora quam scapus pluries breviore, floribus magnis; floris masc. sepalis 2 obovatis integris, petalis 2 obovatis integris, staminibus numerosis toro insertis, antheris oblongo-obovatis filamenta fere aequantibus.

Limbi in sicco membranacei 9.5 cm. longi latique, stomata facie infera sparsa vel binata, cystolitha haud crebra. Scapus usque ad cymam 25 cm. longus, cyma 3 cm. longa, bracteae ovatae integrae subtus glandulis conspersae 1 cm. longae et 8 mm. latae. Floris masc. in vivo albi sepala 17 mm. longa et usque ad 12 mm. lata, petalaque 15 mm. longa et usque ad 10 mm. lata subtus glandulis conspersa, stamina numerosa in sicco rubra, antherae 15 mm. longae rimis dehiscentes; flores feminei ignoti.

PANAMA: Humid forest around Los Siguas Camp, southern slope of Cerro de la Horqueta, Chiriquí, alt. about 1700 m., *W. R. Maxon* 5417.

6. BEGONIA MUCRONISTIPULA C. DC., n. sp.

Omnino glabra; foliis e rhizomate longe petiolatis, stipulis oblongo-ovatis paullo infra apicem dorso mucronatis, limbo transverse reniformi basi cordato apice acute acuminato margine integro vel superne tridentato, palmatinervio; scapo e rhizomate surgente quam folia multo longiore apice cymigero, cyma dichotome ramosa pauciflora, floribus sat longe pedicellatis; floris masc. sepalis 2 rotundatis integris, petalis 2 obovatis integris quam sepala multo minoribus, staminibus liberis, antheris oblongo-obovatis quam filamenta longioribus; floris fem. 3-lobi lobis 2 externis rotundatis integris, tertio obovato multo minore, ovario 3-loculari, placentis bipartitis lamellis utrinque ovuliferis, stilis 3 basi connatis bifidis sub laciniis inflatis et papilliferis laciniis ipsis spiraliter papilliferis, ovarii ala maxima adscendente superne attenuata apice mutica.

Folia alterna. Stipulae membranaceae fere 2 cm. longae. Limbi in sicco membranacei 8 cm. longi, 4 cm. lati, stomata plerumque binata, cystosphaeria crebra. Petioli usque ad 16 cm. longi. Scapus circiter 35 cm. longus. Pedicelli 6 mm. longi, flores rubri; floris masc. sepala 7 mm. longa et fere aequilata, petala 5 mm. longa et 2.5 mm. lata; floris fem. lobi externi 8 mm. longi et 10 mm. lati.

PANAMA: Between the Río Ladrillo and Los Siguas Camp, southern slope of Cerro de la Horqueta, Chiriquí, alt. 1200-1700 m., *H. Pittier* 3172.

7. BEGONIA UVANA C. DC., n. sp.

Foliis e rhizomate modice petiolatis, limbo oblique rotundato basi inaequilatera utrinque rotundato apice acute acuminato margine dentato serratoque dentulis dentibusque apice setiferis, utrinque glabro, palmatinervio, petiolo haud dense piloso, scapo e rhizomate surgente folia superante longe et haud dense piloso apice cymigero, cyma folium fere aequante dichotome ramosa longe et haud dense pilosa, bracteolis 2 rotundato-obovatis ciliatis; floris masc. sepalis 2 rotundato-obovatis integris glabris, petalis nullis, staminibus in apice columnae brevis umbellatis, antheris oblongis filamenta paullo superantibus; floris fem. bilobi lobis ovatis integris glabris, stilis 3 persistentibus inferne connatis bifidis, laciniis apice auriculatis, ovario glabro 3-loculari, placentis bipartitis, lamellis utrinque ovuliferis, capsulae ovatae glabrae alis glabris marginiformibus apice horizontaliter truncatis.

