MINING TABLES

HATCH AND VALLENTINE

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MINING TABLES

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MINING TABLES

BEING A COMPARISON OF THE UNITS OF WEIGHT, MEASURE, CURRENCY, MINING AREA, ETC., OF DIFFERENT COUNTRIES; TOGETHER WITH TABLES, CONSTANTS & OTHER DATA USEFUL TO MINING ENGINEERS AND SURVEYORS

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PREFACE

Most engineers get together a quantity of formulae, constants and other data useful to them in the exercise of their profession, which are not always to be found in text-books. The authors, having arranged and tabulated a collection of this nature for their own use, decided to print it, believing that its pub lication would be of service to other workers in the same field.

The work thus begun has extended beyond the original plan, especially in regard to the tables of weight and measure, which have been compiled from the latest publications of the "Bureau international des Poids et Mesures" and of the Board of Trade. It appears that most published equivalents of the British Imperial and Metric measures of length are based either on a comparison made in Paris in 1818 by Arago and Kater, or on a comparison made in 1866 by Capt. A. R. Clarke of the Ordnance Survey. Similarly, Professor Miller's determination in 1844 of the avoirdupois pound as equal to 453.59265 grammes forms the usual basis of comparison for the weights of the British Imperial and Metric systems. The values adopted in this book are derived from determinations since made under the direction of the International Committee of Weights and Measures and of the Board of Trade, and legalised by Order in Council of the 19th May, 1898. In like manner the equivalents of the Russian weights and measures adopted are based on the results of Prof. D. Mendelieff's work in 1897, which were subsequently embodied in the Russian Weights and Measures Law of June, 1899.

The definitions of the electrical units given in Section II. of Part II. are taken chiefly from the Reports made to the Board of Trade in 1892 and 1894 by the Electrical Standards Committee, and the Order in Council made by her late Majesty on the

23rd August, 1894. They are defined in terms of the fundamental units of length (the centimetre), mass (the gramme), and time (the second), from which this system of units has come to be known as the C.G.S. (centimetre-gramme-second) system.

The compilation of the short section on thermal units disclosed the existence of much confusion in text-books, largely due to the various thermometric scales in use. There is also an absence of any agreement as to the terminology of the units. For instance, as Swinburne points out, there is no name for the unit of difference of temperature, "degree" being almost as primitive as "mark" or "notch."[1] Again, the British thermal unit or pound-degree (Fahrenheit) has no name; and "calorie" may mean either the gramme-degree (Centigrade) or the kilogram-degree (Centigrade). In regard to specific heat, thermal capacity, calorific power and thermal efficiency, there is a lack of authoritative definition such as has fixed for all time the electrical units.

The mining data collected in Part V. refer rather to the physical properties of ore-bodies than to the mechanical devices for their extraction. Thus, hoisting, pumping and ventilation, to which many special treatises have been devoted, are not dealt with. On the other hand, tables are given by which the calculation and valuation of ore-reserves are assisted and simplified. The latest information regarding the question of underground temperatures is summarised. The various methods in use in different countries for expressing gold ore values and for stating copper prices are compared. Finally, there is a section on mining areas which has been carefully compiled from the laws now in force in the Colonies and in foreign countries where mining is carried on.

The data relating to surveying which comprise Part VI. include a description of the conventional methods in practical use for the coordination of survey points, also a description of the use of the tacheometer, and a table for the calculation of heights and distances from tacheometric readings.

[1] *Entropy*, by James Swinburne, Westminster, 1904.

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PART I. WEIGHTS AND MEASURES.

SECTION I. STANDARD UNITS.

THE METRIC SYSTEM.

Length.—The original intention of the founders of the Metric System was to select from nature itself some permanent and invariable unit of length, which could be measured with a high degree of precision, and might therefore be reproduced at will. The metre, which was the unit selected, was intended to be equal to one ten-millionth of a terrestrial meridian contained between the north pole and the equator.* The geodetic survey from Barcelona to Dunkirk, from which the length of the arc of the meridian was computed, was conducted by Méchain and Delambre between the years 1792 and 1798.

A platinum standard was then constructed and deposited in the Archives of the French Republic in 1799, being legalised in the same year. This standard is known as the *Metre of the Archives.* It is a platinum bar 25 millimetres broad, 4 millimetres thick, and, being an 'end' standard, is exactly one metre long at 0° C.

Subsequent researches showed that the length of the arc differs from that determined by the original triangulation to an extent equivalent to about 0.1 millimetre in the standard metre. Nevertheless, the Metre of the Archives is adhered to as the unit of length, although its reference to the earth's quadrant has been abandoned.

In 1875 the International Bureau of Weights and Measures was established at Breteuil, near Paris, under a Metric Convention signed by twenty different High Contracting States† for the

* See Art. 5, Law of April 7, 1795, French Republic.

† Great Britain did not join the Convention until 1884.

purpose of constructing, restoring, and verifying new metric standards (now known as the international prototypes) to replace the standards of the Archives. Accurate copies of the new standards were also to be constructed for all the contracting States. Thirty-one standards of iridio-platinum, with a cross-section nearly of the shape of the letter X, known as the 'Tresca' form, were made, and compared with the Metre of the Archives and with one another. These were approved of by the International Committee in 1889, the standard most nearly approximating to the length of the Metre of the Archives being selected as the International Prototype Standard Metre and deposited in the Observatory at Breteuil. The remaining national prototype standards were distributed by lot to the different contracting States.

The British Prototype Standard Metre "is represented by the distance marked by two fine lines on the iridio-platinum standard bar numbered 16, when at the temperature of 0° Centigrade. This bar is deposited with the Board of Trade." *

An elaborate series of researches carried on at the International Bureau of Weights and Measures has shown that it is possible, after all, to realise the desire of the founders of the Metric System to refer the metre to a natural unit; for the standard can be expressed in terms of wave-lengths of light. In 1893 Professor A. A. Michelson found that, by the interference method, 1553163.5 wave-lengths of the red ray of cadmium, measured in air at 15° C., under an atmospheric pressure of 760 millimetres, are equal to the length of the International Prototype Standard Metre.†

Weight.—The unit of weight in the Metric System is the *Gramme*, which was originally defined "as the absolute weight of a volume of pure water equal to a cube of the one-hundredth part of a metre, and at the temperature of melting ice." As this unit, however, is rather small for accurate weighings, a weight of 1000 grammes was adopted as the practical standard. The first step in the preparation of the original standard kilogram (1000

* *Board of Trade Report*, 367 of 1898, page 9.

† See "Détermination expérimentale de la valeur du mètre en longueurs d'ondes lumineuses," A. A. Michelson, vol. xi., *Travaux et Mémoires*, *Bureau International des Poids et Mesures*; also, *Board of Trade Report*, 373 of 1896, page 37.

grammes) was the determination of the weight *in vacuo* of a cubic decimetre (1000 cubic centimetres) of distilled water at its maximum density. This was found to be 18,827.15 grains of the Pile de Charlemagne. A platinum standard of that weight was then constructed and deposited in the Archives of the French Republic in 1799. It is known as the *Kilogram of the Archives.* In form it is cylindrical, with height equal to the diameter and with its edges slightly rounded. When the construction of new standards for the metre and the kilogram was authorised under the Metric Convention, it was decided, since the kilogram did not represent the mass of a cubic decimetre of water with scientific accuracy, to adopt the Kilogram of the Archives as the standard unit of weight, and subsequently to determine its true relation to the mass of a cubic decimetre of distilled water at its temperature of maximum density. Accordingly, in 1879, three iridio-platinum standard kilograms were made, cylindrical in form, and of a density of 21.55. They were compared with the Kilogram of the Archives and with one another; and in 1883 the one known as K III. was adopted as the International Prototype Standard Kilogram. It has since been designated by 𝔎, although it bears no mark. Forty cylindrical iridio-platinum national prototype kilograms were then made, and compared with 𝔎 and with one another. They were approved of by the International Committee in 1889, and distributed by lot to the different contracting States. The British Prototype Standard Kilogram "is represented by the cylindrical iridio-platinum standard kilogram weight numbered 18, which is deposited with the Board of Trade." *

Capacity.—The unit of capacity in the Metric System is the *Litre*, which was intended to be the volume of a cubic decimetre, so that a litre of distilled water at 4° C. should weigh exactly a kilogram. But on further investigation it was found that this was not scientifically accurate, and it was therefore decided by the International Committee to define the Litre as "the volume occupied by the mass one kilogram of pure water at its maximum density and under normal atmospheric pressure," this definition being sanctioned at the General Conference of 1901. Recent determinations of the weight *in vacuo* of a cubic decimetre of distilled water at its temperature of maximum

* *Board of Trade Report*, 367 of 1898, page 9.

density (4° C.) made independently by Benoît, Chappuis, Macé de Lépinay and Buisson, gave very uniform results, the mean of which was found to be 0.999974 kilogram.* This value has been provisionally adopted by the *Bureau international des Poids et Mesures* pending the completion of a further elaborate series of experiments now being made at the Bureau, the results of which will be announced at the sexennial General Conference of the delegates representing the contracting States of the Metric Convention, which is to be held at Paris in October, 1907. It is anticipated that any variation between the provisional and the new values will only affect the sixth decimal place. Consequently, for all practical purposes a litre can be regarded as the volume of a cubic decimetre, the error involved being only 26 parts in a million.

The British Standard Litre "is represented by the capacity at 0° Centigrade of the cylindrical brass measure marked 'Litre, 1897' (which is deposited with the Board of Trade), and having a diameter equal to one half its height. This Litre at 0° Centigrade when full contains one kilogram of distilled water at the temperature of 4° Centigrade, under an atmospheric pressure equal to that represented by a column of mercury 760 millimetres high at 0° Centigrade, at sea level, and at latitude 45°; the weighing being made in air, but reduced by calculation to a vacuum." †

The Metric System is in use in the following countries, to the exclusion of the older systems, except where noted:

Argentine. Almost exclusively used.
Austria. Old system still sometimes used.
Belgium.
Brazil. In common use.
Bulgaria. Old system not entirely supplanted.
Chile. In common use.
Colombia. Both old and metric systems used.
Denmark. Used by State Railways; but not in general use. It has been made compulsory by a law passed in March, 1907.
Ecuador. Old system used in commerce, metric officially.
Egypt. Old system used in commerce, metric officially and by engineers, etc.
Finland.

* See *Procès-verbaux du Comité international des Poids et Mesures*, Session 1905, p. 55.

† *Board of Trade Report*, 367 of 1898, page 9.

France.
Germany. In general use, but old measures sometimes encountered.
Great Britain. Optional, but not in general use.
Greece. Very little used.
Guatemala. Used officially but not generally.
Hungary. In general use: old system dying out.
Italy. In general use, but old system still found in the south.
Japan. Not in general use.
Luxemburg. Old system practically obsolete.
Mexico. In general use: old system dying out.
Montenegro. In general use.
Netherlands. Almost entirely used, but old system sometimes encountered.
Norway.
Peru. Only used by Government.
Philippine Islands.
Porto Rico.
Portugal.
Russia. Optional, but not in general use.
Servia. In general use.
Siam. Used by railways and public works.
Spain. In general use, but old measures still encountered.
Sweden.
Switzerland.
United States of America. Optional, but not in general use.
Uruguay.
Venezuela. Only used officially.

THE BRITISH IMPERIAL SYSTEM.

Length.—The British Imperial Standard unit of length is the *Yard.* The 'line' standard constructed by Bird in 1760 having been lost in the fire which destroyed the Houses of Parliament in 1834, the present standard yard was made by Messrs. Baily and Sheepshanks in 1843, by reference to the 5-foot brass Shuckburgh scale of 1796, the two iron standards made for the Ordnance Survey in 1826-7, the brass tubular scale of the Royal Astronomical Society, and the Kater scale of 1831 made for the Royal Society.

It is a solid bar of 'Baily's metal' (16 parts by weight of copper, $2\frac{1}{2}$ of tin, and 1 of zinc) 38 inches long, with a cross-section 1 inch square. Near its ends are two circular wells half an inch deep. At the bottom of these wells, and consequently on the 'neutral plane' of the bar, are gold studs, on which the fiducial lines are engraved, the distance between them forming the British Imperial Standard Yard at a temperature of 62° Fahr. It was legalised by the Standards Act of 1855. It is preserved at the Standards Office, Westminster, and has been in the custody of the Board of Trade since 1866.

Thirty-nine copies of this standard were made of the same material and dimensions. Four of these are specially designated Parliamentary Copies, which, by the Weights and Measures Act of 1878, must be compared with each other once in every ten years and with the Imperial Standard once in every twenty years, in order to ensure the perpetuation of the standard. These Parliamentary Copies are stamped with the temperature at which they represent the true standard, namely:

P.C. 2 in the custody of the Royal Mint: standard at 61.94° F.
P.C. 3 " " Royal Society: standard at 62.10° F.
P.C. 4 " " Royal Observatory, Greenwich: standard at 62.16° F.
P.C. 5 " " New Palace, Westminster: standard at 61.98° F.

The remaining thirty-five copies were distributed to various nations and scientific institutions.

Weight.—The British Imperial standard unit of weight is the *Avoirdupois Pound* of 7000 grains. The standard troy pound of 5760 grains having been destroyed in the fire of 1834, the avoirdupois pound of 7000 grains was substituted as the standard, on the recommendation contained in a report submitted by the Parliamentary Standards Committee, Dec. 21, 1841; and the present standard pound was constructed by Prof. W. H. Miller in 1844 by reference to a troy pound belonging to the Royal Society, and a troy pound the property of Prof. Schumacher. It is of platinum, cylindrical in form, 1.35 inches high and 1.15 inches in diameter, with a density of 21.1572. It has a small groove in its circumference to permit of its being lifted with an ivory fork, and is marked 'P.S. 1844. 1 lb.'* on its upper surface. It was legalised in 1855, and is preserved at the Standards

* P.S. signifies Parliamentary Standard.

Office, Westminster, in the custody of the Board of Trade. As in the case of the unit of length, there are four Parliamentary Copies. Compared with the standard,

No. 1 P.C., which is in the custody of the Royal Mint, is 0.00051 grain too heavy.

No. 2 P.C., in the custody of the Royal Society, is 0.00089 grain too light.

No. 3 P.C., in the custody of the Royal Observatory, Greenwich, is 0.00178 grain too light.

No. 4 P.C., in the custody of the New Palace, Westminster, is 0.00314 grain too light.

The Weights and Measures Act of 1878 provides that one additional Parliamentary copy of the Standard Yard and of the Pound should be made. These were constructed and approved of by the Board of Trade, and were accordingly legalised by an Order in Council of Aug. 3, 1886.* The Board of Trade secondary standards, by which all other standards are tested, are required by the Act to be re-verified once every five years by comparison with these new Parliamentary copies.

Capacity.—The British Imperial standard unit of capacity is the *Gallon*, which is the volume of ten Imperial standard pounds of distilled water weighed in air against brass weights, with the water and air at a temperature of 62° Fahr. and under a barometric pressure of 30 inches. The standard is of brass, with a diameter equal to its depth, and bears the date of 1828. It is in the custody of the Board of Trade, and is deposited at the Standards Office, Westminster. A standard Bushel (equal to 8 gallons) is also preserved at the Standards Office as the unit of dry measure It is of gun-metal, with a diameter equal to twice its depth. It dates from 1824, and was verified in 1825.

The Weights and Measures Act of 1824 gives the weight of a cubic inch of distilled water under standard conditions as 252.458 grains, a value derived from weighings made by Sir George Shuckburgh in 1798 † and Captain Henry Kater in 1821.‡ On this basis, 277.274 and 2218.192 cubic inches are the volumes of the Imperial gallon and bushel respectively.

* *Board of Trade Report* 9, Sess. 2 of 1886, p. 1. This Parliamentary Copy of the pound is referred to as No. 5 P.C., and is deposited at the Standards Office.

† *Philosophical Transactions, Royal Society*, 1798, p. 133.

‡ *Phil. Trans., Roy. Soc.*, 1821, pp. 316, 326.

In 1889, Mr. H. J. Chaney determined the mass of a cubic inch of distilled water, freed from air, weighed in air against brass weights of a density of 8.143, with the water and air at a temperature of 62° Fahr. and the barometer at 30 inches, to be 252.286 grains ± .0002 grain.* The weight of a cubic foot of such water under similar conditions would therefore be 62.278601 lbs., and the volume of the Imperial gallon and of the bushel 277.46288 and 2219.70304 cubic inches respectively. Although no direct determination of the weight of a cubic inch of water has since been made, the foregoing values have been superseded. It has been found that 1 litre = 1.000026 cubic decimetres (see p. 4), and that 4.5459631 litres = 1 Imperial gallon (see p. 15); therefore, under standard conditions:

The weight of 1 cubic inch of water at 62° F. = 252.3253 grains.
,, 1 cubic foot of water at 62° F. = 62.2883 lbs.
and the volume of } 1 Imperial gallon { = 277.420 cubic inches.

These values have been provisionally adopted by the Board of Trade Standards Department.

The Imperial Weights and Measures are now legally in force in the following Colonies, etc.:

Antigua.	Jamaica.	Sierra Leone.
Barbadoes.	Malta.	Straits Settlements.
Bermuda.	Natal.	South Australia.
British Guiana.	Nevis.	St. Christopher.
British Honduras.	New Brunswick.	St. Helena.
Canada.	New South Wales.	St. Vincent.
Cape of Good Hope.	New Zealand.	Transvaal.
Cyprus.	Nova Scotia.	Tobago.
Dominica.	Orange River Colony.	Trinidad.
Grenada.	Queensland.	Vancouver's Island.
Hong Kong	Rhodesia.	Victoria.

Western Australia.†

An Act of 1897 permits the use of Metric Weights and Measures in the United Kingdom, and provides that the Board of Trade standards shall include metric standards.

* *Trans. Royal Society*, 1892, pp. 331-354; also *Board of Trade Report*, 302 of 1889, p. 10.

† See *Board of Trade Report* 9, Sess. 2, 1886. The Orange River Colony, the Transvaal, and Rhodesia have since been included.

THE UNITED STATES OF AMERICA.

The weights and measures of the United States are practically identical with those of the British Imperial System, with the exception of the measures of capacity which, although defined in units having the same names and sub-divisions, have quite different volumes.

The use of the Metric System is recognised by an Act of 1866. Prototype standard meters, Nos. 21 and 27, and kilograms, Nos. 4 and 20, were received from the International Bureau of Weights and Measures in 1889, and *Meter No.* 27 and *Kilogram No.* 20 were adopted as the National Prototype Standards in 1890. In Bulletin No. 26 of the 5th April, 1893, issued by the U.S. Coast and Geodetic Survey with the approval of the Secretary of the Treasury, the United States Government recognises "the International Prototype Meter and Kilogram* as fundamental standards," and states that "the customary units, the yard and the pound, will be derived therefrom in accordance with the Act of July 28, 1866." The metric equivalents of the yard and the pound legalised by this Act differ in a slight degree from the British equivalents legalised in 1898, but the differences are so small that, for all practical purposes, they may be disregarded (see pp. 36 and 40). In 1901 the custody of the national standards was transferred from the Coast and Geodetic Survey to the Bureau of Standards, which was established in that year under the Department of Commerce and Labor.

Liquid Measure.—The standard unit of liquid measure is the *U.S. Gallon*, which is derived from the Queen Anne wine gallon of 1707. It is defined as having a volume of 231 cubic inches. It is also the standard unit of Apothecaries' Fluid Measure.

Dry Measure.—The standard unit of dry measure is the *U.S. Bushel*, which is derived from the old Winchester "struck" bushel. It is defined as having a volume of 2150.42 cubic inches. The U.S. Bushel measure has the form of an inverted frustum of a right cone of the following dimensions

* *i.e.* the international metric standards deposited at Breteuil Observatory, near Paris.

(inside measurement): top diameter, $19\frac{1}{2}$ inches; bottom diameter, $18\frac{1}{2}$ inches; depth, 8 inches.

The *dry* measures are considerably larger than the *liquid* measures of the same name; for instance, the *dry* U.S. gallon ($\frac{1}{8}$th bushel) = 268.8025 cubic inches, while the *liquid* U.S. gallon = 231 cubic inches.

RUSSIA.

Length.—In 1833 the Russian units of length were defined in terms of British feet, and a standard *Sagene* (equal to 7 British feet) was constructed and compared with the British Imperial Standard Yard, and subsequently legalised by an Act of Oct 1835. A standard *Archine*, equal to $\frac{1}{3}$ sagene, constructed by Prof. Kupffer, is recognised as the standard unit of length by a law passed in June 1899. It is an iridio-platinum 'line' standard of Tresca form, standard at $16\frac{2}{3}°$ C. (62° F.), and is inscribed $\frac{H}{11}$ 1894. It is defined as equal to 28 British inches or 0.711200 ± 0.000001 metre.

Weight.—The standard unit of weight is the *Funt* or Russian pound. The standard Funt is of iridio-platinum of a density of 21.51 at $16\frac{2}{3}°$ C., and is inscribed $\frac{H}{11}$ 1894. It was reproduced from the platinum funt of 1835, which was derived from a funt of 1747. It is defined as equal to $0.40951241 \pm 0.00000001$ kilogram.

Capacity.—The standard units of liquid and dry measures are respectively the *Vedro* and the *Tchetverik*. The Vedro is defined as the volume of 30 funts, weighed *in vacuo*, of distilled water at a temperature of $16\frac{2}{3}°$ C. The Tchetverik is defined as the volume of 64 funts of such water under similar conditions.

The national standards are deposited at St. Petersburg.

The law of June 1899, which became effective on Jan. 1, 1900, permits the use of the Metric System.

CHINA.

The Weights and Measures of China have different local names and values.* The only standards legally in use for international

* See Dr. Williams' *Chinese Commercial Guide*.

purposes are those adopted in the foreign treaties for the payment of duties at the Foreign Maritime Customs. By Rule IV. of the Rules of Trade signed at Shanghai on Nov. 8, 1858, the weight of a *Pikul* (Tam) of 100 Katis (Kan or Chin) is defined as equal to 133⅓ lbs. avoirdupois, and the length of a *Chang* of 10 Ch'ih as equal to 141 British inches. Similar equations were adopted in the Rules of Trade appended to other foreign treaties. The standard Chinese weights verified for Hong Kong by the Board of Trade in 1900-01 were a *Tam* of 133⅓ lbs., a *Kan* of 1⅓ lbs., and a *Tael* of 1⅓ oz. avoirdupois. The Standard *Ying-tsao Ch'ih* or foot of the Chinese Board of Works, from which all measures connected with the Revenue, whether of length, capacity, or weight, are derived, is approximately equal to 12.5 British inches;* but different local commercial standards obtain throughout the whole of China. A standard Chinese '*Chek*' (Ch'ih) of 14⅝ inches, divided into 10 'Tsun,' and each Tsun into 10 'Fan,' was verified by the Board of Trade Standards Department in 1896-97 for Hong Kong, where both British and Chinese weights and measures are used.† Measures of capacity are seldom used—grains, liquids, etc., being mostly bought and sold by weight.

JAPAN.

In March 1891, a law was passed, with effect from Jan. 1, 1893, permitting the use of the Metric System. The same Act re-organised the national weights and measures, and defined them in terms of the metric units, prototype standards of which had been received in 1889.

Length.—The standard unit of length is the *Shaku*, which is defined as $\frac{10}{33}$ of the length of the national iridio-platinum prototype metre, standard at 0°.15 Centigrade. The unit of square or land measure is the *Bu* or *Tsubo*, which is equal to a square, each side of which measures 6 shakus.

Weight.—The standard unit of weight is the *Kwan*, which is defined as equal to $\frac{15}{4}$ of the weight of the national iridio-platinum prototype kilogram. The density of a Japanese standard iridio-platinum Kwan weight of 3750 grammes was determined

* *Board of Trade Report* 9, Sess. 2, 1886, pp. 46 and 49.

† *Board of Trade Report*, 392 of 1897, p. 6.

as 21.5423 at 0° C. by the Board of Trade Standards Department in 1896-97.*

Capacity.—The standard unit of capacity is the *Shô*, which is defined as equal to 1.80391 litres.

The national standards are in the custody of the Minister of Agriculture and Commerce at Tokio.

BRITISH INDIA.

Various weights and measures are in use in India, the local standards being kept by the district and municipal authorities.

Length.—The British Imperial yard, foot, and inch are statutory by the Measures of Length Act of 1889. This Act does not refer to square measures. A brass standard yard was verified by the Board of Trade Standards Department for the Government of India in 1889. It is inscribed: "Accurate copy of Imperial Standard Yard, 1889, Calcutta. Standard Yard at 85 degrees Fahrenheit." At the same time two similar standards were also supplied to the Presidencies of Bombay and Madras.†

Weight.—The standard unit of weight is the *Tola*, which is equal to 180 grains, the weight of the rupee. Primary standard iridio-platinum weights of 30, 20, and 10 Tolas were verified by the Board of Trade Standards Department for the Calcutta and Bombay Mints in 1892.‡

Capacity.—Measures of capacity are seldom used by the natives —grain, liquids, etc., being usually bought and sold by weight. Measures are made to contain certain weights of some commodities. They are really 'measures of weight,' and are named by the weights which they represent.

THE STRAITS SETTLEMENTS.

The Straits Settlements Ordinance No. VII. of 1886 assimilates the weights and measures of the colony to the British Imperial System, with the exception of certain customary native weights, such as the Tahil, Kati, and Pikul, to which are assigned values in terms of British Imperial weights (see p. 30). The Board

* *Board of Trade Report*, 392 of 1897, p. 6.

† *Board of Trade Report*, 302 of 1889, p. 6.

‡ *Board of Trade Report*, 364 of 1893, p. 13.

of Trade Standards Department assisted in the drawing up of the Ordinance, and verified a large number of copies of the Imperial standards for the colony.* They have also supplied other standards, such as the Kati = $1\frac{1}{3}$ lbs. avoirdupois, and a quarter-Chupah (2 Imperial gills), which contains ten fluid ounces of distilled water at 62° Fahr.† The standards of the colony are deposited at Singapore.

SOUTH AFRICA.

In Natal, the British Imperial is the legal system of weights and measures.‡ This is also the case in Cape Colony, British Bechuanaland, the Orange River Colony, the Transvaal, and Rhodesia, except that there is a special system of land measure. The unit of land measure is a foot "of such length that 1000 of such feet shall be equal to 1033 English feet as now by law defined and established for lineal measurement in England."§ This unit is termed the *Cape Foot*, and is a survival of the Rhynland foot used during the Dutch occupation of the Cape of Good Hope. Twelve Cape feet make a *Rood* and 600 square roods a *Morgen*. This system is used in all land surveys, and standard Roods are deposited with the Surveyor-General of each Colony.

EGYPT.

The use of the metric system is permitted by a decree issued by the Khedive Ismail in 1873. It has been adopted by the government for all purposes except the measurement of areas of land and the tonnage of ships, and is used by the public works, post office, customs and railway departments. A decree issued by the Khedive Mohamed Tewfik on the 28th April 1891, with effect from the 1st of January 1892, recognises the International Prototype Metre and Kilogram ‖ as fundamental

* *Board of Trade Reports*, 262 of 1887, p. 3, and 330 of 1888, p. 1.

† *Board of Trade Report*, 302 of 1889, pp. 2 and 7.

‡ See *Natal Laws*, No. 11 of 1852, No. 19 of 1872, and No. 39 of 1884.

§ *Cape Colony Law*, No. 9 of 1859.

‖ *i.e.* the international metric standards deposited at Breteuil Observatory, near Paris.

standards from which the Egyptian units of length, weight, and capacity are derived by means of equivalents stated in the decree (see page 17).

The old weights and measures are still in general use, the units being as follows:

Length.—There are several different units of length, namely: the *Diraâ baladi* or 'town' diraâ; the *Diraâ mimari*, which is used in building, etc.; the *Pike Istambuli* or Constantinople Pike, used in measuring cloth; and the *Kassabah*, used in land surveying. The *Feddan* of $333\frac{1}{3}$ square kassabahs is the legal unit of land area.

Weight.—The standard unit of weight is the *Dirhem* (drachm).

Capacity.—The standard unit of capacity is the *Ardeb.*

SECTION II. COMPARISON OF STANDARD UNITS.

THE METRIC AND BRITISH IMPERIAL SYSTEMS COMPARED.

In 1894-95 a comparison of the Yard with the Metre was made under the directions of the Board of Trade and the International Committee of Weights and Measures. The Parliamentary Copy of the Standard Yard, P.C. VI., was first carefully compared with the Imperial Standard Yard at the Standards Office, Westminster. It was then taken to the International Bureau of Weights and Measures at Breteuil and compared with the International Prototype Standard Metre,* and the following result was confirmed at a meeting of the Metric Conference in September 1895.† At 16°.667 Centigrade the Imperial Yard is equal to 0.9143992 Metre, the temperature 16°.667 C. being taken as equal to 62° Fahrenheit; or, conversely, at 16°.667 C. (62° F.) the Metre is equal to 39.370113 inches.‡

In 1883 a comparison of the Pound and the Kilogram was made in the same manner. A copy of the pound was compared

* *Board of Trade Report*, 432 of 1895, pp. 3 and 23.

† *Board of Trade Report*, 373 of 1896, p. 37.

‡ *Détermination du Rapport du Yard au Mètre*, by Dr. Benoît (Director of the International Bureau of Weights and Measures), Paris, 1896.

with the Imperial Standard at the Standards Office, and then with the International Prototype Kilogram at the International Bureau, with the following result: the Imperial Avoirdupois Pound weighed *in vacuo* at 0° Centigrade is equal to 453.5924277 Grammes; or, conversely, the Kilogram is equal to 15432.35639 Grains.*

In comparing the units of capacity of the two systems, the weight *in vacuo* of distilled water at 4° C. contained in a Litre is compared with the weight *in air* of distilled water at 16°.667 C. (62° F.) contained in a Gallon. The Imperial Gallon is equal to 4.5459631 Litres; or, conversely, the Litre is equal to 1.75980 Pints. The Board of Trade equivalents of Metric and Imperial Weights and Measures, legalised by an Order in Council of May 19, 1898, are based on the foregoing comparisons, which may be summarised as follows:

1 Yard	= 0.9143992 Metre.
1 Metre	= 39.370113 Inches.
1 Pound	= 453.5924277 Grammes.
1 Kilogram	= 15432.35639 Grains.
1 Gallon	= 4.5459631 Litres.
1 Litre	= 1.75980 Pints.

The French Toise and the Austrian Klafter were the units of length formerly used in most of the European geodetic surveys. They are, however, no longer in use, having been superseded by the Metre. Compared with the Imperial Yard,

1 Toise	= 2.13151116 Yards.
1 Klafter	= 2.07403483 Yards.
1 Metre	= 1.09361426 Yards.†

THE UNITED STATES, THE METRIC, AND THE BRITISH IMPERIAL SYSTEMS.

Since 1893 the International Prototype Meter and Kilogram (deposited at Breteuil Observatory, near Paris) have been regarded in the United States as fundamental standards, from

* *Travaux et Mémoires, Comité international des Poids et Mesures*, Tome IV., 1885; also *Board of Trade Annual Weights and Measures Report*, 1884.

† H. J. Chaney, *Our Weights and Measures*, London, 1897, p. 67.

which all units of weight and measure are derived in terms of the equivalents legalised by the Act of July 1866.* The U.S. yard is reproduced from the meter in terms of the equation: 1 yard = $\frac{3600}{3937}$ meter, while the British equivalent is: 1 yard = 0.9143992 metre. Therefore

1 U.S. Yard = 1.000002875 Imp. Yards,

a difference of only 2.875 in a million. U.S. and British measures of length can therefore be regarded as practically identical.

The British equivalent:

1 Avoirdupois Pound = 453.5924277 Grammes

has been adopted by the U.S. Bureau of Standards. U.S. and British weights are therefore exactly alike.

The Bureau of Standards equivalents of the U.S. units of capacity are:

1 U.S. Liquid Gallon of 231 cubic inches = 3.785434497 Liters.†
1 U.S. Bushel of 2150.42 cubic inches = 0.3523928160 Hectoliter.

The British equivalents are: 1 Imp. Gallon = 4.5459631 Litres, and 1 Imp. Bushel = 0.363677048 Hectolitre. Therefore

1 U.S. Liquid Gallon	= 0.83270 Imp. Gallon.
1 Imp. Gallon	= 1.20091 U.S. Gallons.
1 U.S. Bushel	= 0.96897 Imp. Bushel.
1 Imp. Bushel	= 1.03202 U.S. Bushels.

COMPARISON OF THE RUSSIAN WITH THE METRIC AND THE BRITISH IMPERIAL SYSTEMS.

In 1897 Prof. D. Mendelieff, acting on the authority of the Russian Government, determined the values of the Russian standard units in terms of those of the Metric System by a series of experiments made at the International Bureau of Weights and Measures, which values were subsequently legalised by the Act of June 1899 (see page 10). The units of capacity are derived from the unit of weight by reference to the volume of distilled water at $16\frac{2}{3}°$ C. The equivalents on which the conversion

* Bulletin No. 26, *U.S. Coast and Geodetic Survey*, 5th April, 1893.

† In the United States a liter is regarded as the volume of a cubic decimeter, which, according to the most recent determination (see p. 4), involves an error of only 26 parts in a million.

tables given on page 42 are based, may be summarised as follows:

1 Archine	= 28 British Inches or 0.711200 Metre.*
1 Funt	= 409.51241 Grammes.
1 Vedro	= 12.2993285 Litres.
1 Tchetverik	= 26.2385674 ,,

COMPARISON OF THE EGYPTIAN WITH THE METRIC AND THE BRITISH IMPERIAL SYSTEMS.

A decree issued by the Khedive Mohamed Tewfik on the 28th April, 1891, with effect from the 1st of January, 1892, defines the Egyptian units of length, weight, and capacity in terms of the international metric standards (deposited at Breteuil Observatory, near Paris) as follows:

1 Diraâ baladi	= 0.580 Metre.
1 Diraâ mimari	= 0.750 Metre.
1 Kassabah	= 3.550 Metres.
1 Dirhem	= 3.12 Grammes.
1 Ardeb	= 1.98 Hectolitres.

The decree also embodies a table of the legal Metric and British Imperial equivalents of the Egyptian weights and measures (see page 52).

In 1902 and 1903 the Board of Trade Standards Department verified standard Rotl and Oke weights for the Sudan Customs, 1 rotl being taken as equal to 0.990492 lb. and 1 oke as equal to 2.751367 lbs., these being the Egyptian legal equivalents.†

*28 British inches = 0.7111995 metre.

†*Board of Trade Reports*, 334 of 1903, p. 7, and 348 of 1904, p. 6.

SECTION III. TABLES.

THE METRIC SYSTEM.

Weight.

Unit.	Symbol.	Value in Grammes.
Milligram, - - - -	mg.	.001 g.
Centigram, - - - -	cg.	.01 g.
Decigram, - - - -	dg.	.1 g.
Gramme, - - - -	g.	1 g.
Dekagram, - - - -	dag.	10 g.
Hectogram, - - - -	hg.	100 g.
Kilogram, - - - -	kg.*	1,000 g.
Myriagram, - - - -		10,000 g.
Quintal, - - - - -	q.	100,000 g.
Tonne, Millier or Metric Ton, -	t.	1,000,000 g.

* The abbreviation 'kilo' is frequently used for kilogram.

Lineal Measure.

Unit.	Symbol.	Value in Metres.
Micron, - - - - -	μ.	.000 001 m.
Millimetre, - - - -	mm.	.001 m.
Centimetre, - - - -	cm.	.01 m.
Decimetre, - - - -	dm.	.1 m.
Metre, - - - - -	m.	1 m.
Dekametre, - - - -	dam.	10 m.
Hectometre, - - - -	hm.	100 m.
Kilometre, - - - -	km.	1,000 m.
Myriametre, - - - -	Mm.	10,000 m.
Megametre, - - - -		1,000,000 m.

Square Measure.

Unit.	Symbol.	Value in Square Metres.
Square millimetre, - - -	mm.^{2}	.000 001 m.^{2}
Square centimetre, - - -	cm.^{2}	.0 001 m.^{2}
Square decimetre, - - -	dm.^{2}	.01 m.^{2}
Square metre or centiare, -	m.^{2} or ca.	1 m.^{2}
Are (square dekametre), - -	a.—dm.^{2}	100 m.^{2}
Hectare (square hectometre),	ha.—hm.^{2}	10,000 m.^{2}
Square kilometre, - - -	km.^{2}	1,000,000 m.^{2}

Cubic Measure.

Unit.	Symbol.	Value in Cubic Metres.
Cubic millimetre, - - -	mm.^{3}	.000 000 001 m.^{3}
Cubic centimetre, - - -	cm.^{3}*	.000 001 m.^{3}
Cubic decimetre, - - -	dm.^{3}	.001 m.^{3}
Cubic metre or stere, - -	m.^{3} or s.	1 m.^{3}

* The symbol c.c. is frequently used for the cubic centimetre.

Measure of Capacity.

Unit.	Symbol.	Value in Litres.	Volume.
Millilitre, - -	ml.	.001 l.	1 cm.^{3}
Centilitre, - -	cl.	.01 l.	10 cm.^{3}
Decilitre, - -	dl.	.1 l.	100 cm.^{3}
Litre, - - -	l.	1 l.	1 dm.^{3}
Dekalitre, - -	dal.	10 l.	10 dm.^{3}
Hectolitre, - -	hl.	100 l.	100 dm.^{3}
Kilolitre, - -	kl.	1000 l.	1 m.^{3}

NOTE.—The weight *in vacuo* of a cubic decimetre of distilled water at 4° C. is .999974 kilogram (see page 4). Therefore for all practical purposes a litre may be regarded as the volume of a cubic decimetre, the error involved being only 26 parts in a million.

The above metric symbols are those adopted by the *Comité international des Poids et Mesures.*†

† *Procès-verbaux*, Session 1905, p. 175.

THE BRITISH IMPERIAL SYSTEM.

Avoirdupois or Commercial Weight.

27.34375 grains = 1 drachm.
16 drachms = 1 ounce (oz.) = 437.5 grains.
16 ounces = 1 **pound** (lb.) = 256 drachms = 7000 grains.
28 pounds = 1 quarter (qr.) = 448 ounces.
4 quarters = 1 hundredweight (cwt.) = 112 pounds.
20 hundredweights = 1 ton = 80 quarters = 2240 pounds.

1 stone = 14 pounds: 1 cental = 100 pounds:
20 centals = 1 'short' ton of 2000 pounds.

The ton of 2240 lbs. is usually termed the 'long' ton, in contradistinction to the 'short' ton of 2000 lbs. To convert long into short tons, multiply by 1.12; or from short into long, divide by 1.12.

Ounces (*avoir.*) *in Decimals of a Pound* (*avoir.*).

OUNCES.	POUND.	OUNCES.	POUND.	OUNCES.	POUND.
¼	.0156	5	.3125	10½	.6562
½	.0312	5½	.3437	11	.6875
¾	.0468	6	.375	11½	.7187
1	.0625	6½	.4062	12	.75
1½	.0937	7	.4375	12½	.7812
2	.1250	7½	.4687	13	.8125
2½	.1562	8	.5	13½	.8437
3	.1875	8½	.5312	14	.875
3½	.2187	9	.5625	14½	.9062
4	.25	9½	.5937	15	.9375
4½	.2812	10	.625	15½	.9687

Troy Weight.

(Used for the weighing of precious metals.)

24 grains = 1 pennyweight (dwt.).
20 pennyweights = 1 **ounce** (oz. troy) = 480 grains.
12 ounces = 1 pound (lb. troy) = 240 pennyweights = 5760 grains.

The grain is the same in both troy and avoirdupois weights.

The troy pound is seldom used.

The Diamond Carat and the Pearl Grain, although in general use, are not legal weights. They are thus defined by the Board of Trade: 151½ diamond carats or 600 pearl grains = 1 troy ounce; therefore a diamond carat = $3.\dot{1}68\dot{3}$ grains (205.30 milligrams) and a pearl grain = 0.8 grain (51.84 milligrams).*

* *Board of Trade Reports*, 330 of 1888, p. 13, and 302 of 1889, p.2.

Comparison of Avoirdupois and Troy weights.

1 lb. avoir.	= 14.58$\dot{3}$	oz. troy,	logarithm	= 1.1638568.
1 oz. „	= 0.911458$\dot{3}$	oz. „	„	= 9.9597368.
1 oz. troy	= 1.097143	oz. avoir.,	„	= 0.0402632.

Grains and Dwts. in Decimals of a Troy Oz.

1 Grain	= .0021 Oz.	1 Dwt.	= .05 Oz.
2 Grains	= .0042 „	2 Dwts.	= .1 „
3 „	= .0063 „	3 „	= .15 „
4 „	= .0083 „	4 „	= .2 „
5 „	= .0104 „	5 „	= .25 „
6 „	= .0125 „	6 „	= .3 „
7 „	= .0146 „	7 „	= .35 „
8 „	= .0167 „	8 „	= .4 „
9 „	= .0188 „	9 „	= .45 „
10 „	= .0208 „	10 „	= .5 „
11 „	= .0229 „	11 „	= .55 „
12 „	= .025 „	12 „	= .6 „
13 „	= .0271 „	13 „	= .65 „
14 „	= .0292 „	14 „	= .7 „
15 „	= .0313 „	15 „	= .75 „
16 „	= .0333 „	16 „	= .8 „
17 „	= .0354 „	17 „	= .85 „
18 „	= .0375 „	18 „	= .9 „
19 „	= .0396 „	19 „	= .95 „
20 „	= .0417 „	20 „	= 1.0 „
21 „	= .0438 „		
22 „	= .0458 „		
23 „	= .0479 „		
24 „	= .05 „		

Grains in Decimals of a Dwt.

1 Grain	= .0417 Dwt.	13 Grains	= .5417 Dwt
2 Grains	= .0833 „	14 „	= .5833 „
3 „	= .125 „	15 „	= .625 „
4 „	= .1667 „	16 „	= .6667 „
5 „	= .2083 „	17 „	= .7083 „
6 „	= .25 „	18 „	= .75 „
7 „	= .2917 „	19 „	= .7917 „
8 „	= .3333 „	20 „	= .8333 „
9 „	= .375 „	21 „	= .875 „
10 „	= .4167 „	22 „	= .9167 „
11 „	= .4583 „	23 „	= .9583 „
12 „	= .5 „	24 „	= 1.0 „

Apothecaries' Weight.

20 grains = 1 scruple (℈.)
3 scruples = 1 drachm (ʒ.) = 60 grains.
8 drachms = 1 ounce (℥.) = 480 grains.
12 ounces = 1 pound (lb.) = 5760 grains.

Drugs are now often weighed by avoirdupois weight. The scruple and drachm are not introduced into the British Pharmacopœia, but are still used in prescriptions.

The ounce and pound are the same as in troy weight, while the grain is the same in avoirdupois, troy and apothecaries' weights.

Lineal Measure.

12 inches = 1 foot.
3 feet = 1 **yard** = 36 inches.
5½ yards = 1 rod, pole or perch = 16½ feet = 198 inches.
40 rods = 1 furlong = 220 yards = 660 feet.
8 furlongs = 1 statute mile = 1760 yards = 5280 feet.

1 link = 7.92 inches = 0.66 foot; 100 links = 1 Gunter's chain = 66 feet; 80 chains = 1 statute mile; 6 feet = 1 fathom; 3 statute miles = 1 league; 6075.6 feet = 1 geographical mile.

Inches expressed in Decimals of a Foot.

Ins.	Foot.	Ins.	Foot.	Ins.	Foot.	Ins.	Foot.	Ins.	Foot.	Ins.	Foot.
0	.0000	2	.1667	4	.3333	6	.5000	8	.6667	10	.8333
¼	.0208	¼	.1875	¼	.3542	¼	.5208	¼	.6875	¼	.8542
½	.0417	½	.2083	½	.3750	½	.5417	½	.7083	½	.8750
¾	.0625	¾	.2292	¾	.3958	¾	.5625	¾	.7292	¾	.8958
1	.0833	3	.2500	5	.4167	7	.5833	9	.7500	11	.9167
¼	.1042	¼	.2708	¼	.4375	¼	.6042	¼	.7708	¼	.9375
½	.1250	½	.2917	½	.4583	½	.6250	½	.7917	½	.9583
¾	.1458	¾	.3125	¾	.4792	¾	.6458	¾	.8125	¾	.9792

Fractions of an Inch expressed in Decimals of an Inch.

1/64 = .015625	17/64 = .265625	33/64 = .515625	49/64 = .765625
1/32 = .03125	9/32 = .28125	17/32 = .53125	25/32 = .78125
3/64 = .046875	19/64 = .296875	35/64 = .546875	51/64 = .796875
1/16 = .0625	5/16 = .3125	9/16 = .5625	13/16 = .8125
5/64 = .078125	21/64 = .328125	37/64 = .578125	53/64 = .828125
3/32 = .09375	11/32 = .34375	19/32 = .59375	27/32 = .84375
7/64 = .109375	23/64 = .359375	39/64 = .609375	55/64 = .859375
1/8 = .125	3/8 = .375	5/8 = .625	7/8 = .875
9/64 = .140625	25/64 = .390625	41/64 = .640625	57/64 = .890625
5/32 = .15625	13/32 = .40625	21/32 = .65625	29/32 = .90625
11/64 = .171875	27/64 = .421875	43/64 = .671875	59/64 = .921875
3/16 = .1875	7/16 = .4375	11/16 = .6875	15/16 = .9375
13/64 = .203125	29/64 = .453125	45/64 = .703125	61/64 = .953125
7/32 = .21875	15/32 = .46875	23/32 = .71875	31/32 = .96875
15/64 = .234375	31/64 = .484375	47/64 = .734375	63/64 = .984375
1/4 = .25	1/2 = .5	3/4 = .75	1 = 1

Square Measure.

144 square inches = 1 square foot.
9 square feet = 1 square yard = 1296 square inches.
30¼ square yards = 1 square rod = 272¼ square feet.
40 square rods = 1 rood = 1210 square yards = 10890 square feet.
4 roods = 1 acre = 160 sq. rods = 4840 sq. yards = 43560 sq. feet = 10 sq. chains.
640 acres = 1 square mile = 27,878,400 square feet.

In a square 1 acre in extent, each side measures 208.710 feet.
" " ½ " " " " 147.581 "
" " ¼ " " " " 104.355 "

Cubic Measure.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard = 46656 cubic inches.

Imperial Measures of Capacity, both Liquid and Dry.*

4 gills	= 1 pint (pt.)	= 34.6775	cubic inches.
2 pints	= 1 quart (qt.)	= 69.355	" "
4 quarts	= 1 gallon (gal.)	= 277.420	" "
2 gallons	= 1 peck (pk.)	= 554.840	"
4 pecks	= 1 bushel (bush.)	= 2219.360	" "
8 bushels	= 1 quarter (qr.)	= 10.27481	cubic feet.
36 bushels	= 1 chaldron (chal.)	= 46.236	" "

* See page 8 for the determinations from which the volumes are derived.

Apothecaries' Measure.

1 fluid drachm (fl. dr.)	= 60 minims (min.)	= 0.216734	cubic inch.	
1 fluid ounce (fl. oz.)	= 8 fluid drachms	= 1.733875	,,	inches.
1 pint (O.)	= 20 fluid ounces	= 34.6775	,,	,,
1 gallon (C.)	= 8 pints	= 277.420	,,	,,

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1 minim (♏.)	is the volume of	0.9114583	grain	of distilled	water	at 62°F.
1 fluid drachm (f.ʒ.)	,,	54.6875	grains	,,	,,	,,
1 fluid ounce (f.℥.)	,,	437.5	,,	,,	,,	,,
1 pint (O.)	,,	8,750	,,	,,	,,	,,
1 gallon (C.)	,,	70,000	,,	,,	,,	,,

THE UNITED STATES OF AMERICA.

Avoirdupois or Commercial Weight.

27.34375 grains = 1 dram.
16 drams = 1 ounce (oz.) = 437.5 grains.
16 ounces = 1 pound (lb.) = 7000 grains.
14 pounds = 1 stone.
2 stones = 1 quarter (qr.) = 28 pounds.
4 quarters = 1 hundredweight (cwt.) = 112 pounds.
20 hundredweights = 1 'long' ton = 80 quarters = 2240 pounds.

Also: 100 pounds = 1 quintal; 20 quintals = 1 'short' ton of 2000 pounds.

Troy Weight.

24 grains = 1 pennyweight (dwt.).
20 pennyweights = 1 ounce (oz. troy) = 480 grains.
12 ounces = 1 pound (lb. troy) = 240 dwts. = 5760 grains.

Apothecaries' Weight.

20 grains = 1 scruple (℈).
3 scruples = 1 dram (ʒ) = 60 grains.
8 drams = 1 ounce (℥) = 24 scruples = 480 grains.
12 ounces = 1 pound = 288 scruples = 5760 grains.

In avoirdupois, troy, and apothecaries' weights the grain is of the same weight, and in troy and apothecaries' weights the ounce and pound are the same.

Lineal Measure.

12 inches	= 1 foot (ft.).
3 feet	= 1 yard (yd.) = 36 inches.
$5\frac{1}{2}$ yards	= 1 rod, pole or perch = $16\frac{1}{2}$ feet.
40 rods	= 1 furlong = 220 yards = 660 feet.
8 furlongs	= 1 statute mile = 1760 yards = 5280 feet.
3 miles	= 1 league.

Also: 7.92 inches = 1 link; 100 links = 1 Gunter's chain = 66 feet; 80 chains = 1 mile.

3 inches = 1 palm; 4 inches = 1 hand; 9 inches = 1 span.

6 feet = 1 fathom; 1 cable's length = 120 fathoms.

Square Measure.

144 square inches	= 1 square foot.
9 square feet	= 1 square yard = 1296 square inches.
$30\frac{1}{4}$ square yards	= 1 square rod = $272\frac{1}{4}$ square feet.
40 square rods	= 1 rood = 1210 square yards.
4 roods	= 1 acre = 43560 square feet = 10 square chains.
640 acres	= 1 square mile or section.
36 square miles	= 1 township.

Cubic Measure.

1728 cubic inches	= 1 cubic foot.
27 cubic feet	= 1 cubic yard.
16 cubic feet	= 1 cord.
$24\frac{3}{4}$ cubic feet	= 1 perch of stone or masonry.
128 cubic feet	= 1 cord of wood.

Liquid Measure.

4 gills	= 1 pint (pt.)	= 28.875 cubic inches.
2 pints	= 1 quart (qt.)	= 57.75 "
4 quarts	= **1 gallon** (gal.)	= 231.0 "
$31\frac{1}{2}$ gallons	= 1 barrel.	
2 barrels	= 1 hogshead	= 63 gallons.
2 hogsheads	= 1 pipe or butt	= 126 gallons.
2 pipes	= 1 tun	= 252 gallons.

Also: 42 gallons = 1 tierce; 2 tierces = 1 puncheon = 84 gallons.

Apothecaries' Fluid Measure.

60 minims (♏)	= 1 fluid drachm (f.ʒ)	= 0.2256 cubic inch.
8 fluid drachms	= 1 fluid ounce (f.℥)	= 1.8047 " inches.
16 fluid ounces	= 1 pint (O.)	= 28.875 " "
8 pints	= **1 gallon**	= 231.0 " "

Dry Measure.

2 pints	= 1 quart	= 67.2006	cubic inches.
4 quarts	= 1 gallon	= 268.8025	„
2 gallons	= 1 peck	= 537.605	„
4 pecks	= 1 **bushel**	= 2150.42	„
8 bushels	= 1 quarter.		
21½ bushels	= 1 barrel (dry).		
36 bushels	= 1 chaldron.		

Note that the dry measures are larger than the liquid measures of the same names.

RUSSIA.

Commercial Weight.

96 dolis	= 1 zolotnik.
96 zolotniks	= 1 **funt.**
40 funts	= 1 pood.

Other weights sometimes used are: the loth = 3 zolotniks; the lana = 8 zolotniks; the berkovetz = 10 poods; and the packen = 3 berkovetz.

Gold ore values are expressed in zolotniks per 100 poods (see pages 103 and 104).

Apothecaries' Weight.

60 medical	grains	= 1	medical	drachme.
8 „	drachmes	= 1	„	once.
12 „	onces	= 1	„	**funt** = 84 zolotniks.

Drugs are now mostly weighed by metric weights.

Lineal Measure.

10 totchkas	= 1 liniia.
17.5 liniias	= 1 vershok.
16 vershoks	= 1 **archine.**
3 archines	= 1 sagene = 48 vershoks.
500 sagenes	= 1 verst.

The British Imperial foot and inch and the metre are also in use.

The archine is used in mining and trade, the sagene in land measurement, and the foot and inch in engineering works.

Square Measure.

256 square vershoks	= 1 square archine.	
9 square archines	= 1 square sagene	= 2304 square vershoks.
2400 square sagenes	= 1 **dessiatina.**	
104.16 dessiatinas	= 1 square verst	= 250,000 square sagenes.

Cubic Measure.

4096 cubic vershoks	= 1 cubic archine.	
27 cubic archines	= 1 **cubic sagene**	= 110,592 cubic vershoks.

Liquid Measure.

10 tcharkas	= 1 schtoff.
10 schtoffs	= 1 **vedro.**
16 boutylkas (bottles of wine)	= 1 vedro.
20 boutylkas (bottles)	= 1 vedro.

Dry Measure.

8 garnetz	= 1 **tchetverik.**
4 tchetveriks	= 1 osmina.
2 osminas	= 1 tchetvert.
12 tchetverts	= 1 last.

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1 cubic sagene = { 789.67123 vedros.
46.2698 tchetverts. }

CHINA.

Commercial Weight.

16 liang (taels or tahils)	= 1 chin (kan or kati)	= $1\frac{1}{3}$ lbs. avoir.
100 chin	= tan (tam or pikul)	= $133\frac{1}{3}$ "

Silver Weight.

10 ssŭ	= 1 hao (thousandths).
10 hao	= 1 li (hundredths—'cash').
10 li	= 1 fên (tenths—'candareen').
10 fên	= 1 ch'ien ('mace').
10 ch'ien	= 1 liang (tael or tahil) = $1\frac{1}{3}$ oz. avoir.

Lineal Measure.

10 fan = 1 ts'un	= 1.41 British inches.	
10 ts'un = 1 ch'ih (covid)	= 14.1	„
10 ch'ih = 1 chang (rod)	= 141	„

The foregoing values are those of the British Treaty of 1858. They are used in the payment of duties at the Foreign Maritime Customs. At Hong Kong, where both British Imperial and Chinese weights and measures are in use, the present standard *chek* or *ch'ih* was verified by the Board of Trade. It measures 14⅝ inches, and is therefore 0.525 inch longer than the *ch'ih* of the British Treaty. The standard *ying-tsao ch'ih* of the Chinese Board of Works is approximately 12.5 inches. The Hong Kong weights are identical with those of the British Treaty.

Itinerary Measure.

5 ch'ih (covids) = 1 pu (pace).
360 pu = 1 li (about ⅓ mile).
250 li = 1 tu (degree).

Land Measure.

5 ch'ih (covids) = 1 kung (bow).
240 square kung = 1 mou (rood).

Cubic Measure.

100 cubic ch'ih = 1 fang or ma.

Measures of Capacity.

10 ho = 1 shêng = approx. 2 Imp. pints.
10 shêng = 1 tou.
5 tou = 1 hu.

JAPAN.

Weight.

10 shi = 1 mô.
10 mô = 1 rin.
10 rin = 1 fun.
10 fun = 1 mommē.
160 mommē = 1 kin.
1000 mommē = 1 kwan.

Lineal Measure.

10 shi	= 1 mô.	
10 mô	= 1 rin.	
10 rin	= 1 bu.	
10 bu	= 1 sun.	
10 sun	= 1 **shaku.**	
6 shaku	= 1 ken.	
60 ken	= 1 chô	= 360 shaku.
36 chô	= 1 ri	= 12960 shaku.

For cloth measurement the kujira shaku is used. It is equal to 1 shaku 2 sun 5 bu.

Square Measure.

10 shaku	= 1 gô.	
10 gô	= 1 **bu or tsubo.**	
30 tsubo	= 1 sē.	
10 sē	= 1 tan	= 300 tsubo.
10 tan	= 1 chô	= 3000 tsubo.

A bu or tsubo equals 36 square shaku (1 square ken) *of lineal measure.*

Measures of Capacity.

10 shaku	= 1 gô.	
10 gô	= 1 **shô.**	
10 shô	= 1 to.	
10 to	= 1 koku	= 100 shô.

In the above tables the same name is sometimes applied to units having no connection with each other. For instance, the *shaku* as a lineal measure is quite different from the *shaku* of square measure, which again has no connection with the *shaku* of capacity.

BRITISH INDIA.

The following weights are based on the *tola*, which is the weight of a rupee (180 grains). They are officially recognised, and are used on the railways, etc., but numerous local weights of varying value obtain throughout India. The Burmese *viss* of 100 *tikals* = 3.65 lbs. avoir. exactly.*

* See *Board of Trade Report*, 326 of 1901, p. 5.

Weight.

180 grains	=	1 **tola**.
80 tolas	=	1 seer.
40 seers	=	1 maund.
20 maunds	=	1 kandy.

Lineal Measure.

The Imperial yard, foot and inch are statutory by Act 2 of India, 1889. Various native measures, which are mostly based on the *guz* or yard, are also used.

Square Measure.

The *biga* is the common unit of land measure. It varies in size in almost every village.

The Bengal	biga	=	approximately	1600	sq. yards.
The N.W. Province	„	=	„	3025	„
The Bombay	„	=	„	3927	„

In Madras, the unit is the *kani* = approximately 6400 sq. yards.

THE STRAITS SETTLEMENTS.

Ordinance No. VII. of 1886 assimilates the weights and measures used in the Straits Settlements to the British Imperial weights and measures, with the exception of the following weights :

10 hoons	= 1 chee.			
10 chee	= 1 **tahil** (tael)	=	$1\frac{1}{3}$ oz.	avoir.
16 tahils	= 1 kati (kan)	=	$1\frac{1}{3}$ lbs.	„
100 katis	= 1 pikul (tam)	=	$133\frac{1}{3}$ lbs.	„
40 pikuls	= 1 koyan	=	$5333\frac{1}{3}$ lbs.	„

Measures of Capacity.

1 pau or **quarter chupah**	= 2 Imp.	gills.
1 half chupah	= 1 „	pint.
1 chupah	= 1 „	quart.
1 gantang	= 1 „	gallon.

SOUTH AFRICA.

The British Imperial system of weights and measures is used throughout British South Africa, but in the Cape Colony, British Bechuanaland, the Orange River Colony, the Transvaal and Rhodesia, a special system of land measure known as the *Cape System* is used :

Lineal Measure.

12 Cape inches	= 1 Cape foot.
12 Cape feet	= 1 rood.
425.94385 roods	= 1 statute mile (1760 yards).
NOTE.—1 Cape foot	= 1.033 British feet.

Square Measure.

144 square Cape inches	= 1 square Cape foot.
144 square Cape feet	= 1 square rood.
600 square roods	= 1 morgen.

EGYPT.

Commercial Weight.

12 dirhems (drachms)	= 1 okieh.
12 okiehs	= 1 rotl or rottolo = 144 dirhems.
400 dirhems	= 1 oke.
36 okes 100 rotls	= 1 kantar.
60 okes	= 1 hamlah.
112 „	= 1 Alexandria kantar.
200 „	= 1 heml.

Jewellers' Weight.

4 kamhas	= 1 kirat.
16 kirats	= 1 dirhem.
24 „	= 1 mithkal.

Lineal Measure.

24 kirats = 1 diraâ baladi.

There are several diraâs (cubits or pikes) of different lengths in use, namely, the diraâ baladi or 'town' diraâ ; the diraâ mimari, used in building, etc. ; and the pike istambuli or Constantinople pike, used in measuring cloth.

The kassabah is the unit used in land surveying.

Square or Land Measure.

24 sohts	= 1 sahm.
4 sahms	= 1 danek.
2 daneks	= 1 habbah.
3 habbahs	= 1 kamel kirat.
24 kamel kirats	= 1 feddan (masri).
333⅓ square kassabahs	= 1 feddan (masri).

Measures of Capacity.

2 kirats	= 1 karrūbah.
2 karrūbahs	= 1 tūmnah.
2 tūmnahs	= 1 rūbaah.
2 rūbaahs	= 1 nesf kadah.
2 nesf kadahs	= 1 kadah.
2 kadahs	= 1 malwa.
2 malwas	= 1 rūb.
2 rūbs	= 1 kilah.
2 kilahs	= 1 webah.
6 webahs	= 1 ardeb.
8 ardebs	= 1 daribah.

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7 rūbs	= 1 small fard.
14 „	= 1 large „

SECTION IV. CONVERSION TABLES.

In this section the scientific equivalents of the Metric and British Imperial weights and measures, together with the corresponding logarithms, are first given. These are followed by the Board of Trade legal equivalents of the Metric weights and measures, in which, as they are for use in trade, the same degree of accuracy is not required. The scientific equivalents of the United States and Metric weights and measures as published by the U.S. Bureau of Standards at Washington, and the shorter equivalents legalised in the United States by the Act of July 28, 1866, are also given. Then follow in the order named the Metric and British equivalents, together with the corresponding logarithms, of the Russian, Chinese, Japanese, British, Indian, Straits Settlements, Cape (S. Africa), and Egyptian weights and measures.

SCIENTIFIC EQUIVALENTS OF METRIC AND BRITISH IMPERIAL WEIGHTS AND MEASURES.

METRIC TO BRITISH IMPERIAL.

Weight.

Metric.	*Avoirdupois.*	*Logarithm.*
1 milligram (mg.)	=.01543 grain	8.1884322
1 centigram (cg.)	=.15432 "	9.1884322
1 decigram (dg.)	=1.54324 "	0.1884322
1 gramme (g.)	= **.00220462234 pound**	7.3433342
	15.43235639 grains	1.1884322
1 dekagram (dag.)	=.35274 ounce	9.5474542
1 hectogram (hg.)	=3.52740 ounces	0.5474542
1 kilogram (kg.)	= **2.20462234 pounds**	0.3433342
	15432.35639 grains	4.1884322
1 myriagram	=22.04622 pounds	1.3433342
1 quintal (q.)	=1.96841 hundredweights	0.2941162
1 tonne (t.)	= 0.98420640 tons of 2240 lbs.	9.9930862
	1.10231117 tons of 2000 lbs.	0.0423042

Troy.

1 gramme (g.)	= 0.03215074248 ounce	8.5071910
	0.64301485 pennyweight	9.8082210

Apothecaries.

1 gramme (g.)	= 0.25721 drachm	9.4102809
	0.77162 scruple	9.8874022
	15.43235639 grains	1.1884322

Lineal Measure.

1 micron (μ.)	=.00003937 inch	5.5951667
1 millimetre (mm.)	=.0393870113 "	8.5951667
1 centimetre (cm.)	=.39370113 "	9.5951667
1 decimetre (dm.)	=3.9370113 inches	0.5951667
1 metre (m.)	= **39.370113 inches**	1.5951667
	3.2808427654 feet	0.5159855
	1.09361425513 yards	0.0388642
1 dekametre (dam.)	=10.93614255 yards	1.0388642
1 hectometre (hm.)	=109.3614255 "	2.0388642
1 kilometre (km.)	=0.62137173 mile	9.7933515
1 myriametre (Mm.)	=6.2137173 miles	0.7933515

Square Measure.

		Logarithm.
1 square millimetre ($mm.^2$)	=.001550 square inch	7.1903333
1 square centimetre ($cm.^2$)	=.1550006 „	9.1903333
1 square decimetre ($dm.^2$)	=15.50006 square inches	1.1903333
1 square metre ($m.^2$)	= **1550.005812 sq. inches**	3.1903333
	10.76392925 square feet	1.0319708
	1.195992139 sq. yards	0.0777283
1 are (sq. decametre) (a.—$dm.^2$)	= 119.5992139 square yards	2.0777283
1 hectare (ha.)	=**2.4710581385 acres**	0.3928830
1 square kilometre ($km.^2$)	=.386102834 square mile	9.5867030
1 square myriametre ($Mm.^2$)	=38.6102834 „ miles	1.5867030

Cubic Measure.

1 cubic millimetre ($mm.^3$)	=.000061 cubic inch	5.7855000
1 cubic centimetre ($cm.^3$)	=.0610239 „	8.7855000
1 cubic decimetre ($dm.^3$)	=61.0239 cubic inches	1.7855000
1 cubic metre or stere ($m.^3$ or s.)	= **61023.90426 cubic ins.**	4.7855000
	35.314759411 cubic feet	1.5479563
	1.30795405226 cub. yds.	0.1165925

Measures of Capacity.

1 millilitre (ml.)	=16.89411 minims	1.2277353
1 centilitre (cl.)	=.07039 gill	8.8475241
1 decilitre (dl.)	=.17598 pint	9.2454641
1 litre (l.)	= **1.75980 pints**	0.2454641
	.219975389 gallon	9.3423741
1 dekalitre (dal.)	=2.19975389 gallons	0.3423741
1 hectolitre (hl.)	=2.74969236 bushels	0.4392841
1 kilolitre (kl.)	=3.43711545 quarters	0.5361941

BRITISH IMPERIAL TO METRIC.

Weight.

Avoirdupois.	*Metric.*	*Logarithm.*
1 grain	=64.79891824 milligrams	1.8115678
1 drachm	=1.77185 grammes	0.5897191
1 ounce	=28.34953 „	1.4525458
1 pound	= **453.5924277 grammes**	2.6566658
	.4535924277 kilogram	9.6566658
1 stone	=6.35029 kilograms	0.8027938
1 quarter	=12.70059 „	1.1038238
1 cental (100 lbs.)	=45.35924277 „	1.6566658
1 hundredweight	=50.802352 „	1.7058838
1 'short' ton of 2000 lbs.	=0.90718486 tonne	9.9576958
1 'long' ton of 2240 lbs.	=1.01604704 tonnes	0.0069138

Troy.	*Metric.*	*Logarithm.*
1 grain	=64.79891824 milligrams	1.8115678
1 pennyweight	=1.555174 grammes	0.1917790
1 ounce	=31.1034807566 grammes	1.4928090

Apothecaries.	*Metric.*	*Logarithm.*
1 grain	=64.79891824 milligrams	1.8115678
1 scruple	=1.29598 grammes	0.1125978
1 drachm	=3.88794 grammes	0.5897191
1 ounce	=31.1034807566 grammes	1.4928090

Lineal Measure.

1 inch	=25.39997 millimetres	1.4048333
1 foot	=.30479973 metre	9.4840145
1 yard	**=.9143992 metre**	9.9611358
1 pole	=5.0291956 metres	0.7014985
1 chain	=20.116782 "	1.3035585
1 furlong	=201.16782 "	2.3035585
1 statute mile	=1.60934259 kilometres	0.2066485

Square Measure.

1 square inch	=6.45158871 square centimetres	0.8096667
1 square foot	=.092902877 square metre	8.9680292
1 square yard	=.8361259 "	9.9222717
1 square perch	=25.2928084 square metres	1.4029970
1 rood	=1011.712335 "	3.0050570
1 acre	**=.404684934 hectare**	9.6071170
1 square mile	=2.5899835784 square kilometres	0.4132970

Cubic Measure.

1 cubic inch	=16.387021 cubic centimetres	1.2145000
1 cubic foot	=.02831677 cubic metre	8.4520437
1 cubic yard	**=.76455285** "	9.8834075

Measures of Capacity.

Imperial.	*Metric.*	*Logarithm.*
1 gill	=1.42061 decilitres	0.1524759
1 pint	=.56825 litre	9.7545359
1 quart	=1.13649 litres	0.0555659
1 gallon	**=4.5459631 litres**	0.6576259
1 peck	=9.091926 "	0.9586559
1 bushel	=3.63677 dekalitres	0.5607159
1 quarter	=2.9094164 hectolitres	0.4638059

Apothecaries.	*Metric.*	*Logarithm.*
1 minim	=.059192 millilitre	8.7722647
1 fluid drachm	=3.55153 millilitres	0.5504159
1 fluid ounce	=2.84123 centilitres	0.4535059
1 pint	=.56825 litre.	9.7545359
1 gallon	=4.5459631 litres	0.6576259

THE BOARD OF TRADE LEGAL EQUIVALENTS OF THE METRIC AND IMPERIAL WEIGHTS AND MEASURES FOR USE IN TRADE.*

METRIC TO BRITISH IMPERIAL.

Linear Measure.

1 millimetre (mm.) ($\frac{1}{1000}$ m.)	=0.03937 inch.
1 centimetre ($\frac{1}{100}$ m.)	=0.3937 "
1 decimetre ($\frac{1}{10}$ m.)	=3.937 inches.
1 metre (m.)	= **39.370113 inches.** **3.280843 feet.** **1.0936143 yards.**
1 dekametre (10 m.)	=10.936 yards
1 hectometre (100 m.)	=109.36 "
1 kilometre (1000 m.)	=0.62137 mile.

Square Measure.

1 square centimetre	=0.15500 square inch.
1 square decimetre (100 square centimetres)	=15.500 square inches.
1 square metre (100 square decimetres)	= 10.7639 square feet. 1.1960 square yards.
1 are (100 square metres)	=119.60 "
1 hectare (100 ares or 10,000 square metres)	=2.4711 acres.

Cubic Measure.

1 cubic centimetre	=0.0610 cubic inch.
1 cubic decimetre (1000 cubic centimetres)	=61.024 cubic inches.
1 cubic metre (1000 cubic decimetres)	= 35.3148 cubic feet. 1.307954 cubic yards.

Measures of Capacity.

1 centilitre ($\frac{1}{100}$ litre)	=0.070 gill.
1 decilitre ($\frac{1}{10}$ litre)	=0.176 pint.
1 litre	**=1.75980 pints.**
1 dekalitre (10 litres)	=2.200 gallons.
1 hectolitre (100 litres)	=2.75 bushels.

*These equivalents were legalised by Order in Council of May 19, 1898
(For the Scientific Equivalents see page 33.)

Weight.

Metric.	*Avoirdupois.*
1 milligram ($\frac{1}{1000}$ grm.)	=0.015 grain.
1 centigram ($\frac{1}{100}$ grm.)	=0.154 "
1 decigram ($\frac{1}{10}$ grm.)	=1.543 grains.
1 gramme (1 grm.)	=15.432 "
1 dekagram (10 grm.)	=5.644 drams.
1 hectogram (100 grm.)	=3.527 ounces.
1 kilogram (1000 grm.)	= **2.2046223 pounds or 15432.3564 grains.**
1 myriagram (10 kilog.)	=22.046 pounds.
1 quintal (100 kilog.)	=1.968 hundredweights.
1 tonne (1000 kilog.)	=0.9842 ton.

Metric.	*Troy.*
1 gramme (1 grm.)	= 0.03215 ounce. 15.432 grains.

Metric.	*Apothecaries.*
1 gramme (1 grm.)	= 0.2572 drachm. 0.7716 scruple. 15.432 grains.

BRITISH IMPERIAL TO METRIC.

Linear Measure.

1 inch	=25.400 millimetres.
1 foot (12 in.)	=0.30480 metre.
1 yard (3 ft.)	=**0.914399 metre.**
1 fathom (6 ft.)	=1.8288 metres.
1 pole ($5\frac{1}{2}$ yds.)	=5.0292 "
1 chain (22 yds.)	=20.1168 "
1 furlong (220 yds.)	=201.168 "
1 mile (8 furlongs)	=1.6093 kilometres.

Square Measure.

1 square inch	=6.4516 square centimetres.
1 square foot (144 sq. ins.)	=9.2903 square decimetres.
1 square yard (9 sq. ft.)	=0.836126 square metre.
1 perch ($30\frac{1}{4}$ sq. yds.)	=25.293 square metres.
1 rood (40 perches)	=10.117 ares.
1 acre (4840 sq. yds.)	=0.40468 hectare.
1 square mile (640 acres)	=259.00 hectares.

Cubic Measure.

1 cubic inch	=16.387 cubic centimetres.
1 cubic foot (1728 cub. ins.)	=0.028317 cubic metre.
1 cubic yard (27 cub. ft.)	=0.764553 „

Measures of Capacity.

Imperial.	*Metric.*
1 gill	=1.42 decilitres.
1 pint (4 gills)	=0.568 litre.
1 quart (2 pints)	=1.136 litres.
1 gallon (4 quarts)	=**4.5459631 litres.**
1 peck (2 gallons)	=9.092 litres.
1 bushel (8 gallons)	=3.637 dekalitres.
1 quarter (8 bushels)	=2.909 hectolitres.

Apothecaries.	*Metric.*
1 minim	=0.059 millilitre.
1 fluid scruple	=1.184 millilitres.
1 fluid drachm (60 minims)	=3.552 „
1 fluid ounce (8 drachms)	=2.84123 centilitres.
1 pint	=0.568 litre.
1 gallon (8 pints or 160 fluid oz.)	=**4.5459631 litres.**

Weight.

Avoirdupois.	*Metric.*
1 grain	=0.0648 gramme.
1 dram	=1.772 grammes.
1 ounce (16 drams)	=28.350 „
1 pound (16 oz. or 7000 grains)	=**0.45359243 kilogram.**
1 stone (14 lbs.)	=6.350 kilograms.
1 quarter (28 lbs.)	=12.70 „
1 hundredweight (cwt.) (112 lb.)	={ 50.80 „ / 0.5080 quintal.
1 ton (20 cwt.)	={ 1.0160 tonnes or / 1016 kilograms.

Troy.	*Metric.*
1 grain	=0.0648 gramme.
1 pennyweight (24 grains)	=1.5552 grammes.
1 troy ounce (20 pennyweights)	=31.1035 „

Apothecaries.	*Metric.*
1 grain	=0.0648 gramme.
1 scruple (20 grains)	=1.296 grammes.
1 drachm (3 scruples)	=3.888 „
1 ounce (8 drachms)	=31.1035 „

COMPARISON OF UNITED STATES AND BRITISH IMPERIAL WEIGHTS AND MEASURES.

Lineal Measure.

United States and British Imperial Measures of length are practically the same, as 1 U.S. unit = 1.000002875 Imp. units of the same denomination, a difference of 2.875 in a million.

Square Measure.

1 U.S. unit = 1.00000575 Imp. units, a difference of 5.75 in a million.

Cubic Measure.

1 U.S. unit = 1.000008625 Imp. units, a difference of 8.625 in a million.

Measures of Capacity.

Liquid.

1 U.S. liquid gallon	= 0.83270 Imp. gallon.	log = 9.9204898
1 Imp. gallon	= 1.20091 U.S. liquid gallons.	log = 0.0795102

Dry.

1 U.S. bushel	= 0.96897 Imp. bushel.	log = 9.9863111
1 Imp. bushel	= 1.03202 U.S. bushels.	log = 0.0136889

Weights.

No difference.

EQUIVALENTS OF UNITED STATES AND METRIC WEIGHTS AND MEASURES AS PUBLISHED BY THE U.S. BUREAU OF STANDARDS, WASHINGTON.*

Measures of Length.

Basis: 1 meter = 39.37 inches.

1 U.S. inch	= 25.4000508 millimeter.	log = 1.4048346
1 U.S. foot	= 0.3048006096 meter.	log = 9.4840158
1 U.S. yard	= 0.9144018288 meter.	log = 9.9611371
1 U.S. mile	= 1.609347219 kilometers.	log = 0.2066497
1 millimeter	= 0.03937 U.S. inch.	log = 8.5951654
1 meter	= 3.280833 U.S. feet.	log = 0.5159842
1 kilometer	= 0.6213699495 U.S. mile.	log = 9.7933503

* *Tables of Equivalents*, Washington, Nov. 1906. The U.S. *legal* equivalents are given on page 40.

Measures of Area.

1 U.S. acre	=0.4046872610 hectare.	log=9.6071196
1 hectare	=2.471043930 U.S. acres.	log=0.3928804

Measures of Volume.

1 U.S. cubic yard	=0.7645594453 cubic meter.	log=9.8834113
1 cubic meter	=1.307942772 U.S. cubic yards.	log=0.1165887

Measures of Capacity.

Liquid.

Basis: 1 U.S. liquid gallon=231 cubic inches, and 1 cubic decimeter=1 liter.

1 U.S. liquid gallon	=3.785434497 liters.	log=0.5781157
1 liter	=0.2641704673 U.S. liquid gall.	log=9.4218843

Dry.

Basis: 1 U.S. bushel=2150.42 cubic inches, and 1 cubic decimeter=1 liter.

1 U.S. bushel	=0.3523928160 hectoliter.	log=9.5470270
1 hectoliter	=2.837742299 U.S. bushels.	log=0.4529730

Weights.

Basis: 1 avoirdupois pound=453.5924277 grams.

The equivalents are therefore the same as those given for British Imperial Weights on pages 33 and 34.

THE EQUIVALENTS OF THE METRIC WEIGHTS AND MEASURES LEGALISED IN THE UNITED STATES BY THE ACT OF JULY 28th, 1866.*

Measures of Length.

Metric denominations and values.		Equivalents in denominations in use.
Myriameter - -	10,000 meters.	6.2137 miles.
Kilometer - -	1,000 meters.	0.62137 miles or 3280 feet and 10 inches.
Hectometer - - -	100 meters.	328 feet and 1 inch.
Dekameter - - -	10 meters.	393.7 inches.
Meter - - - - - -	1 meter.	39.37 inches.
Decimeter - -	$\frac{1}{10}$ of a meter.	3.937 inches.
Centimeter - -	$\frac{1}{100}$ of a meter.	0.3937 inch.
Millimeter - -	$\frac{1}{1000}$ of a meter.	0.0394 inch.

*(The scientific equivalents published by the Bureau of Standards, Washington, are given on page 39.)

Measures of Surface.

Metric denominations and values.		Equivalents in denominations in use.
Hectare - - -	10,000 square meters.	2.471 acres.
Are - - - - - -	100 square meters.	119.6 square yards.
Centiare - - - - - -	1 square meter.	1,550 square inches.

Measures of Capacity.

Metric denominations and values.			Equivalents in denominations in use.	
Names.	Number of liters.	Cubic Measure.	Dry Measure.	Liquid or Wine Measure.
Kiloliter or stere	1,000	1 cubic metre	1.308 cubic yards	264.17 gallons.
Hectoliter	100	1/10 of a cubic meter	2 bushels and 3.35 pecks	26.417 gallons.
Dekaliter	10	10 cubic decimeters	9.08 quarts	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quart	1.0567 quarts.
Deciliter	1/10	1/10 of a cubic decimeter	6.1022 cub. inches	0.845 gill.
Centiliter	1/100	10 cubic centimeters	0.6102 cubic inch	0.338 fluid ounce.
Milliliter	1/1000	1 cubic centimeter	0.061 cubic inch	0.27 fluid dram.

Weights.

Metric denominations and values.			Equivalents in denominations in use.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois Weight.
Millier or tonneau	1,000,000	1 cubic meter	2204.6 pounds.
Quintal - - - -	100,000	1 hectoliter	220.46 pounds.
Myriagram - - -	10,000	10 liters	22.046 pounds.
Kilogram or kilo -	1,000	1 liter	2.2046 pounds.
Hectogram - - -	100	1 deciliter	3.5274 ounces.
Dekagram - - -	10	10 cubic centimeters	0.3527 ounce.
Gram - - - -	1	1 cubic centimeter	15.432 grains.
Decigram - - -	1/10	1/10 of a cub. centimeter	1.5432 grains.
Centigram - - -	1/100	10 cubic millimeters	0.1543 grain.
Milligram - - -	1/1000	1 cubic millimeter	0.0154 grain.

EQUIVALENTS OF THE RUSSIAN WEIGHTS AND MEASURES.

Commercial Weight.

Russian.	*Metric.*	*British.*
1 doli	= 44.43494 milligrams	= .6857358 grain.
1 zolotnik	= 4.26575427 grammes	= 65.83064 grains.
1 funt	= **.40951241 kilogram** **409.51241 grammes** **409512.41 milligrams**	= **.902820208 lbs. avoir.** **13.1661280 oz. troy.** **6319.741457 grains.**
1 pood	= .0163804964 tonne 16.3804964 kilograms	= .01612178943 tons of 2240 lbs. .01805640416 tons of 2000 lbs. 36.112808327 lbs. avoir. 526.6451214 oz. troy.

Apothecaries' Weight.

Russian.	*Metric.*	*British.*
1 medical grain	= 62.20892 milligrams	= .96003017 grain.
1 medical drachme	= 3.732535 grammes	= 57.60181 grains.
1 medical once	= 29.860280 „	= .96003017 oz. apoth.
1 medical funt	= 358.323359 „	= 11.5203620 „

Metric.	*Russian.*	*Logarithm.*
1 milligram	= .0225048 doli	8.3522754
1 gramme	= .23442513 zolotnik	9.3700042
	16.074866 medical grains	1.2061474
1 kilogram	= **.061048211 pood**	8.7856729
	2.44192844 funts	0.3877330
	234.42513 zolotniks	2.3700042
	22504.8125 dolis	4.3522754
1 metric quintal	= 244.192844 funts	2.3877330
1 tonne	= 61.04821097 poods	1.7856729

British.	*Russian.*	*Logarithm.*
1 grain	= 1.4582875 dolis	0.1638432
1 ounce troy	= 7.2914375 zolotniks	0.8628132
1 pound avoir.	= **.027691006 pood**	8.4423387
	1.10764025 funts	0.0443987
	106.333464 zolotniks	2.0266700
1 hundredweight	= 124.055708 funts	2.0936168
1 'short' ton (2000 lbs.)	= 55.38201244 poods	1.7433687
1 'long' ton (2240 lbs.)	= 62.02785393 poods	1.7925868

Lineal Measure.

Russian.	*Metric.*	*British.*
1 totchka	=254 microns	=.01 inch.
1 liniia	=2540 microns	=.1 inch.
1 vershok	=44.45 millimetres	=1.75 inches.
1 archine	**=.71120 metre**	**=2 feet 4 inches.**
1 sagene	=2.13360 metres	=7 feet.
1 verst	=1.06680 kilometres	=$.662\dot{8}\dot{7}$ mile.

Metric.	*Russian.*	*Logarithm.*
1 metre	= 1.40607424 archines	1.1480082
	22.49718785 vershoks	1.3521282
1 kilometre	=.9373828 verst	9.9719170

British.	*Russian.*	*Logarithm.*
1 inch	=10 liniias.	
1 foot	=$6.\dot{8}5714\dot{2}$ or $6\frac{6}{7}$ vershoks	0.8361432
1 yard	= $.00\dot{8}5714\dot{2}$ or $\frac{6}{7000}$ verst	7.9330532
	$1.\dot{2}8571\dot{4}$ or $1\frac{2}{7}$ archines	0.1091444
1 chain	=$9.\dot{4}2857\dot{1}$ or $9\frac{3}{7}$ sagenes	0.9744459
1 mile	=$1.50\dot{8}5714\dot{2}$ versts	0.1785659

Square Measure.

Russian.	*Metric.*	*British.*
1 square sagene	=4.55224896 square metres	=49 square feet.
1 dessiatina	=1.09253975 hectares	=2.6997245 acres.
1 square verst	=1.13806224 square kilometres	=.43940829 sq. mile.

Metric.	*Russian.*	*Logarithm.*
1 square metre	=1.97704477 square archines	0.2960165
1 hectare	=.9152985 dessiatina	9.9615628
1 sq. kilometre	=.87868656 square verst	9.9438340

British.	*Russian.*	*Logarithm.*
1 square foot	=47.0204 square vershoks	1.6722864
1 square yard	=.18367347 square sagene	9.2640464
1 acre	=.370408163 dessiatina	9.5686806
1 square mile	=2.2757878 square versts	0.3571318

Cubic Measure.

Russian.	*Metric.*	*British.*
1 cubic vershok	=87.8244 cubic centimetres	=5.359375 cubic inches.
1 cubic archine	=.3597288 cubic metre	=$12.\dot{7}0\dot{3}$ cubic feet.
1 cubic sagene	=9.7126784 cubic metres	=$12.\dot{7}0\dot{3}$ cubic yards.

Metric.	*Russian.*	*Logarithm.*
1 cubic centimetre	=.0113864 cubic vershok	8.0563848
1 cubic decimetre	=.00277987 cubic archine	7.4440248
1 cubic metre (stere)	=.10295821 cubic sagene	9.0126610

British.	*Russian.*	*Logarithm.*
1 cubic inch	=1000 cubic liniias.	
1 cubic foot	=.0787172 cubic archine	8.8960696
1 cubic yard	=.0787172 cubic sagene	8.8960696

Liquid Measure.

Russian.	*Metric.*	*British.*
1 tcharka	=.1229933 litre	=.216444 pint.
1 schtoff	=1.22993285 litres	=2.16444 pints.
1 vedro	**=12.2993285 litres**	**=2.70555 gallons.**
1 boutylka (bottle of wine)	=.76870803 litre	=1.352775 pints.
1 boutylka (bottle)	=.6149664 „	=1.08222 „

Dry Measure.

Russian.	*Metric.*	*British.*
1 garnetz	=3.27982093 litres	=.721480 gallon.
1 tchetverik	**=26.2385674 litres**	**=.721480 bushel.**
1 tchetvert	=2.09908539 hectolitres	=5.77184 bushels.
1 last	=25.18902473 „	=8.65776 quarters.
1 cubic sagene	=97.1242585 „	={267.061832 bushels. 2136.49465 gallons.

Metric.	*Russian.*	*Logarithm.*
1 litre	**={0.8130525 schtoff**	9.9101186
	1.300884 boutylkas of wine	0.1142386
1 hectolitre	={3.81118368 tchetveriks	0.5810599
	8.130525184 vedros	0.9101186
1 cubic metre (stere)	={38.110846 tchetveriks	1.5810486
	81.303138 vedros	1.9101073

British.	*Russian.*	*Logarithm.*
1 gallon	**={0.3696107 vedro**	9.5677445
	1.386040 garnetz	0.1417757
1 bushel	={1.386040 tchetveriks	0.1417757
	11.08832 garnetz	1.0448657
1 cubic foot	={1.0791790 tchetveriks	0.0330935
	2.3022485 vedros	0.3621522
	8.6334318 garnetz	0.9361835

Table for the conversion of Russian Vershoks into British Feet.

Vershoks.	Feet.	Vershoks.	Feet.	Vershoks.	Feet.	Vershoks.	Feet.
1	$0.1458\dot{3}$	5	$0.7291\dot{6}$	9	1.3125	13	$1.8958\dot{3}$
2	$0.291\dot{6}$	6	0.875	10	$1.458\dot{3}$	14	$2.041\dot{6}$
3	0.4375	7	$1.0208\dot{3}$	11	$1.6041\dot{6}$	15	2.1875
4	$0.58\dot{3}$	8	$1.1\dot{6}$	12	1.75	16	$2.\dot{3}$

Table for the conversion of Russian Archines into British Feet.

Archines.	Feet.	Archines.	Feet.	Archines.	Feet.	Archines.	Feet.
1	$2.\dot{3}$	31	$72.\dot{3}$	61	$142.\dot{3}$	91	$212.\dot{3}$
2	$4.\dot{6}$	32	$74.\dot{6}$	62	$144.\dot{6}$	92	$214.\dot{6}$
3	7.0	33	77.0	63	147.0	93	217.0
4	$9.\dot{3}$	34	$79.\dot{3}$	64	$149.\dot{3}$	94	$219.\dot{3}$
5	$11.\dot{6}$	35	$81.\dot{6}$	65	$151.\dot{6}$	95	$221.\dot{6}$
6	14.0	36	84.0	66	154.0	96	224.0
7	$16.\dot{3}$	37	$86.\dot{3}$	67	$156.\dot{3}$	97	$226.\dot{3}$
8	$18.\dot{6}$	38	$88.\dot{6}$	68	$158.\dot{6}$	98	$228.\dot{6}$
9	21.0	39	91.0	69	161.0	99	231.0
10	$23.\dot{3}$	40	$93.\dot{3}$	70	$163.\dot{3}$	100	$233.\dot{3}$
11	$25.\dot{6}$	41	$95.\dot{6}$	71	$165.\dot{6}$	200	$466.\dot{6}$
12	28.0	42	98.0	72	168.0	300	700.0
13	$30.\dot{3}$	43	$100.\dot{3}$	73	$170.\dot{3}$	400	$933.\dot{3}$
14	$32.\dot{6}$	44	$102.\dot{6}$	74	$172.\dot{6}$	500	$1166.\dot{6}$
15	35.0	45	105.0	75	175.0	600	1400.0
16	$37.\dot{3}$	46	$107.\dot{3}$	76	$177.\dot{3}$	700	$1633.\dot{3}$
17	$39.\dot{6}$	47	$109.\dot{6}$	77	$179.\dot{6}$	800	$1866.\dot{6}$
18	42.0	48	112.0	78	182.0	900	2100.0
19	$44.\dot{3}$	49	$114.\dot{3}$	79	$184.\dot{3}$	1000	$2333.\dot{3}$
20	$46.\dot{6}$	50	$116.\dot{6}$	80	$186.\dot{6}$	1100	$2566.\dot{6}$
21	49.0	51	119.0	81	189.0	1200	2800.0
22	$51.\dot{3}$	52	$121.\dot{3}$	82	$191.\dot{3}$	1300	$3033.\dot{3}$
23	$53.\dot{6}$	53	$123.\dot{6}$	83	$193.\dot{6}$	1400	$3266.\dot{6}$
24	56.0	54	126.0	84	196.0	1500	3500.0
25	$58.\dot{3}$	55	$128.\dot{3}$	85	$198.\dot{3}$	1600	$3733.\dot{3}$
26	$60.\dot{6}$	56	$130.\dot{6}$	86	$200.\dot{6}$	1700	$3966.\dot{6}$
27	63.0	57	133.0	87	203.0	1800	4200.0
28	$65.\dot{3}$	58	$135.\dot{3}$	88	$205.\dot{3}$	1900	$4433.\dot{3}$
29	$67.\dot{6}$	59	$137.\dot{6}$	89	$207.\dot{6}$	2000	$4666.\dot{6}$
30	70.0	60	140.0	90	210.0		

Table for converting Russian Poods into avoirdupois pounds, 'short tons of 2000 lbs., 'long' tons of 2240 lbs., or tonnes of 1000 kilograms.