Rhizoma glabrum. Stipulae glabrae apice acuminatae. Folia alterna. Limbi in sicco membranacei usque ad 8 cm. longi latique, stomata sparsa, cystosphaeria crebra. Petioli usque ad 10 cm. longi. Scapus usque ad cymam 20 cm. longus. Bracteolae 7 mm. longae et 5.5 mm. latae. Floris masc. sepala 7 mm. longa et usque ad 7 mm. lata. Capsulae fere 1 cm. longae ala maxima superne usque ad 3 mm. lata, aliae multo angustiores, semina elliptica.

PANAMA: Isla de Uva, Contreras Group, Province of Veraguas, *H. Pittier* 5109.

8. BEGONIA MAMEIANA C. DC., n. sp.

Caule glabro ramoso; foliis breviter petiolatis, limbo ovato-acuminato basi altero latere rotundato altero attenuato apice acute acuminato margine duplicato-serrato dentibus dentulisque subulatis, palmatinervio, supra piloso subtus glabro; cymis dichotome ramosis folia parum superantibus glabris; floris masc. longe pedicellati sepalis 2 ovatis integris glabris, petalis nullis, staminibus in columna brevi insertis, antheris quam filamenta brevioribus ovatis apice connectivo producto apiculatis; floris fem. bracteolis 2 rotundatis dentatis glabris fulti lobis 3 ovatis integris glabris, stilis 3 persistentibus inferne connatis bifidis, laciniis spiraliter papilliferis, ovario ovato 3-loculari, placentis bipartitis lamellis utrinque ovuliferis, capsulae ovatae 3-alatae ala maxima horizontali ovata.

Caulis 35 cm. superans, ramuli tenues. Folia alterna, stipulae glabrae acutae. Limbi in sicco membranacei 4 cm. longi et usque ad 2 cm. lati, stomata in facie infera glomerulata, cystolitha et cystosphaeria nulla. Floris masc. sepala 3 mm. longa et 2 mm. lata, antherae 0.5 mm. longae rimis dehiscentes, floris fem. lobi 2 mm. longi et vix 1 mm. lati; capsulae ala maxima 7 mm. longa.

PANAMA: Mamei, Canal Zone, alt. 10-30 m., in cool wet places, *H. Pittier* 2251.

9. BEGONIA VILLIPETIOLA C. DC., n. sp.

Foliis longe petiolatis, limbo oblique ovato-acuminato basi cordato apice acute et longe acuminato margine serrulato ciliatoque et superne 1-dentato integrove, supra parcissime et subtus sat dense et longe piloso, palmatinervio, petiolo dense villoso; scapo inferne piloso superne glabro apice cymifero, cyma dichotome ramosa glabra multiflora quam scapus multo breviore; floris fem. bilobi lobis rotundatis integris glabris, stilis 3 persistentibus inferne connatis superne bifidis, laciniis spiraliter papilliferis ovario glabro, placentis bipartitis lamellis utrinque ovuliferis, capsulae ellipticae glabrae trialatae ala maxima horizontali ovata, seminibus minutis obovatis.

Folia alterna. Limbi in sicco membranacei 13 cm. longi et usque ad 11 cm. lati, stomata in facie infera sparsa, cystosphaeria crebra. Petioli usque ad 15 cm. longi. Scapus usque ad cymam 23 cm. longus. Cymae rami usque ad 6 cm. longi. Floris fem. in vivo albi lobi 7 mm. longi et fere aequilati, capsulae ala maxima 11 mm. longa et 8 mm. lata, aliae multo minores.

PANAMA: Bismarck, above Penonomé, *R. S. Williams* 309.