Poods.	Avoirdupois Pounds.	'Short' Tons of 2000 lbs.	'Long' Tons of 2240 lbs.	Tonnes of 1000 kilograms.
1	36.112808327	0.018056404	0.016121789	0.0163804964
2	72.225616654	0.036112808	0.032243579	0.0327609928
3	108.338424980	0.054169212	0.048365368	0.0491414892
4	144.451233307	0.072225617	0.064487158	0.0655219856
5	180.564041634	0.090282021	0.080608947	0.0819024820
6	216.676849961	0.108338425	0.096730737	0.0982829784
7	252.789658287	0.126394829	0.112852526	0.1146634748
8	288.902466614	0.144451233	0.128974315	0.1310439712
9	325.015274941	0.162507637	0.145096105	0.1474244676

A table for converting Russian weight into troy ounces is given on page 102.

EQUIVALENTS OF THE CHINESE WEIGHTS AND MEASURES.

Commercial Weight.

Chinese.	*Metric.*	*British.*
1 liang (tael or tahil)	= 37.799368975 grammes	= $1.\dot{3}$ or $1\frac{1}{3}$ oz. avoir.
1 chin (kan or kati)	= .6047899036 kilogram	= $1.\dot{3}$ or $1\frac{1}{3}$ lbs. avoir.
1 tan (tam or pikul)	= 60.47899036 kilograms	= $133.\dot{3}$,,

Silver Weight.

Chinese.	*Metric.*	*British.*
1 ssŭ	= .37799369 milligram	= $.0058\dot{3}$ grain.
1 hao	= 3.7799369 milligrams	= $.058\dot{3}$,,
1 li (cash)	= 37.799369 ,,	= $.58\dot{3}$,,
1 fên (candareen)	= 377.99369 ,,	= $5.8\dot{3}$ grains.
1 ch'ien (mace)	= 3.7799369 grammes	= $58.\dot{3}$,,
1 liang (tael)	= 37.799368975 ,,	= $583.\dot{3}$,,

Metric.	*Chinese.*	*Logarithm.*
1 milligram	= 2.6455468 ssŭ	0.4225155
1 gramme	= .026455468 liang	8.4225155
1 kilogram	= 1.653466757 chin	0.2183955
1 tonne	= 16.53466757 tan	1.2183955

British.	*Chinese.*	*Logarithm.*
1 grain	$=1.\dot{7}1428\dot{5}$ or $1\frac{5}{7}$ li	0.2340832
1 pound avoir.	=.75 or $\frac{3}{4}$ chin	9.8750613
1 short ton (2000 lbs.)	=15 tan	1.1760913
1 long ton (2240 lbs.)	=16.8 tan	1.2253093

Note.—Similar weights to the above, but bearing different names, are used in the Straits Settlements (see page 50).

Lineal Measure (*a*).

Basis: 1 ch'ih=14.1 inches.

(As adopted in the British Treaty of 1858, and used in the assessment of duties at the Foreign Maritime Customs.)

Chinese.	*Metric.*	*British.*
1 fan	$=3.5813968\dot{6}$ millimetres	=.141 inch.
1 ts'un	$=35.813968\dot{6}$,,	=1.41 inches.
1 ch'ih (covid)	$=.35813968\dot{6}$ metre	=1.175 feet.
1 chang (rod)	$=3.5813968\dot{6}$ metres	=11.75 ,,

Metric.	*Chinese.*	*Logarithm.*
1 millimetre	=.27922066 fan	9.4459475
1 metre	=2.792206609 ch'ih	0.4459475

British.	*Chinese.*	*Logarithm.*
1 inch	=.709219858 ts'un	9.8507809
1 foot	=.85106383 ch'ih	9.9299621
1 yard	=.25531915 chang	9.4070834

Lineal Measure (*b*).

Basis: 1 chek or ch'ih=$14\frac{5}{8}$ inches.

(This is the Hong Kong standard chek or ch'ih, as verified by the Board of Trade.)

Chinese.	*Metric.*	*British.*
1 fan	=3.71474675 millimetres	=.14625 inch.
1 ts'un	=37.1474675 ,,	=1.4625 inches.
1 chek or ch'ih	=.371474675 metre	=1.21875 feet.

Metric.	*Chinese.*	*Logarithm.*
1 millimetre	=.269197355 fan	9.4300708
1 metre	=2.69197355 chek or ch'ih	0.4300708

British.	*Chinese.*	*Logarithm.*
1 inch	$=.\dot{6}8376\dot{0}$ ts'un	9.8349041
1 foot	$=.\dot{8}2051\dot{2}$ chek or ch'ih	9.9140853
1 yard	$=2.\dot{4}6153\dot{8}$,,	0.3912066

EQUIVALENTS OF THE JAPANESE WEIGHTS AND MEASURES.

Weight.

Japanese.	*Metric.*	*British.*
1 mô	= 3.75 milligrams	=.05787 grain.
1 rin	=.0375 gramme	=.5787 grain.
1 fun	= .375 gramme	=5.787 grains.
1 mommē	= 3.75 grammes	=57.8713365 grains.
1 kin	= 600 grammes	=1.3227734 lbs. avoir.
1 kwan	= 3.75 kilograms	=8.26733378 lbs. avoir.

Metric.	*Japanese.*	*Logarithm.*
1 milligram	$=.2\dot{6}$ mô	9.4259687
1 gramme	$=.2\dot{6}$ mommē	9.4259687
1 kilogram	$=1.\dot{6}$ or $1\frac{2}{3}$ kin	0.2218487
	$=.2\dot{6}$ kwan	9.4259687

British.	*Japanese.*	*Logarithm.*
1 grain	=17.27971153 mô	1.2375365
1 lb. avoir.	=.75598738 kin	9.8785145
	=.12095798 kwan	9.0826345

Lineal Measure.

Japanese.	*Metric.*	*British.*
1 mô	$=\frac{1}{33}$ or $.\dot{0}\dot{3}$ millimetre	=.001193 inch.
1 rin	$=\frac{10}{33}$ or $.\dot{3}\dot{0}$ millimetre	=.01193 inch.
1 bu	$=\frac{10}{33}$ or $.\dot{0}\dot{3}$ centimetre	=.11930337 inch.
1 sun	$=\frac{1}{33}$ or $.\dot{0}\dot{3}$ metre	=1.1930337 inches.
1 shaku	$=\frac{10}{33}$ or $.\dot{3}\dot{0}$ metre	=.9941948 foot.
1 ken	$=\frac{20}{11}$ or $1.\dot{8}\dot{1}$ metres	=1.98839 yards.
1 chô	$=\frac{1200}{11}$ or $109.\dot{0}\dot{9}$ metres	=119.30337 yards.
1 ri	$=\frac{432}{110}$ or $3.9\dot{2}\dot{7}$ kilometres	=2.440296 statute miles.
1 kujira shaku (cloth measure)	$=\frac{25}{66}$ or $.3\dot{7}\dot{8}$ metre	=1.24274 feet.

Metric.	*Japanese.*	*Logarithm.*
1 millimetre	=33 mô	1.5185139
1 metre	=3.3 shaku	0.5185139
1 kilometre	$=.2546\dot{2}9\dot{6}$ ri	9.4059090

British.	*Japanese.*	*Logarithm.*
1 inch	=.838199 sun	9.9233473
1 foot	=1.005839 shaku	0.0025285
1 yard	=3.017517 shaku	0.4796498
1 mile	=.4097863 ri	9.6125575

Square Measure.

Japanese.	*Metric.*	*British.*
1 shaku	=.03306 square metre	=.3558 square foot.
1 gô	=.3305785 square metre	=3.558324 square feet.
1 bu or tsubo	=3.3057851 square metres	=3.953693 square yards.
1 sē	=.99173554 are	=39.53693 square yards.
1 tan	=.099173554 hectare	=.245064 acre.
1 chô	=.991735537 hectare	=2.45064 acres.

Metric.	*Japanese.*	*Logarithm.*
1 square metre	=.3025 tsubo	9.4807254
1 are	=30.25 tsubo	1.4807254
1 hectare	=1.0083 chô	0.0036041

British.	*Japanese.*	*Logarithm.*
1 square foot	=.281031 gô	9.4487545
1 square yard	=.2529277 tsubo	9.4029971
1 acre	=.40805667 chô	9.6107205

Measures of Capacity.

Japanese.	*Metric.*	*British.*
1 shaku	=.01804 litre	=.12698 gill.
1 gô	=.18039 litre	=.3174515 pint.
1 shô	=1.8039068 litres	=3.174515 pints.
1 to	=18.039068 litres	=3.968144 gallons.
1 koku	=1.8039068 hectolitres	=4.96018 bushels.

Metric.	*Japanese.*	*Logarithm.*
1 centilitre	=.5543524 shaku	9.7437859
1 litre	=.5543524 shô	9.7437859
1 hectolitre	=.5543524 koku	9.7437859

British.	*Japanese.*	*Logarithm.*
1 pint	=3.15008 gô	0.4983218
1 gallon	=2.5200654 shô	0.4014118
1 bushel	=.2016052 koku	9.3045018

EQUIVALENTS OF THE INDIAN WEIGHTS.

Indian.	*Metric.*		*British.*
1 tola	**=11.66380528 grammes**	=	**180 grains.**
1 seer	=.933104423 kilogram	=	$2.0\dot{5}7142\dot{8}$ lbs. avoir.
1 maund	=37.3241769 kilograms	=	$82.\dot{2}8571\dot{4}$,,
1 kandy	=.746483538 tonne	=	$1645.\dot{7}1428\dot{5}$,, $.82\dot{2}8571\dot{4}$ short ton (2000 lbs.). .7346939 long ton (2240 lbs.).
1 Burmese tikal	=16.55612361 grammes	=	255.5 grains.
1 ,, viss	=1.655612361 kilograms	=	3.65 lbs. avoir.

Metric.	*Indian.*	*Logarithm.*
1 gramme =	.0857353133 tola	8.9331598
	.0604006121 Burmese tikal	8.7810413
1 kilogram =	1.071691416 seers	0.0300697
	.604006121 Burmese viss	9.7810413
1 tonne =	1.33961427 kandy	0.1269797

British.	*Indian.*	*Logarithm.*
1 pound avoir. =	$38.\dot{8}$ tolas	1.5898256
	$.486\dot{1}$ seer	9.6867356
	.2739726 Burmese viss	9.4377071
1 short ton (2000 lbs.) =	$1.2152\dot{7}$ kandy	0.0846756
1 long ton (2240 lbs.) =	$1.36\dot{1}$ kandy	0.1338936

EQUIVALENTS OF THE STRAITS SETTLEMENTS WEIGHTS.

Straits Settlements.	*Metric.*		*British.*
1 hoon (candareen)	=377.99369 milligrams	=	$5.8\dot{3}$ grains.
1 chee (mace)	=3.7799369 grammes	=	$58.\dot{3}$,,
1 tahil (tael)	=37.799368975 ,,	=	$583.\dot{3}$,, or $1\frac{1}{3}$ oz. avoir.
1 kati (kan)	=.6047899036 kilogram	=	$1.\dot{3}$ or $1\frac{1}{3}$ lbs. avoir.
1 pikul (tam)	=60.47899036 kilograms	=	$133.\dot{3}$,,
1 koyan	=2.4191596144 tonnes	=	$5333.\dot{3}$,, $2.\dot{6}$ or $2\frac{2}{3}$ short tons (2000 lbs.). $2.\dot{3}8095\dot{2}$ long tons (2240 lbs.).

Metric.	*Straits Settlements.*	*Logarithm.*
1 milligram	=.002645547 hoon	7.4225155
1 gramme	=.02645546 8 tahil	8.4225155
1 kilogram	=1.653466757 kati	0.2183955
1 tonne	=.413366689 koyan	9.6163355

British.	*Straits Settlements.*	*Logarithm.*
1 grain	=$.\dot{1}71428\dot{5}$ or $\frac{12}{70}$ hoon	9.2340832
1 pound avoir.	=.75 or $\frac{3}{4}$ kati	9.8750613
1 short ton (2000 lbs.)	=.375 or $\frac{3}{8}$ koyan	9.5740313
1 long ton (2240 lbs.)	=.42 koyan	9.6232493

Note.—Similar weights to the above, but bearing different names, are used in China (see page 46.)

EQUIVALENTS OF THE CAPE (S. AFRICA) MEASURES.

Lineal Measure.

		Logarithm.
1 Cape foot	=1.033 British feet	=0.0141003
	=$0.3148581245\dot{3}$ metre	=9.4981149.
1 Cape rood	=12.396 British feet	=1.0932816
	=3.77829749440 metres	=0.5772961.
1 metre	=3.1760336548 Cape feet	=0.5018851
	=0.26466947123 Cape rood	=9.4227039.
1 British foot	=0.96805421036 Cape foot	=9.9858997
	=0.08067118425 3 Cape rood	=8.9067184
1 statute mile	=425.9438528557 Cape roods	=2.6293523.

Square Measure.

		Logarithm.
1 square Cape rood	=0.0035275669 acre	=7.5474752.
1 morgen	=0.85653191734 hectare	=9.9327435
	=2.1165401652 acres	=0.3256265.
1 hectare	=1.1674988166 morgen	=0.0672565.
1 acre	=40821.337301762 square Cape feet	=4.6108872
	=283.48150904 square Cape roods	=2.4525247
	=0.4724691817 morgen	=9.6743734.
1 square mile	=302.3802763093 morgen	=2.4805535

LEGAL EQUIVALENTS* OF THE EGYPTIAN WEIGHTS AND MEASURES.

(Legalised by a decree issued by the Khedive on the 28th April, 1891, with effect from the 1st of January, 1892.)

Commercial Weight.

Egyptian.	*Metric.*	*British.*
1 dirhem	=3.12 grms.	=48.148928 grains.
1 okieh	=37.44 grms.	=1.320656 oz. avoir.
1 rotl or rottolo	=449.28 grms.	=.990492 lb. avoir.
1 oke	=1.248 kilog.	=2.751367 lbs. avoir.
1 kantar	=44.928 kilog.	= { 99.049223 lbs. avoir. .0495246 short ton (2000 lbs.). .0442184 long ton (2240 lbs.).
1 hamlah	=74.880 kilog.	= { 165.082039 lbs. avoir. .08254102 short ton (2000 lbs.). .07369734 long ton (2240 lbs.).
1 Alexandria kantar	=139.776 kilog.	= { 308.153139 lbs. avoir. .15407657 short ton (2000 lbs.). .1375684 long ton (2240 lbs.).
1 heml	=249.60 kilog.	= { 550.273463 lbs. avoir. .27513673 short ton (2000 lbs.). .2456578 long ton (2240 lbs.).

Jewellers' Weight.

Egyptian.	*Metric.*	*British.*
1 kamha	=48.75 milligrams	=.752327 grain.
1 kirat	=.195 gramme	=3.009308 grains.
1 dirhem	=3.12 grammes	=48.148928 grains.
1 mithkal	=4.68 grammes	=72.223392 grains.

Metric.	*Egyptian.*	*Logarithm.*
1 gramme	=5.1282 kirats	0.7099654
	=.32051282 dirhem	9.5058454
1 kilogram	=2.2257835 rotls	0.3474829
	=.801282 oke	9.9037854
	=.022257835 kantar	8.3474829
1 tonne	=4.0064103 hemls	0.6027554

British.	*Egyptian.*	*Logarithm.*
1 grain	=.3323023 kirat	9.5215333
	=.0207689 dirhem	8.3174133
1 oz. troy	=9.969067 dirhems	0.9986545
1 lb. avoir.	=1.00960 rotls	0.0041489
1 short ton (2000 lbs.)	=20.1920 kantars	1.3051789
1 long ton (2240 lbs.)	=22.6150 kantars	1.3543969
	=4.0707 hemls	0.6096695

* The relation of the British Imperial to the Metric equivalents given in these tables is not quite accurate, as will be seen by reference to page 14.

Lineal Measure.

Egyptian.	*Metric.*	*British.*
1 diraâ baladi	=0.580 metre	= { 22.835058 inches. / 1.9029215 feet.
1 diraâ mimari	=0.750 metre	= { 29.5281 inches. / 2.460675 feet.
1 pike istambuli	=0.665 metre	=2.18176 feet.
1 kassabah	=3.550 metres	= { 139.766304 inches. / 11.647192 feet.

Metric.	*Egyptian.*	*Logarithm.*
1 metre	=1.724138 diraâs baladi	0.2365720
	=1.$\dot{3}$ or 1⅓ diraâs mimari	0.1249387
	=1.50376 pikes istambuli	0.1771784
	=.28169 kassabah	9.4497716

British.	*Egyptian.*	*Logarithm.*
1 foot	=.525508 diraâ baladi	9.7205791
	=.4063926 diraâ mimari	9.6089458
	=.4583455 pike istambuli	9.6611930
	=.0858576 kassabah	8.9337787
1 yard	=.2575728 kassabah	9.4109000

Square Measure.

Egyptian.	*Metric.*	*British.*
1 square diraâ baladi	=.3364 square metre	=3.62111 square feet.
1 square diraâ mimari	=.5625 square metre	=6.05492 square feet.
1 square kassabah	=12.6025 square metres	=15.073009 sq. yards.
1 feddan	=.42008$\dot{3}$ hectare	=1.038086 acres.*

Metric.	*Egyptian.*	*Logarithm.*
1 square metre	=2.97265 square diraâs baladi	0.4731440
	=1.$\dot{7}$ or 1$\frac{7}{9}$ square diraâs mimari	0.2498775
	=.079349 square kassabah	8.8995433
1 hectare	=2.380480 feddans	0.3766646

British.	*Egyptian.*	*Logarithm.*
1 square foot	=.27615845 square diraâ baladi	9.4411582
	=.165155 square diraâ mimari	9.2178916
1 square yard	=.06634374 square kassabah	8.8218000
1 acre	=.9633113 feddan.	9.9837667

* From the equivalent given on page 34, .42008$\dot{3}$ hectare=1.03805 acres.

Measures of Capacity.

Egyptian.	*Metric.*	*British.*
1 kirat	=.06445 litre	=.453949 gill.
1 karrūbah	=.1289 litre	=.9079 gill.
1 tūmnah	=.2578 litre	=1.815797 gills.
1 rūbaah	=.515625 litre	=.9079 pint.
1 nesf kadah	=1.03125 litres	=1.815797 pints.
1 kadah	=2.0625 litres	=3.631595 pints.
1 malwa	=4.125 litres	=3.631595 quarts.
1 rūb	=8.25 litres	=1.815797 gallons.
1 kilah	=16.5 litres	=3.631595 gallons.
1 webah	=33.0 litres	=7.26319 gallons.
1 ardeb	=1.98 hectolitres	= { 43.579136 gallons.* 5.447392 bushels.

Metric.	*Egyptian.*	*Logarithm.*
1 hectolitre	=.5̇0̇ ardeb	9.7033348
1 litre	=.3̇0̇ webah	8.4814861
	=.6̇0̇ kilah	8.7825161
	=.1̇2̇ rūb	9.0835461
	=.2̇4̇ malwa	9.3845761
	=.4̇8̇ kadah	9.6856061
	=.9̇6̇ nesf kadah	9.9866361
	=1.9̇3̇ rūbaahs	0.2876661
	=3.8̇7̇ tūmnahs.	0.5886961
	=7.7̇5̇ karrūbahs	0.8897261
	=15.5̇1̇ kirats	1.1907561

British.	*Egyptian.*	*Logarithm.*
1 bushel	=.18357409 ardeb	9.2638114
1 gallon	=.02294676 ardeb	8.3607214
	=.13768 webah	9.1388727
	=.275361 kilah	9.4399027
	=.550722 rūb	9.7409327
1 quart	=.275361 malwa	9.4399027
1 pint	=.275361 kadah	9.4399027
	=.550722 nesf kadah	9.7409327
	=1.1014445 rūbaahs	0.0419627
	=2.202889 tūmnahs	0.3429927
1 gill	=1.1014445 karrūbahs	0.0419627
	=2.202889 kirats	0.3429927

* The British legal equivalent of 198 litres is 43.55505 gallons.

SECTION V. COMPARISON OF PRICES AND RATES OF EXCHANGE.

COMPARISON OF FRENCH AND GERMAN PRICES FOR METRIC UNITS, BRITISH PRICES FOR IMPERIAL UNITS, AND UNITED STATES PRICES FOR UNITED STATES UNITS.

Francs per kilogram.	Shillings per avoir. pound.	Francs per metre.	Shillings per yard.	Francs per litre.	Shillings per British Imp. gal.	Francs per hectolitre.	Shillings per British bushel.	Dollars per U.S. unit ot weight or lineal measure.	Shillings per British unit of weight or lineal measure.
1	= .360	1	= .725	1	= 3.605	1	= .288	1	= 4.110
2	= .719	2	= 1.450	2	= 7.210	2	= .577	2	= 8.219
3	= 1.079	3	= 2.175	3	= 10.815	3	= .865	3	= 12.329
4	= 1.439	4	= 2.901	4	= 14.420	4	= 1.154	4	= 16.439
5	= 1.799	5	= 3.626	5	= 18.025	5	= 1.442	5	= 20.549
6	= 2.158	6	= 4.351	6	= 21.630	6	= 1.730	6	= 24.658
7	= 2.518	7	= 5.076	7	= 25.235	7	= 2.019	7	= 28.768
8	= 2.878	8	= 5.801	8	= 28.840	8	= 2.307	8	= 32.878
9	= 3.237	9	= 6.526	9	= 32.445	9	= 2.596	9	= 36.988
2.780 = 1		1.379 = 1		.277 = 1		3.467 = 1		.243 = 1	
5.560 = 2		2.758 = 2		.555 = 2		6.935 = 2		.487 = 2	
8.340 = 3		4.137 = 3		.832 = 3		10.402 = 3		.730 = 3	
11.120 = 4		5.516 = 4		1.110 = 4		13.869 = 4		.973 = 4	
13.900 = 5		6.895 = 5		1.387 = 5		17.337 = 5		1.217 = 5	
16.680 = 6		8.274 = 6		1.664 = 6		20.804 = 6		1.460 = 6	
19.460 = 7		9.653 = 7		1.942 = 7		24.272 = 7		1.703 = 7	
22.240 = 8		11.032 = 8		2.219 = 8		27.739 = 8		1.947 = 8	
25.020 = 9		12.411 = 9		2.497 = 9		31.206 = 9		2.190 = 9	

Marks per kilogram.	Shillings per avoir. pound.	Marks per metre.	Shillings per yard.	Marks per litre.	Shillings per British Imp. gal.	Marks per hectolitre.	Shillings per British bushel.	Cents per U.S. unit of weight or lineal measure.	Pence per British unit of weight or lineal measure.
1	= .444	1	= .895	1	= 4.450	1	= .356	1	= .493
2	= .888	2	= 1.790	2	= 8.901	2	= .712	2	= .986
3	= 1.332	3	= 2.685	3	= 13.351	3	= 1.068	3	= 1.480
4	= 1.776	4	= 3.581	4	= 17.801	4	= 1.424	4	= 1.973
5	= 2.220	5	= 4.476	5	= 22.251	5	= 1.780	5	= 2.466
6	= 2.664	6	= 5.371	6	= 26.702	6	= 2.136	6	= 2.959
7	= 3.108	7	= 6.266	7	= 31.152	7	= 2.492	7	= 3.452
8	= 3.552	8	= 7.161	8	= 35.602	8	= 2.848	8	= 3.945
9	= 3.996	9	= 8.056	9	= 40.053	9	= 3.204	9	= 4.439
2.252 = 1		1.117 = 1		.225 = 1		2.809 = 1		2.028 = 1	
4.504 = 2		2.234 = 2		.449 = 2		5.618 = 2		4.055 = 2	
6.756 = 3		3.351 = 3		.674 = 3		8.426 = 3		6.083 = 3	
9.008 = 4		4.469 = 4		.899 = 4		11.235 = 4		8.111 = 4	
11.260 = 5		5.586 = 5		1.124 = 5		14.044 = 5		10.139 = 5	
13.512 = 6		6.703 = 6		1.348 = 6		16.853 = 6		12.166 = 6	
15.764 = 7		7.820 = 7		1.573 = 7		19.662 = 7		14.194 = 7	
18.016 = 8		8.937 = 8		1.798 = 8		22.470 = 8		16.222 = 8	
20.268 = 9		10.054 = 9		2.022 = 9		25.279 = 9		18.249 = 9	

Comparison of French and German Prices for Metric Units, British Prices for Imperial Units, and United States Prices for United States Units (*Continued*).

Francs per kilogram.	Dollars per avoir. pound.	Francs per metre.	Dollars per yard.	Francs per litre.	Dollars per U.S. liquid gal.	Francs per hectolitre.	Dollars per U.S. bushel.	Shillings per British Imp. gal.	Dollars per U.S. liquid gal.
1	=.088	1	= .176	1	= .731	1	=.068	1	= .203
2	=.175	2	= .353	2	=1.461	2	=.136	2	= .405
3	=.263	3	= .529	3	=2.192	3	=.204	3	= .608
4	=.350	4	= .705	4	=2.922	4	=.272	4	= .810
5	=.438	5	= .882	5	=3.653	5	=.340	5	=1.013
6	=.525	6	=1.058	6	=4.384	6	=.408	6	=1.216
7	=.613	7	=1.234	7	=5.114	7	=.476	7	=1.418
8	=.700	8	=1.411	8	=5.844	8	=.544	8	=1.621
9	=.788	9	=1.587	9	=6.575	9	=.612	9	=1.824
11.423=1		5.667=1		1.369=1		14.703=1		4.935=1	
22.846=2		11.334=2		2.738=2		29.407=2		9.871=2	
34.269=3		17.000=3		4.106=3		44.110=3		14.806=3	
45.691=4		22.667=4		5.475=4		58.813=4		19.742=4	
57.115=5		28.334=5		6.844=5		73.517=5		24.677=5	
68.537=6		34.001=6		8.213=6		88.220=6		29.612=6	
79.960=7		39.668=7		9.581=7		102.923=7		34.548=7	
91.383=8		45.334=8		10.950=8		117.627=8		39.483=8	
102.806=9		51.001=9		12.319=9		132.330=9		44.419=9	

Marks per kilogram.	Dollars per avoir. pound.	Marks per metre.	Dollars per yard.	Marks per litre.	Dollars per U.S. liquid gal.	Marks per hectolitre.	Dollars per U.S. bushel.	Shillings per British bus.	Dollars per U.S. bushel.
1	=.108	1	= .218	1	= .901	1	=.084	1	= .236
2	=.216	2	= .435	2	=1.802	2	=.168	2	= .472
3	=.324	3	= .653	3	=2.703	3	=.252	3	= .707
4	=.432	4	= .871	4	=3.604	4	=.335	4	= .943
5	=.540	5	=1.088	5	=4.505	5	=.419	5	=1.179
6	=.648	6	=1.306	6	=5.406	6	=.503	6	=1.415
7	=.756	7	=1.523	7	=6.307	7	=.587	7	=1.650
8	=.864	8	=1.741	8	=7.207	8	=.671	8	=1.886
9	=.972	9	=1.959	9	=8.108	9	=.755	9	=2.122
9.263=1		4.595=1		1.110=1		11.923=1		4.241=1	
18.526=2		9.190=2		2.220=2		23.847=2		8.483=2	
27.789=3		13.785=3		3.330=3		35.770=3		12.724=3	
37.052=4		18.380=4		4.440=4		47.693=4		16.965=4	
46.316=5		22.975=5		5.550=5		59.616=5		21.207=5	
55.579=6		27.570=6		6.660=6		71.540=6		25.448=6	
64.842=7		32.165=7		7.770=7		83.463=7		29.689=7	
74.105=8		36.760=8		8.880=8		95.386=8		33.931=8	
83.368=9		41.355=9		9.990=9		107.310=9		38.172=9	

TABLE OF RATES OF EXCHANGE FOR MONEY.

Country.	Gold Import Point.	Mint Parity.	Gold Export Point.
France, Belgium, Italy, Switzerland,	Francs 25.35	Fr. 25.22	Fr. 25.09
Holland, - - -	Florins 12.15	Fl. 12.10¾	Fl. 12.04
Germany, - -	Marks 20.51	M. 20.43	M. 20.35
Austria-Hungary, -	Kronen 24.20	Kr. 24.02	Kr. 23.90
Scandinavia, - -	Kroner 18.30	Kr. 18.16	Kr. 18.02
Russia, - - -	Roubles 9.6 (1 Rr.=25d.)	Rs. 9.459 (1 Rs.=25⅜d.)	Rs. 9.366 (1 Rs.=25⅝d.)
United States of America,	Dollars 4.90	$ 4.8665	$ 4.84
British India, -		Rupees 15 (1 R=1s. 4d.)	R 14.657 (1 R=1s.4⅜d.)
Egypt, - - -	Piastrés 97⅞	Piastres 97½	Piastres 97⅛

The above table* gives the value of £1 sterling in the currencies of the following countries: France, Belgium, Italy, Switzerland, Holland, Germany, Austria-Hungary, Scandinavia, Russia, United States of America, British India and Egypt.

The middle column gives the exchange at mint parity, *i.e.* the actual gold value of the foreign currency in comparison with the pound sterling, while the other columns show the extremes of fluctuation in the rate of exchange *in normal times.* In the left-hand column are the rates of exchange at which in sending remittances *to* London it would be more profitable to send gold than to purchase drafts; while in the right-hand column are the rates at which in remitting *from* London it would be more profitable to buy gold and send it abroad than to purchase drafts.

* Kindly compiled by Mr. F. Moshack of the Deutsche Bank.

PART II. DATA RELATING TO FORCE AND ENERGY.

SECTION I. MECHANICAL UNITS.

Force.—The British unit of force is termed the *poundal*; it is that force which, acting on a mass of 1 lb. for one second, gives it a velocity of one foot per second. On the C.G.S. (centimetre-gramme-second) system the unit of force is the *dyne*, which may be defined as that force which, acting on a mass of 1 gramme, gives it a velocity of 1 centimetre per second.

1 poundal = 13825 dynes.

Gravity.—The apparent acceleration (or increase of velocity per unit of time) of a body falling freely under the influence of gravity in vacuo (g) varies according to locality. The value of g in C.G.S. units is 981.17 centimetres per second at Greenwich, 980.94 at Paris, 981.25 at Berlin, 978.10 at the equator and 983.11 at the poles. The mean value adopted by the International Bureau of Weights and Measures for latitude 45° at sea-level is 980.665.* In British measure the value of g for London at sea-level is about 32.19 feet per second.† The length of the seconds pendulum for the same places is as follows:

Greenwich, 99.413 cm.; Paris, 99.390 cm.; Berlin, 9.422 cm.; equator, 99.103 cm.; and the poles, 99.610 cm.

Work.—The British unit of work is the *foot-poundal*. It is the work done by a force of 1 poundal acting over a distance of 1 foot. Work is also expressed in *foot-pounds*, the unit in this case being the work done when a body moves through 1 foot against a resistance of gravity equal to 1 lb.

1 foot-pound = g poundals.

* *Comptes Rendus des séances de la Troisième Conférence générale des Poids et Mesures à Paris*, 1901, p. 70.

† This is the value adopted by the Board of Trade Standards Department.

On the C.G.S. system the unit of work is the *erg*. It is the work done by a force of 1 dyne acting over a distance of 1 centimetre.

1 foot poundal = 421401 ergs.

1 foot-pound = 1.356×10^7 ergs (g being taken as 981).

Power.—The British unit of power or rate of doing work is the *horse-power*. It is equivalent to 33,000 foot-pounds per minute or 550 foot-pounds per second. The French unit—the *force de cheval*—is defined as 75 kilogram-metres per second. One "force de cheval" equals 0.9863 horse-power or 542.48 foot-pounds per second, and conversely 1 horse-power = 1.01385 "force de cheval."

On the C.G.S. system the unit of power is 1 erg per second.

Taking g as equal to 981, we have

1 horse-power = 7.46×10^9 ergs per second.

1 force de cheval = 7.36×10^9 ergs per second.

SECTION II. ELECTRICAL UNITS.

Resistance.—The unit of electrical resistance is the *ohm*.* It is defined by the Board of Trade † as "the resistance offered to an unvarying electric currrent by a column of mercury, at the temperature of melting ice, 14.4521 grammes in mass of a constant cross sectional area and of a length of 106.3 centimetres." For practical purposes, however, the Board of Trade use as the standard of electrical resistance the resistance between the copper terminals of a coil of insulated wire of platinum alloy to the passage of an unvarying electrical current, at a temperature of 15.4 C. This standard is marked "Board of Trade Ohm Standard, verified 1894,"‡ and is deposited at the Board of Trade Standardising Laboratory. The ohm has the value of 10^9 absolute units on the C.G.S. system.

Current.—The unit of current is the *ampere*. It is defined by

* The terms *ohm* and *volt* were first suggested by Sir C. Bright and Mr. Latimer Cross; together with *ampere*, *coulomb* and *farad*, they were adopted by an International Congress which met in 1881. The use of the terms *joule*, *watt* and *henry* was recommended by the Chamber of Delegates at the Chicago Exhibition in 1893.

† *Final Report of the Electrical Standards Committee*, 1894, p. 10.

‡ This Standard was legalised by Order in Council of her late Majesty Queen Victoria of Aug. 23, 1894.

the Board of Trade as the electric current, which, when passed through a neutral solution containing 15 per cent. of nitrate of silver, deposits silver at the rate of 0.001118 of a gramme per second.* For practical purposes the standard used by the Board of Trade is the current "which is passing in and through the coils of wire forming part of the instrument marked 'Board of Trade Ampere Standard, verified 1894' when in reversing the current in the fixed coils the change in the forces acting upon the suspended coil in its righted position is exactly balanced by the force exerted by gravity in Westminster upon the iridio-platinum weight marked *A* and forming part of the said instrument."† The ampere has the value of $\frac{1}{10}$ or 10^{-1} C.G.S. units.

1 milli-ampere = $\frac{1}{1000}$ ampere.

1 kilo-ampere = 1000 amperes.

Pressure.—The unit of electrical pressure is the *volt.* It is "the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere, and is represented by 0.6974 of the electrical pressure at a temperature of 15° C. between the poles of the voltaic cell, known as Clark's cell."‡ For practical purposes the unit is measured by a particular instrument marked "Board of Trade Volt Standard, verified 1894," deposited at the Board of Trade Standardising Laboratory. On the C.G.S. system the volt has the value of 10^8.

Quantity.—The unit of quantity is the *coulomb.* It is the quantity of electricity which in one second of time passes any part of a circuit in which the current has the strength of one ampere. Therefore 1 coulomb equals 1 ampere-second.

On the C.G.S. system the coulomb has the value of 10^{-1}.

$$1 \text{ micro coulomb} = \frac{1}{1,000,000} \text{ or } 10^{-6} \text{ coulomb.}$$

Capacity.—The unit of capacity is the *farad.* It is the capacity of a condenser charged to the potential of 1 volt by 1 coulomb of electricity. On the C.G.S. system the farad has the value of 10^{-9}.

$$1 \text{ micro-farad} = \frac{1}{1,000,000} \text{ or } 10^{-6} \text{ farad.}$$

* *Final Rep. of the Elect. Stand. Comm.*, 1894, p. 10.

† *Loc. cit.*, p. 11.

‡ *Loc. cit.* Clark's cell consists of zinc or an amalgam of zinc with mercury and of mercury in a neutral saturated solution of zinc sulphate and mercurous sulphate in water, prepared with mercurous sulphate in excess.

Work.—The unit of work is the *joule.* It is equivalent to the energy disengaged as heat in one second by a current of 1 ampere flowing through a resistance of 1 ohm, or in other words, under an electro-motive force of 1 volt.

$$1 \text{ joule} = 10^7 \text{ ergs or absolute units of work.}$$

Power.—The unit of power or rate of doing work is the *watt.* It is the work done at the rate of 1 joule per second. In other words, the watt represents the energy contained in a current of one ampere flowing under an electro-motive force of 1 volt. On the C.G.S. system the watt represents 10^7 ergs per second. The practical unit of work is the *kilowatt.*

1 kilowatt = 1000 watts
= 1.34 horse-power.
1 horse-power = 746 watts or .746 kilowatt.

The commercial or Board of Trade unit is the *kilowatt-hour.* It is defined by the Board of Trade as "the energy contained in a current of one thousand amperes flowing under an electro-motive force of one volt during one hour."

Induction.—The unit of induction is the *henry.* It is the induction in a circuit when the electro-motive force induced in this circuit is one volt, while the inducing current varies at the rate of one ampere per second.

On the C.G.S. system the henry has the value of 10^9.

Table of Horse Power and Kilowatts in terms of one another.

1 Horse-power	=0.746 Kilowatt.	1 Kilowatt	= 1.340 Horse power
2 ,,	=1.492 Kilowatts.	2 Kilowatts	= 2.681 ,,
3 ,,	=2.238 ,,	3 ,,	= 4.021 ,,
4 ,,	=2.984 ,,	4 ,,	= 5.362 ,,
5 ,,	=3.730 ,,	5 ,,	= 6.702 ,,
6 ,,	=4.476 ,,	6 ,,	= 8.043 ,,
7 ,,	=5.222 ,,	7 ,,	= 9.383 ,,
8 ,,	=5.968 ,,	8 ,,	=10.724 ,,
9 ,,	=6.714 ,,	9 ,,	=12.064 ,,

SECTION III. THERMAL UNITS.

The **British thermal unit** is the amount of heat required to raise 1 pound of water through 1 degree Fahrenheit. The thermal capacity of water varies slightly with the temperature; but the standard temperature of the water at which the unit should be defined has not yet been fixed by convention.

The **French thermal unit** is the *therm* or *gramme-degree.* It has also been termed the *minor calorie.* It is the quantity of heat required to raise 1 gramme of water through 1 degree Centigrade. It is sometimes defined as the amount of heat required to raise 1 gramme of water from 0° C. to 1° C., or as the one-hundredth part of the heat required to raise one gramme of water from 0° to 100° C.

The *major calorie* is the quantity of heat required to raise 1 kilogramme of water through 1 degree Centigrade.

1 major calorie = 1000 therms.
1 therm or minor calorie = 0.00396832 British thermal unit (log = 7.5986067).
1 British thermal unit = 251.99579 therms (log = 2.4013933).

The **capacity for heat** (or **thermal capacity**) of a substance is the quantity of heat required to raise the temperature of that substance 1 degree (Centigrade or Fahrenheit, according to the units in use).

The capacity for heat of water can be expressed thus:

1 calorie (therm) = 4.180 joules at 20° C.*

The **specific heat** of a substance is the ratio of the quantity of heat required to raise the temperature of a given mass of any substance one degree to the quantity of heat required to raise the temperature of an equal mass of water one degree (Glazebrook).

The **latent heat of fusion** is the quantity of heat required to change 1 gramme (or 1 lb.) of a substance from the solid to its liquid form without raising its temperature. The latent

* Preston's *Theory of Heat*, 2nd edition, London, 1904, p. 322.

heat of fusion of ice is 80 therms (Bunsen) or 144 British thermal units.

The **latent heat of vaporization** of a liquid is the amount of heat required to change 1 gramme (or 1 lb.) of the liquid into vapour without raising its temperature. The latent heat of vaporization of water is 537 therms, or 967 British thermal units.

The **evaporative power** or **calorific value** of a fuel is the number of pounds of water evaporated at 212° F. by the combustion of 1 lb. of that fuel. It may be expressed in British thermal units by multiplying the number of pounds of water evaporated at 212° F. by 967 (the latent heat of vaporization of water).

The mechanical equivalent of heat. The symbol J is used to designate the number of units of work necessary to generate one unit of heat when the unit is all spent in generating heat. Prof. Rowland's experiments show that at 20° C.*

$$J = 427.5 \text{ gramme-metres}$$
$$= 779 \text{ foot-pounds,}$$

i.e. the work done in raising $\left\{\begin{matrix}\text{1 gramme}\\ \text{1 pound}\end{matrix}\right\}$ through $\left\{\begin{matrix}\text{427.5 metres}\\ \text{779.0 feet}\end{matrix}\right\}$ will, if spent in friction, raise the temperature of $\left\{\begin{matrix}\text{1 gramme}\\ \text{1 pound}\end{matrix}\right\}$ of water 1 degree $\left\{\begin{matrix}\text{Centigrade}\\ \text{Fahrenheit}\end{matrix}\right\}$.

* Preston's *Theory of Heat*, London, 1904, p. 45.

Thermometric Scales.

Comparative Table of Fahrenheit, Réaumur and Centigrade Degrees.

Degrees.			Degrees.			Degrees.		
Fahr.	Réaum.	Cent.	Fahr.	Réaum.	Cent.	Fahr.	Réaum.	Cent.
212	80.0	100.0	171	61.8	77.2	130	43.6	54.4
211	79.6	99.4	170	61.3	76.7	129	43.1	53.9
210	79.1	98.9	169	60.9	76.1	128	42.7	53.3
209	78.7	98.3	168	60.4	75.6	127	42.2	52.8
208	78.2	97.8	167	60.0	75.0	126	41.8	52.2
207	77.8	97.2	166	59.6	74.4	125	41.3	51.7
206	77.3	96.7	165	59.1	73.9	124	40.9	51.1
205	76.9	96.1	164	58.7	73.3	123	40.4	50.6
204	76.4	95.6	163	58.2	72.8	122	40.0	50.0
203	76.0	95.0	162	57.8	72.2	121	39.6	49.4
202	75.6	94.4	161	57.3	71.7	120	39.1	48.9
201	75.1	93.9	160	56.9	71.1	119	38.7	48.3
200	74.7	93.3	159	56.4	70.6	118	38.2	47.8
199	74.2	92.8	158	56.0	70.0	117	37.8	47.2
198	73.8	92.2	157	55.6	69.4	116	37.3	46.7
197	73.3	91.7	156	55.1	68.9	115	36.9	46.1
196	72.9	91.1	155	54.7	68.3	114	36.4	45.6
195	72.4	90.6	154	54.2	67.8	113	36.0	45.0
194	72.0	90.0	153	53.8	67.2	112	35.6	44.4
193	71.6	89.4	152	53.3	66.7	111	35.1	43.9
192	71.1	88.9	151	52.9	66.1	110	34.7	43.3
191	70.7	88.3	150	52.4	65.6	109	34.2	42.8
190	70.2	87.8	149	52.0	65.0	108	33.8	42.2
189	69.8	87.2	148	51.6	64.4	107	33.3	41.7
188	69.3	86.7	147	51.1	63.9	106	32.9	41.1
187	68.9	86.1	146	50.7	63.3	105	32.4	40.6
186	68.4	85.6	145	50.2	62.8	104	32.0	40.0
185	68.0	85.0	144	49.8	62.2	103	31.6	39.4
184	67.6	84.4	143	49.3	61.7	102	31.1	38.9
183	67.1	83.9	142	48.9	61.1	101	30.7	38.3
182	66.7	83.3	141	48.4	60.6	100	30.2	37.8
181	66.2	82.8	140	48.0	60.0	99	29.8	37.2
180	65.8	82.2	139	47.6	59.4	98	29.3	36.7
179	65.3	81.7	138	47.1	58.9	97	28.9	36.1
178	64.9	81.1	137	46.7	58.3	96	28.4	35.6
177	64.4	80.6	136	46.2	57.8	95	28.0	35.0
176	64.0	80.0	135	45.8	57.2	94	27.6	34.4
175	63.6	79.4	134	45.3	56.7	93	27.1	33.9
174	63.1	78.9	133	44.9	56.1	92	26.7	33.3
173	62.7	78.3	132	44.4	55.6	91	26.2	32.8
172	62.2	77.8	131	44.0	55.0	90	25.8	32.2

Comparative Table of Fahrenheit, Réaumur and Centigrade Degrees (*Continued*).