10. BEGONIA CILIBRACTEOLA C. DC., n. sp.

Caule glabro; foliis modice petiolatis, limbo rotundato basi fere aequilatera cordato margine crenulato dentibus rotundatis, utrinque breviter et haud dense piloso, palmatinervio; cymis folia superantibus paucifloris glabris; floris masc. sepalis 2 late lunulatis petalisque 2 obovatis integris glabris, staminibus liberis, antheris oblongis apice connectivo producto obtuse apiculatis filamenta multo superantibus; floris fem. bracteolis 2 oblongo-ovatis margine ciliatis fulti lobis 5 rotundato-obovatis integris glabris quorum 4 externi aequales, quintus minor, stilis persistentibus 3 tantum basi ima connatis 2-fidis, laciniis spiraliter papilliferis, ovario ovato glabro 3-loculari, placéntis bipartitis lamellis utrinque ovuliferis, capsulae ovatae glabrae ala maxima late falcata subadscendente apice obtusa, seminibus inferne sat longe attenuatis.

Caulis erectus, in sicco membranaceus fere 4 mm. crassus. Folia alterna. Limbi in sicco membranacei 2.5 cm. longi et 3 cm. lati, stomata 3-4-glomerulata, cystolitha et cystosphaeria nulla. Petioli 1.5 cm. longi haud dense pilosi. Cyma fructifera fere 5 cm. longa, floris masc. sepala 7 mm. longa et 8 mm. lata, antherae 2 mm. longae rimis dehiscentes; floris fem. lobi externi 3 mm. longi latique, capsulae 1.8 cm. longae ala maxima superne 1.2 cm. lata.

PANAMA: Ahorca Lagarto to Culebra, *J. F. Cowell* 388.

11. BEGONIA LEPTOPODA C. DC., n. sp.

Caule a rhizomate erecto glabro; foliis modice petiolatis, limbo oblique ovato-acuminato basi inaequilatera altero latere rotundato altero attenuato apice longe acuminato utrinque parce et breviter piloso subglabrove, margine dentato serratoque dentibus denticulatis subulatisque, palmatim 8-nervio nervis tenuibus; cymis axillaribus dichotome ramulosis glabris, pedicellis tenuissimis; floris masc. sepalis 2 ovatis integris glabris, petalis nullis, staminibus in columna brevi glabra insertis, antheris ovatis filamenta aequantibus; floris fem. lobis 4 elliptico-lanceolatis integris glabris, stilis persistentibus bifidis laciniis spiraliter papilliferis, ovario glabro 3-loculari, placentis bipartitis lamellis utrinque ovuliferis, capsulae ovatae glabrae 3-alatae ala maxima horizontali ovata apice obtusa, aliis marginiformibus, seminibus ovatis.

Caulis circiter 30 cm. altus in sicco membranaceus usque ad 5 mm. crassus. Folia alterna. Limbi in sicco membranacei 9 cm. longi et usque ad 3.5 cm. lati, stomata in facie infera glomerulata, cystosphaeria creberrima, cymae 5-6 cm. longae; floris masc. sepala 3 mm. longa; floris fem. lobi 1.5 mm. longi, capsulae 6 mm. longae ala maxima 7 mm. longa basi 6 mm. lata.

PANAMA: Vicinity of San Felix, eastern Chiriquí, alt. 0-120 m., *H. Pittier* 5215.

12. BEGONIA PUBIPEDICELLA C. DC., n. sp.

Caule hirsuto; foliis longe petiolatis, limbo oblique ovato-acuminato palmatinervio margine serrulato dentulis acutis utrinque hirsuto pilis brevibus, petiolo hirsuto in sicco rubro, cymae axillaris pauciflorae quam petiolus brevioris pedunculo pedicellisque hirsutis; floris masc. sepala 2 rotundata integra dorso pilosa, petalis 2 obovatis integris glabris, staminibus liberis, antheris oblongis quam filamenta paullo longioribus; floris fem. 3-lobi lobis integris glabris, 2 externis rotundatis tertio multo minore, stilis 3 inferne connatis bifidis sub laciniis extus elatis et papilliferis, laciniis ipsis spiraliter papilliferis, ovario glabro 3-loculari, alis juvenilibus marginiformibus, placentis bipartitis lamellis utrinque ovuliferis.

Caulis ut videtur erectus circiter 25 cm. altus et 3 mm. crassus in sicco durus et ruber. Folia alterna. Limbi in sicco membranacei circiter 7.5 cm. longi et usque ad 6.5 cm. lati, stomata in facie infera sparsa, cystolitha et cystosphaeria nulla. Petioli usque ad 7 cm. longi. Bracteolae ovato-rotundatae glabrae integrae 5 mm. longae 4 mm. latae. Pedicelli usque ad 1.5 cm. longi; flores in vivo rosei; floris masc. sepala 7 mm. longa et fere aequilata, petala usque ad 5 mm. longa et 2.5 mm. lata, antherae 1.5 mm. longae rimis dehiscentes; floris fem. lobi externi 8 mm. longi et 10 mm. lati.

PANAMA: Humid forest of Cuesta de las Palmas, southern slope of Cerro de la Horqueta, Chiriquí, alt. 1700-2100 m., *H. Pittier* 3248.

13. BEGONIA SERRATIFOLIA C. DC., n. sp.

Omnino glabra; foliis breviter petiolatis, limbo oblongo basi inaequilatera utrinque rotundato apice acute et sat longe acuminato, penninervio, margine serrato dentibus subulatis; cyma terminali dichotome ramosa; floris masc. sepalis 2 rotundato-ovatis basi cordatis margine integris, petalis 2 oblongis integris apice acutis, staminibus liberis numerosis, antheris oblongis quam filamenta paullo brevioribus; floris fem. lobis 5 oblongo-ovatis integris, ovario 3-loculari, placentis bipartitis lamellis utrinque ovuliferis, stilis 3 persistentibus inferne breviter connatis superne inaequilater trifidis, laciniis spiraliter papilliferis, capsulae oblongo-ovatae ala maxima oblongo-obovata apice rotundata.

Caulis erectus usque ad 6 mm. crassus in sicco coriaceus. Limbi in sicco membranacei usque ad 10.5 cm. longi et 3.5 cm. lati, stomata in facie infera glomerulata, cystolitha et cystosphaeria nulla. Petioli usque ad limbi latus longius et inter limbi latera 3 mm. longi. Floris masc. sepala usque ad 12 mm. longa et 7 mm. lata, petala angustiora.

Floris fem. lobi 2 externi 1 cm. longi et 5 mm. lati, 2 interni aequilongi et angustiores, quintus aliis multo minor, capsulae 12 mm. longae pedicellus circiter 13 mm. longus, ala maxima superne 6 mm. lata, aliae marginiformes.—Species sectionis *Begoniella* A. DC.

PANAMA: Vicinity of San Felix, eastern Chiriquí, alt. 0-120 m., *H. Pittier* 5126 (type). Railroad relocation between Gorgona and Gatún, Canal Zone, alt. 10-50 m., *Pittier* 2258.

14. BEGONIA CHIRIQUINA C. DC., n. sp.

Omnino glabra; foliis modice petiolatis, limbo ovato-oblongo basi inaequilatera utrinque rotundato apice acute acuminato margine acute denticulato, penninervio; cymis dichotome ramulosis paucifloris; floris masc. sepalis 2 rotundato-reniformibus integris basi cordatis, petalis nullis, staminibus liberis numerosis, antheris oblongis filamenta fere aequantibus apice connectivo producto obtuse apiculatis; floris fem. lobis 2 rotundatis integris, stilis 3 caducis inferne connatis superne bifidis, sub laciniis linearibus inflatis et papilliferis laciniisque spiraliter papilliferis, ovario glabro 3-loculari, placentis integris, capsulae obovatae 3-alatae ala maxima ovata subadscendente apice obtusa, secunda et tertia marginiformibus.