Degrees.			Degrees.			Degrees.		
Fahr.	Réaum.	Cent.	Fahr.	Réaum.	Cent.	Fahr.	Réaum.	Cent.
89	25.3	31.7	48	7.1	8.9	7	−11.1	−13.9
88	24.9	31.1	47	6.7	8.3	6	−11.6	−14.4
87	24.4	30.6	46	6.2	7.8	5	−12.0	−15.0
86	24.0	30.0	45	5.8	7.2	4	−12.4	−15.6
85	23.6	29.4	44	5.3	6.7	3	−12.9	−16.1
84	23.1	28.9	43	4.9	6.1	2	−13.3	−16.7
83	22.7	28.3	42	4.4	5.6	1	−13.8	−17.2
82	22.2	27.8	41	4.0	5.0	0	−14.2	−17.8
81	21.8	27.2	40	3.6	4.4	−1	−14.7	−18.3
80	21.3	26.7	39	3.1	3.9	−2	−15.1	−18.9
79	20.9	26.1	38	2.7	3.3	−3	−15.6	−19.4
78	20.4	25.6	37	2.2	2.8	−4	−16.0	−20.0
77	20.0	25.0	36	1.8	2.2	−5	−16.4	−20.6
76	19.6	24.4	35	1.3	1.7	−6	−16.9	−21.1
75	19.1	23.9	34	0.9	1.1	−7	−17.3	−21.7
74	18.7	23.3	33	0.4	0.6	−8	−17.8	−22.2
73	18.2	22.8	32	0.0	0.0	−9	−18.2	−22.8
72	17.8	22.2	31	−0.4	−0.6	−10	−18.7	−23.3
71	17.3	21.7	30	−0.9	−1.1	−11	−19.1	−23.9
70	16.9	21.1	29	−1.3	−1.7	−12	−19.6	−24.4
69	16.4	20.6	28	−1.8	−2.2	−13	−20.0	−25.0
68	16.0	20.0	27	−2.2	−2.8	−14	−20.4	−25.6
67	15.6	19.4	26	−2.7	−3.3	−15	−20.9	−26.1
66	15.1	18.9	25	−3.1	−3.9	−16	−21.3	−26.7
65	14.7	18.3	24	−3.6	−4.4	−17	−21.8	−27.2
64	14.2	17.8	23	−4.0	−5.0	−18	−22.2	−27.8
63	13.8	17.2	22	−4.4	−5.6	−19	−22.7	−28.3
62	13.3	16.7	21	−4.9	−6.1	−20	−23.1	−28.9
61	12.9	16.1	20	−5.3	−6.7	−21	−23.6	−29.4
60	12.4	15.6	19	−5.8	−7.2	−22	−24.0	−30.0
59	12.0	15.0	18	−6.2	−7.8	−23	−24.4	−30.6
58	11.6	14.4	17	−6.7	−8.3	−24	−24.9	−31.1
57	11.1	13.9	16	−7.1	−8.9	−25	−25.3	−31.7
56	10.7	13.3	15	−7.6	−9.5	−26	−25.8	−32.2
55	10.2	12.8	14	−8.0	−10.0	−27	−26.2	−32.8
54	9.8	12.2	13	−8.4	−10.6	−28	−26.7	−33.3
53	9.3	11.7	12	−8.9	−11.1	−29	−27.1	−33.9
52	8.9	11.1	11	−9.3	−11.7	−30	−27.6	−34.4
51	8.4	10.6	10	−9.8	−12.2	−31	−28.0	−35.0
50	8.0	10.0	9	−10.2	−12.8	−32	−28.4	−35.6
49	7.6	9.4	8	−10.7	−13.3	−33	−28.9	−36.1

To convert Fahrenheit degrees to Centigrade or Réaumur, subtract 32 and multiply the difference by $\frac{5}{9}$ or $\frac{4}{9}$ respectively. To convert Centigrade or Réaumur to Fahrenheit, multiply by $\frac{9}{5}$ or $\frac{9}{4}$, as the case may be, and add 32 to the product. To convert Centigrade to Réaumur, multiply Centigrade degrees by $\frac{4}{5}$; and to convert to Centigrade, multiply Réaumur degrees by $\frac{5}{4}$. To obtain absolute temperature, add 273° to the Centigrade scale.

Photometric Standards.

The British unit of light, the *candle power*, as originally defined,* is the illuminating power of a sperm candle $\frac{7}{8}$ inch in diameter (6 to the pound) burning 120 grains per hour. The Harcourt 10-candle power pentane lamp, however, is accepted by the Gas Referees as representing ten British candles.

The French unit, the *Carcel*, is the illuminating power of a lamp burning 42 grammes of pure colza oil per hour.

The German unit, the *Hefner*, is the illuminating power of the Hefner-Alteneck lamp, burning amyl-acetate with a cylindrical wick 8 mm. in diameter and a flame-height of 40 mm.

The International Congress, held at Paris in April, 1884, proposed the illuminating power of a square centimetre of molten platinum at the temperature of solidification as a unit; but at the Congress held in 1890 the 20th part of this unit was adopted as the international standard unit, under the name of the *decimal candle.*

The following relations between these lamps have been established by tests made in the German Reichsanstalt, at the instance of the International Committee on Photometry. The tests were made in air containing 8.8 litres of aqueous vapour per cubic metre of dry air, and under a barometric pressure of 760 mm. †

Name of Lamp.	Harcourt Units (=10 British Candles).	Carcel Units.	Hefner Units.	Decimal Candles.
Harcourt, - -	1	1 02	11	9.8
Carcel, - -	.98	1	10.8	9.61
Hefner, - -	.091	.093	1	.891

1 Decimal candle = .102 Harcourt units.
= 1.02 British candles.
= .104 Carcels.
= 1.122 Hefners.

* Metropolis Gas Act of 1860.

† *Journal für Gasbeleuchtung*, Munich, 30 June, 1906, pp. 559-561.

PART III. DATA RELATING TO WATER.

SECTION I. CONSTANTS.

Relation of Weight and Volume.

THE Imperial Gallon is the volume of 10 avoir. lbs. of distilled water weighed *in air* against brass weights, with the water and air at a temperature of 62° Fahr., under a barometric pressure of 30 inches. The following constants apply to water under these conditions: *

Weight of 1 cubic inch of water at 62° F.	
= 252.3253 grains.	log = 2.4019608
= .0360465 lb.	log = 8.5568628
= .00360465 Imp. gallon.	log = 7.5568628
Weight of 1 cubic foot of water at 62° F.	
= 62.2883 lbs.	log = 1.7944065
= 6.22883 Imp. gallons.	log = 0.7944065
Volume of 1 short ton (2000 lbs.) of water at 62° F.	
= 32.1088 cub. feet.	log = 1.5066235
Volume of 1 long ton (2240 lbs.) of water at 62° F.	
= 35.9618 cub. feet.	log = 1.5558415
1 Imperial gallon	
= 277.420 cub. inches.	log = 2.4431372
= .160544 cub. foot.	log = 9.2055935

A column of water 1 foot high at 62° F. exerts a pressure of .432$\dot{5}$ lb. per sq. inch: log = 9.6360419.

A pressure of 1 lb. per sq. in. is exerted by a column of water at 62° F., 2.31184 feet high: log = 0.3639581.

The Litre is the volume of a kilogram of distilled water weighed *in vacuo* at its temperature of maximum density

* See page 7.

(4° C. or 39°.2 F.). By means of the equivalents given on page 33, and the weight of a cubic decimetre of water on page 4, we find that

1 gramme per cubic centimetre = 62.4278 lbs. per cubic foot; and the weight *in vacuo* of 1 cubic decimetre of distilled water at 4° C. = .999974 kilogram.

Therefore the weight *in vacuo* of 1 cubic foot of distilled water at 4° C. = 62.4278 × .999974 = 62.4262 lbs.

Constants used in the measurement of flow.

1 cusec* of water at 62° F.

= 60 cubic feet per minute	log = 1.7781513
= 3600 cubic feet per hour	log = 3.5563025
= 86400 cubic feet per day of 24 hours	log = 4.9365137
= 6.22883 Imp. gallons per second	log = 0.7944065
= 373.73 Imp. gallons per minute	log = 2.5725578
= 22423.8 Imp. gallons per hour	log = 4.3507090
= 538170.9 Imp. gallons per day of 24 hours	log = 5.7309202
= 7.48026 U.S. gallons per second	log = 0.8739167
= 448.816 U.S. gallons per minute	log = 2.6520680
= 26928.94 U.S. gallons per hour	log = 4.4302192
= 646294.4 U.S. gallons per day of 24 hours.	log = 5.8104304

1 cubic foot per minute of water at 62° F.

= 60 cubic feet per hour	log = 1.7781513
= 1440 cubic feet per day of 24 hours	log = 3.1583625
= 6.22883 Imp. gallons per minute	log = 0.7944065
= 373.73 Imp. gallons per hour	log = 2.5725578
= 8969.54 Imp. gallons per day of 24 hours	log = 3.5927700
= 7.48026 U.S. gallons per minute	log = 0.8739167
= 448.816 U.S. gallons per hour	log = 2.6520680
= 10771.58 U.S. gallons per day of 24 hours.	log = 4.0322792

The *miner's inch* is usually taken to be a flow of 1.5 cubic feet per minute.

* 'Cusec' is the abbreviation of 'cubic foot per second,' commonly used in referring to the flow of water.

The volume in cubic centimetres at various temperatures from 0° to 35° Centigrade of a cubic centimetre of distilled water at 4° C.*

Temp. C.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0°	1.000127	120	114	108	102	096	091	086	080	075
1	070	066	061	057	052	048	044	040	037	033
2	030	027	024	021	019	017	014	012	010	009
3	007	006	004	003	002	002	001	001	000	000
4	000	000	001	001	001	002	003	004	005	007
5	1.000008	010	012	014	016	018	020	023	026	029
6	032	035	038	041	045	049	053	057	061	065
7	069	074	079	084	089	094	099	105	110	116
8	122	128	134	141	147	154	160	167	174	181
9	189	196	204	211	219	227	235	244	252	260
10	1.000269	278	287	296	305	314	324	334	343	353
11	363	373	383	394	405	415	426	437	448	459
12	471	482	494	505	517	529	541	553	566	578
13	591	603	616	629	642	655	668	681	695	709
14	722	736	750	765	779	794	809	823	838	853
15	1.000868	884	899	914	930	945	961	977	993	009
16	1025	042	058	075	091	108	125	142	159	177
17	194	211	229	247	265	283	301	319	338	356
18	374	393	412	431	450	469	488	507	527	546
19	566	585	605	625	645	666	686	707	727	748
20	1.001768	789	810	831	852	874	895	916	938	960
21	981	003	025	047	069	092	114	137	159	182
22	2205	228	251	274	297	320	343	367	391	414
23	438	462	486	510	534	559	583	607	632	657
24	682	707	732	757	782	807	833	858	884	910
25	1.002935	961	987	014	040	066	092	119	146	172
26	3199	226	253	280	307	335	362	389	417	445
27	472	500	528	556	584	612	641	669	697	726
28	754	783	812	841	870	899	928	957	987	016
29	4045	075	105	134	164	194	224	254	284	315
30	1.004345	375	406	436	467	498	529	560	591	622
31	653	684	716	748	780	811	843	875	907	939
32	971	003	036	068	101	133	166	199	231	264
33	5297	330	363	396	430	463	497	530	564	597
34	631	665	699	733	767	801	835	870	904	939
35	1.005973	008	042	077	111	146	181	217	252	287

For 16⅔° C. (62° F.) the volume is 1.001136.

* This table was compiled by Landolt and Börnstein from determinations made by Thiesen, Scheel and Marek. It is taken from the *Smithsonian Physical Tables*, Washington, 1906.

SECTION II. MEASUREMENT OF THE FLOW OF WATER.

In measuring the flow of a stream by means of a rectangular-notched weir (Fig. 1), the length of the notch should be at least three times the depth of water on the sill. Air should have free access to the space behind the falling sheet of water, and the sill should be carefully levelled.

FIG. 1.

End contraction, which occurs when the weir at each end of the notch projects into the approach channel, diminishes the discharge. The contraction is complete, that is as great as it can be, when the distance from the end of the notch to the side of the approach channel is equal to the depth of water on the sill. If the width of the notch be not less than three times the depth of water on the sill, a complete end contraction diminishes the *effective width* of the notch by an amount equal to one-tenth of the depth of the water on the sill. If contraction occurs at both ends of the notch, the effective width will of course be diminished by twice the above amount.

The notches of weirs should be made preferably in thin sheet iron; if in wood, the *downstream* side should be bevelled off so as to present a smooth sharp edge to the water on the upstream side. In a wooden weir two inches thick, a notch cut with square edges (without bevel) gives a discharge 15½ per cent. less than that of a similar notch in thin sheet iron. The weir can be made of deal boards with the notch cut in the wood, or a thin sheet iron plate with the notch can be attached to the topmost board. The weir site should be chosen at a point where the stream will be dammed back for at least six feet. The weir should be let into the banks and should be firmly fixed into position and made water-tight by means of clay. Unless a proper approach channel is provided, the ends of the notch should be far enough from the banks to ensure complete end contraction, which must then be allowed for. No measurements should be made until the normal flow of the stream is passing through the notch. The depth of the water must not be measured on the notch itself, but from the sill to the surface of the still water at a point some six feet above the weir, a level being employed.

For gauging a small flow, a right-angled triangular notch (Fig. 2) will be found more convenient. It is the only form of notch in which the periphery always bears the same ratio to the cross-sectional area of the stream flowing through it.

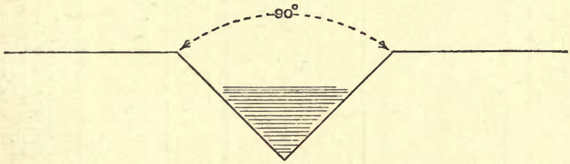

FIG. 2.

On pages 72 and 73 are tables giving the discharges through each form of notch for a varying depth of water. In the first table, which is for a rectangular-notched weir in thin sheet iron,

Q = Discharge in 'cusecs' (cubic feet per second).

H = Depth in feet of water, measured from sill of notch to surface of still water above the weir.

L = Width in feet of notch.

$Q = 3.33\, LH\sqrt{H}$ (Francis' formula).

The table is calculated for a notch 1 foot in width, and no deduction has been made for end contraction which is hardly appreciable when H is less than $\frac{L}{10}$. In using the table, multiply Q by the *effective* width of the notch in feet.

[Table

Table for Estimating Discharge of Water through a Rectangular-notched Weir, without end contraction.

H	*Q*	*H*	*Q*	*H*	*Q*	*H*	*Q*	*H*	*Q*
.01	0.003	.51	1.213	1.01	3.380	1.51	6.179	2.01	9.489
.02	0.009	.52	1.249	1.02	3.430	1.52	6.240	2.02	9.560
.03	0.017	.53	1.285	1.03	3.481	1.53	6.302	2.03	9.631
.04	0.027	.54	1.321	1.04	3.532	1.54	6.364	2.04	9.703
.05	0.037	.55	1.358	1.05	3.583	1.55	6.426	2.05	9.774
.06	0.049	.56	1.395	1.06	3.634	1.56	6.488	2.06	9.846
.07	0.062	.57	1.433	1.07	3.686	1.57	6.551	2.07	9.917
.08	0.075	.58	1.471	1.08	3.737	1.58	6.613	2.08	9.989
.09	0.090	.59	1.509	1.09	3.790	1.59	6.676	2.09	10.062
.10	0.105	.60	1.548	1.10	3.842	1.60	6.739	2.10	10.134
.11	0.121	.61	1.586	1.11	3.894	1.61	6.803	2.11	10.206
.12	0.138	.62	1.626	1.12	3.947	1.62	6.866	2.12	10.279
.13	0.156	.63	1.665	1.13	4.000	1.63	6.930	2.13	10.352
.14	0.174	.64	1.705	1.14	4.053	1.64	6.994	2.14	10.425
.15	0.193	.65	1.745	1.15	4.107	1.65	7.058	2.15	10.498
.16	0.213	.66	1.786	1.16	4.160	1.66	7.122	2.16	10.571
.17	0.233	.67	1.826	1.17	4.214	1.67	7.187	2.17	10.645
.18	0.254	.68	1.867	1.18	4.268	1.68	7.251	2.18	10.718
.19	0.276	.69	1.909	1.19	4.323	1.69	7.316	2.19	10.792
.20	0.298	.70	1.950	1.20	4.377	1.70	7.381	2.20	10.866
.21	0.320	.71	1.992	1.21	4.432	1.71	7.446	2.21	10.940
.22	0.344	.72	2.034	1.22	4.487	1.72	7.512	2.22	11.015
.23	0.367	.73	2.077	1.23	4.543	1.73	7.577	2.23	11.089
.24	0.392	.74	2.120	1.24	4.598	1.74	7.643	2.24	11.164
.25	0.416	.75	2.163	1.25	4.654	1.75	7.709	2.25	11.239
.26	0.441	.76	2.206	1.26	4.710	1.76	7.775	2.26	11.314
.27	0.467	.77	2.250	1.27	4.766	1.77	7.842	2.27	11.389
.28	0.493	.78	2.294	1.28	4.822	1.78	7.908	2.28	11.464
.29	0.520	.79	2.338	1.29	4.879	1.79	7.975	2.29	11.540
.30	0.547	.80	2.383	1.30	4.936	1.80	8.042	2.30	11.615
.31	0.575	.81	2.428	1.31	4.993	1.81	8.109	2.31	11.691
.32	0.603	.82	2.473	1.32	5.050	1.82	8.176	2.32	11.767
.33	0.631	.83	2.518	1.33	5.108	1.83	8.244	2.33	11.843
.34	0.660	.84	2.564	1.34	5.165	1.84	8.311	2.34	11.920
.35	0.690	.85	2.610	1.35	5.223	1.85	8.379	2.35	11.996
.36	0.719	.86	2.656	1.36	5.281	1.86	8.447	2.36	12.073
.37	0.749	.87	2.702	1.37	5.340	1.87	8.515	2.37	12.150
.38	0.780	.88	2.749	1.38	5.398	1.88	8.584	2.38	12.227
.39	0.811	.89	2.796	1.39	5.457	1.89	8.652	2.39	12.304
.40	0.842	.90	2.843	1.40	5.516	1.90	8.721	2.40	12.381
.41	0.874	.91	2.891	1.41	5.575	1.91	8.790	2.41	12.459
.42	0.906	.92	2.939	1.42	5.635	1.92	8.859	2.42	12.536
.43	0.939	.93	2.987	1.43	5.694	1.93	8.929	2.43	12.614
.44	0.972	.94	3.035	1.44	5.754	1.94	8.998	2.44	12.692
.45	1.005	.95	3.083	1.45	5.814	1.95	9.068	2.45	12.770
.46	1.039	.96	3.132	1.46	5.875	1.96	9.138	2.46	12.848
.47	1.073	.97	3.181	1.47	5.935	1.97	9.208	2.47	12.927
.48	1.107	.98	3.231	1.48	5.996	1.98	9.278	2.48	13.005
.49	1.142	.99	3.280	1.49	6.057	1.99	9.348	2.49	13.084
.50	1.177	1.00	3.330	1.50	6.118	2.00	9.419	2.50	13.163

Table for Estimating Discharge of Water through a Right-angled Triangular Notch in Thin Sheet Iron.

Q = Discharge in cubic feet per minute.

n = Head in inches measured from bottom of notch to surface of still water above weir.

$Q = .306\sqrt{n^5}$ (Thomson's formula).

The Table is calculated for heads from 1 to 15 inches, increasing by decimal parts of an inch. No deduction has to be made for end contraction.

n	*Q*	*n*	*Q*	*n*	*Q*	*n*	*Q*
1	.306	4.6	13.886	8.2	58.935	11.8	146.329
1.1	.388	4.7	14.654	8.3	60.701	11.9	148.838
1.2	.480	4.8	15.446	8.4	62.577	12	151.032
1.3	.589	4.9	16.263	8.5	64.574	12.1	155.813
1.4	.709	5	17.105	8.6	66.371	12.2	159.058
1.5	.843	5.1	17.974	8.7	68.329	12.3	163.333
1.6	.990	5.2	18.867	8.8	70.288	12.4	165.168
1.7	1.153	5.3	19.789	8.9	72.338	12.5	169.034
1.8	1.330	5.4	20.734	9	74.358	12.6	172.431
1.9	1.523	5.5	21.707	9.1	77.662	12.7	175.858
2	1.731	5.6	22.708	9.2	78.550	12.8	179.346
2.1	1.954	5.7	23.736	9.3	80.722	12.9	182.865
2.2	2.197	5.8	24.792	9.4	82.895	13	186.463
2.3	2.454	5.9	25.875	9.5	85.129	13.1	190.056
2.4	2.730	6	26.983	9.6	87.393	13.2	193.698
2.5	3.023	6.1	28.121	9.7	89.688	13.3	197.400
2.6	3.338	6.2	29.290	9.8	92.014	13.4	201.103
2.7	3.665	6.3	30.483	9.9	94.370	13.5	204.897
2.8	4.014	6.4	31.701	10	96.787	13.6	208.692
2.9	4.384	6.5	32.956	10.1	99.174	13.7	212.578
3	4.767	6.6	34.241	10.2	101.653	13.8	216.464
3.1	5.177	6.7	35.557	10.3	104.162	13.9	220.411
3.2	5.605	6.8	36.903	10.4	106.702	14	224.389
3.3	6.055	6.9	38.280	10.5	109.303	14.1	228.429
3.4	6.523	7	39.688	10.6	111.934	14.2	232.498
3.5	7.013	7.1	41.095	10.7	114.570	14.3	236.599
3.6	7.525	7.2	42.564	10.8	117.289	14.4	240.760
3.7	8.069	7.3	44.064	10.9	120.013	14.5	244.983
3.8	8.673	7.4	45.594	11	122.797	14.6	249.206
3.9	9.192	7.5	47.154	11.1	125.582	14.7	253.521
4	9.792	7.6	48.745	11.2	128.458	14.8	257.835
4.1	10.400	7.7	50.337	11.3	131.352	14.9	262.211
4.2	11.061	7.8	51.989	11.4	134.272	15	266.709
4.3	11.735	7.9	53.672	11.5	137.332		
4.4	12.426	8	55.386	11.6	138.220		
4.5	13.151	8.1	57.160	11.7	143.269		

SECTION III. STORAGE OF WATER BY SMALL DAMS FOR MINING AND IRRIGATION PURPOSES.

Dimensions for Small Earthen Dams.

Mr. A. M. Strange* recommends the following dimensions for small earthen dams :

Maximum height of Dam above Ground Level.	Height of top of Dam above High Flood Level.	Top Width.	Upstream (or Reservoir side) Slope.	Downstream Slope.
	Feet.	Feet.	Ratio of Horizontal Width to Vertical Height.	
1. Under 8 feet, - - -	3	6	$1\frac{1}{2}$ to 1	1 to 1
2. From 8 to 15 feet, - -	4	8	2 to 1	$1\frac{1}{2}$ to 1

The above dimensions only apply when the soil is of a suitable nature and the wall is well and compactly made on a site from which all vegetation has first been removed. A clay core is usually effective in preventing leakage. The by-wash or waste weir channel and the upstream face of the wall should be "pitched" with stone. The high flood level is the level of the maximum discharge over the waste weir in time of flood.

Flood Discharge Allowances for Waste Weir Channels.

The following table gives what should prove quite safe allowances for the widths of waste weirs required for ordinary small catchment or drainage areas.

TABLE OF WASTE WEIR CHANNELS.

For catchment areas up to	Discharge per 250 acres of catchment	Width of Waste Weir Channels required per 250 acres of catchment.	
		1 ft. deep.	2 ft. deep.
1	2	3	4
Acres.	Cubic feet per second.	Feet.	Feet.
640	75	31.5	10.3
1280	70	29.5	9.6
1920	66	27.7	9.06
2560	62	26.0	8.5
3200	59	24.8	8.0

Note. In regard to the catchment area, take the figure entered in column 1, which is the nearest greater than the one under consideration, and use the corresponding figures in columns 2–4. For

* *Bulletin No. 1*, *Irrigation Dept.*, *Transvaal*, Pretoria, 1905.

catchments above 3200 acres (5 square miles), the discharges (*vide* column 2) should be reduced gradually.

Example. A catchment area of 1000 acres may be expected to produce a high-flood discharge of (4×70=)280 cubic feet per sec., which would require a waste weir channel flowing 1 foot deep to be (4×29.5=)118 feet wide; or a channel flowing 2 feet deep to be (4×9.6=)38.4 feet wide.

The tables on pp. 76, 77 will be found of use in calculating the amount of earthwork contained in the wall. The height of the wall should be taken at each change of slope in the contour of the site, also the distance between each height measurement. Then half the sum of the areas of two adjoining cross-sections multiplied by the distance *in feet* between them gives the contents in cubic feet of that portion of the wall.

The Relation of Rainfall to Irrigation.

1 inch	rainfall	over	1 acre	= 3630	cubic	feet of	water.
2	”	”	”	= 7260	”	”	”
2.5	”	”	”	= 9075	”	”	”
3	”	”	”	= 10890	”	”	”
4	”	”	”	= 14520	”	”	”
7.13	”	”	”	= 25882	”	”	”

Therefore, water flowing at the rate of 1 cubic foot per second for 30 days (1 month) is equivalent to

a rainfall	of	1	inch	per month	on	713	acres.
”	”	2	”	”	”	356	”
”	”	2.5	”	”	”	285	”
”	”	3	”	”	”	237	”
”	”	4	”	”	”	178	”
”	”	7.13	”	”	”	100	”

It will be seen from the above table that a rainfall of $2\frac{1}{2}$ inches per month corresponds to the flow of 1 cubic foot per second (1 cusec) over 285 acres.

This is termed an 'irrigating duty' of 285 acres per cusec, which means that one cubic foot of water per second has to irrigate 285 acres.

The irrigating duty of water varies according to the climate, the nature of the soil, the class of crop and the method of cultivation.

An irrigating duty of

285	acres	per cusec	= 9075	cub. ft.	per acre	per month.
250	”	”	= 10345	”	”	”
200	”	”	= 12931	”	”	”
150	”	”	= 17242	”	”	”
100	”	”	= 25863	”	”	”

Tables for Calculation of Cubic Contents of Earthen Dam Embankments.*

TABLE I.

Top width, 6 ft.; upstream slope, $1\frac{1}{2}$ to 1; downstream slope, 1 to 1.

Height in Feet.	Cross Sectional Area in Square Feet.									
0	0.00	0.61	1.25	1.91	2.60	3.31	4.05	4.81	5.60	6.41
1	7.25	8.11	9.00	9.91	10.85	11.81	12.80	13.81	14.85	15.91
2	17.00	18.11	19.25	20.41	21.60	22.81	24.05	25.31	26.60	27.91
3	29.25	30.61	32.00	33.41	34.85	36.31	37.80	39.31	40.85	42.41
4	44.00	45.61	47.25	48.91	50.60	52.31	54.05	55.81	57.60	59.41
5	61.25	63.11	65.00	66.91	68.85	70.81	72.80	74.81	76.85	78.91
6	81.00	83.11	85.25	87.41	89.60	91.81	94.05	96.31	98.60	100.91
7	103.25	105.61	108.00	110.41	112.85	115.31	117.80	120.31	122.85	125.41
8	128.00	130.61	133.25	135.91	138.60	141.31	144.05	146.81	149.60	152.41
Decimals of a Foot.	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9

* *Bulletin No. 1*, *Irrigation Dept.*, *Transvaal*, Pretoria, 1905.

TABLE 2.

Top width, 8 ft.; upstream slope, 2 to 1; downstream slope, 1½ to 1.

Height in Feet.	Cross Sectional Area in Square Feet.									
0	0.00	0.82	1.67	2.56	3.48	4.44	5.43	6.46	7.52	8.62
1	9.75	10.92	12.12	13.36	14.63	15.94	17.28	18.66	20.07	21.52
2	23.00	24.52	26.07	27.66	29.28	30.94	32.63	34.36	36.12	37.92
3	39.75	41.62	43.52	45.46	47.43	49.44	51.48	53.56	55.67	57.82
4	60.00	62.22	64.47	66.76	69.08	71.44	73.83	76.26	78.72	81.22
5	83.75	86.32	88.92	91.56	94.23	96.94	99.68	102.46	105.27	108.12
6	111.00	113.92	116.87	119.86	122.88	125.94	129.03	132.16	135.32	138.52
7	141.75	145.02	148.32	151.66	155.03	158.44	161.88	165.36	168.87	172.42
8	176.00	179.62	183.27	186.96	190.68	194.44	198.23	202.06	205.92	209.82
9	213.75	217.72	221.72	225.76	229.83	233.94	238.08	242.26	246.47	250.72
10	255.00	259.32	263.67	268.06	272.48	276.94	281.43	285.96	290.52	295.12
11	299.75	304.42	309.12	313.86	318.63	323.44	328.28	333.16	338.07	343.02
12	348.00	353.02	358.07	363.16	368.28	373.44	378.63	383.86	389.12	394.42
13	399.75	405.12	410.52	415.96	421.43	426.94	432.48	438.06	443.67	449.32
14	455.00	460.72	466.47	472.26	478.08	483.94	489.93	495.76	501.72	507.72
15	513.75	519.82	525.92	532.06	538.23	544.44	550.68	556.96	563.27	569.62
Decimals of a Foot.	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9

A general rule for dimensions of dams over 16 feet high is:

Top width $= \frac{1}{2}$ the maximum height.
Upstream slope $=3$ to 1.
Downstream slope $=2$ to 1.

The level of the waste weir should be from 5 to 6 feet below the level of the top of the wall.

SECTION IV. FLOW OF WATER IN PIPES.

General Laws.—1. When the diameter and length are constant, the discharge varies directly as the square root of the head. Conversely, the head is directly as the square of the discharge.

2. When the head and length are constant, the discharge is directly as the 2.5th power of the diameter. Conversely, the diameter will vary as the 2.5th root of the discharge.

3. When the discharge and length are constant, the head will be inversely as the 5th power of the diameter. Conversely, the diameter will be inversely as the 5th root of the head.

4. When the head and diameter are constant, the discharge will be inversely as the square root of the length. Conversely, the length varies as the square of the discharge.

5. When the discharge and diameter are constant, the head is directly and simply as the length.

The hydraulic mean gradient corresponds to a straight line drawn between the points of intake and delivery of a pipe. No loss of effect will arise from the pipe following the contour of the ground as long as it keeps below the hydraulic mean gradient. If the pipe be carried over a hill which is above the hydraulic mean gradient but below the level of the intake, the first section, having a low head, must be of a greater diameter than the subsequent section, which has a greater head.

The sine of slope of the hydraulic mean gradient is the head divided by the length of the pipe.

The hydraulic mean depth, or *mean radius*, is the cross-sectional area of the water divided by the length of the wetted perimeter of the pipe or channel; in a circular pipe running full it is equal to one-fourth the diameter ($\frac{d}{4}$).

Except under considerable pressure, flowing water does not entirely fill the pipe, and yet if it be more than three-quarters full, the discharge is but slightly less than if it were full. This is due to the fact that the full circle does not give the maximum discharging velocity, which is attained when the pipe is filled to the level of the chord of an arc of $78\frac{1}{2}°$. This gives an increase over the full circle of $9\frac{1}{2}$ per cent. in velocity, and over $2\frac{1}{2}$ per cent. in discharge. The mean radius can therefore be safely taken as equal to $\frac{d}{4}$ when the pipe is more than three-quarters full.

Discharge in cubic feet per second = cross-sectional area of water in square feet × mean velocity in feet per second.

Cross-Sectional Areas and Capacities of Cylindrical Pipes of Various Diameters.

D = the diameter of the pipe in inches.

A = the cross-sectional area of the pipe in square feet; or the number of cubic feet in a length of 1 foot.

D	A	D	A	D	A
½	.0014	10½	.6013	20½	2.292
1	.0055	11	.6600	21	2.405
1½	.0123	11½	.7213	21½	2.521
2	.0218	12	.7854	22	2.640
2½	.0341	12½	.8522	22½	2.761
3	.0491	13	.9218	23	2.885
3½	.0668	13½	.9940	23½	3.012
4	.0873	14	1.069	24	3.142
4½	.1104	14½	1.147	25	3.409
5	.1363	15	1.227	26	3.687
5½	.1650	15½	1.310	27	3.976
6	.1964	16	1.396	28	4.276
6½	.2304	16½	1.485	29	4.587
7	.2673	17	1.576	30	4.909
7½	.3068	17½	1.670	31	5.241
8	.3491	18	1.767	32	5.585
8½	.3941	18½	1.867	33	5.940
9	.4418	19	1.969	34	6.305
9½	.4922	19½	2.074	35	6.681
10	.5454	20	2.182	36	7.069

Velocity.—Let v = the mean velocity in feet per second.
r = the hydraulic mean depth.
s = the sine of slope.

Then $v = C\, r^{\frac{2}{3}}\, s^{\frac{1}{2}}$.

Or v = the cube root of the square of r × the square root of s × the value of C in the table. C is a coefficient which varies according to the smoothness of the interior surface of the pipe or conduit; but which is not appreciably affected by differences in slope or diameter.

Values of C.

Asphalted wrought-iron pipe = 170.
Plain „ „ „ = 160.
Cast-iron pipe, new, = 130.
„ „ in service, = 104.
Lap-riveted pipe, = 115.
Brick conduits, = 110.

Loss of Head in Friction

(1) is proportional to the length of the pipe,

(2) is increased by roughness of the interior surface of the pipe,

(3) decreases as the diameter of the pipe is increased,

(4) increases nearly as the square of the velocity,

(5) is independent of the pressure of the water.

These five laws may be expressed by the formula:

$$h' = f \frac{l}{d} \frac{v^2}{2g}$$

where h' = loss of head in friction in feet
l = length of pipe in feet.
d = diameter of pipe in feet.
v = mean velocity in feet per second.
g = acceleration due to gravity = 32.19 feet per second.
f = a variable constant (see table).
$\frac{v^2}{2g}$ = velocity head due to mean velocity of flow.

Values of f. (Mansfield Merriman.*)

Diameter of Pipe in feet.	Velocity in feet per second.						
	1	2	3	4	6	10	15
.05	.047	.041	.037	.034	.031	.029	.028
.1	.038	.032	.030	.028	.026	.024	.023
.25	.032	.028	.026	.025	.024	.022	.021
.5	.028	.026	.025	.023	.022	.020	.019
.75	.026	.025	.024	.022	.021	.019	.018
1.0	.025	.024	.023	.022	.020	.018	.017
1.25	.024	.023	.022	.021	.019	.017	.016
1.5	.023	.022	.021	.020	.018	.016	.015
1.75	.022	.021	.020	.018	.017	.015	.014
2.0	.021	.020	.019	.017	.016	.014	.013

* *Treatise on Hydraulics*, New York, 1904, p. 559.

Loss of Head in Curvature.

Let h'' = loss of head in curvature in feet.
R = radius of curve in feet.
f_1 = a variable coefficient.

Then $h'' = f_1 \frac{l}{d} \frac{v^2}{2g}$

Values of f_1.

$\frac{R}{d}$	20	10	5	3	2	1.5	1.0
f_1	.004	.008	.016	.030	.047	.072	.184

In laying down a permanent pipe-line, allowance should be made for incrustation, which reduces the effective diameter of a pipe by from $\frac{1}{2}$ to $1\frac{1}{2}$ inches. A small reduction in the size of a pipe makes a large reduction in the discharge. $\frac{1}{10}$th increase in the diameter gives an increase of about 25%, and $\frac{1}{6}$th about 50% in the discharge.

PART IV. DATA RELATING TO AIR AND STEAM.

SECTION I. AIR.

THE coefficient of expansion of air at constant pressure per 1 degree Centigrade = $\frac{1}{273}$ or .00366957 (Jolly).

The standard height of a mercury barometer is 29.922 inches or 760 millimetres.

The standard atmospheric pressure at sea-level and standard barometric pressure

= 14.706 lbs. per square inch = 1 atmosphere

= 1033.3 grammes per square centimetre.

The average atmospheric pressure at $\frac{1}{4}$ mile above sea-level = 14.02 lbs. per sq. in.

,,	,,	at $\frac{1}{2}$	mile	above	sea-level	= 13.33	,,	,,
,,	,,	$\frac{3}{4}$	,,	,,	,,	= 12.66	,,	,,
,,	,,	1	,,	,,	,,	= 12.02	,,	,,
,,	,,	$1\frac{1}{4}$	,,	,,	,,	= 11.42	,,	,,
,,	,,	$1\frac{1}{2}$	,,	,,	,,	= 10.88	,,	,,
,,	,,	2	,,	,,	,,	= 9.80	,,	,,

The pressure of one atmosphere (or 14.706 lbs. to the square inch) = that of a column of water at 62° F. 34 feet in height. This is therefore the maximum theoretical lift of a pump at sea-level.

One lb. of dry air at 0° C. (32° F.) has a volume of 12.39 cub. ft.

,, ,, ,, 15° C. (60° F.) ,, ,, 13.072 ,,

One cubic foot of dry air at 0° C. (32° F.) weighs .0807 lb.

,, ,, ,, ,, 15° C. (60° F.) ,, .0765 ,,

One gramme of dry air at 0° C. has a volume of 773.3 $cm.^3$

One cubic centimetre of dry air at 0° C. weighs .001293 gramme.

Pressure of Columns of Mercury and Water.*

Metric and British measures. Correct at 0° C. for mercury and 4° C. for water.

METRIC MEASURE.			BRITISH MEASURE.		
Cms. of Mercury.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.	Inches of Mercury.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.
1	13.5956	0.193376	1	34.533	0.491174
2	27.1912	0.386752	2	69.066	0.982348
3	40.7868	0.580128	3	103.598	1.473522
4	54.3824	0.773504	4	138.131	1.964696
5	67.9780	0.966880	5	172.664	2.455870
6	81.5736	1.160256	6	207.197	2.947044
7	95.1692	1.353632	7	241.730	3.438218
8	108.7648	1.547008	8	276.262	3.929392
9	122.3604	1.740384	9	310.795	4.420566
10	135.9560	1.933760	10	345.328	4.911740
Cms. of Water.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.	Inches of Water.	Pressure in grammes per sq. cm.	Pressure in pounds per sq. inch.
1	1	0.0142234	1	2.54	0.036227
2	2	0.0284468	2	5.08	0.072255
3	3	0.0426702	3	7.62	0.108382
4	4	0.0568936	4	10.16	0.144510
5	5	0.0711170	5	12.70	0.180637
6	6	0.0853404	6	15.24	0.216764
7	7	0.0995658	7	17.78	0.252892
8	8	0.1137872	8	20.32	0.289019
9	9	0.1280106	9	22.86	0.325147
10	10	0.1422340	10	25.40	0.361274

SECTION II. STEAM.

The following table (from the *Smithsonian Physical Tables*) summarises the chief properties of steam for pressures ranging from 1 to 219 lbs. per square inch:

* *Smithsonian Physical Tables*, Washington, 1906, p. 119.

PROPERTIES OF STEAM.*

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B.T.U.	Internal latent heat per pound of steam in B.T.U.	External latent heat per pound of steam in B.T.U.	Total latent heat per pound of steam in B.T.U.	Total heat per pound of steam in B.T.U.
1	144	0.068	102.0	334.23	0.0030	70.1	980.6	62.34	1043.	1113.0
2	288	.136	126.3	173.23	.0058	94.4	961.4	64.62	1026.	1120.4
3	432	.204	141.6	117.98	.0085	109.9	949.2	66.58	1011.	1127.0
4	576	.272	153.1	89.80	.0111	121.4	940.2	67.06	1007.	1128.6
5	720	.340	162.3	72.50	.0137	130.7	932.8	67.89	1001.	1131.4
6	864	0.408	170.1	61.10	0.0163	138.6	926.7	68.58	995.2	1133.8
7	1008	.476	176.9	53.00	.0189	145.4	921.3	69.18	990.5	1135.9
8	1152	.544	182.9	46.60	.0214	151.5	916.5	69.71	986.2	1137.7
9	1296	.612	188.3	41.82	.0239	156.9	912.2	70.18	982.4	1139.4
10	1440	.680	193.2	37.80	.0264	161.9	908.3	70.61	979.0	1140.9
11	1584	0.748	197.8	34.61	0.0289	166.5	904.8	70.99	975.8	1142.3
12	1728	.816	202.0	31.90	.0314	170.7	901.5	71.34	972.8	1143.5
13	1872	.884	205.9	29.58	.0338	174.7	898.4	71.68	970.0	1144.7
14	2016	.952	209.5	27.59	.0362	178.4	895.4	72.00	967.4	1145.9
15	2160	1.020	213.0	25.87	.0387	181.9	892.7	72.29	965.0	1146.9
16	2304	1.088	216.3	24.33	0.0411	185.2	890.1	72.57	962.7	1147.9
17	2448	.156	219.4	22.98	.0435	188.4	887.6	72.82	960.4	1148.9
18	2592	.224	222.4	21.78	.0459	191.4	885.3	73.07	958.3	1149.8
19	2736	.292	225.2	20.70	.0483	194.3	883.1	73.30	956.3	1150.6
20	2880	.360	227.9	19.72	.0507	197.0	880.9	73.53	954.4	1151.4
21	3024	1.429	230.5	18.84	0.0531	199.7	878.8	73.74	952.6	1152.2
22	3168	.497	233.0	18.03	.0554	202.2	876.8	73.94	950.8	1153.0
23	3312	.565	235.4	17.30	.0578	204.7	874.9	74.13	949.1	1153.7
24	3456	.633	237.7	16.62	.0602	207.0	873.1	74.32	947.4	1154.4
25	3600	.701	240.0	15.99	.0625	209.3	871.3	74.51	945.8	1155.1
26	3744	1.769	242.2	15.42	0.0649	211.5	869.6	74.69	944.3	1155.8
27	3888	.837	244.3	14.88	.0672	213.7	867.9	74.85	942.8	1156.4
28	4032	.905	246.3	14.38	.0695	215.7	866.3	75.01	941.3	1157.1
29	4176	.973	248.3	13.91	.0619	217.8	864.7	75.17	939.9	1157.7
30	4320	2.041	250.2	13.48	.0742	219.7	863.2	75.33	938.5	1158.3
31	4464	2.109	252.1	13.07	0.0765	221.6	861.7	75.47	937.2	1158.8
32	4608	.177	253.9	12.68	.0788	223.5	860.3	75.61	935.9	1159.4
33	4752	.245	255.7	12.32	.0811	225.3	858.9	75.76	934.6	1159.9
34	4896	.313	257.5	11.98	.0835	227.1	857.5	75.89	933.4	1160.5
35	5040	.381	259.2	11.66	.0858	228.8	856.1	76.02	932.1	1161.0
36	5184	2.449	260.8	11.36	0.0881	230.5	854.8	76.16	931.0	1161.5
37	5328	.517	262.5	11.07	.0903	232.2	853.5	76.28	929.8	1162.0
38	5472	.585	264.0	10.79	.0926	233.8	852.3	76.40	928.7	1162.5
39	5616	.653	265.6	10.53	.0949	235.4	851.0	76.52	927.6	1162.9
40	5760	.722	267.1	10.29	.0972	236.9	849.8	76.63	926.5	1163.4
41	5904	2.789	268.6	10.05	0.0995	238.5	848.7	76.75	925.4	1163.9
42	6048	.857	270.1	9.83	.1018	239.9	847.5	76.86	924.4	1164.3
43	6192	.925	271.5	9.61	.1040	241.4	846.4	76.97	923.3	1164.7
44	6336	.993	272.9	9.41	.1063	242.9	845.2	77.07	922.3	1165.2
45	6480	3.061	274.3	9.21	.1086	244.3	844.1	77.18	921.3	1165.6
46	6624	3.129	275.6	9.02	0.1108	245.6	843.1	77.29	920.4	1166.0
47	6768	.197	277.0	8.84	.1131	247.0	842.0	77.39	919.4	1166.4
48	6912	.265	278.3	8.67	.1153	248.3	841.0	77.49	918.5	1166.8
49	7056	.333	279.6	8.50	.1176	249.7	840.0	77.58	917.5	1167.2

* From the *Smithsonian Physical Tables*, Washington, 1904: based on a Table by Dwelshauvers-Dery (*Trans. Am. Soc. Mech. Eng.*, vol. xi.).