Caulis erectus in sicco teres durus et rubescens 2.5 mm. crassus. Folia alterna. Limbi in sicco rigide membranacei 9 cm. longi 3.5 cm lati, cystolitha et cystosphaeria nulla, stomata in facie infera plerumque binata. Petioli 1 cm. longi; stipulae oblongo-ovatae apice acuminatae, fere 1 cm. longae. Floris masc. sepala 5 mm. longa et 8 mm. lata, antherae rimis dehiscentes; floris fem. juvenilis lobi 2 mm. longi, capsulae 1 cm. longae ala maxima 1 cm. longa.

PANAMA: Humid forest of Cuesta de las Palmas, southern slope of Cerro de la Horqueta, Chiriquí, alt. 1700-2000 m., *H. Pittier,* sine numero.

15. BEGONIA CHEPOENSIS C. DC., n. sp.

Caule glabro; foliis petiolatis, limbo oblongo-ovato basi inaequilatera altero latere rotundato altero acuto, apice acute acuminato, supra parce piloso subtus glabro, penninervio, margine dentato serratoque dentibus dentulisque apice subulatis; cymis dichotome ramosis glabris, floris masc. tenuiter pedicellati sepalis 2 ovatis integris glabris, petalis nullis, staminibus in columna tenui glabra insertis, antheris quam filamenta brevioribus ovatis apice connectivo producto mucronulatis; floris fem. bracteolis 2 obovatis apice acutis margine acute serratis fulti lobis 5 anguste lanceolatis integris glabris, stilis 3 persistentibus breviter connatis apice bifidis laciniis spiraliter papilliferis, ovario 3-loculari glabro, placentis bipartitis lamellis utrinque ovuliferis; capsulae ovatae 3-alatae glabrae ala maxima horizontaliter triangulari apice subacuta, secunda fere conformi apice magis obtusa, tertia multo minore marginiformi, seminibus minutis ellipticis basi et apice rotundatis.

Herba circiter 45 cm. alta, radix fibrosa, caulis ramosus inferne usque ad 5 cm. crassus. Folia alterna. Limbi in sicco membranacei, foliorum superorum 2 cm. inferorum 5.5 cm. longi et 1-2 cm. lati, stomata in facie infera glomerulatim disposita, cystolitha et cystosphaeria nulla. Petioli 1-11 mm. longi. Floris masc. sepala 3.5 mm. longa et 2 mm. lata, antherae paullo ultra 0.5 mm. longae rimis dehiscentes; floris fem. pedicellus usque ad 2.5 mm., capsulae usque ad 4 cm. longus, capsulae 3.5 mm. longae ala maxima 5 mm. longa.

PANAMA: Along Chararé River near Chepo, Province of Panama, alt. 50-200 m., *H. Pittier* 4713.

16. BEGONIA CAUDILIMBA C. DC., n. sp.

Foliis e rhizomate longe petiolatis, limbo paullo supra $\frac{1}{4}$ longitudinis suae peltato ovato apice longe et acute acuminato, superne 3-dentato, supra glabro subtus ut petiolus longe piloso; cyma in apice scapi longi longe et parce pilosa dichotome ramosa, capsula sat longe pedicellata ovata glabra 3-alata, ala maxima rotundata, stilis 3 persistentibus inferne connatis superne bifidis, laciniis spiraliter papilliferis; seminibus minutis obovatis.

Folia alterna. Limbi in sicco membranacei usque ad 19 cm. longi et 8 cm. lati, stomata in facie infera 3-4-glomerulata, cystolitha nulla, cellulae spiculares in mesophyllo crebrae. Petioli usque ad 20 cm. longi. Scapus in vivo ruber, in sicco fuscescens, 45 cm. longus. Pedicelli usque ad 12 mm. longi tenues, capsulae 8 mm. longae ala maxima usque ad 8 mm. lata, placentae bipartitae.

PANAMA: Forest along the Río Indio de Gatún, Canal Zone, near sea-level, *W. R. Maxon* 4866.