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B.T.U.	Internal latent heat per pound of steam in B.T.U.	External latent heat per pound of steam in B.T.U.	Total latent heat per pound of steam in B.T.U.	Total heat per pound of steam in B.T.U.
50	7200	3.401	280.8	8.34	0.1198	251.0	839.0	77.67	916.6	1167.6
51	7344	.469	282.1	8.19	.1221	252.2	838.0	77.76	915.7	1168.0
52	7488	.537	283.3	8.04	.1243	253.5	837.0	77.85	914.9	1168.3
53	7632	.605	284.5	7.90	.1266	254.7	836.0	77.94	914.0	1168.7
54	7776	.673	285.7	7.76	.1288	256.0	835.1	78.03	913.1	1169.1
55	7920	3.741	286.9	7.63	0.1310	257.1	834.2	78.12	912.3	1169.4
56	8064	.801	288.1	7.50	.1333	258.3	833.2	78.21	911.5	1169.8
57	8208	.878	289.2	7.38	.1355	259.5	832.3	78.29	910.6	1170.1
58	8352	.946	290.3	7.26	.1377	260.7	831.5	78.37	909.8	1170.5
59	8496	4.014	291.4	7.14	.1400	261.8	830.6	78.45	909.0	1170.8
60	8640	4.082	292.5	7.03	0.1422	262.9	829.7	78.53	908.2	1171.2
61	8784	.150	293.6	6.92	.1444	264.0	828.9	78.61	907.5	1171.5
62	8928	.218	294.7	6.82	.1466	265.1	828.0	78.68	906.7	1171.8
63	9072	.286	295.7	6.72	.1488	266.1	827.2	78.76	905.9	1172.1
64	9216	.354	296.7	6.62	.1511	267.2	826.4	78.83	905.2	1172.4
65	9360	4.422	297.8	6.52	0.1533	268.3	825.6	78.90	904.5	1172.8
66	9504	.490	298.8	6.43	.1555	269.3	824.8	78.97	903.7	1173.1
67	9648	.558	299.8	6.34	.1577	270.4	824.0	79.04	903.1	1173.4
68	9792	.626	300.1	6.25	.1599	271.4	823.2	79.11	902.3	1173.7
69	9936	.694	301.8	6.17	.1621	272.4	822.4	79.18	901.6	1174.0
70	10080	4.762	302.7	6.09	0.1643	273.4	821.6	79.25	900.9	1174.3
71	10224	.830	303.7	6.00	.1665	274.3	820.9	79.32	900.2	1174.6
72	10368	.898	304.6	5.93	.1687	275.3	820.1	79.39	899.5	1174.9
73	10512	.966	305.5	5.85	.1709	276.3	819.4	79.46	898.8	1175.1
74	10656	5.034	306.5	5.78	.1731	277.2	818.7	79.53	898.1	1175.4
75	10800	5.102	307.4	5.70	0.1753	278.2	817.9	79.59	897.5	1175.7
76	10944	.170	308.3	5.63	.1775	279.1	817.2	79.65	896.9	1176.0
77	11088	.238	309.2	5.57	.1797	280.0	816.5	79.71	896.2	1176.2
78	11232	.306	310.1	5.50	.1818	280.9	815.8	79.77	895.6	1176.5
79	11376	.374	310.9	5.43	.1840	281.8	815.1	79.83	895.0	1176.8
80	11520	5.442	311.8	5.37	0.1862	282.7	814.4	79.89	894.3	1177.0
81	11664	.510	312.7	5.31	.1884	283.6	813.8	79.95	893.7	1177.3
82	11808	.578	313.5	5 25	.1906	284.5	813.0	80.01	893.1	1177.6
83	11952	.646	314.4	5.19	.1928	285.3	812.4	80.07	892.5	1177.8
84	12096	.714	315.2	5.13	.1949	286.2	811.7	80.13	891.9	1178.0
85	12240	5.782	316.0	5.07	0.1971	287.0	811.1	80.19	891.3	1178.3
86	12384	.850	316.8	5.02	.1993	287.9	810.4	80.25	890.7	1178.6
87	12528	.918	317.6	4.96	.2015	288.7	809.8	80.30	890.1	1178.9
88	12672	.986	318.4	4.91	.2036	289.5	809.2	80.35	889.5	1179.0
89	12816	6.054	319.2	4.86	.2058	290.4	808.5	80.40	888.9	1179.3
90	12960	6.122	320.0	4.81	0.2080	291.2	807.9	80.45	888.4	1179.5
91	13104	.190	320.8	4.76	.2102	292.0	807.3	80.50	887.8	1179.8
92	13248	.258	321.6	4.71	.2123	292.8	806.7	80.56	887.2	1180.0
93	13392	.327	322.4	4.66	.2145	293.6	806.1	80.61	886.7	1180.3
94	13536	.396	323.1	4.62	.2166	294.3	805.5	80.66	886.1	1180.5
95	13680	6.463	323.9	4.57	0.2188	295.1	804.9	80.71	885.6	1180.7
96	13824	.531	324.6	4.53	.2209	295.9	804.3	80.76	885.0	1180.9
97	13968	.599	325.4	4.48	.2231	296.7	803.7	80.81	884.5	1181.2
98	14112	.667	326.1	4.44	.2252	297.4	803.1	80.86	884.0	1181.4
99	14256	.735	326.8	4.40	.2274	298.2	802.5	80.91	883.4	1181.6

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B.T.U.	Internal latent heat per pound of steam in B.T.U.	External latent heat per pound of steam in B.T.U.	Total latent heat per pound of steam in B.T.U.	Total heat per pound of steam in B.T.U.
100	14400	6.803	327.6	4.356	0.2295	298.9	802.0	80.95	882.9	1181.8
101	14544	.871	328.3	.316	.2317	299.7	801.4	81.00	882.4	1182.1
102	14688	.939	329.0	.276	.2338	300.4	800 8	81.05	881.9	1182.3
103	14832	7.007	329.7	.237	.2360	301.1	800.3	81.10	881.4	1182.5
104	14976	.075	330.4	.199	.2381	301.9	799.7	81.14	880.8	1182.7
105	15120	7.143	331.1	4.161	0.2403	302.6	799.2	81.18	880.3	1182.9
106	15264	.211	331.8	.125	.2424	303.3	798.6	81.23	879.8	1183.1
107	15408	.279	332.5	.088	.2446	304.0	798.1	81.27	879.3	1183.4
108	15552	.347	333.2	.053	.2467	304.7	797.5	81.31	878.8	1183.6
109	15696	.415	333.8	.018	.2489	305.4	797.0	81.36	878.3	1183.8
110	15840	7.483	334.5	3.984	0.2510	306.1	796.5	81.41	877.9	1184.0
111	15984	.551	335.2	.950	.2531	306.8	795.9	81.45	877.4	1184.2
112	16128	.619	335.8	.917	.2553	307.5	795.4	81.50	876.9	1184.4
113	16272	.687	336.5	.885	.2574	308.2	794.9	81.54	876.4	1184.6
114	16416	.757	337.2	.853	.2596	308.8	794.4	81.58	875.9	1184.8
115	16560	7.823	337.8	3.821	0.2617	309.5	793.8	81.62	875.5	1185.0
116	16704	.891	338.5	.790	.2638	310.2	793.3	81.66	875.0	1185.2
117	16848	.959	339.1	.760	.2660	310.8	792.8	81.70	874.5	1185.4
118	16992	8.027	339.7	.730	.2681	311.5	792.3	81.74	874.1	1185.6
119	17136	.095	340.4	.700	.2702	312.1	791.8	81.78	873.6	1185.7
120	17280	8.163	341.0	3.671	0.2724	312.8	791.3	81.82	873.2	1185.9
121	17424	.231	341.6	.643	.2745	313.4	790.8	81.86	872.7	1186.1
122	17568	.299	342.2	.615	.2766	314.1	790.3	81.90	872.2	1186.3
123	17712	.367	342.8	.587	.2787	314.7	789.9	81.94	871.8	1186 5
124	17856	.435	343.5	.560	.2809	315.3	789.4	81.98	871.4	1186.7
125	18000	8.503	344.1	3.534	0.2830	316.0	788.9	82.02	870.9	1186.9
126	18144	.571	344.7	.507	.2851	316.6	788.4	82.06	870.5	1187.1
127	18288	.639	345 3	.481	.2872	317.2	787.9	82.09	870.0	1187.2
128	18432	.708	345.9	.456	.2893	317.8	787.5	82.13	869.6	1187.4
129	18576	.776	346.5	.431	.2915	318.4	787.0	82.17	869.2	1187.6
130	18720	8.844	347.1	3.406	0.2936	319.0	786.5	82.21	868.7	1187.8
131	18864	.912	347.6	.382	.2957	319.7	786.1	82.25	868.3	1188.0
132	19008	.980	348.2	.358	.2978	320.3	785.6	82.28	867.9	1188.1
133	19152	9.048	348.8	.334	.2999	320.9	785.1	82.32	867.5	1188.3
134	19296	.116	349.4	.310	.3021	321.5	784.7	82.35	867.0	1188.5
135	19440	9.184	349.9	3.287	0.3042	322.1	784.2	82.38	866.6	1188.7
136	19584	.252	350.5	.265	.3063	322.6	783.8	82.42	866.2	1188.8
137	19728	.320	351.1	.424	.3084	323.2	783.3	82.45	865.8	1189.0
138	19872	.388	351.6	.220	.3105	323.8	782.9	82.49	865.4	1189.2
139	20016	.456	352.2	.199	.3126	324.4	782.4	82.52	865.0	1189.4
140	20160	9.524	352.8	3.177	0.3147	325.0	782.0	82.56	864.6	1189.5
141	20304	.592	353.3	.156	.3168	325.5	781.6	82.59	864.2	1189.7
142	20448	.660	353.9	.135	.3190	326.1	781.1	82.63	863.8	1189.9
143	20592	.728	354.4	.115	.3211	326.7	780.7	82.66	863.4	1190.0
144	20736	.796	355.0	.094	.3232	327.2	780.3	82.69	863.0	1190.2
145	20880	9.864	355.5	3.074	0.3253	327.8	779.8	82.72	862.6	1190.4
146	21024	.932	356.0	.054	.3274	328.4	779.4	82.75	862.2	1190.5
147	21168	10.000	356.6	.035	.3295	328.9	779.0	82.79	861.8	1190.7
148	21312	.068	357.1	.016	.3316	329.5	778.6	82.82	861.4	1190.9
149	21456	.136	357.6	.997	.3337	330.0	778.1	82.86	861.0	1191.0

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B.T.U.	Internal latent heat per pound of steam in B.T.U.	External latent heat per pound of steam in B.T.U.	Total latent heat per pound of steam in B.T.U.	Total heat per pound of steam in B.T.U.
150	21600	10.204	358.2	2.978	0.3358	330.6	777.7	82.89	860.6	1191.2
151	21744	.272	358.7	.960	.3379	331.1	777.3	82.92	860.2	1191.3
152	21888	.340	359.2	.941	.3400	331.6	776.9	82.95	859.9	1191.5
153	22032	.408	359.7	.923	.3421	332.2	776.5	82.98	859.5	1191.7
154	22176	.476	360.2	.906	.3442	332.7	776.1	83.01	859.1	1191.8
155	22320	10.544	360.7	2.888	0.3462	333.2	775.7	83.04	858.7	1192.0
156	22464	.612	361.3	.871	.3483	333.8	775.3	83.07	858.3	1192.1
157	22608	.680	361.8	.854	.3504	334.3	774.9	83.10	858.0	1192.3
158	22752	.748	362.3	.837	.3525	334.8	774.5	83.13	857.6	1192.4
159	22896	.816	362.8	.820	.3546	335.3	774.1	83.16	857.2	1192.6
160	23040	10.884	363.3	2.803	0.3567	335.9	773.7	83.19	856.9	1192.7
161	23184	.952	363.8	.787	.3588	336.4	773.3	83.22	856.5	1192.9
162	23328	11.020	364.3	.771	.3609	336.9	772.9	83.25	856.1	1193.0
163	23472	.088	364.8	.755	.3630	337.4	772.5	83.28	855.8	1193.2
164	23616	.157	365.3	.739	.3650	337.9	772.1	83.31	855.4	1193.3
165	23760	11.225	365.7	2.724	0.3671	338.4	771.7	83.34	855.1	1193.5
166	23904	.293	366.2	.708	.3692	338.9	771.3	83.37	854.7	1193.6
167	24048	.361	366.7	.693	.3713	339.4	771.0	83.39	854.3	1193.8
168	24192	.429	367.2	.678	.3734	339.9	770.6	83.42	854.0	1193.9
169	24336	.497	367.7	.663	.3754	340.4	770.2	83.45	853.6	1194.1
170	24480	11.565	368.2	2.649	0.3775	340.9	769.8	83.48	853.3	1194.2
171	24624	.633	368.6	.634	.3796	341.4	769.4	83.51	852.9	1194.4
172	24768	.701	369.1	.620	.3817	341.9	769.1	83.54	852.6	1194.5
173	24912	.769	369.6	.606	.3838	342.4	768.7	83.56	852.2	1194.7
174	25056	.837	370.0	.592	.3858	342.9	768.3	83.59	851.9	1194.8
175	25200	11.905	370.5	2.578	0.3879	343.4	767.9	83.62	851.6	1194.9
176	25344	.973	371.0	.564	.3900	343.9	767.6	83.64	851.2	1195.1
177	25488	12.041	371.4	.550	.3921	344.3	767.2	83.67	850.9	1195.2
178	25632	.109	371.9	.537	.3942	344.8	766.8	83.70	850.5	1195.4
179	25776	.177	372.4	.524	.3962	345.3	766.5	83.73	850.2	1195.5
180	25920	12.245	372.8	2.510	0.3983	345.8	766.1	83.75	849 9	1195.6
181	26064	.313	373.3	.497	.4004	346.3	765.8	83.77	849.5	1195.8
182	26208	.381	373.7	.485	.4025	346.7	765.4	83.80	849.2	1195.9
183	26352	.449	374.2	.472	.4046	347.2	765.0	83.83	848.9	1196.1
184	26496	.517	374.6	.459	.4066	347.7	764.7	83.86	848.5	1196.2
185	26640	12.585	375.1	2.447	0.4087	348.1	764.3	83.88	848.2	1196.3
186	26784	.653	375.5	.434	.4108	348.6	764.0	83.90	847.9	1196.5
187	26928	.721	376.0	.422	.4129	349.1	763.6	83.92	847.5	1196.6
188	27072	.789	376.4	.410	.4150	349.5	763.3	83.95	847.2	1196.7
189	27216	.857	376.8	.398	.4170	350.0	762.9	83.97	846.9	1196.9
190	27360	12.925	377.3	2.386	0.4191	350.4	762.6	83.99	846.6	1197.0
191	27504	.993	377.7	.374	.4212	350.9	762.2	84.02	846.3	1197.1
192	27648	13.061	378.2	.362	.4233	351.3	761.9	84.04	845.9	1197.3
193	27792	.129	378.6	.351	.4254	351.8	761.6	84.06	845.6	1197.4
194	27936	.197	379.0	.339	.4275	352.2	761.2	84.08	845.3	1197.5
195	28080	13.265	379.4	2.328	0.4296	352.7	760.9	84.10	845.0	1197.7
196	28224	.333	379.9	.317	.4316	353.1	760.5	84.13	844.7	1197.8
197	28368	.401	380.3	.306	.4337	353.6	760.2	84.16	844.4	1197.9
198	28512	.469	380.7	.295	.4358	354.0	759.9	84.19	844.0	1198.1
199	28656	.537	381.1	.284	.4379	354.4	759.5	84.21	843.7	1198.2

Pressure in pounds per square inch.	Pressure in pounds per square foot.	Pressure in atmospheres.	Temp. in degrees Fahr.	Volume per pound in cubic feet.	Weight per cubic foot in pounds.	Heat of water per pound in B.T.U.	Internal latent heat per pound of steam in B.T.U.	External latent heat per pound of steam in B.T.U.	Total latent heat per pound of steam in B.T.U.	Total heat per pound of steam in B.T.U.
200	28800	13.605	381.6	2.273	0.4399	354.9	759.2	84.23	843.4	1198.3
201	28944	13.673	382.0	.262	.4420	355.3	758.9	84.26	843.1	1198.4
202	29088	13.742	382.4	.252	.4441	355.8	758.5	84.28	842.8	1198.6
203	29232	13.810	382.8	.241	.4461	356.2	758.2	84.30	842.5	1198.7
204	29376	13.878	383.2	.231	.4482	356.6	757.9	84.33	842.2	1198.8
205	29520	13.946	383.7	2.221	0.4503	357.1	757.5	84.35	841.9	1199.0
206	29664	14.014	384.1	.211	.4523	357.5	757.2	84.37	841.6	1199.1
207	29808	14.082	384.5	.201	.4544	357.9	756.9	84.40	841.3	1199.2
208	29952	14.150	384.9	.191	.4564	358.3	756.6	84.42	841.0	1199.3
209	30096	14.218	385.3	.181	.4585	358.8	756.2	84.44	840.7	1199.4
210	30240	14.386	385.7	2.171	0.4605	359.2	755.9	84.46	840.4	1199.6
211	30384	14.454	386.1	.162	.4626	359.6	755.6	84.48	840.1	1199.7
212	30528	14.522	386.5	.152	.4646	360.0	755.3	84.51	839.8	1199.8
213	30672	14.590	386.9	.143	.4666	360.4	755.0	84.53	839.5	1199.9
214	30816	14.658	387.3	.134	.4687	360.9	754.7	84.55	839.2	1200.1
215	30960	14.726	387.7	2.124	0.4707	361.3	754.3	84.57	838.9	1200.2
216	31104	14.794	388.1	.115	.4727	361.7	754.0	84.60	838.6	1200.3
217	31248	14.862	388.5	.106	.4748	362.1	753.7	84.62	838.3	1200.4
218	31392	14.930	388.9	.097	.4768	362.5	753.4	84.64	838.0	1200.5
219	31536	14.998	389.3	.088	.4788	362.9	753.1	84.66	837.7	1200.7

PART V. DATA SPECIALLY RELATING TO MINING.

SECTION I. DENSITY AND OTHER PHYSICAL PROPERTIES OF VARIOUS MINERAL SUBSTANCES, ORES, METALS, ETC.

DENSITY AND SPECIFIC GRAVITY.

Density is the weight *in vacuo* of unit volume. On the C.G.S. system it is expressed in grammes per cubic centimetre.

The *Specific Gravity* of a substance is the ratio of its density to that of water at 4° C. (this being the temperature at which water has its maximum density).

The density of water at 4° C. (39°.2 F.) is very little less than unity. According to the latest determination, the weight *in vacuo* of a cubic centimetre of water at 4° C. is 0.999974 gramme (see page 4).

For practical purposes, therefore, 'specific gravity,' as above defined, is identical with 'density.'

The first table (p. 90) gives the weight in pounds per cubic foot and the number of cubic feet per ton corresponding to a given density. The density of a given substance being known, this table gives either its weight per cubic foot or its volume per ton, as may be required. The densities of the principal ores are given on p. 93, those of the rock-forming minerals and gemstones on pp. 94 and 95. The remaining tables give the density and pounds per cubic foot of various mineral substances in common use, of the metals and their alloys and of different kinds of wood.

Table giving the weight in pounds per cubic foot and the number of cubic feet per short ton of 2000 lbs. and per long ton of 2240 lbs. corresponding to a given density.

A density of 1.0=1 gramme per cubic centimetre=62.4278 lbs. per cubic foot.

Density = grammes per cubic centi-metre.	Pounds per cubic foot.	Cubic feet per ton of 2000 lbs.	Cubic feet per ton of 2240 lbs.	Density = grammes per cubic centi-metre.	Pounds per cubic foot.	Cubic feet per ton of 2000 lbs.	Cubic feet per ton of 2240 lbs.
0.5	31.2	64.1	71.8	2.55	159.2	12.6	14.1
0.55	34.3	58.3	65.3	2.6	162.3	12.3	13.8
0.6	37.5	53.3	59.7	2.65	165.4	12.1	13.5
0.65	40.6	49.3	55.2	2.7	168.6	11.9	13.3
0.7	43.7	45.8	51.3	2.75	171.7	11.6	13.0
0.75	46.8	42.7	47.9	2.8	174.8	11.4	12.8
0.8	49.9	40.1	44.9	2.85	177.9	11.2	12.6
0.85	53.1	37.7	42.2	2.9	181.0	11.0	12.4
0.9	56.2	35.6	39.9	2.95	184.2	10.9	12.2
0.95	59.3	33.7	37.8	3.0	187.3	10.7	12.0
1.0	62.4	32.1	35.9	3.05	190.4	10.5	11.8
1.05	65.5	30.5	34.2	3.1	193.5	10.3	11.6
1.1	68.7	29.1	32.6	3.2	199.8	10.0	11.2
1.15	71.8	27.9	31.2	3.3	206.0	9.7	10.9
1.2	74.9	26.7	29.9	3.4	212.3	9.4	10.5
1.25	78.0	25.6	28.7	3.5	218.5	9.2	10.3
1.3	81.2	24.6	27.6	3.6	224.7	8.9	10.0
1.35	84.3	23.7	26.6	3.7	231.0	8.7	9.7
1.4	87.4	22.9	25.6	3.8	237.2	8.4	9.4
1.45	90.5	22.1	24.8	3.9	243.5	8.2	9.2
1.5	93.6	21.4	23.9	4.0	249.7	8.0	9.0
1.55	96.8	20.7	23.1	4.1	256.0	7.8	8.8
1.6	99.9	20.0	22.4	4.2	262.2	7.6	8.5
1.65	103.0	19.4	21.7	4.3	268.4	7.5	8.3
1.7	106.1	18.9	21.1	4.4	274.7	7.3	8.2
1.75	109.2	18.3	20.5	4.5	280.9	7.1	8.0
1.8	112.4	17.8	19.9	4.6	287.2	7.0	7.8
1.85	115.5	17.3	19.4	4.7	293.4	6.8	7.6
1.9	118.6	16.9	18.9	4.8	299.7	6.7	7.5
1.95	121.7	16.4	18.4	4.9	305.9	6.5	7.3
2.0	124.9	16.0	17.9	5.0	312.1	6.4	7.2
2.05	128.0	15.6	17.5	5.1	318.4	6.3	7.0
2.1	131.1	15.3	17.1	5.2	324.6	6.2	6.9
2.15	134.2	14.9	16.7	5.3	330.9	6.0	6.8
2.2	137.3	14.6	16.3	5.4	337.1	5.9	6.6
2.25	140.5	14.2	15.9	5.5	343.4	5.8	6.5
2.3	143.6	13.9	15.6	5.6	349.6	5.7	6.4
2.35	146.7	13.6	15.3	5.7	355.8	5.6	6.3
2.4	149.8	13.4	15.0	5.8	362.1	5.5	6.2
2.45	152.9	13.1	14.7	5.9	368.3	5.4	6.1
2.5	156.1	12.8	14.3	6.0	374.6	5.3	6.0

Density or grammes per cubic centimetre, also pounds per cubic foot and cubic feet per short ton of 2000 lbs. and per long ton of 2240 lbs. of various mineral substances.

A density of 1.0=1 gramme per cubic centimetre=62.4278 lbs. per cubic foot.

SUBSTANCE.	Density =grammes per cubic centimetre.	Pounds per cubic foot.	Cubic feet per ton of 2000 lbs.	Cubic feet per ton of 2240 lbs.
Anthracite (solid), -	1.4–1.8	87.4–112.4	22.9–17.8	25.6–19.9
Asbestos, - - -	2.0–2.8	124.9–174.8	16.0–11.4	17.9–12.8
Asphaltum, - - -	1.1–1.2	68-7–74.9	29.1–26.7	32.6–29.9
Basalt, - - - -	2.8–3.0	174.8–187.3	11.4–10.7	12.8–12.0
Bricks (see end of table).				
Brickwork ,,				
Cement—				
Pulverized, loose, -	1.15–1.7	71.8–106.1	27.9–18.9	31.2–21.1
Set, - - - -	2.7–3.0	168.6–187.3	11.9–10.7	13.3–12.0
Chalk, - - - -	1.9–2.8	118.6–174.8	16.9–11.4	18.9–12.8
Clay, - - - -	1.8–2.6	112.4–162.3	17.8–12.3	19.9–13.8
Clay Slate, - - -	2.8–2.9	174.8–181.0	11.4–11.0	12.8–12.4
Coal—				
'Soft' or bituminous, *in situ*, - - -	1.2–1.5	74.9–93.6	26.7–21.4	29.9–23.9
'Round,' in trucks, -	0.88–0.9	54.9–56.2	36.4–35.6	40.8–39.9
Coke, - - -	—	23.0–28.0	87.0–71.4	97.4–80.0
Diorite, - - -	2.8–3.0	174.8–187.3	11.4–10.7	12.8–12.0
Dolomite, - - -	2.8–2.9	174.8–181.0	11.4–11.0	12.8–12-4
Earth (dry), - - -	1.3–1.9	81.2–118.6	24.6–16.9	27.6–18.9
Gneiss, - - -	2.59–2.7	161.7–168.6	12.4–11.9	13.9–13.3
Granite, - - -	2.59–2.75	161.7–171.7	12.4–11.6	13.9–13.0
Graphite, - - -	1.9–2.3	118.6–143.6	16.9–13.9	18.9–15.6
Gravel, - - -	1.2–1.8	74.9–112.4	26.7–17.8	29.9–19.9
Greenstone, - - -	2.9–3.0	181.0–187.3	11.0–10.7	12.4–12.0
Ice, - - - -	0.88–0.91	54.9–56.8	36.4–35.2	40.8–39.4
Kaolin, - - -	2.2	137.3	14.6	16 3
Lime—				
Quick, - - -	0.9–1.2	56.2–74.9	35.6–26.7	39.9–29.9
Slaked, - - -	1.3–1.4	81.2–87.4	24.6–22.9	27.6–25.6
Mortar, - - -	1.65–1.78	103.0–111.1	19.4–18.0	21.7–20.2
Limestone, - - -	2.46–2.86	153.6–178.5	13.0–11.2	14.6–12.5
Marble, - - -	2.5–2.8	156.1–174.8	12.8–11.4	14.3–12.8
Marl, - - - -	1.6–2.5	99.9–156.1	20.0–12.8	22.4–14.3
Masonry (see end of table).				

SUBSTANCE.	Density =grammes per cubic centimetre.	Pounds per cubic foot.	Cubic feet per ton of 2000 lbs.	Cubic feet per ton of 2240 lbs.
Oolite, - - - -	2.0–2.4	124.9–149.8	16.0–13.4	17.9–15.0
Peat, - - - -	0.84	52.4	38.2	42.7
Peridotite, - - -	3.0–3.3	187.3–206.0	10.7–9.7	12.0–10.9
Quartz—				
Solid, as in lodes, -	2.67	166.7	12.0	13.4
Broken, ready for milling, - - -	1.6	99.9	20.0	22.4
Tailings, *i.e.* the sands from the mill pulp, wet, as collected in settling vats, - -	1.42	88.7	22.5	25.3
Do., dry, - -	1.23	76.8	26.0	29.2
Slimes, *i.e.* the slowly settled portion of the mill pulp, wet, in collecting dam, -	1.92	119.9	16.7	18.7
Sand—				
Dry, - - - -	1.3–1.65	81.2–103.0	24.6–19.4	27.6–21.7
Damp, - - -	1.9–2.05	118.6–128.0	16.9–15.6	18.9–17.5
Sandstone, - - -	2.2–2.5	137.3–156.1	14.6–12.8	16.3–14.3
Serpentine, - - -	2.43–2.66	151.7–166.0	13.2–12.0	14.8–13.5
Shale, - - - -	2.4–2.8	149.8–174.8	13.4–11.4	15.0–12.8
Slate, - - - -	2.6–2.7	162.3–168.6	12.3–11.9	13.8–13.3
Slimes (see under Quartz).				
Syenite, - - -	2.75–2.9	171.7–181.0	11.6–11.0	13.0–12.4
Tailings (see under Quartz).				
Trachyte, - - -	2.7–2.8	168.6–174.8	11.9–11.4	13.3–12.8

Bricks—
- Best, pressed, weigh from 145 to 155 lbs. per cubic foot.
- Common, hard, ,, 120 to 130 ,, ,,
- Inferior, soft, ,, 90 to 110 ,, ,,

Masonry—

Of granite or limestone—
- Best ashlar, weighs from 155 to 180 lbs. per cubic foot.
- Best mortar rubble, ,, 150 to 160 ,, ,,
- Best dry rubble, ,, 130 to 145 ,, ,,
- Rough mortar rubble, ,, 140 to 150 ,, ,,
- Rough dry rubble, ,, 120 to 130 ,, ,,

Of sandstone, deduct ⅛th from the above weights.

Of brickwork—
- Best pressed brick, fine joints, weighs from 135 to 145 lbs. per cubic ft.
- Common hard brick, ,, 120 to 130 ,, ,,
- Inferior soft brick, coarse work, ,, 90 to 110 ,, ,,

Cement concrete weighs from 125 to 145 lbs. per cubic foot.

Density and pounds per cubic foot of various metals and alloys.

Metal or Alloy.	Density =grammes per cubic centimetre.	Pounds per cubic foot.
Aluminium, - - - - - -	2.6–2.8	162.3–174.8
Antimony, - - - - -	6.7–6.72	418.3–419.5
Bismuth, - - - - -	9.7–9.9	605.5–618.0
Brass, - - - - - -	8.44–8.7	526.9–543.1
Bronze, - - - - -	8.74–8.89	545.6–555.0
Cobalt, - - - - - -	8.5–9.1	530.6–568.1
Copper,- - - - - -	8.8–8.95	549.4–558.7
Gold, - - - - - -	19.26–19.34	1202.4–1207.4
Iridium, - - - - -	21.78–22.42	1359.7–1399.6
Iron—		
Gray cast, - - - - -	7.03–7.13	438.9–445.1
White cast, - - - -	7.58–7.73	473.2–482.6
Wrought, - - - - -	7.8–7.9	486.9–493.2
Lead, - - - - - -	11.34–11.36	707.9–709.2
Mercury at 0° C., - - - -	13.596	848.8
Nickel, - - - - - -	8.3–8.9	518.2–555.6
Platinum, - - - - -	21.2–21.7	1323.5–1354.7
Platinum and Iridium, - - -	21.62–22.38	1349.7–1397.1
Silver, - - - - - -	10.4–10.57	649.2–659.9
Steel, - - - - - -	7.8–7.9	486.9–493.2
Tin, - - - - - -	7.29–7.3	455.1–455.7
Tungsten, - - - - -	19.12	1193.6
Zinc, - - - - - -	7.04–7.19	439.5–448.9

Density of the principal ores of the metals.

Antimonite, -	4.6–4.7	Hemimorphite, -	3.4–3.5
Argentite, - -	7.0–7.4	Kerargyrite, -	5.58–5.6
Blende, - -	3.9–4.2	Limonite, - -	3.4–3.9
Bornite, - -	4.9–5.2	Magnetite, - -	4.9–5.2
Calamine, - -	4.1–4.5	Malachite, - -	3.7–4.1
Cassiterite, - -	6.8–7.0	Manganese-spar,	3.3–3.6
Cerussite, - -	6.4–6.6	Nagyagite, - -	6.85–7.2
Chalcopyrite, -	4.1–4.3	Platinum, - -	12–18
Chessylite, - -	3.7–3.8	Proustite, - -	5.5–5.6
Chromite, - -	4.4–4.6	Psilomelane, -	3.14–3.36
Cinnabar, - -	8.0–8.2	Pyrargyrite, -	5.75–5.85
Copper (Native),	8.5–8.9	Pyrolusite, - -	4.7–5.0
Copper Glance, -	5.5–5.8	Siderite, - -	3.7–3.9
Covellite - -	4.6	Silver (Native), -	10.5–11.0
Cryolite, - -	2.95–2.99	Stephanite, -	6.2–6.3
Cuprite, - -	5.7–6.0	Sylvanite, - -	7.99–8.33
Galena, - -	7.3–7.6	Wad, - - -	2.3–3.7
Gold (Native), -	15.6–19.4	Willemite, - -	3.9–4.2
Hæmatite, - -	5.19–5.28		

Density and pounds per cubic foot of different kinds of wood.*

The wood is supposed to be seasoned and of average dryness.

Wood.	Density = grammes per cubic cm.	Pounds per cubic foot.	Wood.	Density = grammes per cubic cm.	Pounds per cubic foot.
Alder - - - - -	0.42–0.68	26–42	Greenheart - - -	0.93–1.04	58–65
Apple - - - - -	0.66–0.84	41–52	Hazel - - - - -	0.60–0.80	37–49
Ash - - - - - -	0.65–0.85	40–53	Hickory - - - -	0.60–0.93	37–58
Basswood. See Linden.			Iron-bark - - - -	1.03	64
Beech - - - - -	0.70–0.90	43–56	Laburnum - - - -	0.92	57
Blue gum - - - -	0.84	52	Lancewood - - -	0.68–1.00	42–62
Birch - - - - - -	0.51–0.77	32–48	Lignum vitæ - - -	1.17–1.33	73–83
Box - - - - - -	0.95–1.16	59–72	Linden or Lime-tree	0.32–0.59	20–37
Bullet-tree - - - -	1.05	65	Locust - - - - -	0.67–0.71	42–44
Butternut - - - -	0.38	24	Mahogany, Honduras	0.56	35
Cedar - - - - -	0.49–0.57	30–35	,, Spanish -	0.85	53
Cherry - - - - -	0.70–0.90	43–56	Maple - - - - -	0.62–0.75	39–47
Cork - - - - - -	0.22–0.26	14–16	Oak - - - - -	0.60–0.90	37–56
Ebony - - - - -	1.11–1.33	69–83	Pear-tree - - - -	0.61–0.73	38–45
Elm - - - - - -	0.54–0.60	34–37	Plum-tree - - - -	0.66–0.78	41–49
Fir or Pine, American			Poplar - - - - -	0.35–0.5	22–31
White	0.35–0.50	22–31	Satinwood - - -	0.95	59
,, Larch -	0.50–0.56	31–35	Sycamore - - - -	0.40–0.60	24–37
,, Pitch - -	0.83–0.85	52–53	Teak, Indian - - -	0.66–0.88	41–55
,, Red - -	0.48–0.70	30–44	,, African - -	0.98	61
,, Scotch -	0.43–0.53	27–33	Walnut - - - -	0.64–0.70	40–43
,, Spruce -	0.48–0.70	30–44	Water gum - - -	1.00	62
,, Yellow -	0.37–0.60	23–37	Willow - - - - -	0.40–0.60	24–37

Density of the rock-forming minerals and of gem-stones.

Agate, - - - - - - - - - -	2.6
Apatite, - - - - - - - - - -	3.2
Aragonite, - - - - - - - - -	2.9
Augite, - - - - - - - - - -	3.3–3.49
Barytes (heavy spar), - - - - - - -	4.5
Beryl (aquamarine, emerald), - - - - -	2.7
Calcite (calcspar, Icelandspar), - - - - -	2.72
Chlorite, - - - - - - - - -	2.6–3.0
Chrysoberyl (Alexandrite), - - - - - -	3.7
Corundum (ruby, sapphire), - - - - - -	4.0
Diamond, - - - - - - - - -	3.52
Diopside, - - - - - - - - -	3.3
Dolomite, - - - - - - - - -	2.85
Felspar, - - - - - - - - - -	2.56–2.75
Fluorspar, - - - - - - - - -	3.2
Garnet (almandine, carbuncle, pyrope, etc.), - - -	3.15–4.3
Gypsum, - - - - - - - - -	2.3
Hornblende, - - - - - - - - -	3.18–3.22

* *Smithsonian Physical Tables*, Washington, 1906.

Ilmenite,	4.8
Magnetite,	5.2
Mica,	2.84–2.93
Olivine (peridote, chrysolite),	3.4
Opal,	2.6
Phenakite,	3.0
Quartz,	2.65
Serpentine,	2.6
Spinel (balas-ruby),	3.5
Talc,	2.7
Topaz,	3.5
Tourmaline,	3.1
Turquoise,	2.7
Zircon (jargoon, hyacinth),	4.7

HARDNESS OF MINERALS.

The hardness of a mineral is measured by the force required to scratch (*i.e.* to separate) the superficial particles of the mineral with a steel point or the sharp-pointed fragment of some harder mineral. In Moh's scale, the hardness of 10 minerals is taken to represent 10 successive degrees of hardness. The degrees of hardness are, however, arbitrarily fixed, and there is no constant ratio between them :

Moh's Scale of hardness.

1. Talc.
2. Gypsum or rock salt.
3. Calcite.
4. Fluorspar.
5. Apatite.
6. Felspar (orthoclase).
7. Quartz.
8. Topaz.
9. Corundum (sapphire).
10. Diamond.

Each of the minerals forming this scale can be scratched by those which follow, and will itself scratch those that precede it in the list; consequently the hardness of a mineral is estimated by its capability of scratching or being scratched by any mineral in this list:

Hardness of gem-stones (on Moh's scale).

Agate,	7
Beryl (aquamarine, emerald),	$7\frac{1}{2}$
Chrysoberyl (Alexandrite),	$8\frac{1}{2}$
Corundum (ruby, sapphire),	9
Diamond,	10
Diopside,	$5\frac{1}{2}$
Felspar (moonstone),	6
Fluorspar,	4
Garnet (almandine, carbuncle, pyrope, etc.),	7
Olivine (peridote, chrysolite),	7
Opal,	7
Phenakite,	8
Quartz (rock-crystal, cairngorm, prase),	7
Serpentine,	3
Spinel (balas-ruby),	8
Topaz,	8
Tourmaline,	7
Turquoise,	6
Zircon (jargoon, hyacinth),	$7\frac{1}{2}$

Linear expansion of the principal metals, in microns per metre (or millionths per unit length).*

Name of Metal.	Expansion per degree C.	Expansion per degree F.
Aluminium, - -	20	11.1
Brass, - - -	19	10.5
Copper, - - -	17	9.4
Glass, - - -	9	5.0
Gold, - - -	15	8.3
Iron, cast, - -	11	6.1
Iron, wrought, - -	12	6.7
Lead, - - -	28	15.5
Platinum, - - -	9	5.0
Platinum-iridium,† -	8.7	4.8
Silver, - - -	19	10.5
Steel, hard, - -	12	6.7
Steel, soft, - -	11	6.1
Tin, - - -	19	10.5
Zinc, - - -	29	16.1

SECTION II. ORE-TONNAGE PER UNIT AREA.

By means of the table on p. 97 the number of tons of an ore or mineral contained in an acre of surface can be calculated if we know the density of the ore or mineral and the average thickness and dip of the vein or bed in which it occurs: for the tonnage given in the table for the angle of dip × the thickness of the vein or bed in feet × the density of the ore or mineral = the number of tons per acre of surface. For example, supposing it is required to know the number of long tons of coal contained in an area of 300 acres, the seam being of an average thickness of 5 feet, having a dip of 6°, and the density of the coal having been determined to be 1.4. For a dip of 6° the table gives the constant 1220.6. Therefore the required tonnage is: 1220.6 × 5 × 1.4 × 300 = 2,563,260 long tons. From this figure a considerable deduction has to be made in order to obtain the amount of marketable coal, the percentage to be deducted depending on the local conditions.

The table on p. 98 gives the tons of quartz per Transvaal claim.

* *Smithsonian Geographical Tables*, 1906, p. 170.

† Or Iridio-platinum; 90% platinum and 10% iridium. It is the alloy of which the International Prototype Metric Standards are made.

Table giving the number of short tons (2000 lbs.) and of long tons (2240 lbs.) per acre of surface contained in a vein or bed one foot thick and of a density = 1, for each degree of dip from 0° to 85°.*

Degrees of dip.	Short tons of 2000 lbs. per acre for a density = 1.	Long tons of 2240 lbs. per acre for a density = 1.	Degrees of dip.	Short tons of 2000 lbs. per acre for a density = 1.	Long tons of 2240 lbs. per acre for a density = 1.
0°	1359.6	1213.9	45°	1922.7	1716.7
1	1359.8	1214.1	46	1957.1	1747.4
2	1360.4	1214.6	47	1993.4	1779.9
3	1361.4	1215.6	48	2031.8	1814.1
4	1362.9	1216.8	49	2072.3	1850.3
5	1364.7	1218.5	50	2115.1	1888.5
6	1367.0	1220.6	51	2160.3	1928.9
7	1369.8	1223.0	52	2208.3	1971.7
8	1372.9	1225.8	53	2259.1	2017.1
9	1376.5	1229.0	54	2313.0	2065.2
10	1380.5	1232.6	55	2370.3	2116.3
11	1385.0	1236.6	56	2431.3	2170.8
12	1389.9	1241.0	57	2496.2	2228.8
13	1395.3	1245.8	58	2565.6	2290.7
14	1401.2	1251.0	59	2639.7	2356.9
15	1407.5	1256.7	60	2719.1	2427.8
16	1414.3	1262.8	61	2804.3	2503.8
17	1421.7	1269.3	62	2895.9	2585.6
18	1429.5	1276.4	63	2994.7	2673.8
19	1437.9	1283.8	64	3101.4	2769.1
20	1446.8	1291.8	65	3217.0	2872.3
21	1456.3	1300.2	66	3342.6	2984.5
22	1466.3	1309.2	67	3479.5	3106.7
23	1477.0	1318.7	68	3629.3	3240.4
24	1488.2	1328.8	69	3793.7	3387.3
25	1500.1	1339.7	70	3975.1	3549.2
26	1512.6	1350.6	71	4175.9	3728.5
27	1525.9	1362.4	72	4399.6	3928.2
28	1539.8	1374.8	73	4650.1	4151.9
29	1554.4	1387.9	74	4932.4	4403.9
30	1569.9	1401.7	75	5252.9	4690.1
31	1586.1	1416.2	76	5619.8	5017.7
32	1603.2	1431.4	77	6043.8	5396.2
33	1621.1	1447.4	78	6539.1	5838.4
34	1639.9	1464.2	79	7125.2	6361.8
35	1659.7	1481.9	80	7829.3	6990.5
36	1680.5	1500.4	81	8690.9	7759.7
37	1702.3	1519.9	82	9768.8	8722.1
38	1725.3	1540.4	83	11155.8	9960.5
39	1749.4	1562.0	84	13006.5	11613.0
40	1774.8	1584.6	85	15599.1	13927.8
41	1801.4	1608.4			
42	1829.5	1633.4			
43	1859.0	1659.8			
44	1890.0	1687.5			
45	1922.7	1716.7			

* The tonnage is not affected by the shape of the area. No deduction has been made for dykes or faults.

Table giving the number of short tons (2000 lbs.) of Quartz contained in a Transvaal claim of 60,000 square Cape feet per one British foot thickness of Reef, for each degree of dip from 0° to 85°, calculated on a basis of 12 cubic feet to the ton.*

Rule: Multiply the tonnage given by the thickness of the reef in feet.

Degrees of dip.	Tons of 2000 lbs. per claim.	Degrees of dip.	Tons of 2000 lbs. per claim.	Degrees of dip.	Tons of 2000 lbs. per claim.
0°	5335				
1	5336	31°	6225	61°	11005
2	5339	32	6291	62	11365
3	5343	33	6362	63	11752
4	5348	34	6436	64	12171
5	5356	35	6513	65	12625
6	5365	36	6595	66	13118
7	5376	37	6681	67	13655
8	5388	38	6771	68	14243
9	5402	39	6865	69	14888
10	5418	40	6965	70	15600
11	5435	41	7070	71	16388
12	5455	42	7180	72	17266
13	5476	43	7295	73	18249
14	5499	44	7417	74	19357
15	5524	45	7545	75	20615
16	5550	46	7681	76	22054
17	5579	47	7823	77	23718
18	5610	48	7974	78	25662
19	5643	49	8133	79	27962
20	5678	50	8300	80	30726
21	5715	51	8478	81	34107
22	5754	52	8666	82	38337
23	5796	53	8866	83	43780
24	5840	54	9077	84	51043
25	5887	55	9302	85	61217
26	5936	56	9541		
27	5988	57	9796		
28	6043	58	10068		
29	6100	59	10359		
30	6161	60	10671		

*The tonnage is not affected by the shape of the claim. No deduction has been made for dykes and faults.

SECTION III. UNDERGROUND TEMPERATURES.

The rise in temperature with increasing depth is a factor of great importance in deep-level mining. The rate of increase of temperature in boreholes and deep shafts has therefore to be carefully determined. The method of observing the temperature in deep boreholes by the use of clinical thermometers is described in detail by H. F. Marriott (*Trans. Inst. Min. Met.*, vol. xv., p. 405). Since in deep boring there is a considerable deviation from the vertical, the correct depth at the point of observation can only be obtained by a survey. Several instruments for this purpose have been invented. The simplest and most practical is that invented by Mr. Oehmen of Johannesburg, Transvaal. By this ingenious instrument the deviation from the vertical and the direction of the deviation are recorded by taking photographs of the position of a plumb-bob and a magnetic needle at any desired point in the borehole. The photographs are taken after the instrument has been lowered to the desired point, by means of two small incandescent lamps, which are illuminated by a dry battery by means of a time-contact regulated by a watch. The amount of deviation and its direction are calculated from the photograph after the sensitised paper has been developed at the surface. The amount of deviation is calculated by measuring the distance between the centre of the photograph of the plumb-bob and the centre of the disc, the length of the plumb-bob being a known factor. The direction of the deviation is obtained from the photograph of the magnetic needle, the correct orientation being fixed by two pin-pricks, which have the same relative position both in the photograph of the needle and in that of the plumb-bob.*

* *Brit. Assoc. Rep.* for 1905, p. 404.

Table of Underground Temperatures in Mines and Vertical Boreholes. (J. D. Everett, *Royal Commission on Coal Supplies*, 1904, vol. ii., p. 293.)

Place.	Temp. (Fahr.)	Depth (Feet).	Feet per Degree of Increase of Temp.	Recorded in Brit. Association Report for
Sperenberg (near Berlin), - - -	116	3,492	51½	1876
Rosebridge (near Wigan), - - -	94	2,445	54	1870
Paruschowitz (Silesia), - - -	157	6,445	60	1901
Pendleton (near Manchester), - -	100.6	3,480	66	—
Schladebach (near Leipzig), - -	134	5,630	67	1889
Kingswood (near Bristol), - - -	75	1,769	68	1879
Searle (Lincolnshire), - - -	79	2,000	69	1876
Dukinfield (Manchester), - - -	86.5	2,700	72	1880
Wheeling (W. Virginia), - - -	110	4,462	74	1892
Port Jackson (N.S.W.), - - -	97	2,733	80	1895
Ashton Moss (near Manchester), -	84	2,880	82	1881
Tamerack (Lake Superior), - -	84	4,450	100	1901

From a number of observations made in deep boreholes and mines in the Witwatersrand, Transvaal, Mr. Marriott has deduced a mean rate of increase of temperature for that district of 1° Fahrenheit for each 208 feet of depth, or .48° Fahr. increase per 100 feet of depth. He finds the mean temperature at 1000 feet depth to be 68.75° Fahr. (*Trans. Inst. Min. and Met.*, vol. xv., 1905-6.)