17. BEGONIA UDISILVESTRIS C. DC., n. sp.

Omnino glabra; foliis longe petiolatis, limbo oblongo-ovato basi valde inaequilatera cordato apice longissime et acute acuminato, margine praesertim superne acute serrulato, palmatinervio, petiolo verruculoso; cymis axillaribus quam petioli paullo brevioribus; floris masc. sepalis 2 rotundatis integris, petalis 2 obovatis integris, staminibus liberis, antheris oblongis quam filamenta brevioribus; floris fem. trilobi lobis integris, 2 externis rotundatis tertio elliptico-lanceolato, stilis caducis 3 inferne connatis superne bifidis, infra lacinias extus elatis papilliferis laciniisque ipsis spiraliter papilliferis, ovario glabro basi et apice attenuato 3-alato, alis marginiformibus quorum 2 aequales et tertia multo angustior, placentis in loculo 2 utrinque ovuliferis et ex angulo segregatis, capsula ovata apice in rostellum attenuata, seminibus ellipticis.

Caulis erectus ultra 30 cm. altus in sicco coriaceus usque ad 5 mm. crassus. Folia alterna. Limbi in sicco subcoriacei usque ad 11.5 cm. longi et 6.5 cm. lati margine et subtus ad nervos rubescentes, stomata in facie infera sparsa, cystolitha et cystosphaeria nulla. Petioli usque ad 11 cm. longi, in sicco rubri et verruculis pallidis conspersi. Pedicelli usque ad 1 cm. longi. Floris masc. sepala 5 mm. longa lataque, petala 4 mm. longa, 2 mm. lata, antherae paullulo ultra 0.5 mm. longae rimis dehiscentes. Floris fem. lobi externi fere 5 mm. longi et 3.5 mm. lati, capsula 1 cm. longa et 5 mm. lata angulis dehiscens.—Species sectionis *Casparya* Warb., floribus fem. 3-lobis ab aliis discrepans.

PANAMA: Humid forest of Cuesta de las Palmas, southern slope of Cerro de la Horqueta, Chiriquí, alt. 1700-2000 m., *H. Pittier* 3249.

18. BEGONIA PARCIFOLIA C. DC., n. sp.

Caule haud dense villoso; foliis paucis longe petiolatis, limbo oblique rotundato-elliptico basi cordato apice breviter acuminato margine breviter dentato serratoque, palmatinervio utrinque et subtus densius villoso; cyma villosa, bracteis caducis villosis; floris masc. sepalis 2 rotundatis petalisque 2 obovatis integris glabris, staminibus liberis, antheris ellipticis quam filamenta brevioribus; floris fem. 5-lobi lobis integris glabris, quorum externi 2 obovati, interni 2 rotundato-obovati et paullo breviores, quintus obovatus multo brevior, stilis 3 inferne connatis bifidis sub laciniis externe elatis et papilliferis, laciniis ipsis spiraliter papilliferis, ovario glabro, capsulae glabrae rotundatae ala maxima falcata apice horizontaliter subacuta media rotundata, tertia marginiformi.

Caulis circiter 36 cm. altus. Limbi in sicco membranacei circiter 7 cm. longi et 10 cm. lati, stomata in facie infera sparsa, cystolitha nulla. Petioli 10 cm. longi. Floris masc. sepala 5 mm. longa et 6 mm. lata, petala 3 mm. longa et paullo ultra 2 mm. lata, antherae 1 mm. longae rimis dehiscentes; floris fem. in vivo albi lobi 2 externi 6.5 mm. longi et 4.5 mm. lati, interni 2-2.6 mm. longi et 5 mm. lati; capsulae 3-locularis pedicellus 12 mm. longus, placentae 2-partitae, lamellae utrinque ovuliferae, ala maxima fere 10 mm. longa et basi 7 mm. lata, semina elliptica obtusa.

ECUADOR: Cariamanga, *C. H. T. Townsend* 947.