SECTION IV. DATA RELATING TO GOLD AND COPPER RETURNS.

The Valuation of Gold Bullion.

The value of pure gold (1000 fine) is £4 4s. 11.4545d. per troy ounce.* The following table for the valuation of gold bullion is calculated on this basis, namely one troy ounce of gold (1000 fine) equals £4.24773.

Weight in Grains.	Value in pounds sterling.	Weight in Dwts.	Value in pounds sterling.	Weight in Oz. Troy.	Value in pounds sterling.
1	0.00885	1	0.21239	1	4.24773
2	0.01770	2	0.42477	2	8.49546
3	0.02655	3	0.63716	3	12.74319
4	0.03540	4	0.84955	4	16.99092
5	0.04425	5	1.06193	5	21.23865
6	0.05310	6	1.27432	6	25.48638
7	0.06195	7	1.48671	7	29.73411
8	0.07080	8	1.69909	8	33.98184
9	0.07964	9	1.91148	9	38.22957
10	0.08849	10	2.12386		
11	0.09734	11	2.33625		
12	0.10619	12	2.54864		
13	0.11504	13	2.76102		
14	0.12389	14	2.97341		
15	0.13274	15	3.18580		
16	0.14159	16	3.39818		
17	0.15044	17	3.61057		
18	0.15929	18	3.82296		
19	0.16814	19	4.03534		
20	0.17699				
21	0.18584				
22	0.19469				
23	0.20354				

Example of Application of Table.

Find value of 464 oz. 13 dwts. 3 grns. of gold bullion having a fineness of 850.5.

400 oz. = 1699.092
60 „ = 254.8638
4 „ = 16.99092
13 dwts. = 2.76102
3 grns. = 0.02655

1973.73429 × 0.8505
5 058

15789874
986867
9869

£1678.6610 or £1678. 13*s.* 2.64*d.*

* The British sovereign, which is 916.6 (22 carats) fine, weighs 123.27447 grains. The gold of which it is coined is termed "standard gold," and has a value of £3 17s. 10½d. per oz.

Table for the conversion of Metric weight into Troy ounces.

Grammes.	Troy ounce.
1	.03215074248
2	.06430148496
3	.09645222744
4	.12860296992
5	.16075371239
6	.19290445487
7	.22505519735
8	.25720593983
9	.28935668231

Table for the conversion of Russian weight into Troy ounces.

1 Pood = 40 Funts = 526.6451214319 oz. troy.
1 Funt = 96 Zolotniks = 13.1661280358 oz. troy.
1 Zolotnik = 96 Dolis = 0.1371471670 oz. troy.
1 Doli = 0.0014286163 oz. troy.

	Troy ounces.		Troy ounces.
1 Pood =	526.6451214	1 Zolotnik =	0.137147
2 Poods =	1053.2902429	2 Zolotniks =	0.274294
3 " =	1579.9353643	3 " =	0.411442
4 " =	2106.5804857	4 " =	0.548589
5 " =	2633.2256072	5 " =	0.685736
6 " =	3159.8707286	6 " =	0.822883
7 " =	3686.5158500	7 " =	0.960030
8 " =	4213.1609715	8 " =	1.097177
9 " =	4739.8060929	9 " =	1.234324
1 Funt =	13.166128	1 Doli =	0.001429
2 Funts =	26.332256	2 Dolis =	0.002857
3 " =	39.498384	3 " =	0.004286
4 " =	52.664512	4 " =	0.005714
5 " =	65.830640	5 " =	0.007143
6 " =	78.996768	6 " =	0.008572
7 " =	92.162896	7 " =	0.010000
8 " =	105.329024	8 " =	0.011429
9 " =	118.495152	9 " =	0.012858

Example of use of Table.

Convert 28 poods 39 funts 76 zolotniks 24 dolis into troy ounces.

20 p. =	10532.902429	oz. troy.
8 p. =	4213.160972	"
30 f. =	394.98384	"
9 f. =	118.495152	"
70 z. =	9.60030	"
6 z. =	0.822883	"
20 d. =	0.02857	"
4 d. =	0.005714	"
	15269.999860 or say 15270 oz. troy.	

Comparison of the various methods of expressing gold ore values in use in different countries.

Dwts. per short ton to dwts. per long ton and to Metric and Russian values.

Dwts. per short ton (2000 lbs.).	Dwts. per long ton (2240 lbs.).	Grammes per tonne (1000 kgs.).	Zolotniks per 100 poods.
1	1.1200	1.7143	0.6583
2	2.2400	3.4286	1.3166
3	3.3600	5.1429	1.9749
4	4.4800	6.8571	2.6331
5	5.6000	8.5714	3.2914
6	6.7200	10.2857	3.9497
7	7.8400	12.0000	4.6080
8	8.9600	13.7143	5.2663
9	10.0800	15.4286	5.9246

Dwts. per long ton to dwts. per short ton and to Metric and Russian values.

Dwts. per long ton (2240 lbs.).	Dwts. per short ton (2000 lbs.).	Grammes per tonne (1000 kgs.).	Zolotniks per 100 poods.
1	0.8929	1.5306	0.5878
2	1.7857	3.0612	1.1755
3	2.6786	4.5918	1.7633
4	3.5714	6.1224	2.3510
5	4.4643	7.6531	2.9388
6	5.3571	9.1837	3.5265
7	6.2500	10.7143	4.1143
8	7.1429	12.2449	4.7020
9	8.0357	13.7755	5.2898

Grammes per tonne to British and Russsian values.

Grammes per tonne (1000 kgs.).	Dwts. per short ton (2000 lbs.).	Dwts. per long ton (2240 lbs.).	Zolotniks per 100 poods.
1	0.5833	0.6533	0.3840
2	1.1667	1.3067	0.7680
3	1.7500	1.9600	1.1520
4	2.3333	2.6133	1.5360
5	2.9167	3.2667	1.9200
6	3.5000	3.9200	2.3040
7	4.0833	4.5733	2.6880
8	4.6667	5.2267	3.0720
9	5.2500	5.8800	3.4560

Zolotniks per 100 poods to British and Metric values.

Zolotniks per 100 poods.	Dwts. per short ton (2000 lbs.).	Dwts. per long ton (2240 lbs.).	Grammes per tonne (1000 kgs.).
1	1.5191	1.7014	2.6042
2	3.0382	3.4028	5.2083
3	4.5573	5.1042	7.8125
4	6.0764	6.8056	10.4167
5	7.5955	8.5069	13.0208
6	9.1146	10.2083	15.6250
7	10.6337	11.9097	18.2292
8	12.1528	13.6111	20.8333
9	13.6719	15.3125	23.4375

Dolis per 100 poods to British and Metric values.

Dolis per 100 poods.	Dwts. per short ton (2000 lbs.).	Dwts. per long ton (2240 lbs.).	Grammes per tonne (1000 kgs.).
1	0.0158	0.0177	0.0271
2	0.0316	0.0354	0.0543
3	0.0475	0.0532	0.0814
4	0.0633	0.0709	0.1085
5	0.0791	0.0886	0.1356
6	0.0949	0.1063	0.1628
7	0.1108	0.1241	0.1899
8	0.1266	0.1418	0.2170
9	0.1424	0.1595	0.2441

Grammes per cubic Metre to Grains and Dwts. per cubic Yard.

Grammes per cubic metre.	Grains per cubic yard.	Grammes per cubic metre.	Dwts. per cubic yard.
0.1	1.1799	1.0	0.4916
0.2	2.3598	2.0	0.9832
0.3	3.5397	3.0	1.4749
0.4	4.7195	4.0	1.9665
0.5	5.8994	5.0	2.4581
0.6	7.0793	6.0	2.9497
0.7	8.2592	7.0	3.4413
0.8	9.4391	8.0	3.9330
0.9	10.6190	9.0	4.4246

Grains and Dwts. per cubic Yard to Grammes per cubic Metre.

Grains per cubic yard.	Grammes per cubic metre.	Dwts. per cubic yard.	Grammes per cubic metre.
1	0.0848	1	2.0341
2	0.1695	2	4.0682
3	0.2543	3	6.1023
4	0.3390	4	8.1364
5	0.4238	5	10.1705
6	0.5085	6	12.2046
7	0.5933	7	14.2387
8	0.6780	8	16.2728
9	0.7628	9	18.3069

Comparison of the British and American Methods of stating Copper Prices.

Based on 1 British pound sterling=$4.8665, the legal equivalent given in the circular issued by the Secretary of the U.S. Treasury in October 1906.
£1 per long ton of 2240 lbs.=.217254464 cent per lb.

Price per long ton of 2240 lbs. in British pounds sterling.	Price per lb. avoir. in U.S.A. cents.	Price per long ton of 2240 lbs. in British pounds sterling.	Price per lb. avoir. in U.S.A. cents.	Price per long ton of 2240 lbs. in British pounds sterling.	Price per lb. avoir. in U.S.A. cents.
£50	10.863 c.	£80	17.380 c.	£110	23.898 c.
51	11.080	81	17.598	111	24.115
52	11.297	82	17.815	112	24.331
53	11.513	83	18.032	113	24.550
54	11.732	84	18.249	114	24.767
55	11.949	85	18.467	115	24.984
56	12.166	86	18.684	116	25.202
57	12.384	87	18.901	117	25.419
58	12.601	88	19.118	118	25.636
59	12.818	89	19.336	119	25.853
60	13.035	90	19.553	120	26.071
61	13.253	91	19.770	121	26.288
62	13.470	92	19.987	122	26.505
63	13.687	93	20.205	123	26.722
64	13.904	94	20.422	124	26.940
65	14.122	95	20.639	125	27.157
66	14.339	96	20.856	126	27.374
67	14.556	97	21.074	127	27.591
68	14.773	98	21.291	128	27.809
69	14.991	99	21.508	129	28.026
70	15.208	100	21.725	130	28.243
71	15.425	101	21.943	131	28.460
72	15.642	102	22.160	132	28.678
73	15.860	103	22.377	133	28.895
74	16.077	104	22.594	134	29.112
75	16.294	105	22.812	135	29.329
76	16.511	106	23.029	136	29.547
77	16.729	107	23.246	137	29.764
78	16.964	108	23.463	138	29.981
79	17.163	109	23.681	139	30.198
80	17.380	110	23.898	140	30.416

Comparison of the British and Russian Methods of stating Copper Prices.

Based on the equivalent: 1 rouble=2s. 1⅝d. (see page 57). £1 per long ton of 2240 lbs.=0.15248195 rouble per pood.

Price per long ton of 2240 lbs. in British pounds sterling.	Price in roubles per pood.	Price per long ton of 2240 lbs. in British pounds sterling.	Price in roubles per pood.	Price per long ton of 2240 lbs. in British pounds sterling.	Price in roubles per pood.
£60	9.149 r.	£90	13.723 r.	£120	18.298 r.
61	9.301	91	13.876	121	18.450
62	9.453	92	14.028	122	18.603
63	9.606	93	14.181	123	18.755
64	9.759	94	14.333	124	18.908
65	9.911	95	14.486	125	19.060
66	10.064	96	14.638	126	19.213
67	10.216	97	14.791	127	19.365
68	10.369	98	14.943	128	19.518
69	10.521	99	15.096	129	19.670
70	10.674	100	15.248	130	19.823
71	10.826	101	15.401	131	19.975
72	10.979	102	15.553	132	20.128
73	11.131	103	15.706	133	20.280
74	11.284	104	15.858	134	20.433
75	11.436	105	16.011	135	20.585
76	11.589	106	16.163	136	20.738
77	11.741	107	16.316	137	20.890
78	11.894	108	16.467	138	21.043
79	12.046	109	16.621	139	21.195
80	12.199	110	16.773	140	21.347
81	12.351	111	16.925	141	21.500
82	12.504	112	17.078	142	21.652
83	12.656	113	17.230	143	21.805
84	12.808	114	17.383	144	21.957
85	12.961	115	17.535	145	22.110
86	13.113	116	17.688	146	22.262
87	13.266	117	17.840	147	22.415
88	13.418	118	17.993	148	22.567
89	13.571	119	18.145	149	22.720
90	13.723	120	18.298	150	22.872

SECTION V. MINING AREAS OF DIFFERENT COUNTRIES.

AFRICA.

Transvaal.—The unit area for mining on proclaimed ground in the Transvaal is the *Claim.*

For vein and reef mining, the claim has an area of 60,000 square Cape feet. Where practicable it is rectangular in form, measuring 150 Cape feet along the strike by 400 Cape feet in a direction at right angles to the strike.

For alluvial gold mining the claim has an area of 22,500 square Cape feet. Where practicable it is square in form, measuring 150 by 150 Cape feet.

For diamond ('pipe') mining the claim has an area of 900 square Cape feet. Where practicable it is a square of 30 by 30 Cape feet.

For alluvial diamond mining the claim has an area of 1800 square Cape feet. Where practicable it is a rectangle measuring 60 by 30 Cape feet.

A vein or reef claim	=64025.34 sq. British feet	log=4.8063519
	=1.4698195592 acres	log=0.1672640
	=0.694 morgen.	log=9.8416375
1 acre	=0.6803556217 reef claim.	log=9.8327360
1 morgen	=1.44 reef claims.	log=0.1583625
An alluvial gold claim	=24009.5025 sq. British feet	log=4.3803832
	=0.5511823347 acre	log=9.7412953
	=0.260416 morgen.	log=9.4156688
1 acre	=1.814281658 alluvial gold claims.	log=0.2587047
1 morgen	=3.84 alluvial gold claims.	log=0.5843312
A diamond ('pipe') claim	=960.3801 sq. British feet	log=2.9824432
	=0.0220472934 acres	log=8.3433553
	=0.010416 morgen.	log=8.0177288
1 acre	=45.35704155 diamond ('pipe') claims.	log=1.6566447
1 morgen	=96 diamond ('pipe') claims.	log=1.9822712
An alluvial diamond claim	=1920.7602 sq. British feet	log=3.2834732
	=0.044094587 acre	log=8.6443853
	=0.02083 morgen.	log=8.3187588
1 acre	=22.6785208 alluvial diamond claims.	log=1.3556147
1 morgen	=48 alluvial diamond claims.	log=1.6812412

Orange River Colony.—For precious metal mining a reef claim on a public diggings has an area of 60,000 square Cape feet, and where practicable is rectangular in form, measuring 150 Cape feet along the strike by 400 Cape feet in a direction at right angles to the strike. An alluvial gold claim measures 150 by 150 Cape feet, and is either square or as nearly as possible the equivalent thereof.* A diamond ('pipe') claim is 30 by 30, and an alluvial diamond claim 90 by 90 Cape feet.† Concessions for the mining of base metals (including coal, oil, salt, etc.) can be granted by the Government or the private owner as the case may be.

An alluvial diamond claim	=8643.4209 sq. British feet	log=3.9366857
	=0.19842564 acre	log=9.2975978
	=0.09375 morgen.	log=8.9719713
1 acre	=5.03967128 alluvial diamond claims.	log=0.7024022
1 morgen	=10.6 alluvial diamond claims.	log=1.0280287

For equivalents of reef, alluvial gold and diamond ('pipe') claims, see under Transvaal.

Cape Colony and British Bechuanaland.—A claim on a reef digging is a rectangle measuring 150 Cape feet in the direction of the strike by 800 Cape feet either across or on one side of the reef. On any Government land not proclaimed as a public diggings or on any abandoned public diggings a mining lease of an area not exceeding 100 morgen (211.654 acres) may be granted by the Governor. An alluvial gold claim is a square of 150 by 150 Cape feet. A diamond ('pipe') claim is usually 30 Cape feet square, and an alluvial diamond claim is usually 60 by 30 Cape feet, but the size of the claim to be pegged is stated by the Government on the proclamation of a diamond diggings. Mining concessions for coal, copper or any mineral except gold, silver and platinum are granted by the Government or the private owner, as the case may be.‡

A reef claim	=128050.68 square British feet	log=5.1073819
	=2.939639118 acres	log=0.4682940
	=1.38 morgen.	log=0.1426675
1 acre	=0.340177811 reef claim.	log=9.5317060
1 morgen	=0.72 reef claim.	log=9.8573325

For equivalents of alluvial gold, 'pipe' and alluvial diamond claims, see under Transvaal.

* The O.R.C. Precious Metals Ordinance of 1904.

† The O.R.C. Precious Stones Ordinance of 1904.

‡ Cape of Good Hope Colony, Precious Minerals Act of 1898 and Precious Stones Act of 1899.

Natal.—The claim for the mining of gold and other minerals, including coal, but excepting precious stones and alluvial minerals, must not exceed 300 by 300 yards (18.595 acres). A mineral claim for the mining of coal, limestone, stratified ironstone, slate, soapstone, and such minerals as may from time to time be included by order of the Governor in Council, must not exceed 700 by 700 yards (101.239 acres).* An alluvial claim for the mining of alluvial deposits of precious stones or minerals must not exceed 100 by 100 British feet (0.229 acre).

Rhodesia.—A reef claim is a rectangle of 150 by 600 Cape feet, the shorter sides of which are parallel to the strike of the reef. It carries the so-called 'extra-lateral right,' that is, the reef can be followed underground beyond the vertical planes in which the surface boundaries lie. Reef claims are pegged in blocks of 10, a block being under ordinary circumstances a parallelogram of 1500 by 600 Cape feet, and in no case of a greater area than 900,000 square Cape feet. An alluvial gold claim must, where possible, be a square of 200 by 200 Cape feet, and must in no case contain more than 40,000 square Cape feet. Coal mining locations of either 50, 100 or 150 morgen (105.827, 211.654 or 327.481 acres) are granted. A copper-mining location may be pegged of an area equivalent to not more than 30 reef claims of 90,000 square Cape feet each. No extra lateral rights exist in the mining of coal or copper locations.†

A reef claim	=96038.01 sq. British feet	log=4.9824432
	=2.20472934 acres	log=0.3433553
	=$1.041\dot{6}$ morgen.	log=0.0177288
1 acre	=0.4535704155 reef claim.	log=9.6566447
1 morgen	=0.96 reef claim.	log=9.9822712
A block of 10 reef claims	=22.0472934 acres	log=1.3433553
	=$10.41\dot{6}$ morgen.	log=1.0177288
An alluvial gold claim	=42683.56 sq. British feet	log=4.6302606
	=0.9798797 acre	log=9.9911727
	=$0.4\dot{6}2\dot{9}$ morgen.	log=9.6655462
1 acre	=1.02053343 alluvial gold claims.	log=0.0088273
1 morgen	=2.16 alluvial gold claims.	log=0.3344538

* Natal Mines Act of 1899.

† The British South Africa Company's Mining Ordinance of 1903.

The Gold Coast Colony and Ashanti.—Mining concessions obtained from natives must not exceed five square miles in area. This does not apply to concessions obtained and registered previous to October 1895.*

Egypt.—There is no definite limit as to the size of a mining lease, which may be granted by the Government at a price per *feddan* (.420083 hectare or 1.038086 acres), which varies according to the nature of the mineral to be mined. There is in addition a tax of 10% on all net profits accruing from the working of the lease.

Sudan.—The maximum areas of mining leases are:

For non-alluvial gold,	64	hectares	or	160	acres.
" silver,	64	"	"	160	"
" any other metal,	128	"	"	320	"
" oil,	256	"	"	640	"
" coal,	512	"	"	1280	"

Each lease must be rectangular in shape, and of a length not exceeding four times its breadth.†

AUSTRALASIA.

New South Wales.—A gold-mining lease must not exceed an area of 25 acres, except when the Secretary for Mines is "satisfied that special difficulties exist in working the ground either by way of great depth or wetness, or on account of the cost by appliances required." In such case a special lease is granted, the tenure, form and area of which is prescribed by the Governor. If an ordinary gold-mining lease not exceeding 25 acres be located on a quartz vein or lode, the maximum length (measured in the direction of the strike) is 600 yards and the maximum width (measured across the lode) 200 yards. "In no case shall the area be marked out so that the lode will be distant from either extremity of the boundaries defining the width of the said area less than one-tenth of such width, nor shall the length along the lode in any such area be

* The Gold Coast Colony and Ashanti Concessions Ordinance of 1900.

† *Mining Laws of the British Empire*, C. J. Alford, London, 1906, p. 35 *et seq.*

greater than three times the width of such area." * All other gold-mining leases must be, where practicable, in the form of a parallelogram, the maximum length of which must not be more than twice the maximum breadth. "The area of a mining lease for any mineral shall not exceed 640 acres and (unless specially authorised by the Secretary for Mines) shall not be less than 40 acres for coal-mining lots, and shall not exceed 80 acres nor be less than 20 acres for other mineral lots." . . . "Mineral lots shall be measured in the form of a square, except in any case where the Minister shall authorise a departure from that form." †

Queensland.—The area of a gold-mining lease is limited to 12 acres until seven years from the date of the proclamation of the gold-field, or to 25 acres until fourteen years from the date of proclamation. After the expiration of this latter period the area of the lease may be extended to 50 acres if the ground in question has previously been worked and abandoned, or if, in the opinion of the Warden of the gold-field, the undue wetness or great depth of the workings and the consequent high working costs warrant the extension. A mining lease for silver, antimony or tin within the limits of any gold-field or mineral-field specially notified by proclamation shall not exceed 80 acres, and beyond such limits shall not exceed 120 acres. The maximum area of a mining lease for any other mineral except coal is 160 acres. A coal-mining lease may not be larger than 320 acres, except in the case of the discovery of a new seam of coal at least 15 miles from any known payable coal-field, or of a hitherto unknown coal seam at a depth of at least 600 feet. The discoverer in such case is entitled to a lease of 640 acres. ‡ Wherever practicable, a mining lease must be rectangular in form, with the length not exceeding twice the breadth, but in special cases leases of irregularly shaped areas may be granted.

South Australia.—The maximum areas of mining leases are: for gold, 20 acres; for other minerals except coal, oil, salt and gypsum, 40 acres; for coal, oil, salt or gypsum, 640 acres.

* The New South Wales Mining Act of 1874, Section 36.

† *Regulations relating to Mineral Leases on Crown Lands*, February 1885.

‡ The Mining Act of Queensland, 1898.

Any number of leases may be held by one person, but not more than four adjoining gold or mineral leases may be amalgamated.*

Victoria.—The maximum area of a gold-mining lease is 100 acres, while a mining lease for any other mineral (including coal) must not exceed 640 acres. There are no regulations as to the form of a mining lease.†

West Australia.—The maximum area of an ordinary gold-mining lease is 24 acres; but where the ground has previously been worked for alluvial gold and afterwards abandoned, or where, in the opinion of the Warden, the working will be costly by reason of excessive wetness or great depth, a lease not exceeding 48 acres may be granted. The maximum area of a mining lease for all minerals, except gold and coal, is 48 acres. A coal-mining lease must not exceed 320 acres, except in the case of the discovery of a new seam of coal at least 15 miles from any known payable coal. The discoverer in such case is granted a lease of 640 acres free of royalty for ten years.‡

Tasmania.—The maximum area of a gold-mining lease is 20 acres. A mining lease for coal, shale, slate, freestone or limestone must not exceed 320 acres, while the maximum area of a mining lease for any mineral except those already mentioned is 80 acres. If gold be found associated or combined with other minerals in such proportion that the amount recovered is of less value than that of the minerals with which it is associated or combined, the lease may have a maximum area of 80 acres. All mining leases must, where practicable, be square in form with the bearings of the boundary lines corresponding to the cardinal points of the compass. Two or more leases may be amalgamated.§

New Zealand.—The unit of mining area in New Zealand is the *Claim*. Claims may be either *ordinary*, *extended* or *special*. The maximum areas are: for an ordinary claim, 1 acre if under license, or 10,000 square feet if not under license; for an extended claim, 5 acres; and for a special claim, 100 acres.

* From the South Australian Mining Act of 1893.
† The Victorian Mines Acts of 1890 and 1897.
‡ The Mining Act of West Australia, 1904.
§ Tasmanian Mining Acts of 1900 and 1905.

The maximum lengths in the direction of the strike of the reef are: for an ordinary *quartz* claim 200 feet, and for an extended quartz claim 500 feet. The maximum lengths along the watercourse are: for an ordinary *dredging* or river claim, 3 chains (198 feet); for an extended dredging claim, 15 chains (990 feet): and for a special dredging claim, 1 mile. The maximum lengths of shore frontage are: for an ordinary *sea-beach* claim, 200 feet; for an extended sea-beach claim, 500 feet; and for a special sea-beach claim, 1 mile. A special sea-beach claim may be extended beyond 100 acres * in the seawards direction.

NORTH AMERICA.

British Columbia.—From 1884 to 1892 the vein-mining claim of British Columbia was the same as that of the United States, namely, an area of 1500 by 600 feet, carrying the 'extra-lateral right.' The Mineral Act, however, was revised in 1891, and further augmented in 1896 and 1897. It now defines the unit of mining area as a rectangular claim not exceeding 1500 feet in either length or width (measured horizontally), with no extra-lateral right. The underground rights are therefore confined to the vertical planes in which the surface boundaries lie.

A vein-mining claim	=51.65289 acres	log=1.7130946
	=20.90315 hectares.	log=1.3202116
1 acre	=.01936 claim.	log=8.2869054
1 hectare	=.0478397 claim.	log=8.6797884

In 'creek diggings' a placer claim is 250 feet square, the side lines of which must run in the general direction of the watercourse or stream. In 'bar diggings' a placer claim may be either 250 feet square on any bar which is covered at high water, or 250 in length, and of the width contained between the high-water and the extreme low-water marks. In 'dry diggings' a claim is 250 feet square.

A placer claim must be as nearly as possible rectangular in form. The maximum length of a dredging lease is 5 miles. The maximum areas of leases for hydraulicing and precious stone diggings are 80 acres and 10 acres respectively. A coal or petroleum lease is a square block of a maximum area of 640 acres.

* New Zealand Mining Act, No. 38 of 1898.

Nova Scotia.—For gold and silver mining the unit area is a rectangle measuring 250 feet by 150 feet, laid off with the shorter sides running east and west. Any number of these areas, not exceeding 100, can be taken up. For the mining of other minerals an area of 5 square miles, not exceeding 2½ miles in length, may be granted.

Quebec.—The total area of the mining concessions which can be acquired by one person is 400 acres, but under special circumstances the Lieutenant-Governor in Council may grant an area not exceeding 1000 acres.

Ontario.—A mining claim may be either 15 chains square (22½ acres) or 20 chains square (40 acres).

New Brunswick.—From 10 to 100 rectangular areas of 250 by 150 feet may be acquired for gold and silver mining. The boundaries must be laid off in the direction of the cardinal points of the compass. Mining leases of a maximum area of one square mile are granted for oil, natural gas or any mineral excepting gold and silver, but the Surveyor-General may, under special circumstances, sanction a larger lease.

Manitoba and the North-West Territories.—A gold quartz claim is a square of 1500 by 1500 feet without the extra-lateral right (see British Columbia).

Placer mining claims generally are 100 feet square. On the North Saskatchewan River, placer claims "are either bar or bench, the former being 100 feet long and extending between high and low-water mark. The latter includes bar diggings, but extends back to the base of the hill or bank, but not exceeding 1000 feet. Where steam power is used, claims 200 feet wide may be obtained."

Two dredging leases of five miles each may be obtained. "The lessee's right is confined to the submerged bed or bars of the river below low-water mark, and subject to the rights of all persons who have, or who may receive entries for bar diggings or bench claims, except on the Saskatchewan River, where the lessee may dredge to high-water mark on each alternate leasehold."

For iron and mica the maximum area of a location is 160 acres; a coal-mining location may not exceed 320 acres; and the area of a petroleum location may not be larger than 1920 acres.

Yukon Territory.—A gold quartz claim is a square 1500 by 1500 feet, without the extra-lateral right (see British Columbia). Creek, gulch, river and hill claims may not exceed 250 feet in length, measured in the general direction of the creek or gulch, with a width of from 1000 to 2000 feet. All other placer claims are 250 feet square. For dredging, six leases, each five miles long, may be acquired. "The lessee's right is confined to the submerged bed or bars in the river below low-water mark, that boundary to be fixed by its position on the 1st day of August in the year of the date of the lease."

For iron, mica or copper mining, the Minister of the Interior may grant an area of 160 acres. The size of coal-mining areas is not defined, but applications for the purchase of such lands may be made to the Crown Timber and Land Agent. Petroleum leases of an area not exceeding 1920 acres (3 square miles) can also be acquired.

The United States.—The unit area for vein mining in the United States is the claim of 1500 feet along the strike of the vein by 600 feet in width. The 'law of the apex' gives the extra-lateral right, *i.e.* the vein may be followed beyond the vertical planes in which the surface boundaries lie, to an indefinite depth on all its 'dips, spurs and angles.'

1 vein-mining claim	=20.661157 acres	log=1.3151546
	=8.3613 hectares.	log=0.9222742
1 acre	=.0484 vein-mining claim.	log=8.6848454
1 hectare	=.119585 vein-mining claim.	log=9.0777258

The maximum area of a *placer* claim is: for one person 20 acres, or for an association or company of eight or more persons, 160 acres.

The maximum area of a coal-mining location is: for one person 160 acres, or for an association or company of not less than four persons, 640 acres.

Mexico.—The unit area for the mining of all metals, also precious stones, rock-salt and sulphur, is the *Pertenencia*, which by a decree of President Diaz issued on June 4, 1892, with effect from July 1, 1892, is "a solid block of unlimited depth, defined above ground by that part of the surface which in horizontal projection gives a square, each side of which measures 100 metres; and bounded underground by the four vertical planes corresponding to the sides of the said square."

1 pertenencia	= 1 hectare	
	= 2.471058 acres.	log = 0.3928830
1 acre	= 0.404685 pertenencia.	log = 9.6071170

SOUTH AMERICA.

British Guiana.—A gold-mining claim must not exceed 1500 feet in length by 800 feet in width. A claim located for the purpose of searching for precious stones must not exceed 1500 feet in length by 800 feet in width, nor contain a greater area than 500 acres. A claim must, where practicable, be rectangular in form and it is limited underground by the vertical planes in which the surface boundaries lie.*

Colombia.—The unit area for vein mining is 600 by 240 metres, and for alluvial mining 5 by 2 kilometres.†

1 vein-mining area	= 14.4 hectares	log = 1.1583625
	= 35.583235 acres.	log = 1.5512455
1 hectare	= .0694 vein-mining claim.	log = 8.8416375
1 acre	= .028103 vein-mining claim.	log = 8.4487545
1 alluvial-mining area	= 10 sq. kilometres	
	= 1000 hectares	
	= 2471.05814 acres	log = 3.3928830
	= 3.86103 square miles.	log = 0.5867030

Chile.—For coal the mining area or pertenencia is 50 hectares (123.5529 acres); while for any other mineral it may be from 1 to 5 hectares (2.47106 to 12.3553 acres). There is no 'extra-lateral right.' ‡

Peru.—The mining area or pertenencia for gold, silver, platinum, lead, tin, copper, antimony, zinc, coal or petroleum is a square of 200 by 200 metres (4 hectares or 9.88423 acres), while a pertenencia located on a deposit of borax, sulphur or any other non-metallic mineral is half that size

* British Guiana Mining Regulations, 1903.

† H. G. Granger and E. B. Treville, p. 85, *Trans. Am. Inst. M.E.*, vol. 28, 1899.

‡ Chilian Mining Law of 1888.

(2 hectares or 4.942116 acres). The maximum holding is limited to 240 hectares (593.05395 acres, 60 large or 120 small pertenencias). There is no 'extra-lateral right.'

ASIA.

British India.—The Collector of any district in British India can grant a prospecting license carrying with it the right to a lease for 30 years on a block of ground of any size not exceeding 1 square mile, provided the ratio of the length (in the direction of strike of the vein) to the breadth does not exceed 4 to 1. Applications for more than 1 square mile are dealt with by the Board of Revenue.

In the Native State of Mysore, the size of the mining area granted to one applicant is limited to 2 square miles.

Ceylon.—On Crown lands, mining leases for one or more blocks, each of which must be over 10 and not more than 100 acres in extent, may be granted by the Governor, but the total area held by the lessee or by those joined in interest with him must not exceed 500 acres. Except when specially sanctioned, the length of a block must not exceed four times its breadth.*

Malay Peninsula.—Mining leases for large areas are granted by the Sultan of Pahang on the recommendation of the British Resident; but mining permits giving the holder the right to dig for gold and tin within an area of 5 acres are also granted.†

Russian Empire.—For vein-mining the maximum area of an *Otwod* or concession is 1 square verst (1.138062 square kilometres or .439408 square mile). The ratio of the length (in the direction of the strike of the vein) to the breadth must not exceed 3 to 1.

For alluvial mining in Siberia, the length of the concession is limited to 5 versts (5.3340 kilometres or 3.314394 miles), while the breadth may extend to the full width of the valley in which the auriferous gravels lie. In the Urals the size of

* From *Mining Laws of the British Empire*, by C. J. Alford, London, 1906, p. 64.

† The States of Pahang Mining Enactment of 1904.

an alluvial concession is limited to 1 square verst (1.138062 square kilometres or .439408 square mile), the maximum length being 5 versts (5.3340 kilometres or 3.314394 miles) and the minimum breadth 100 sagenes (213.36 metres or 700 feet).*

Japan.—The right to exploit alluvial gold, iron-sand or stream tin deposits is restricted to Japanese subjects, but foreign companies registered under, and conforming to, the laws of the country are permitted to mine all minerals occurring otherwise than as alluvial deposits.

The area of a mining concession for any mineral except coal must not be less than 3000 tsubo (2.45064 acres or .99173553 hectare) or more than 600,000 tsubo (490.128 acres or 198.347106 hectares). A coal concession must not be less than 10,000 tsubo (8.1688 acres or 3.3057851 hectares) or more than 600,000 tsubo. If two or more concessions be amalgamated, the combined areas may exceed 600,000 tsubo.†

* *Code Minière Russe*, St. Petersburg, 1893, p. 105.

† From *Sketch of the Mining Industry of Japan*, published by the Japanese Bureau of Mines in 1904.

PART VI. DATA RELATING TO SURVEYING.

SECTION I. TRIGONOMETRICAL AND MISCELLANEOUS FORMULÆ AND CONSTANTS.

LET A be any acute angle, and let a perpendicular BC be drawn from any point in one side to the other side. Then, if the sides

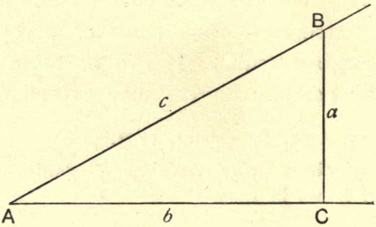

FIG. 1.

of the right triangle thus formed are denoted by letters, as in the figure, we have these six formulæ:

1. $\sin A = \frac{a}{c}$. **4.** $\operatorname{cosec} A = \frac{c}{a}$.

2. $\cos A = \frac{b}{c}$. **5.** $\sec A = \frac{c}{b}$.

3. $\tan A = \frac{a}{b}$. **6.** $\cot A = \frac{b}{a}$.

Solution of Right Angles. (Fig. 1.)

	GIVEN.	SOUGHT.	FORMULÆ.
7.	a, c	$A, B; b$	$\sin A = \frac{a}{c}$, $\cos B = \frac{a}{c}$, $b = \sqrt{(c+a)(c-a)}$.
8.	a, b	A, B, c	$\tan A = \frac{a}{b}$, $\cot B = \frac{a}{b}$, $c = \sqrt{a^2+b^2}$.
9.	A, a	B, b, c	$B = 90° - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$.
10.	A, b	B, a, c	$B = 90° - A$, $a = b \tan A$, $c = \frac{b}{\text{c s}\,A}$.
11.	A, c	B, a, b	$B = 90° - A$, $a = c \sin A$, $b = c \cos A$.

Solution of Oblique Triangles. (Fig. 2.)

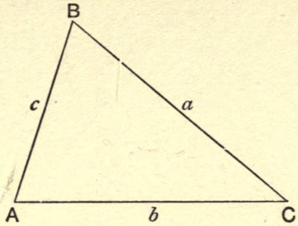

FIG. 2.

	GIVEN.	SOUGHT.	FORMULÆ.
12.	A, B, a	b	$b=\dfrac{a\sin B}{\sin A}=a\sin B\operatorname{cosec} A.$
13.	A, a, b	B	$\sin B=\dfrac{b\sin A}{a}.$
14.	a, b, C	A, B	$\tan\frac{1}{2}(A-B)=\dfrac{a-b}{a+b}\cot\frac{1}{2}C,$ then $A=(90^\circ-\frac{1}{2}C)+\frac{1}{2}(A-B)$ and $B=(90^\circ-\frac{1}{2}C)-\frac{1}{2}(A-B),$ a being the longer side.
15.	a, b, c	A	Let $s=\frac{1}{2}(a+b+c)$: $\sin\frac{1}{2}A=\sqrt{\dfrac{(s-b)(s-c)}{bc}}$; $\cos\frac{1}{2}A=\sqrt{\dfrac{s(s-a)}{bc}}$, $\tan\frac{1}{2}A=\sqrt{\dfrac{(s-b)(s-c)}{s(s-a)}}$; $\sin A=\dfrac{2\sqrt{[s(s-a)(s-b)(s-c)]}}{bc}.$
16.	A, B, C, a	Area	$\text{Area}=\dfrac{a^2\sin B\sin C}{2\sin A}.$
17.	A, b, c	Area	$\text{Area}=\frac{1}{2}bc\sin A.$
18.	a, b, c	Area	Let $s=\frac{1}{2}(a+b+c)$: area $=\sqrt{s(s-a)(s-b)(s-c)}.$

General Trigonometrical Formulæ.

19.	$\sin^2 A+\cos^2 A=1.$
20.	$\sin(A\pm B)=\sin A\cos B\pm\sin B\cos A.$
21.	$\cos(A\pm B)=\cos A\cos B\mp\sin A\sin B.$
22.	$\sin 2A=2\sin A\cos A.$
23.	$\cos 2A=\cos^2 A-\sin^2 A=1-2\sin^2 A=2\cos^2 A-1.$
24.	$\sin^2 A=\frac{1}{2}-\frac{1}{2}\cos 2A.$
25.	$\cos^2 A=\frac{1}{2}+\frac{1}{2}\cos 2A.$

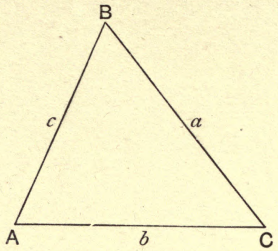

FIG. 2*a*.

General Trigonometrical Formulæ—*continued.*

26. $\sin A + \sin B = 2 \sin \frac{1}{2}(A + B) \cos \frac{1}{2}(A - B)$.

27. $\sin A - \sin B = 2 \cos \frac{1}{2}(A + B) \sin \frac{1}{2}(A - B)$.

28. $\cos A + \cos B = 2 \cos \frac{1}{2}(A + B) \cos \frac{1}{2}(A - B)$.

29. $\cos B - \cos A = 2 \sin \frac{1}{2}(A + B) \sin \frac{1}{2}(A - B)$.

30. $\sin^2 A - \sin^2 B = \cos^2 B - \cos^2 A = \sin (A + B) \sin (A - B)$.

31. $\cos^2 A - \sin^2 B = \cos (A + B) \cos (A - B)$.

32. $\tan A = \dfrac{\sin A}{\cos A}$.

33. $\cot A = \dfrac{\cos A}{\sin A}$.

34. $\tan (A \pm B) = \dfrac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$.

35. $\tan A \pm \tan B = \dfrac{\sin (A \pm B)}{\cos A \cos B}$.

36. $\cot A \pm \cot B = \pm \dfrac{\sin (A \pm B)}{\sin A \sin B}$.

37. $\dfrac{\sin A + \sin B}{\sin A - \sin B} = \dfrac{\tan \frac{1}{2}(A + B)}{\tan \frac{1}{2}(A - B)}$.

38. $\dfrac{\sin A + \sin B}{\cos A + \cos B} = \tan \frac{1}{2}(A + B)$.

39. $\dfrac{\sin A + \sin B}{\cos B - \cos A} = \cot \frac{1}{2}(A - B)$.

40. $\dfrac{\sin A - \sin B}{\cos A + \cos B} = \tan \frac{1}{2}(A - B)$.

41. $\dfrac{\sin A - \sin B}{\cos B - \cos A} = \cot \frac{1}{2}(A + B)$.

42. $\tan \frac{1}{2}A = \dfrac{\sin A}{1 + \cos A}$.

43. $\cot \frac{1}{2}A = \dfrac{\sin A}{1 - \cos A}$.

Miscellaneous Formulæ.

	SOUGHT.	GIVEN.	FORMULÆ.
	Area of		
44.	Circle,	Radius $=r$,	πr^2.
45.	Ellipse,	Semi-axes $=a$ and b,	πab.
46.	Parabola,	Chord $=c$, height $=h$,	$\frac{2}{3}ch$.*
47.	Regular Polygon,	Side $=a$, number of sides $=n$,	$\frac{1}{4}a^2n\cot\frac{180^\circ}{n}$.
	Surface of		
48.	Sphere,	Radius $=r$,	$4\pi r^2$.
49.	Zone,	Radius $=r$, height $=h$,	$2\pi rh$.
50.	Spherical Polygon,	Radius of sphere $=r$, sum of angles $=S$, number of sides $=n$,	$\pi r^2\times\frac{S-(n-2)180^\circ}{180^\circ}$.
	Solidity of		
51.	Prism or Cylinder,	Base $=b$, height $=h$,	bh.
52.	Pyramid or cone,	Base $=b$, height $=h$,	$\frac{1}{3}bh$
53.	Frustum of Pyramid or Cone,	Bases $=b$ and b_1, height $=h$,	$\frac{1}{3}h(b+b_1+\sqrt{bb_1})$.
54.	Sphere,	Radius $=r$,	$\frac{4}{3}\pi r^3$.
55.	Spherical Segment,	Radii of bases $=r$ and r_1, height $=h$,	$\frac{1}{2}\pi h(r^2+r_1{}^2+\frac{1}{3}h^2)$.
56.	Prolate Spheroid,	Semi-transverse axis of ellipse $=a$,	$\frac{4}{3}\pi ab^2$.
57.	Oblate Spheroid,	Semi-conjugate axis of ellipse $=b$,	$\frac{4}{3}\pi a^2b$.
58.	Paraboloid,	Radius of base $=r$, height $=h$,	$\frac{1}{2}\pi r^2h$.

$\pi=3.1415926536$; logarithm $=0.4971498727$.
$\pi^2=9.8696044011$; ,, $=0.9942997454$.
$\sqrt{\pi}=1.7724538509$; ,, $=0.2485749363$.

* The area of a circular segment on railroad curves, where the chord is very long in proportion to the height, may be found with great accuracy by this formula.

Physical Constants.

Velocity of light (Harkness)

= 186,337 miles per second

= 299,878 kilometres per second.

Velocity of sound through dry air

$= 1090\sqrt{1 + 0.00367t}$ feet per second,

where t = temperature in degrees Centigrade.

The general mean deduced by Rowland (*Proc. Am. Acad.*, vol. xv., p. 144) for dry air at 0° C.

= 331.75 metres per second

= 1088.42 feet per second.

	Velocity in metres per sec.	Velocity in feet per sec.	Authority.
In rock—			
Granite, - - -	3950	12,960	Gray and Milne.
Marble, - - -	3810	12,500	" "
Slate, - - -	4510	14,800	" "
Brick, - - -	3652	11,980	Chladni.
In wood—			
Pine, along the fibre, -	3320	10,900	Wertheim.
Oak, " " -	3850	12,620	"
Ash, " " -	4670	15,310	"
In water—At 13.7° C., -	1437	4714	Martini.

From the *Smithsonian Physical Tables*, p. 100.

Astronomical Constants (Harkness).

Sidereal year = 365.2563578 mean solar days.

Sidereal day = 23 hours 56 min. 4.100 seconds mean solar time.

Mean solar day = 24 hours 3 min. 56.546 seconds sidereal time.

Mean distance of the earth from the sun = 92,800,000 miles.

Geodetic Constants.

Dimensions of the earth (Clarke's spheroid):

Equatorial semi-axis 3963.3 miles.

Polar " 3949.8 "

Perimeter of meridian ellipse 24,854.76 miles.

Circumference of equator 24,901.96 "

Area of earth's surface 196,940,400 sq. miles.

Mean density of the earth (Harkness) 5.576 ± 0.016.

Surface density of the earth (Harkness) 2.56 ± 0.16.

Acceleration of gravity at sea-level (Harkness)

$= 980.60\ (1 - 0.002662 \cos 2\phi)$ centimetres per second,

where $\phi =$ the latitude.

Length of seconds pendulum (Harkness)

$= 0.990910 + 0.005290 \sin^2\phi$ metres,

where $\phi =$ the latitude.

SECTION II. THE COORDINATION OF SURVEY POINTS.

The permanent stations of a modern survey are usually plotted by means of rectangular coordinates, the use of the protractor being restricted to the draughting of the temporary points and

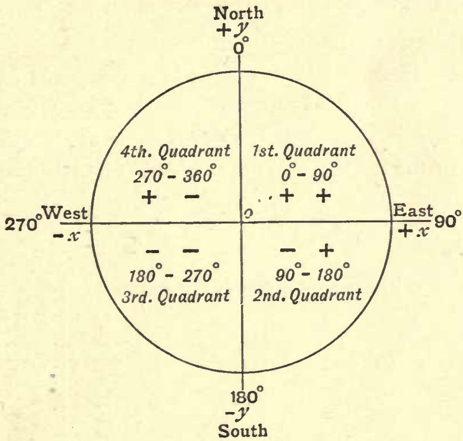

FIG. 1.

detail. The customary method of coordinating a survey is as follows:

The most prominent and central station of the survey, from which the direction of the true meridian has been determined, is selected as the 'point of origin' *o*. At this point two fixed *axes*, *y* and *x*, are assumed to intersect at right angles, the direction of the *y* axis being made to coincide with the true meridian. From the starting point *o*, the *latitude* (distance north or south) and the *departure* (distance east or west) of each station of the survey are calculated, the latitudes being the *y* and the departures the *x* coordinates.

The y coordinates to the north of, and the x coordinates to the east of o are positive and carry a plus sign, while those to the south of and to the west of o are negative and carry a minus sign. They are stated with the ys before (to the left of) the xs; thus $+950.13-726.48$ may represent the coordinates of a point 950.13 units north of, and 726.48 units west of o. From o, the bearing of the true north (along the y axis) is taken as 360° or 0°, the east (along the x axis) as 90°, the south as 180° and the west as 270°. Therefore, if the coordinates of a point carry the signs:

+ +,	its bearing from o is in the	1st	quadrant between	0° and 90°
− +,	" " "	2nd	" "	90° " 180°
− −,	" " "	3rd	" "	180° " 270°
+ −,	" " "	4th	" "	270° " 360°

Coordinates are usually calculated by means of logarithms and checked by natural sines and cosines, using 'short' multiplication.*

EXAMPLE. Given the measured lengths

$$oA=377.92,\ AB=1015.74 \text{ and } BC=284.63,$$

and the observed angles $yoA=47°\ 19'\ 20''$ (the bearing of the line oA), $oAB=83°\ 47'\ 40''$ and $ABC=321°\ 33'\ 50''$. The coordinates of the points A, B and C are calculated as follows:

To Determine A.

	(By logarithms.)		*Check.* (By nat. sines and cosines.)	
Length $oA=377.92$	$=2.5773999$	$=2.5773999$	37792	37792
Bearing $oA=47°\ 19'\ 20''$	cos $=9.8311493$	sin $=9.8663922$	78776	81537
	2.4085492	2.4437921	22675	26454
			2645	1134
	+256.18	+277.84	265	189
	$o=\pm$ 0.00	$\pm$ 0.00	33	7
	$A=+256.18$	+277.84	+256.18	+277.84

* Rule for 'short' multiplication: Reverse the multiplier and place it below the multiplicand so that its unit figure (the one preceding the decimal point) is directly under that decimal place of the multiplicand to which the product is required. For example, to multiply 103.75 by 39.445, the product being required to two decimal places, the unit figure 9 is placed under the 5.

Therefore in checking by natural sines and cosines, in order to get the product to two decimal places reverse the function and place its initial figure under the first decimal place of the multiplicand. (See the above calculation, where .67787 = the nat. cos of 47° 19′ 20″).

10375
54493
311250
93375
4150
415
52
4092.42

To Determine *B*.

				Check.	
Length AB=1015.74		=3.0067826	=3.0067826		
Bearing Ao=227° 19′ 20″				101574	101574
Angle oAB= 83° 47′ 40″				495756	75337
Bearing AB=311° 7′ 00″		sin=9.8179581	cos=9.8770096	60944	71102
		2.8247407	2.8837922	5079	5079
				711	305
		+667.95	−765.23	61	37
		A=+256.18	+277.84	+667.95	−765.23
		B=+924.13	−487.39	+924.13	−487.39

To Determine *C*.

				Check.	
Length BC=284.63		=2.4542807	=2.4542807		
Bearing BA=131° 7′ 00″				28463	28463
Angle ABC=321° 33′ 50″				77640	19899
Bearing BC= 92° 40′ 50″		sin=8.6699437	cos=9.9995245	1138	25617
		1.1242244	2.4538052	171	2562
				20	228
		− 13.31	+284.32	2	25
		B=+924.13	−487.39	− 13.31	+284.32
		C=+910.82	−203.07	+910.82	−203.07

The bearing of a line = that of the backsight + its angle with reference to the backsight (measured clockwise, from left to right); and the bearing of the line used as a backsight differs by 180° from its bearing when a foresight. For example, in the above calculations the bearing of the line *oA* is 47° 19′ 20″; therefore, when used as a backsight from the station *A*, its bearing is 47° 19′ 20″ + 180° = 227° 19′ 20″, which, added to the observed angle *oAB* which *Ao* makes with *AB*, gives the bearing of the line *AB*.

Similarly the bearing *BC* = (the bearing *AB* − 180°) + the angle *ABC*, which sum, being greater than 360°, has that amount deducted from it. A bearing is denoted by the prefix *y*. For example, *yAB* signifies the bearing of the line *AB*, or its direction with reference to *y* (the true north, 0°).

If the bearing of a line be in the 1st quadrant,
its length × the cosine of the bearing is the *y* distance or latitude,
„ × the sine „ „ *x* „ departure;

if in the 2nd quadrant,
its length × the sine of the (bearing − 90°) is the *y* distance or lat.,
„ × the cosine „ „ *x* „ departure;

if in the 3rd quadrant,

its length × the cosine of the (bearing − 180°) is the y distance or lat.,

" × the sine " " x " departure;

and if in the 4th quadrant,

its length × the sine of the (bearing − 270°) is the y distance or lat.,

" × the cosine " " x " departure.

To coordinate any point *B* which has been fixed from a coordinated point *A*, the y and the x distances of *B* from *A* are added algebraically to the coordinates of *A*. For example, in the foregoing calculations the y distance $AB = +667.95$, and the x distance $AB = -765.23$, which, when added algebraically to the coordinates of *A*, give the coordinates of *B* with reference to the point of origin *o*.

Method used in calculating the length and bearing of a line connecting two coordinated points:

		Check.	
$A = +256.18$	$+277.84$	101574	101574
$B = +924.13$	-487.39	495756	73357
Diff. $= +667.95$	-765.23	60944	71102
		5079	5079
		711	305
		61	37
		+667.95	−765.23

667.95 = 2.8247440
765.23 = 2.8837920

9.9409320 = tan 41° 7′ 00″
270° 0′ 00″
311° 7′ 00″ = *vAB*.

cosine 41° 7′ 00″ = 9.8770096
(Subtracted from log 765.23)
3.0067824 = 1015.74 = length *AB*.

The signs before the y and x differences of the coordinates of the two points indicate the quadrant in which the bearing of the connecting line lies. Divide the y difference by the x difference. Then:

$\dfrac{y \text{ difference}}{x \text{ difference}} =$	the cotangent of the bearing	if in the 1st quadrant.
	the tangent of (the bearing − 90°)	" 2nd "
	the cotangent of (" − 180°)	" 3rd "
	the tangent of (" − 270°)	" 4th "

For example, in the foregoing calculation, as the differences carry the signs + −, the bearing is in the 4th quadrant. Consequently $\frac{667.95}{765.23}$ = the tangent of 41° 7′ 00″, which, + 270°, = 311° 7′ 00″ = *yAB*.

The distance between the two points =

$$\frac{y \text{ difference}}{\text{cosine of the bearing}} \quad \text{or} \quad \frac{x \text{ difference}}{\text{sine of the bearing}}$$

if the bearing be in the 1st quadrant.

$$\frac{y \text{ difference}}{\text{the sine of (the bearing} - 90°)} \quad \text{or} \quad \frac{x \text{ difference}}{\text{cosine of (the bearing} - 90°)}$$

if the bearing be in the 2nd quadrant.

$$\frac{y \text{ difference}}{\text{cosine of (the bearing} - 180°)} \quad \text{or} \quad \frac{x \text{ difference}}{\text{sine of (the bearing} - 180°)}$$

if the bearing be in the 3rd quadrant.

$$\frac{y \text{ difference}}{\text{sine of (the bearing} - 270°)} \quad \text{or} \quad \frac{x \text{ difference}}{\text{cosine of (the bearing} - 270°)}$$

if the bearing be in the 4th quadrant.

For example, in the foregoing calculation the bearing is in the 4th quadrant. Consequently $\frac{765.23}{\text{cosine } 41° \; 7' \; 00''} = 1015.74$, the length of the line *AB*.

Method used in calculating the coordinates of a triangulation.

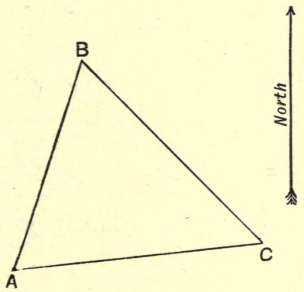

FIG. 2.

Given the coordinates of the points *A* and *C*, and by observation the interior angles of the triangle *ABC*. Required the coordinates of the point *B*.

Angles.	Coordinates.	
	y	x
$A = 72° \; 15' \; 30''$	$A = +7230.91$	$+538.64$
$B = 51° \; 55' \; 40''$		
$C = 55° \; 48' \; 50''$	$C = +8522.77$	$+9367.05$

The first step is to determine the length and bearing of the line *AC*:

	Check.	
$A = +7230.91 + 538.64$		
$C = +8522.77 + 9367.05$	892243	892243
$+1291.86 + 8828.41$	887441	364989
	89224	803019
3.1112155	35690	71379
3.9458825	3569	8030
$9.1653330 = 81° \; 40' \; 30'' = yAC$	625	357
9.9953994	78	56
$3.9504831 = 8922.43 = AC.$	+1291.86	+8828.41

The coordinates of *B* are then determined from the two sides *AB* and *CB*, each calculation acting as a check on the other. The lengths of these sides are:

$AB = AC$ sine C cosecant B, and $BC = AC$ sine A cosecant B; and their bearings are derived from the known bearing yAC, and the observed angles of the triangle. The logarithm of the cosecant of *B* is got by subtracting the logarithm of the sine from 10.0000000. This is most easily done by subtracting each figure from 9, except the right-hand one, which is subtracted from 10.

$yAC = 81° \; 40' \; 30''$		$yCA = 261° \; 40' \; 30''$	
$A = 72° \; 15' \; 30''$		$C = 55° \; 48' \; 50''$	
$yAB = 9° \; 25' \; 00''$		$yCB = 317° \; 29' \; 20''$	
		$B = 51° \; 55' \; 40''$	
		(Check) $yAB = 9° \; 25' \; 00''$	

log 8922.43 = 3.9504832			
cosec B = 0.1038961			
sin A = 9.9788377			
sin C = 9.9176193			
log AB = 3.9719986	3.9719986	log CB = 4.0332170	4.0332170
yAB = 9.9941079	9.2138176	yCB = 9.8675537	9.8297752
3.9661065	3.1858162	3.9007707	3.8629922
+ 9249.25	+1533.97	+ 7957.39	−7294.44
A = + 7230.91	+ 538.64	C = + 8522.77	+9367.05
B = +16480.16	+2072.61	B = +16480.16	+2072.61

The method of calculating the lengths of the sides *AB* and *CB* is not clear in the finished calculation. It is as follows: First, to determine the length *AB*,

$$\begin{aligned} \log 8922.43 &= 3.9504832 \\ \operatorname{cosec} B &= 0.1038961 \\ \sin A &= \\ \sin C &= 9.9176193 \\ \hline \log AB &= 3.9719986 \end{aligned}$$

the space for the log sin *A* being left blank. Then, to determine the length *CB*, log sin *A* is filled in, and the sum of the three top lines = log *CB*, which is placed to the right of the repeated log *AB*.

Then, as already described, *AB* × the cos and sin of *yAB* (1st quadrant) = the latitude and departure of *B* from *A*; and *CB* × the sin and cos of $yCB - 270°$ (4th quadrant) = the latitude and departure of *B* from *C*.

Calculation of the area of a figure from its coordinates.

$$\text{Area} = \frac{\text{sums of the } y\text{s} \times \text{diffs. of the } x\text{s}}{2} \text{ or } \frac{\text{sums of the } x\text{s} \times \text{diffs. of the } y\text{s}}{2}$$

The sum and difference of the coordinates of each two adjoining points is taken separately, and the sum of the products is divided by 2, care being taken to distinguish between the positive and the negative signs when making the addition. The computation is checked by calculating by each way separately, using either 'short' multiplication or logarithms as preferred, the former method being the more accurate for dealing with large amounts.

For example, in the triangle *ABC* we have the coordinates:

	y	*x*
A =	+ 7230.91	+ 538.64
B =	+ 16480.16	+ 2072.61
C =	+ 8522.77	+ 9367.05

	Sums of the *y*s.		Diffs. of the *x*s.		
AB	+ 23711.07	×	+ 1533.97	=	+ 36,372,070.04
BC	+ 25002.93	×	+ 7294.44	=	+ 182,382,372.71
CA	+ 15753.68	×	− 8828.41	=	− 139,079,946.05
					+ 79,674,496.70
				÷ 2 =	39,837,248.35

Check.

	Sums of the *x*s.	Diffs. of the *y*s.	
AB	+ 2611.25 ×	+ 9249.25 =	+ 24,152,104.06
BC	+ 11439.66 ×	− 7957.39 =	− 91,029,836.09
CA	+ 9905.69 ×	− 1291.86 =	− 12,796,764.68
			− 79,674,496.69
			÷ 2 = 39,837,248.35

Area *ABC* = 39,837,248.35 square units.

The calculation of an area may often be simplified by deducting either a positive or a negative constant from each of the *y*s, and similarly, another positive or negative constant from each of the *x*s.

For example, in the foregoing calculation + 7000*y* and + 500*x* may be deducted from the coordinates of *A*, *B* and *C*, giving:

	y	*x*
A =	+ 230.91 +	38.64
B =	+ 9480.16 +	1572.61
C =	+ 1522.77 +	8867.05

	Sums of the *y*s.	Diffs. of the *x*s.	
AB	+ 9711.07 ×	+ 1533.97 =	+ 14,896,490.05
BC	+ 11002.93 ×	+ 7294.44 =	+ 80,260,212.71
CA	+ 1753.68 ×	− 8828.41 =	− 15,482,206.05
			+ 79,674,496.71
			÷ 2 = 39,837,248.35

Check.

	Sums of the *x*s.	Diffs. of the *y*s.	
AB	+ 1611.25 ×	+ 9249.25 =	+ 14,902,854.06
BC	+ 10439.66 ×	− 7957.39 =	− 83,072,446.08
CA	+ 8905.69 ×	− 1291.86 =	− 11,504,904.68
			− 79,674,496.70
			÷ 2 = 39,837,248.35

Area *ABC* = 39,837,248.35 square units.

Calculation of the coordinates of a point, the angles which it makes with three coordinated points having been observed.

Given the coordinates of the points *A*, *C* and *B*, and the observed angles *ARC* and *BRC* which subtend these points at *R*. Required the coordinates of the point *R* (Fig. 3).

Describe a circle cutting *A*, *B* and *R*. Join *RA*, *RB*, *RC* and *AB*. Produce *RC* to the circumference of the circle at *D*, and join *AD* and *BD*. Then:

the observed angle *ARD* = the angle *ABD*
and the observed angle *BRD* = the angle *BAD*,

as they subtend the same chords *AD* and *BD*. Determine the length and bearing of *AB* and coordinate *D* from the triangle *ABD*. Then calculate the bearing *yCD* which = the bearing *yRD*. Determine *yRA* and *yRB* from *yRC* and the angles *ARD* and *BRD*, and coordinate *R* from the triangle *ABR*.

It is apparent that the calculation will not be accurate when the middle point *C* is close to the circumference of the circle,

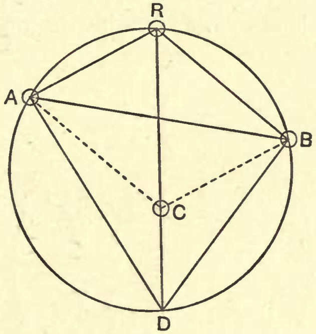

FIG. 3.

and quite impossible when *C* is cut by the circle. It is therefore advisable to first add the observed angles *ARC* and *BRC* to the known angle *ACB*; if their sum be 180°, all four points will be cut by the circle, as the opposite angles of a quadrilateral inscribed within a circle are together equal to 180°. Therefore, when the sum of the angles *ARC*, *BRC* and *ACB* is more than 180°, *C* is inside the circle and *yCD* = *yRD*; and when it is less than 180°, *C* is outside the circle and *yCD* = *yDR*.

R may also be calculated by the following formula:

Let $T = (\angle RBC + \angle RAC) = 360° - (\angle ACB + \angle ARC + \angle BRC)$.
When T is 90° or under,

$$\text{cotan}\, RBC = \text{cotan}\, T\left(\frac{BC \sin ARC}{AC \sin BRC \cos T} + 1\right).$$

When T is between 90° and 180°, the 1 in the formula is negative instead of positive, thus:

$$\text{cotan } RBC = \text{cotan } T\left(\frac{BC \sin ARC}{AC \sin BRC \cos T} - 1\right).$$

R is then coordinated from the triangle CBR.

The Cape System.

In South Africa, a method of coordination which is known as the *Cape System* is in general use. It differs from the conventional method in that the x axis is positive to the *west*, which is taken as 360° or 0°, and the bearings are therefore stated with reference to the west instead of to the north, the bearing of a line being consequently denoted by the prefix x instead of y. It is best explained by the following diagram:

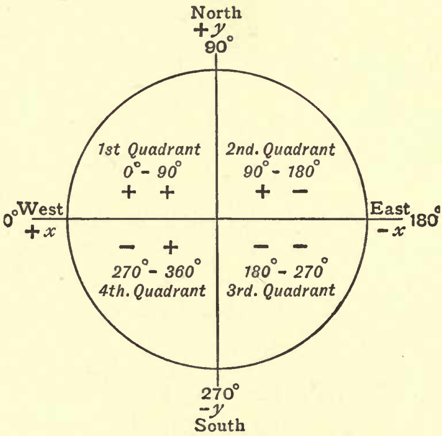

FIG. 4.

The methods of calculation are similar to those already described, but the arrangement of the quadrants is of course quite different. Therefore, if the bearing of a line be:

In the 1st quadrant,	its length	× the sin	of the	bearing	is the	y	distance.
	,,	× ,, cos	,,	,,	,,	x	,,
,, 2nd ,,	,,	× ,, cos	,,	(bearing − 90°)	is the	y	distance.
	,,	× ,, sin	,,	(,, ,,)	,,	x	,,
,, 3rd ,,	,,	× ,, sin	,,	(bearing − 180°)	,,	y	,,
	,,	× ,, cos	,,	(,, ,,)	,,	x	,,
,, 4th ,,	,,	× ,, cos	,,	(bearing − 270°)	,,	y	,,
	,,	× ,, sin	,,	(,, ,,)	,,	x	,,

In determining the length and bearing of a line between two coordinated points:

$$\frac{y \text{ difference}}{x \text{ difference}} = \begin{cases} \text{the tan of the bearing if in the 1st quadrant.} \\ \text{,, cotan of (the bearing} - 90^\circ\text{) if in the 2nd quadrant.} \\ \text{,, tan ,, (,, } - 180^\circ\text{) ,, 3rd ,,} \\ \text{,, cotan ,, (,, } - 270^\circ\text{) ,, 4th ,,} \end{cases}$$

$$\text{Length} = \frac{y \text{ difference}}{\text{sin of bearing}} \text{ or } \frac{x \text{ difference}}{\text{cos of bearing}} \text{ if in the 1st quadrant.}$$

$$\text{,,} = \frac{y \text{ difference}}{\text{cos of (bearing} - 90^\circ)} \text{ or } \frac{x \text{ difference}}{\text{sin of (bearing} - 90^\circ)} \text{ ,, 2nd ,,}$$

$$\text{,,} = \frac{y \text{ difference}}{\text{sin of (bearing} - 180^\circ)} \text{ or } \frac{x \text{ difference}}{\text{cos of (bearing} - 180^\circ)} \text{ ,, 3rd ,,}$$

$$\text{,,} = \frac{y \text{ difference}}{\text{cos of (bearing} - 270^\circ)} \text{ or } \frac{x \text{ difference}}{\text{sin of (bearing} - 270^\circ)} \text{ ,, 4th ,,}$$

SECTION III. THE COMPARISON AND VERIFICATION OF STANDARD MEASURES OF LENGTH.

1. The following measures of length can be tested by the Board of Trade Standards Department, Westminster:

Metal measures in the form of 'ribands' or 'tapes':

100 links or 66 feet.
50 links or 33 feet.
100 feet.
50 feet.
25 feet.
20 metres.
10 metres.

2. The whole or total length only of each of the above measures will be tested, except in the case of a standard measure required for survey purposes, when the corrected values of each part or interval of the measure will be given, *e.g.* every 5 metres on 20 metres, or every 10 feet on 100 feet.

3. Unless otherwise required, each measure will be tested under the following condition as to normal tension, 'pull,' or

stretching-weight, when the measure under test is supported throughout its whole length on a plane and even base:

	Metal Measures.
100 link riband - - 100 feet to 50 feet - -	10 lb. avoir.
20 metres - - - 10 metres - - -	5 kilograms.

Linked chains, or round-wire chains composed of links and rings and tapes made of linen or other fabric are only verified for certain official purposes.

4. All results are reduced to 62° F. for links and feet and to 0° C. for metres.

The coefficient of linear expansion of a metal measure is taken to be as follows, unless otherwise stated:

	For 1° F.	For 1° C.
Steel - - - - - -	0.00000689	0.00001240
'Invar' or Nickel Steel - (35.7 Nickel, 64.3 Steel.)	0.000000487	0.000000877

5. The following design of stamp or mark of verification (including the year) is placed on a verified measure:

Metal measures should have a brass disc ($\frac{1}{2}$-inch diameter) affixed upon which to place the official stamp.

6. In certain cases Treasury fees are required, particulars of which can be obtained at the Standards Office. Fees are not payable on measures for Government Departments or for Local Authorities.

A certificate of verification is given with each measure, in which its error or difference from Standard is stated, and also, in some instances, the modulus of elasticity and 'sag' of a chain.

In standard steel tapes for the use of local Inspectors of Weights and Measures an error in manufacture of 0.1 inch is allowed in excess or deficiency. In other steel standards 0.25 inch is allowed, and in linen tapes 0.5 inch is permitted.

Metric measures should be accurate to about 5 millimetres in 20 metres or to one four-thousandth of the whole length. The verification of measures can be carried out to nearly one four-thousandth part of the whole length.

The above regulations were issued by the Board of Trade Standards Department on the 1st of August, 1904.

SECTION IV. TACHEOMETRY.

The Use of the Tacheometer in Contouring.

For accurate contouring, a sufficient number of stations should be flagged so that any part of the ground is not more than about 1200 feet distant from at least one station, this being about the limit for accurate reading with the usual 5-inch instrument. The levels of the stations should then be determined, and their positions fixed by triangulation in the following manner. When the instrument is levelled up over a station, set it so that the clamped bottom plate has always the same position relative to the true or to the magnetic meridian. This is done by clamping the top plate at the known bearing which the instrument station makes with the back-sight, and then directing the telescope on the back sight with the bottom plate unclamped. The bearing of each sight can thus be booked direct, which saves time in plotting. The angles to all the fixed stations to be located by triangulation should be carefully read and booked before any staff readings are taken. With one man observing and another booking, two or even three staff men can be kept going. Great care should be insisted on in the holding of the staffs perpendicularly, more especially at a point above or below the level of the instrument station, where the sight has to be taken with an inclined telescope. The form of field book given on the following page is recommended.

A pocket steel tape 6 feet long, in a circular metal case and winding up by means of a spring, will be found very convenient for measuring the height of the instrument. In setting up at a

Specimen Page of Field Book.

Field .... | .... *Office*

Inst. Stn.	Hght. Inst.	Sighted Stn.	Bearing.	Vert. Angle.	Wires.	Distances. Slope.	Distances. Hor.	Distances. Vert.	Rise.	Fall.	Axis Level.	Red. Level.	Remarks.
△*B*	4.54										+91.89	+ 87.35	
		1	73° 15′	83° 40′	10.87 9.00 7.13	374	369.45	+41.01	32.01			+123.90	
		2	129° 43′	level	8.95 7.21 5.47		348			7.21		+ 84.68	
		3	4° 18′	94° 21′	10.48 9.00 7.52	296	294.06	−23.92		32.92		+ 58.97	

station, first level up, then take height of instrument (from centre of telescope axis to top of peg), then set bottom plate to correct bearing as already described. Take sights with a level telescope where possible, so as to save calculation in the office. Book the readings of the top, middle and bottom wires in the same column. When sighting to the rise or dip, bring the middle wire on to the same even number on the staff whenever possible, as an error in the reading of the top or bottom wire can then be easily detected when booking, and there is less liability to error in working out reduced levels. For instance, on sighting an ordinary 16 feet level staff, keep cutting the 9 foot mark with the middle wire, then the sum of the top and bottom wire readings should always be $9 \times 2 = 18$, and the 'Rise' or 'Fall' is more easily calculated. In the office first get the slope distance from the wire readings, then work out the horizontal and vertical readings by multiplying by the constants given in the table on pages 141–171. Enter them up, putting a + sign before the vertical distance for a rise, and a – sign for a fall. Then fill in the Axis Level, which is the Reduced Level + the height of the instrument. In case of a rise (see Sighted Station 1 in field book) *subtract* the middle wire reading from the Vertical Distance and book the result in the 'Rise' column. With a level telescope (see Sighted Station 2 in field book) enter the middle wire reading in the 'Fall' column. In case of a fall (see Sighted Station 3 in field book) *add* the middle wire reading to the Vertical Distance and book result in the 'Fall' column. Although in the specimen page everything is worked out to two decimal places, it is usual to work the Horizontal Distance to the nearest foot, which is sufficiently accurate for plotting.

Corrections for Curvature and Refraction.

Distance.	Correction.	Distance.	Correction.	Distance.	Correction.
300	.002	800	.013	1300	.035
400	.003	900	.017	1400	.040
500	.005	1000	.020	1500	.046
600	.007	1100	.025	1600	.052
700	.010	1200	.030	1700	.059

In + or rise angles, add the correction to the amount of rise in 'Rise' column. *In level distances*, book the correction in the 'Rise' column. *In – or dip angles*, deduct correction from amount of fall in 'Fall' column.

The stadia wires of a tacheometer are usually set to a 'measuring angle' twice the tangent of the half of which is 0.01, *i.e.*, the distance between the wires as read on the staff is 0.01 of the actual distance between the staff and the instrument, and consequently the difference between the top and bottom wire readings × 100 = the slope distance. Tacheometer telescopes are now made with an 'anallatic lens,' by which the stadia readings are referred to the centre of the instrument. If a telescope which is not 'anallatic' be used, a correction for 'focal length' has to be applied to all the readings.

The vertical circles of most tacheometers are graduated so that with a level telescope the right hand vernier is at 90° and the left hand vernier at 270°, with 360° at the tangent screw. Therefore a rise angle reads less, and a dip angle more than 90° on the right hand vernier, which is the one usually read. The following table is arranged for instruments of this type, but with an instrument where the actual rise or dip angle is read direct, add 90° when looking up the constants for the angle.

The horizontal distance and the difference in height are calculated from the slope distance and the vertical angle as follows:

Let G = the slope distance, or 'generating number.'
V = the vertical angle, or inclination of G from the horizontal.
D = the horizontal distance.
H = the vertical distance, or difference in height.

Then $D = G \cos^2 V$
and $H = G \sin V \cos V$.*

The following table gives the values of $\cos^2 V$ and $\sin V \cos V$ for each minute of arc from 0° to an inclination of 30° from the horizontal.

Rule: Multiply the slope distance by the constants given in the table for the vertical angle.

* $H = D \tan V$.

Table for the Calculation of Heights and Distances from Tacheometer Readings.

90 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	1.0000	.0000	60	30	.9999	.0087	30
1	1.0000	.0003	59	31	.9999	.0090	29
2	1.0000	.0006	58	32	.9999	.0093	28
3	1.0000	.0009	57	33	.9999	.0096	27
4	1.0000	.0012	56	34	.9999	.0099	26
5	1.0000	.0015	55	35	.9999	.0102	25
6	1.0000	.0018	54	36	.9999	.0105	24
7	1.0000	.0020	53	37	.9999	.0108	23
8	1.0000	.0023	52	38	.9999	.0111	22
9	1.0000	.0026	51	39	.9999	.0113	21
10	1.0000	.0029	50	40	.9999	.0116	20
11	1.0000	.0032	49	41	.9999	.0119	19
12	1.0000	.0035	48	42	.9999	.0122	18
13	1.0000	.0038	47	43	.9998	.0125	17
14	1.0000	.0041	46	44	.9998	.0128	16
15	1.0000	.0044	45	45	.9998	.0131	15
16	1.0000	.0047	44	46	.9998	.0134	14
17	1.0000	.0050	43	47	.9998	.0137	13
18	1.0000	.0052	42	48	.9998	.0140	12
19	1.0000	.0055	41	49	.9998	.0143	11
20	1.0000	.0058	40	50	.9998	.0145	10
21	1.0000	.0061	39	51	.9998	.0148	9
22	1.0000	.0064	38	52	.9998	.0151	8
23	1.0000	.0067	37	53	.9998	.0154	7
24	1.0000	.0070	36	54	.9998	.0157	6
25	1.0000	.0073	35	55	.9997	.0160	5
26	.9999	.0076	34	56	.9997	.0163	4
27	.9999	.0079	33	57	.9997	.0166	3
28	.9999	.0081	32	58	.9997	.0169	2
29	.9999	.0084	31	59	.9997	.0172	1
30	.9999	.0087	30	60	.9997	.0175	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

89 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

91 Degrees.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9997	.0175	60	30	.9993	.0262	30
1	.9997	.0177	59	31	.9993	.0265	29
2	.9997	.0180	58	32	.9993	.0268	28
3	.9997	.0183	57	33	.9993	.0270	27
4	.9997	.0186	56	34	.9993	.0273	26
5	.9996	.0189	55	35	.9992	.0276	25
6	.9996	.0192	54	36	.9992	.0279	24
7	.9996	.0195	53	37	.9992	.0282	23
8	.9996	.0198	52	38	.9992	.0285	22
9	.9996	.0201	51	39	.9992	.0288	21
10	.9996	.0204	50	40	.9992	.0291	20
11	.9996	.0207	49	41	.9991	.0294	19
12	.9996	.0209	48	42	.9991	.0297	18
13	.9995	.0212	47	43	.9991	.0300	17
14	.9995	.0215	46	44	.9991	.0302	16
15	.9995	.0218	45	45	.9991	.0305	15
16	.9995	.0221	44	46	.9991	.0308	14
17	.9995	.0224	43	47	.9990	.0311	13
18	.9995	.0227	42	48	.9990	.0314	12
19	.9995	.0230	41	49	.9990	.0317	11
20	.9995	.0233	40	50	.9990	.0320	10
21	.9994	.0236	39	51	.9990	.0323	9
22	.9994	.0238	38	52	.9989	.0326	8
23	.9994	.0241	37	53	.9989	.0328	7
24	.9994	.0244	36	54	.9989	.0331	6
25	.9994	.0247	35	55	.9989	.0334	5
26	.9994	.0250	34	56	.9989	.0337	4
27	.9994	.0253	33	57	.9988	.0340	3
28	.9994	.0256	32	58	.9988	.0343	2
29	.9993	.0259	31	59	.9988	.0346	1
30	.9993	.0262	30	60	.9988	.0349	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

88 Degrees.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

92 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9988	.0349	60	30	.9981	.0436	30
1	.9988	.0352	59	31	.9981	.0439	29
2	.9987	.0355	58	32	.9981	.0442	28
3	.9987	.0358	57	33	.9980	.0445	27
4	.9987	.0360	56	34	.9980	.0447	26
5	.9987	.0363	55	35	.9980	.0450	25
6	.9987	.0366	54	36	.9980	.0453	24
7	.9986	.0369	53	37	.9979	.0456	23
8	.9986	.0372	52	38	.9979	.0459	22
9	.9986	.0375	51	39	.9979	.0462	21
10	.9986	.0378	50	40	.9978	.0465	20
11	.9986	.0381	49	41	.9978	.0468	19
12	.9985	.0384	48	42	.9978	.0471	18
13	.9985	.0387	47	43	.9978	.0474	17
14	.9985	.0389	46	44	.9977	.0476	16
15	.9985	.0392	45	45	.9977	.0479	15
16	.9984	.0395	44	46	.9977	.0482	14
17	.9984	.0398	43	47	.9976	.0485	13
18	.9984	.0401	42	48	.9976	.0487	12
19	.9984	.0404	41	49	.9976	.0491	11
20	.9983	.0407	40	50	.9976	.0494	10
21	.9983	.0410	39	51	.9975	.0497	9
22	.9983	.0413	38	52	.9975	.0500	8
23	.9983	.0416	37	53	.9975	.0502	7
24	.9983	.0418	36	54	.9974	.0505	6
25	.9982	.0421	35	55	.9974	.0508	5
26	.9982	.0424	34	56	.9974	.0511	4
27	.9982	.0427	33	57	.9974	.0514	3
28	.9982	.0430	32	58	.9973	.0517	2
29	.9981	.0433	31	59	.9973	.0520	1
30	.9981	.0436	30	60	.9973	.0523	0
	Constant for Distance.	Constant for Difference in Height.	Minutes		Constant for Distance.	Constant for Difference in Height.	Minutes.

87 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

93 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9973	.0523	60	30	.9963	.0609	30
1	.9972	.0526	59	31	.9962	.0612	29
2	.9972	.0529	58	32	.9962	.0615	28
3	.9972	.0531	57	33	.9962	.0618	27
4	.9971	.0534	56	34	.9961	.0621	26
5	.9971	.0537	55	35	.9961	.0624	25
6	.9971	.0540	54	36	.9961	.0627	24
7	.9971	.0543	53	37	.9960	.0629	23
8	.9970	.0546	52	38	.9960	.0632	22
9	.9970	.0549	51	39	.9960	.0635	21
10	.9970	.0552	50	40	.9959	.0638	20
11	.9969	.0554	49	41	.9959	.0641	19
12	.9969	.0557	48	42	.9958	.0644	18
13	.9969	.0560	47	43	.9958	.0647	17
14	.9968	.0563	46	44	.9958	.0650	16
15	.9968	.0566	45	45	.9957	.0653	15
16	.9968	.0569	44	46	.9957	.0656	14
17	.9967	.0572	43	47	.9956	.0658	13
18	.9967	.0575	42	48	.9956	.0661	12
19	.9967	.0578	41	49	.9956	.0664	11
20	.9966	.0580	40	50	.9955	.0667	10
21	.9966	.0583	39	51	.9955	.0670	9
22	.9966	.0586	38	52	.9955	.0673	8
23	.9965	.0589	37	53	.9954	.0676	7
24	.9965	.0592	36	54	.9954	.0679	6
25	.9965	.0595	35	55	.9953	.0682	5
26	.9964	.0598	34	56	.9953	.0684	4
27	.9964	.0601	33	57	.9953	.0687	3
28	.9964	.0604	32	58	.9952	.0690	2
29	.9963	.0607	31	59	.9952	.0693	1
30	.9963	.0609	30	60	.9951	.0696	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

86 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

94 Degrees.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	·9951	.0696	60	30	·9938	.0782	30
1	·9951	.0699	59	31	·9938	.0785	29
2	·9951	.0702	58	32	·9938	.0788	28
3	·9950	.0705	57	33	·9937	.0791	27
4	·9950	.0707	56	34	·9937	.0794	26
5	·9949	.0710	55	35	·9936	.0797	25
6	·9949	.0713	54	36	·9936	.0799	24
7	·9949	.0716	53	37	·9935	.0802	23
8	·9948	.0719	52	38	·9935	.0805	22
9	·9948	.0722	51	39	·9934	.0808	21
10	·9947	.0725	50	40	·9934	.0811	20
11	·9947	.0728	49	41	·9933	.0814	19
12	·9946	.0731	48	42	·9933	.0817	18
13	·9946	.0733	47	43	·9932	.0820	17
14	·9946	.0736	46	44	·9932	.0822	16
15	·9945	.0739	45	45	·9931	.0825	15
16	·9945	.0742	44	46	·9931	.0828	14
17	·9944	.0745	43	47	·9930	.0831	13
18	·9944	.0748	42	48	·9930	.0834	12
19	·9943	.0751	41	49	·9929	.0837	11
20	·9943	.0753	40	50	·9929	.0840	10
21	·9943	.0756	39	51	·9929	.0843	9
22	·9942	.0759	38	52	·9928	.0845	8
23	·9942	.0762	37	53	·9928	.0848	7
24	·9941	.0765	36	54	·9927	.0851	6
25	·9941	.0768	35	55	·9927	.0854	5
26	·9940	.0771	34	56	·9926	.0857	4
27	·9940	.0774	33	57	·9926	.0860	3
28	·9939	.0776	32	58	·9925	.0863	2
29	·9939	.0779	31	59	·9925	.0865	1
30	·9938	.0782	30	60	·9924	.0868	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

85 Degrees.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

95 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9924	.0868	60	30	.9908	.0954	30
1	.9924	.0871	59	31	.9908	.0957	29
2	.9923	.0874	58	32	.9907	.0960	28
3	.9923	.0877	57	33	.9907	.0963	27
4	.9922	.0880	56	34	.9906	.0965	26
5	.9922	.0883	55	35	.9905	.0968	25
6	.9921	.0885	54	36	.9905	.0971	24
7	.9921	.0888	53	37	.9904	.0974	23
8	.9920	.0891	52	38	.9904	.0977	22
9	.9920	.0894	51	39	.9903	.0980	21
10	.9919	.0897	50	40	.9903	.0983	20
11	.9918	.0900	49	41	.9902	.0985	19
12	.9918	.0903	48	42	.9901	.0988	18
13	.9917	.0905	47	43	.9901	.0991	17
14	.9917	.0908	46	44	.9900	.0994	16
15	.9916	.0911	45	45	.9900	.0997	15
16	.9916	.0914	44	46	.9899	.1000	14
17	.9915	.0917	43	47	.9898	.1003	13
18	.9915	.0920	42	48	.9898	.1005	12
19	.9914	.0923	41	49	.9897	.1008	11
20	.9914	.0926	40	50	.9897	.1011	10
21	.9913	.0928	39	51	.9896	.1014	9
22	.9913	.0931	38	52	.9896	.1017	8
23	.9912	.0934	37	53	.9895	.1020	7
24	.9912	.0937	36	54	.9894	.1023	6
25	.9911	.0940	35	55	.9894	.1025	5
26	.9910	.0943	34	56	.9893	.1028	4
27	.9910	.0946	33	57	.9893	.1031	3
28	.9909	.0948	32	58	.9892	.1034	2
29	.9909	.0951	31	59	.9891	.1037	1
30	.9908	.0954	30	60	.9891	.1040	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

84 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

96 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9891	.1040	60	30	.9872	.1125	30
1	.9890	.1042	59	31	.9871	.1128	29
2	.9890	.1045	58	32	.9871	.1130	28
3	.9889	.1048	57	33	.9870	.1133	27
4	.9888	.1051	56	34	.9869	.1136	26
5	.9888	.1054	55	35	.9869	.1139	25
6	.9887	.1057	54	36	.9868	.1142	24
7	.9887	.1059	53	37	.9867	.1145	23
8	.9886	.1062	52	38	.9867	.1148	22
9	.9885	.1065	51	39	.9866	.1150	21
10	.9885	.1068	50	40	.9865	.1153	20
11	.9884	.1071	49	41	.9865	.1156	19
12	.9883	.1074	48	42	.9864	.1159	18
13	.9883	.1077	47	43	.9863	.1162	17
14	.9882	.1079	46	44	.9863	.1164	16
15	.9882	.1082	45	45	.9862	.1167	15
16	.9881	.1085	44	46	.9861	.1170	14
17	.9880	.1088	43	47	.9860	.1173	13
18	.9880	.1091	42	48	.9860	.1176	12
19	.9879	.1094	41	49	.9859	.1179	11
20	.9878	.1096	40	50	.9858	.1181	10
21	.9878	.1099	39	51	.9858	.1184	9
22	.9877	.1102	38	52	.9857	.1187	8
23	.9876	.1105	37	53	.9856	.1190	7
24	.9876	.1108	36	54	.9856	.1193	6
25	.9875	.1111	35	55	.9855	.1196	5
26	.9875	.1113	34	56	.9854	.1198	4
27	.9874	.1116	33	57	.9854	.1201	3
28	.9873	.1119	32	58	.9853	.1204	2
29	.9873	.1122	31	59	.9852	.1207	1
30	.9872	.1125	30	60	.9852	.1210	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

83 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

97 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9852	.1210	60	30	.9830	.1294	30
1	.9851	.1213	59	31	.9829	.1297	29
2	.9850	.1215	58	32	.9828	.1300	28
3	.9849	.1218	57	33	.9827	.1303	27
4	.9849	.1221	56	34	.9827	.1305	26
5	.9848	.1224	55	35	.9826	.1308	25
6	.9847	.1227	54	36	.9825	.1311	24
7	.9847	.1229	53	37	.9824	.1314	23
8	.9846	.1232	52	38	.9824	.1317	22
9	.9845	.1235	51	39	.9823	.1319	21
10	.9844	.1238	50	40	.9822	.1322	20
11	.9844	.1241	49	41	.9821	.1325	19
12	.9843	.1243	48	42	.9821	.1328	18
13	.9842	.1246	47	43	.9820	.1331	17
14	.9842	.1249	46	44	.9819	.1333	16
15	.9841	.1252	45	45	.9818	.1336	15
16	.9840	.1255	44	46	.9817	.1339	14
17	.9839	.1258	43	47	.9817	.1342	13
18	.9839	.1260	42	48	.9816	.1345	12
19	.9838	.1263	41	49	.9815	.1347	11
20	.9837	.1266	40	50	.9814	.1350	10
21	.9836	.1269	39	51	.9814	.1353	9
22	.9836	.1272	38	52	.9813	.1356	8
23	.9835	.1274	37	53	.9812	.1359	7
24	.9834	.1277	36	54	.9811	.1361	6
25	.9833	.1280	35	55	.9810	.1364	5
26	.9833	.1283	34	56	.9810	.1367	4
27	.9832	.1286	33	57	.9809	.1370	3
28	.9831	.1289	32	58	.9808	.1373	2
29	.9830	.1291	31	59	.9807	.1375	1
30	.9830	.1294	30	60	.9806	.1378	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

82 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

98 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9806	.1378	60	30	.9782	.1462	30
1	.9806	.1381	59	31	.9781	.1465	29
2	.9805	.1384	58	32	.9780	.1467	28
3	.9804	.1387	57	33	.9779	.1470	27
4	.9803	.1390	56	34	.9778	.1473	26
5	.9802	.1392	55	35	.9777	.1476	25
6	.9802	.1395	54	36	9776	.1479	24
7	.9801	.1398	53	37	9776	.1481	23
8	.9800	.1401	52	38	.9775	.1484	22
9	.9799	.1403	51	39	.9774	.1487	21
10	.9798	.1406	50	40	.9773	.1490	20
11	.9797	.1409	49	41	.9772	.1492	19
12	.9797	.1412	48	42	.9771	.1495	18
13	.9796	.1415	47	43	.9770	.1498	17
14	.9795	.1417	46	44	.9770	.1501	16
15	.9794	.1420	45	45	.9769	.1504	15
16	.9793	.1423	44	46	.9768	.1506	14
17	.9792	.1426	43	47	.9767	.1509	13
18	.9792	.1429	42	48	.9766	.1512	12
19	.9791	.1431	41	49	.9765	.1515	11
20	.9790	.1434	40	50	.9764	.1517	10
21	.9789	.1437	39	51	.9763	.1520	9
22	.9788	.1440	38	52	.9763	.1523	8
23	.9788	.1442	37	53	.9762	.1526	7
24	.9787	.1445	36	54	.9761	.1529	6
25	.9786	.1448	35	55	.9760	.1531	5
26	.9785	.1451	34	56	.9759	.1534	4
27	.9784	.1454	33	57	.9758	.1537	3
28	.9783	.1456	32	58	.9757	.1540	2
29	.9782	.1459	31	59	.9756	.1542	1
30	.9782	.1462	30	60	.9755	.1545	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

81 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

99 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9755	.1545	60	30	.9728	.1628	30
1	.9754	.1548	59	31	.9727	.1631	29
2	.9754	.1551	58	32	.9726	.1633	28
3	.9753	.1553	57	33	.9725	.1636	27
4	.9752	.1556	56	34	.9724	.1639	26
5	.9751	.1559	55	35	.9723	.1642	25
6	.9750	.1562	54	36	.9722	.1644	24
7	.9749	.1565	53	37	.9721	.1647	23
8	.9748	.1567	52	38	.9720	.1650	22
9	.9747	.1570	51	39	.9719	.1653	21
10	.9746	.1573	50	40	.9718	.1655	20
11	.9745	.1575	49	41	.9717	.1658	19
12	.9744	.1578	48	42	.9716	.1661	18
13	.9744	.1581	47	43	.9715	.1664	17
14	.9743	.1584	46	44	.9714	.1666	16
15	.9742	.1587	45	45	.9713	.1669	15
16	.9741	.1589	44	46	.9712	.1672	14
17	.9740	.1592	43	47	.9711	.1675	13
18	.9739	.1595	42	48	.9710	.1677	12
19	.9738	.1598	41	49	.9709	.1680	11
20	.9737	.1600	40	50	.9708	.1683	10
21	.9736	.1603	39	51	.9707	.1686	9
22	.9735	.1606	38	52	.9706	.1688	8
23	.9734	.1609	37	53	.9705	.1691	7
24	.9733	.1611	36	54	.9704	.1694	6
25	.9733	.1614	35	55	.9703	.1697	5
26	.9732	.1617	34	56	.9702	.1700	4
27	.9731	.1620	33	57	.9701	.1703	3
28	.9730	.1622	32	58	.9701	.1705	2
29	.9729	.1625	31	59	.9700	.1707	1
30	.9728	.1628	30	60	.9699	.1710	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

80 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

100 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9699	.1710	60	30	.9668	.1792	30
1	.9698	.1713	59	31	.9667	.1795	29
2	.9697	.1716	58	32	.9666	.1797	28
3	.9696	.1718	57	33	.9665	.1800	27
4	.9695	.1721	56	34	.9664	.1803	26
5	.9694	.1724	55	35	.9663	.1806	25
6	.9693	.1727	54	36	.9662	.1808	24
7	.9692	.1729	53	37	.9661	.1811	23
8	.9691	.1732	52	38	.9660	.1814	22
9	.9689	.1735	51	39	.9659	.1816	21
10	.9688	.1737	50	40	.9657	.1819	20
11	.9687	.1740	49	41	.9656	.1822	19
12	.9686	.1743	48	42	.9655	.1824	18
13	.9685	.1746	47	43	.9654	.1827	17
14	.9684	.1748	46	44	.9653	.1830	16
15	.9683	.1751	45	45	.9652	.1833	15
16	.9682	.1754	44	46	.9651	.1835	14
17	.9681	.1757	43	47	.9650	.1838	13
18	.9680	.1759	42	48	.9649	.1841	12
19	.9679	.1762	41	49	.9648	.1843	11
20	.9678	.1765	40	50	.9647	.1846	10
21	.9677	.1767	39	51	.9646	.1849	9
22	.9676	.1770	38	52	.9645	.1851	8
23	.9675	.1773	37	53	.9643	.1854	7
24	.9674	.1776	36	54	.9642	.1857	6
25	.9673	.1778	35	55	.9641	.1860	5
26	.9672	.1781	34	56	.9640	.1862	4
27	.9671	.1784	33	57	.9639	.1865	3
28	.9670	.1786	32	58	.9638	.1868	2
29	.9669	.1789	31	59	.9637	.1870	1
30	.9668	.1792	30	60	.9636	.1873	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

79 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

101 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9636	.1873	60	30	.9603	.1954	30
1	.9635	.1876	59	31	.9601	.1956	29
2	.9634	.1878	58	32	.9600	.1959	28
3	.9633	.1881	57	33	.9599	.1962	27
4	.9632	.1884	56	34	.9598	.1964	26
5	.9630	.1887	55	35	.9597	.1967	25
6	.9629	.1889	54	36	.9596	.1970	24
7	.9628	.1892	53	37	.9595	.1972	23
8	.9627	.1895	52	38	.9593	.1975	22
9	.9626	.1897	51	39	.9592	.1977	21
10	.9625	.1900	50	40	.9591	.1980	20
11	.9624	.1903	49	41	.9590	.1983	19
12	.9623	.1905	48	42	.9589	.1986	18
13	.9622	.1908	47	43	.9588	.1988	17
14	.9621	.1911	46	44	.9587	.1991	16
15	.9619	.1913	45	45	.9585	.1994	15
16	.9618	.1916	44	46	.9584	.1997	14
17	.9617	.1919	43	47	.9583	.1999	13
18	.9616	.1922	42	48	.9582	.2002	12
19	.9615	.1924	41	49	.9581	.2004	11
20	.9614	.1927	40	50	.9580	.2007	10
21	.9613	.1930	39	51	.9578	.2010	9
22	.9612	.1932	38	52	.9577	.2012	8
23	.9610	.1935	37	53	.9576	.2015	7
24	.9609	.1938	36	54	.9575	.2018	6
25	.9608	.1940	35	55	.9574	.2020	5
26	.9607	.1943	34	56	.9573	.2023	4
27	.9606	.1946	33	57	.9571	.2026	3
28	.9605	.1948	32	58	.9570	.2028	2
29	.9604	.1951	31	59	.9569	.2031	1
30	.9603	.1954	30	60	.9568	.2034	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

78 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

102 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	·9568	.2034	60	30	·9532	.2113	30
1	·9567	.2036	59	31	·9530	.2116	29
2	·9565	.2039	58	32	·9529	.2118	28
3	·9564	.2042	57	33	·9528	.2121	27
4	·9563	.2044	56	34	·9527	.2124	26
5	·9562	.2047	55	35	·9525	.2126	25
6	·9561	.2050	54	36	·9524	.2129	24
7	·9559	.2052	53	37	·9523	.2132	23
8	·9558	.2055	52	38	·9522	.2134	22
9	·9557	.2058	51	39	·9520	.2137	21
10	·9556	.2060	50	40	·9519	.2139	20
11	·9555	.2063	49	41	·9518	.2142	19
12	·9553	.2066	48	42	·9517	.2145	18
13	·9552	.2068	47	43	·9515	.2147	17
14	·9551	.2071	46	44	·9514	.2150	16
15	·9550	.2074	45	45	·9513	.2153	15
16	·9549	.2076	44	46	·9512	.2155	14
17	·9547	.2079	43	47	·9510	.2158	13
18	·9546	.2081	42	48	·9509	.2160	12
19	·9545	.2084	41	49	·9508	.2163	11
20	·9544	.2087	40	50	·9507	.2166	10
21	·9543	.2089	39	51	·9505	.2168	9
22	·9541	.2092	38	52	·9504	.2171	8
23	·9540	.2095	37	53	·9503	.2174	7
24	·9539	.2097	36	54	·9502	.2176	6
25	·9538	.2100	35	55	·9500	.2179	5
26	·9537	.2103	34	56	·9499	.2181	4
27	·9535	.2105	33	57	·9498	.2184	3
28	·9534	.2108	32	58	·9497	.2187	2
29	·9533	.2111	31	59	·9495	.2189	1
30	·9532	.2113	30	60	·9494	.2192	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

77 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

103 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	·9494	.2192	60
1	·9493	.2194	59
2	·9492	.2197	58
3	·9490	.2200	57
4	·9489	.2202	56
5	·9488	.2205	55
6	·9486	.2208	54
7	·9485	.2210	53
8	·9484	.2213	52
9	·9482	.2215	51
10	·9481	.2218	50
11	·9480	.2221	49
12	·9479	.2223	48
13	·9477	.2226	47
14	·9476	.2228	46
15	·9475	.2231	45
16	·9473	.2234	44
17	·9472	.2236	43
18	·9471	.2239	42
19	·9470	.2241	41
20	·9468	.2244	40
21	·9467	.2247	39
22	·9466	.2249	38
23	·9464	.2252	37
24	·9463	.2254	36
25	·9462	.2257	35
26	·9460	.2260	34
27	·9459	.2262	33
28	·9458	.2265	32
29	·9456	.2267	31
30	·9455	.2270	30
	Constant for Distance.	Constant for Difference in Height.	Minutes.

Minutes.	Constant for Distance.	Constant for Difference in Height.	
30	·9455	.2270	30
31	·9454	.2273	29
32	·9452	.2275	28
33	·9451	.2278	27
34	·9450	.2280	26
35	·9448	.2283	25
36	·9447	.2286	24
37	·9446	.2288	23
38	·9444	.2291	22
39	·9443	.2293	21
40	·9442	.2296	20
41	·9440	.2299	19
42	·9439	.2301	18
43	·9438	.2304	17
44	·9436	.2306	16
45	·9435	.2309	15
46	·9434	.2311	14
47	·9433	.2314	13
48	·9431	.2316	12
49	·9430	.2319	11
50	·9428	.2322	10
51	·9427	.2324	9
52	·9426	.2327	8
53	·9424	.2329	7
54	·9423	.2332	6
55	·9422	.2335	5
56	·9420	.2337	4
57	·9419	.2340	3
58	·9418	.2342	2
59	·9416	.2345	1
60	·9415	.2347	0
	Constant for Distance.	Constant for Difference in Height.	Minutes

76 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

104 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9415	.2347	60	30	.9373	.2424	30
1	.9413	.2350	59	31	.9372	.2427	29
2	.9412	.2353	58	32	.9370	.2429	28
3	.9411	.2355	57	33	.9369	.2432	27
4	.9409	.2358	56	34	.9367	.2434	26
5	.9408	.2360	55	35	.9366	.2437	25
6	.9407	.2363	54	36	.9365	.2439	24
7	.9405	.2365	53	37	.9363	.2442	23
8	.9404	.2368	52	38	.9362	.2444	22
9	.9402	.2370	51	39	.9360	.2447	21
10	.9401	.2373	50	40	.9359	.2450	20
11	.9400	.2376	49	41	.9358	.2452	19
12	.9398	.2378	48	42	.9356	.2455	18
13	.9397	.2381	47	43	.9355	.2457	17
14	.9396	.2383	46	44	.9353	.2460	16
15	.9394	.2386	45	45	.9352	.2462	15
16	.9393	.2388	44	46	.9350	.2465	14
17	.9391	.2391	43	47	.9349	.2467	13
18	.9390	.2394	42	48	.9348	.2470	12
19	.9389	.2396	41	49	.9346	.2472	11
20	.9387	.2399	40	50	.9345	.2475	10
21	.9386	.2401	39	51	.9343	.2477	9
22	.9384	.2404	38	52	.9342	.2480	8
23	.9383	.2406	37	53	.9340	.2482	7
24	.9382	.2409	36	54	.9339	.2485	6
25	.9380	.2411	35	55	.9337	.2487	5
26	.9379	.2414	34	56	.9336	.2490	4
27	.9377	.2417	33	57	.9335	.2493	3
28	.9376	.2419	32	58	.9333	.2495	2
29	.9375	.2422	31	59	.9332	.2498	1
30	.9373	.2424	30	60	.9330	.2500	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

75 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

105 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9330	.2500	60	30	.9286	.2575	30
1	.9329	.2503	59	31	.9284	.2578	29
2	.9327	.2505	58	32	.9283	.2580	28
3	.9326	.2508	57	33	.9281	.2583	27
4	.9324	.2510	56	34	.9280	.2585	26
5	.9323	.2513	55	35	.9278	.2588	25
6	.9321	.2515	54	36	.9277	.2590	24
7	.9320	.2518	53	37	.9275	.2593	23
8	.9319	.2520	52	38	.9274	.2595	22
9	.9317	.2523	51	39	.9272	.2598	21
10	.9316	.2525	50	40	.9271	.2600	20
11	.9314	.2528	49	41	.9269	.2603	19
12	.9313	.2530	48	42	.9268	.2605	18
13	.9311	.2533	47	43	.9266	.2608	17
14	.9310	.2535	46	44	.9265	.2610	16
15	.9308	.2538	45	45	.9263	.2613	15
16	.9307	.2540	44	46	.9262	.2615	14
17	.9305	.2543	43	47	.9260	.2618	13
18	.9304	.2545	42	48	.9259	.2620	12
19	.9302	.2548	41	49	.9257	.2622	11
20	.9301	.2550	40	50	.9256	.2625	10
21	.9299	.2553	39	51	.9254	.2627	9
22	.9298	.2555	38	52	.9253	.2630	8
23	.9296	.2558	37	53	.9251	.2632	7
24	.9295	.2560	36	54	.9249	.2635	6
25	.9293	.2563	35	55	.9248	.2637	5
26	.9292	.2565	34	56	.9246	.2640	4
27	.9290	.2568	33	57	.9245	.2642	3
28	.9289	.2570	32	58	.9243	.2645	2
29	.9287	.2573	31	59	.9242	.2647	1
30	.9286	.2575	30	60	.9240	.2650	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

74 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

106 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9240	.2650	60	30	.9193	.2723	30
1	.9239	.2652	59	31	.9192	.2726	29
2	.9237	.2655	58	32	.9190	.2728	28
3	.9236	.2657	57	33	.9189	.2731	27
4	.9234	.2660	56	34	.9187	.2733	26
5	.9233	.2662	55	35	.9185	.2735	25
6	.9231	.2664	54	36	.9184	.2738	24
7	.9230	.2667	53	37	.9182	.2740	23
8	.9228	.2669	52	38	.9181	.2743	22
9	.9226	.2672	51	39	.9179	.2745	21
10	.9225	.2674	50	40	.9177	.2748	20
11	.9223	.2677	49	41	.9176	.2750	19
12	.9222	.2679	48	42	.9174	.2752	18
13	.9220	.2682	47	43	.9173	.2755	17
14	.9219	.2684	46	44	.9171	.2757	16
15	.9217	.2687	45	45	.9169	.2760	15
16	.9215	.2689	44	46	.9168	.2762	14
17	.9214	.2691	43	47	.9166	.2765	13
18	.9212	.2694	42	48	.9165	.2767	12
19	.9211	.2696	41	49	.9163	.2769	11
20	.9209	.2699	40	50	.9161	.2772	10
21	.9208	.2701	39	51	.9160	.2774	9
22	.9206	.2704	38	52	.9158	.2777	8
23	.9204	.2706	37	53	.9157	.2779	7
24	.9203	.2709	36	54	.9155	.2781	6
25	.9201	.2711	35	55	.9153	.2784	5
26	.9200	.2713	34	56	.9152	.2786	4
27	.9198	.2716	33	57	.9150	.2789	3
28	.9197	.2718	32	58	.9148	.2791	2
29	.9195	.2721	31	59	.9147	.2794	1
30	.9193	.2723	30	60	.9145	.2796	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

73 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

107 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9145	.2796	60	30	.9096	.2868	30
1	.9144	.2798	59	31	.9094	.2870	29
2	.9142	.2801	58	32	.9092	.2873	28
3	.9140	.2803	57	33	.9091	.2875	27
4	.9139	.2806	56	34	.9089	.2878	26
5	.9137	.2808	55	35	.9087	.2880	25
6	.9135	.2810	54	36	.9086	.2882	24
7	.9134	.2813	53	37	.9084	.2885	23
8	.9132	.2815	52	38	.9082	.2887	22
9	.9130	.2818	51	39	.9081	.2889	21
10	.9129	.2820	50	40	.9079	.2892	20
11	.9127	.2822	49	41	.9077	.2894	19
12	.9126	.2825	48	42	.9076	.2896	18
13	.9124	.2827	47	43	.9074	.2899	17
14	.9122	.2830	46	44	.9072	.2901	16
15	.9121	.2832	45	45	.9071	.2904	15
16	.9119	.2834	44	46	.9069	.2906	14
17	.9117	.2837	43	47	.9067	.2908	13
18	.9116	.2839	42	48	.9066	.2911	12
19	.9114	.2842	41	49	.9064	.2913	11
20	.9112	.2844	40	50	.9062	.2915	10
21	.9111	.2846	39	51	.9060	.2918	9
22	.9109	.2849	38	52	.9059	.2920	8
23	.9107	.2851	37	53	.9057	.2922	7
24	.9106	.2854	36	54	.9055	.2925	6
25	.9104	.2856	35	55	.9054	.2927	5
26	.9102	.2858	34	56	.9052	.2930	4
27	.9101	.2861	33	57	.9050	.2932	3
28	.9099	.2863	32	58	.9049	.2934	2
29	.9098	.2866	31	59	.9047	.2937	1
30	.9096	.2868	30	60	.9045	.2939	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

72 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

108 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.9045	.2939	60	30	.8993	.3009	30
1	.9043	.2941	59	31	.8991	.3011	29
2	.9042	.2944	58	32	.8990	.3014	28
3	.9040	.2946	57	33	.8988	.3016	27
4	.9038	.2948	56	34	.8986	.3018	26
5	.9037	.2951	55	35	.8984	.3021	25
6	.9035	.2953	54	36	.8983	.3023	24
7	.9033	.2955	53	37	.8981	.3025	23
8	.9031	.2958	52	38	.8979	.3028	22
9	.9030	.2960	51	39	.8977	.3030	21
10	.9028	.2962	50	40	.8976	.3032	20
11	.9026	.2965	49	41	.8974	.3035	19
12	.9024	.2967	48	42	.8972	.3037	18
13	.9023	.2969	47	43	.8970	.3039	17
14	.9021	.2972	46	44	.8969	.3041	16
15	.9019	.2974	45	45	.8967	.3044	15
16	.9018	.2977	44	46	.8965	.3046	14
17	.9016	.2979	43	47	.8963	.3048	13
18	.9014	.2981	42	48	.8962	.3051	12
19	.9012	.2984	41	49	.8960	.3053	11
20	.9011	.2986	40	50	.8958	.3055	10
21	.9009	.2988	39	51	.8956	.3058	9
22	.9007	.2991	38	52	.8954	.3060	8
23	.9005	.2993	37	53	.8953	.3062	7
24	.9004	.2995	36	54	.8951	.3065	6
25	.9002	.2998	35	55	.8949	.3067	5
26	.9000	.3000	34	56	.8947	.3069	4
27	.8998	.3002	33	57	.8946	.3071	3
28	.8997	.3004	32	58	.8944	.3074	2
29	.8995	.3007	31	59	.8942	.3076	1
30	.8993	.3009	30	60	.8940	.3078	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

71 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued*

109 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8940	.3078	60	30	.8886	.3147	30
1	.8938	.3081	59	31	.8884	.3149	29
2	.8937	.3083	58	32	.8882	.3151	28
3	.8935	.3085	57	33	.8880	.3153	27
4	.8933	.3088	56	34	.8878	.3156	26
5	.8931	.3090	55	35	.8877	.3158	25
6	.8929	.3092	54	36	.8875	.3160	24
7	.8928	.3094	53	37	.8873	.3162	23
8	.8926	.3097	52	38	.8871	.3165	22
9	.8924	.3099	51	39	.8869	.3167	21
10	.8922	.3101	50	40	.8867	.3169	20
11	.8920	.3103	49	41	.8866	.3171	19
12	.8918	.3106	48	42	.8864	.3174	18
13	.8917	.3108	47	43	.8862	.3176	17
14	.8915	.3110	46	44	.8860	.3178	16
15	.8913	.3113	45	45	.8858	.3180	15
16	.8911	.3115	44	46	.8856	.3183	14
17	.8909	.3117	43	47	.8854	.3185	13
18	.8908	.3119	42	48	.8853	.3187	12
19	.8906	.3122	41	49	.8851	.3189	11
20	.8904	.3124	40	50	.8849	.3192	10
21	.8902	.3126	39	51	.8847	.3194	9
22	.8900	.3129	38	52	.8845	.3196	8
23	.8899	.3131	37	53	.8843	.3198	7
24	.8897	.3133	36	54	.8842	.3201	6
25	.8895	.3136	35	55	.8840	.3203	5
26	.8893	.3138	34	56	.8838	.3205	4
27	.8891	.3140	33	57	.8836	.3207	3
28	.8889	.3142	32	58	.8834	.3209	2
29	.8888	.3144	31	59	.8832	.3212	1
30	.8886	.3147	30	60	.8830	.3214	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

70 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

110 Degrees.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8830	.3214	60	30	.8774	.3280	30
1	.8828	.3216	59	31	.8772	.3283	29
2	.8826	.3218	58	32	.8770	.3285	28
3	.8825	.3221	57	33	.8768	.3287	27
4	.8823	.3223	56	34	.8766	.3289	26
5	.8821	.3225	55	35	.8764	.3291	25
6	.8819	.3227	54	36	.8762	.3293	24
7	.8817	.3230	53	37	.8760	.3296	23
8	.8815	.3232	52	38	.8758	.3298	22
9	.8813	.3234	51	39	.8756	.3300	21
10	.8811	.3236	50	40	.8754	.3302	20
11	.8810	.3238	49	41	.8753	.3304	19
12	.8808	.3241	48	42	.8751	.3307	18
13	.8806	.3243	47	43	.8749	.3309	17
14	.8804	.3245	46	44	.8747	.3311	16
15	.8802	.3247	45	45	.8745	.3313	15
16	.8800	.3249	44	46	.8743	.3315	14
17	.8798	.3252	43	47	.8741	.3318	13
18	.8796	.3254	42	48	.8739	.3320	12
19	.8794	.3256	41	49	.8737	.3322	11
20	.8793	.3258	40	50	.8735	.3324	10
21	.8791	.3261	39	51	.8733	.3326	9
22	.8789	.3263	38	52	.8731	.3328	8
23	.8787	.3265	37	53	.8729	.3331	7
24	.8785	.3267	36	54	.8727	.3333	6
25	.8783	.3269	35	55	.8725	.3335	5
26	.8781	.3272	34	56	.8723	.3337	4
27	.8779	.3274	33	57	.8722	.3339	3
28	.8777	.3276	32	58	.8720	.3341	2
29	.8776	.3278	31	59	.8718	.3344	1
30	.8774	.3280	30	60	.8716	.3346	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

69 Degrees.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

111 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8716	·3346	60	30	.8657	·3410	30
1	.8714	·3348	59	31	.8655	·3412	29
2	.8712	·3350	58	32	.8653	·3414	28
3	.8710	·3352	57	33	.8651	·3416	27
4	.8708	·3354	56	34	.8649	·3419	26
5	.8706	·3356	55	35	.8647	·3421	25
6	.8704	·3359	54	36	.8645	·3423	24
7	.8702	·3361	53	37	.8643	·3425	23
8	.8700	·3363	52	38	.8641	·3427	22
9	.8698	·3365	51	39	.8639	·3429	21
10	.8696	·3367	50	40	.8637	·3431	20
11	.8694	·3369	49	41	.8635	·3433	19
12	.8692	·3372	48	42	.8633	·3436	18
13	.8690	·3374	47	43	.8631	·3438	17
14	.8688	·3376	46	44	.8629	·3440	16
15	.8686	·3378	45	45	.8627	·3442	15
16	.8684	·3380	44	46	.8625	·3444	14
17	.8682	·3382	43	47	.8623	·3446	13
18	.8680	·3384	42	48	.8621	·3448	12
19	.8678	·3387	41	49	.8619	·3450	11
20	.8677	·3389	40	50	.8617	·3452	10
21	.8675	·3391	39	51	.8615	·3454	9
22	.8673	·3393	38	52	.8613	·3457	8
23	.8671	·3395	37	53	.8611	·3459	7
24	.8669	·3397	36	54	.8609	·3461	6
25	.8667	·3399	35	55	.8607	·3463	5
26	.8665	·3402	34	56	.8605	·3465	4
27	.8663	·3404	33	57	.8603	·3467	3
28	.8661	·3406	32	58	.8601	·3469	2
29	.8659	·3408	31	59	.8599	·3471	1
30	.8657	·3410	30	60	.8597	·3473	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

68 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

112 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8597	.3473	60	30	.8536	.3536	30
1	.8595	.3475	59	31	.8534	.3538	29
2	.8593	.3478	58	32	.8531	.3540	28
3	.8591	.3480	57	33	.8529	.3542	27
4	.8589	.3482	56	34	.8527	.3544	26
5	.8587	.3484	55	35	.8525	.3546	25
6	.8585	.3486	54	36	.8523	.3548	24
7	.8583	.3488	53	37	.8521	.3550	23
8	.8581	.3490	52	38	.8519	.3552	22
9	.8579	.3492	51	39	.8517	.3554	21
10	.8576	.3494	50	40	.8515	.3556	20
11	.8574	.3496	49	41	.8513	.3558	19
12	.8572	.3498	48	42	.8511	.3560	18
13	.8570	.3500	47	43	.8509	.3562	17
14	.8568	.3503	46	44	.8507	.3564	16
15	.8566	.3505	45	45	.8505	.3566	15
16	.8564	.3507	44	46	.8503	.3568	14
17	.8562	.3509	43	47	.8500	.3570	13
18	.8560	.3511	42	48	.8498	.3572	12
19	.8558	.3513	41	49	.8496	.3574	11
20	.8556	.3515	40	50	.8494	.3576	10
21	.8554	.3517	39	51	.8492	.3578	9
22	.8552	.3519	38	52	.8490	.3581	8
23	.8550	.3521	37	53	.8488	.3583	7
24	.8548	.3523	36	54	.8486	.3585	6
25	.8546	.3525	35	55	.8484	.3587	5
26	.8544	.3527	34	56	.8482	.3589	4
27	.8542	.3529	33	57	.8480	.3591	3
28	.8540	.3531	32	58	.8478	.3593	2
29	.8538	.3534	31	59	.8475	.3595	1
30	.8536	.3536	30	60	.8473	.3597	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

67 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

113 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8473	.3597	60	30	.8410	.3657	30
1	.8470	.3599	59	31	.8408	.3659	29
2	.8468	.3601	58	32	.8406	.3661	28
3	.8466	.3603	57	33	.8404	.3663	27
4	.8464	.3605	56	34	.8401	.3665	26
5	.8463	.3607	55	35	.8399	.3667	25
6	.8461	.3609	54	36	.8397	.3669	24
7	.8459	.3611	53	37	.8395	.3671	23
8	.8457	.3613	52	38	.8393	.3673	22
9	.8454	.3615	51	39	.8391	.3675	21
10	.8452	.3617	50	40	.8389	.3677	20
11	.8450	.3619	49	41	.8387	.3679	19
12	.8448	.3621	48	42	.8384	.3681	18
13	.8446	.3623	47	43	.8382	.3682	17
14	.8444	.3625	46	44	.8380	.3684	16
15	.8442	.3627	45	45	.8378	.3686	15
16	.8440	.3629	44	46	.8376	.3688	14
17	.8438	.3631	43	47	.8374	.3690	13
18	.8436	.3633	42	48	.8372	.3692	12
19	.8433	.3635	41	49	.8369	.3694	11
20	.8431	.3637	40	50	.8367	.3696	10
21	.8429	.3639	39	51	.8365	.3698	9
22	.8427	.3641	38	52	.8363	.3700	8
23	.8425	.3643	37	53	.8361	.3702	7
24	.8423	.3645	36	54	.8359	.3704	6
25	.8421	.3647	35	55	.8356	.3706	5
26	.8419	.3649	34	56	.8354	.3708	4
27	.8416	.3651	33	57	.8352	.3710	3
28	.8414	.3653	32	58	.8350	.3712	2
29	.8412	.3655	31	59	.8348	.3714	1
30	.8410	.3657	30	60	.8346	.3716	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

66 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

114 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8346	.3716	60	30	.8280	.3774	30
1	.8344	.3718	59	31	.8278	.3776	29
2	.8341	.3720	58	32	.8276	.3777	28
3	.8339	.3722	57	33	.8274	.3779	27
4	.8337	.3724	56	34	.8272	.3781	26
5	.8335	.3725	55	35	.8269	.3783	25
6	.8333	.3727	54	36	.8267	.3785	24
7	.8331	.3729	53	37	.8265	.3787	23
8	.8328	.3731	52	38	.8263	.3789	22
9	.8326	.3733	51	39	.8261	.3791	21
10	.8324	.3735	50	40	.8258	.3793	20
11	.8322	.3737	49	41	.8256	.3794	19
12	.8320	.3739	48	42	.8254	.3796	18
13	.8318	.3741	47	43	.8252	.3798	17
14	.8315	.3743	46	44	.8249	.3800	16
15	.8313	.3745	45	45	.8247	.3802	15
16	.8311	.3747	44	46	.8245	.3804	14
17	.8309	.3749	43	47	.8243	.3806	13
18	.8307	.3751	42	48	.8241	.3808	12
19	.8304	.3753	41	49	.8238	.3810	11
20	.8302	.3754	40	50	.8236	.3811	10
21	.8300	.3756	39	51	.8234	.3813	9
22	.8298	.3758	38	52	.8232	.3815	8
23	.8296	.3760	37	53	.8230	.3817	7
24	.8294	.3762	36	54	.8227	.3819	6
25	.8291	.3764	35	55	.8225	.3821	5
26	.8289	.3766	34	56	.8223	.3823	4
27	.8287	.3768	33	57	.8221	.3825	3
28	.8285	.3770	32	58	.8218	.3827	2
29	.8283	.3772	31	59	.8216	.3828	1
30	.8280	.3774	30	60	.8214	.3830	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

65 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

115 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8214	.3830	60	30	.8147	.3886	30
1	.8212	.3832	59	31	.8144	.3888	29
2	.8210	.3834	58	32	.8142	.3889	28
3	.8207	.3836	57	33	.8140	.3891	27
4	.8205	.3838	56	34	.8138	.3893	26
5	.8203	.3840	55	35	.8135	.3895	25
6	.8201	.3841	54	36	.8133	.3897	24
7	.8198	.3843	53	37	.8131	.3899	23
8	.8196	.3845	52	38	.8128	.3900	22
9	.8194	.3847	51	39	.8126	.3902	21
10	.8192	.3849	50	40	.8124	.3904	20
11	.8189	.3851	49	41	.8122	.3906	19
12	.8187	.3853	48	42	.8119	.3908	18
13	.8185	.3854	47	43	.8117	.3909	17
14	.8182	.3856	46	44	.8115	.3911	16
15	.8180	.3858	45	45	.8113	.3913	15
16	.8178	.3860	44	46	.8110	.3915	14
17	.8176	.3862	43	47	.8108	.3917	13
18	.8174	.3864	42	48	.8106	.3919	12
19	.8171	.3866	41	49	.8103	.3920	11
20	.8169	.3867	40	50	.8101	.3922	10
21	.8167	.3869	39	51	.8099	.3924	9
22	.8165	.3871	38	52	.8097	.3926	8
23	.8163	.3873	37	53	.8094	.3928	7
24	.8160	.3875	36	54	.8092	.3929	6
25	.8158	.3877	35	55	.8090	.3931	5
26	.8156	.3878	34	56	.8088	.3933	4
27	.8154	.3880	33	57	.8085	.3935	3
28	.8151	.3882	32	58	.8083	.3937	2
29	.8149	.3884	31	59	.8081	.3938	1
30	.8147	.3886	30	60	.8078	.3940	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

64 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

116 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.8078	.3940	60	30	.8009	.3993	30
1	.8076	.3942	59	31	.8007	.3995	29
2	.8074	.3944	58	32	.8004	.3997	28
3	.8071	.3946	57	33	.8002	.3998	27
4	.8069	.3947	56	34	.8000	.4000	26
5	.8067	.3949	55	35	.7998	.4002	25
6	.8065	.3951	54	36	.7995	.4004	24
7	.8062	.3953	53	37	.7993	.4005	23
8	.8060	.3954	52	38	.7991	.4007	22
9	.8058	.3956	51	39	.7988	.4009	21
10	.8055	.3958	50	40	.7986	.4011	20
11	.8053	.3960	49	41	.7984	.4012	19
12	.8051	.3962	48	42	.7981	.4014	18
13	.8048	.3963	47	43	.7979	.4016	17
14	.8046	.3965	46	44	.7976	.4018	16
15	.8044	.3967	45	45	.7974	.4019	15
16	.8042	.3969	44	46	.7972	.4021	14
17	.8039	.3970	43	47	.7970	.4023	13
18	.8037	.3972	42	48	.7967	.4025	12
19	.8035	.3974	41	49	.7965	.4026	11
20	.8032	.3976	40	50	.7962	.4028	10
21	.8030	.3977	39	51	.7960	.4030	9
22	.8028	.3979	38	52	.7958	.4031	8
23	.8025	.3981	37	53	.7955	.4033	7
24	.8023	.3983	36	54	.7953	.4035	6
25	.8021	.3984	35	55	.7951	.4037	5
26	.8018	.3986	34	56	.7948	.4038	4
27	.8016	.3988	33	57	.7946	.4040	3
28	.8014	.3990	32	58	.7944	.4042	2
29	.8011	.3991	31	59	.7941	.4043	1
30	.8009	.3993	30	60	.7939	.4045	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

63 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

117 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	·7939	·4045	60	30	·7868	·4096	30
1	·7937	·4047	59	31	·7866	·4098	29
2	·7934	·4049	58	32	·7863	·4099	28
3	·7932	·4050	57	33	·7861	·4101	27
4	·7930	·4052	56	34	·7858	·4102	26
5	·7927	·4054	55	35	·7857	·4104	25
6	·7925	·4055	54	36	·7854	·4106	24
7	·7922	·4057	53	37	·7851	·4107	23
8	·7920	·4059	52	38	·7849	·4109	22
9	·7918	·4060	51	39	·7846	·4111	21
10	·7915	·4062	50	40	·7844	·4112	20
11	·7913	·4064	49	41	·7842	·4114	19
12	·7911	·4066	48	42	·7839	·4116	18
13	·7908	·4067	47	43	·7837	·4117	17
14	·7906	·4069	46	44	·7835	·4119	16
15	·7904	·4071	45	45	·7832	·4121	15
16	·7901	·4072	44	46	·7830	·4122	14
17	·7899	·4074	43	47	·7827	·4124	13
18	·7896	·4076	42	48	·7825	·4126	12
19	·7894	·4077	41	49	·7822	·4127	11
20	·7892	·4079	40	50	·7820	·4129	10
21	·7889	·4081	39	51	·7818	·4131	9
22	·7887	·4082	38	52	·7815	·4132	8
23	·7885	·4084	37	53	·7813	·4134	7
24	·7882	·4086	36	54	·7810	·4135	6
25	·7880	·4087	35	55	·7808	·4137	5
26	·7877	·4089	34	56	·7806	·4139	4
27	·7875	·4091	33	57	·7803	·4140	3
28	·7873	·4092	32	58	·7801	·4142	2
29	·7870	·4094	31	59	·7798	·4144	1
30	·7868	·4096	30	60	·7796	·4145	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

62 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

118 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.7796	.4145	60	30	.7723	.4193	30
1	.7794	.4147	59	31	.7721	.4195	29
2	.7791	.4149	58	32	.7718	.4197	28
3	.7789	.4150	57	33	.7716	.4198	27
4	.7786	.4152	56	34	.7713	.4200	26
5	.7784	.4153	55	35	.7711	.4201	25
6	.7782	.4155	54	36	.7709	.4203	24
7	.7779	.4157	53	37	.7706	.4204	23
8	.7777	.4158	52	38	.7704	.4206	22
9	.7774	.4160	51	39	.7701	.4208	21
10	.7772	.4162	50	40	.7699	.4209	20
11	.7769	.4163	49	41	.7696	.4211	19
12	.7767	.4165	48	42	.7694	.4212	18
13	.7765	.4166	47	43	.7692	.4214	17
14	.7762	.4168	46	44	.7689	.4215	16
15	.7760	.4169	45	45	.7687	.4217	15
16	.7757	.4171	44	46	.7684	.4219	14
17	.7755	.4173	43	47	.7682	.4220	13
18	.7752	.4174	42	48	.7679	.4222	12
19	.7750	.4176	41	49	.7677	.4223	11
20	.7748	.4177	40	50	.7674	.4225	10
21	.7745	.4179	39	51	.7672	.4226	9
22	.7743	.4181	38	52	.7669	.4228	8
23	.7740	.4182	37	53	.7667	.4230	7
24	.7738	.4184	36	54	.7664	.4231	6
25	.7735	.4185	35	55	.7662	.4233	5
26	.7733	.4187	34	56	.7659	.4234	4
27	.7731	.4189	33	57	.7657	.4236	3
28	.7728	.4190	32	58	.7655	.4237	2
29	.7726	.4192	31	59	.7652	.4239	1
30	.7723	.4193	30	60	.7650	.4240	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

61 DEGREES.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

119 Degrees.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	.7650	.4240	60	30	.7575	.4286	30
1	.7647	.4242	59	31	.7573	.4287	29
2	.7645	.4243	58	32	.7570	.4289	28
3	.7642	.4245	57	33	.7568	.4290	27
4	.7640	.4246	56	34	.7565	.4292	26
5	.7637	.4248	55	35	.7563	.4293	25
6	.7635	.4250	54	36	.7560	.4295	24
7	.7632	.4251	53	37	.7558	.4296	23
8	.7630	.4253	52	38	.7555	.4298	22
9	.7627	.4255	51	39	.7553	.4299	21
10	.7625	.4256	50	40	.7550	.4301	20
11	.7622	.4257	49	41	.7548	.4302	19
12	.7620	.4259	48	42	.7545	.4304	18
13	.7617	.4260	47	43	.7543	.4305	17
14	.7615	.4262	46	44	.7540	.4307	16
15	.7613	.4263	45	45	.7538	.4308	15
16	.7610	.4265	44	46	.7535	.4310	14
17	.7608	.4266	43	47	.7533	.4311	13
18	.7605	.4268	42	48	.7530	.4313	12
19	.7603	.4269	41	49	.7528	.4314	11
20	.7600	.4271	40	50	.7525	.4316	10
21	.7598	.4272	39	51	.7523	.4317	9
22	.7595	.4274	38	52	.7520	.4318	8
23	.7593	.4275	37	53	.7518	.4320	7
24	.7590	.4277	36	54	.7515	.4321	6
25	.7588	.4278	35	55	.7513	.4323	5
26	.7585	.4280	34	56	.7510	.4324	4
27	.7583	.4281	33	57	.7508	.4326	3
28	.7580	.4283	32	58	.7505	.4327	2
29	.7578	.4284	31	59	.7503	.4329	1
30	.7575	.4286	30	60	.7500	.4330	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

60 Degrees.

Table for the Calculation of Heights and Distances from Tacheometer Readings—*continued.*

120 DEGREES.

Minutes.	Constant for Distance.	Constant for Difference in Height.		Minutes.	Constant for Distance.	Constant for Difference in Height.	
0	·7500	·4330	60	30	·7424	·4373	30
1	·7498	·4332	59	31	·7422	·4375	29
2	·7495	·4333	58	32	·7419	·4376	28
3	·7492	·4335	57	33	·7416	·4377	27
4	·7490	·4336	56	34	·7414	·4379	26
5	·7487	·4337	55	35	·7411	·4380	25
6	·7485	·4339	54	36	·7409	·4382	24
7	·7482	·4340	53	37	·7406	·4383	23
8	·7480	·4342	52	38	·7404	·4384	22
9	·7477	·4343	51	39	·7401	·4386	21
10	·7475	·4345	50	40	·7399	·4387	20
11	·7472	·4346	49	41	·7396	·4389	19
12	·7470	·4348	48	42	·7394	·4390	18
13	·7467	·4349	47	43	·7391	·4391	17
14	·7466	·4350	46	44	·7388	·4393	16
15	·7462	·4352	45	45	·7386	·4394	15
16	·7460	·4353	44	46	·7383	·4396	14
17	·7457	·4355	43	47	·7381	·4397	13
18	·7455	·4356	42	48	·7378	·4398	12
19	·7452	·4358	41	49	·7376	·4400	11
20	·7449	·4359	40	50	·7373	·4401	10
21	·7447	·4360	39	51	·7370	·4402	9
22	·7444	·4362	38	52	·7368	·4404	8
23	·7442	·4363	37	53	·7365	·4405	7
24	·7439	·4365	36	54	·7363	·4407	6
25	·7437	·4366	35	55	·7360	·4408	5
26	·7434	·4368	34	56	·7358	·4409	4
27	·7432	·4369	33	57	·7355	·4411	3
28	·7429	·4370	32	58	·7353	·4412	2
29	·7427	·4372	31	59	·7350	·4413	1
30	·7424	·4373	30	60	·7347	·4415	0
	Constant for Distance.	Constant for Difference in Height.	Minutes.		Constant for Distance.	Constant for Difference in Height.	Minutes.

59 DEGREES.

SECTION V. TABLE OF CHORDS.

The Accurate Plotting of Angles on Large Scale Plans by means of Chords.

The TABLE OF CHORDS furnishes a means of laying down angles on paper more accurately than by an ordinary protractor. The procedure is as follows: after having drawn and measured the first side (say *ac*) of the figure to be plotted, describe from its end *c* as a centre, an arc *ny* of sufficient length to subtend the angle at that point. The radius *cn* with which the arc is described should be as great as convenience will permit. It must be decimally sub-divided, to be used as a scale for laying down the

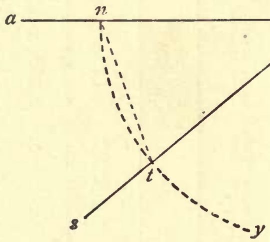

FIG. 3.

chords taken from the table, in which their lengths are given in terms of the radius taken as 1. Having described the arc, find in the table the length of the chord *nt* corresponding to the angle *act*. Suppose this angle to be 45°, the corresponding chord is .7654. Therefore from *n* lay off the chord *nt*, equal to .7654 of the radius-scale; and the line *cs* drawn through the point *t* will form the required angle *act* of 45°. The degree of accuracy attained will evidently depend on the length of the radius, and the care taken in drafting. The dividers in boxes of instruments are rarely fit for accurate arcs of more than about 6 inches diameter. For larger radii the beam-compass is the best instrument to use, or if not obtainable, a straight strip of paper with the length of the radius marked on one edge; by laying it from *c* toward *s*, and at the same time placing another strip (with one edge divided to a radius-scale) from *n* toward *t*, we can by trial find their exact point of intersection at the required point *t*. The fastest method of plotting the chords is by the use of a beam-compass and a $\frac{1}{1000}$ scale, the compass being set to the length of the scale.

Table of Chords, in parts of a radius 1; for protracting.

Minutes	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	Minutes
0	.0000	.0175	.0349	.0524	.0698	.0872	.1047	.1221	.1395	.1569	.1743	0
2	.0006	.0180	.0355	.0529	.0704	.0878	.1053	.1227	.1401	.1575	.1749	2
4	.0012	.0186	.0361	.0535	.0710	.0884	.1058	.1233	.1407	.1581	.1755	4
6	.0017	.0192	.0366	.0541	.0715	.0890	.1064	.1238	.1413	.1587	.1761	6
8	.0023	.0198	.0372	.0547	.0721	.0896	.1070	.1244	.1418	.1592	.1766	8
10	.0029	.0204	.0378	.0553	.0727	.0901	.1076	.1250	.1424	.1598	.1772	10
12	.0035	.0209	.0384	.0558	.0733	.0907	.1082	.1256	.1430	.1604	.1778	12
14	.0041	.0215	.0390	.0564	.0739	.0913	.1087	.1262	.1436	.1610	.1784	14
16	.0047	.0221	.0396	.0570	.0745	.0919	.1093	.1267	.1442	.1616	.1789	16
18	.0052	.0227	.0401	.0576	.0750	.0925	.1099	.1273	.1447	.1621	.1795	18
20	.0058	.0233	.0407	.0582	.0756	.0931	.1105	.1279	.1453	.1627	.1801	20
22	.0064	.0239	.0413	.0588	.0762	.0936	.1111	.1285	.1459	.1633	.1807	22
24	.0070	.0244	.0419	.0593	.0768	.0942	.1116	.1291	.1465	.1639	.1813	24
26	.0076	.0250	.0425	.0599	.0774	.0948	.1122	.1296	.1471	.1645	.1818	26
28	.0081	.0256	.0430	.0605	.0779	.0954	.1128	.1302	.1476	.1650	.1824	28
30	.0087	.0262	.0436	.0611	.0785	.0960	.1134	.1308	.1482	.1656	.1830	30
32	.0093	.0268	.0442	.0617	.0791	.0965	.1140	.1314	.1488	.1662	.1836	32
34	.0099	.0273	.0448	.0622	.0797	.0971	.1145	.1320	.1494	.1668	.1842	34
36	.0105	.0279	.0454	.0628	.0803	.0977	.1151	.1325	.1500	.1674	.1847	36
38	.0111	.0285	.0460	.0634	.0808	.0983	.1157	.1331	.1505	.1679	.1853	38
40	.0116	.0291	.0465	.0640	.0814	.0989	.1163	.1337	.1511	.1685	.1859	40
42	.0122	.0297	.0471	.0646	.0820	.0994	.1169	.1343	.1517	.1691	.1865	42
44	.0128	.0303	.0477	.0651	.0826	.1000	.1175	.1349	.1523	.1697	.1871	44
46	.0134	.0308	.0483	.0657	.0832	.1006	.1180	.1355	.1529	.1703	.1876	46
48	.0140	.0314	.0489	.0663	.0838	.1012	.1186	.1360	.1534	.1708	.1882	48
50	.0145	.0320	.0494	.0669	.0843	.1018	.1192	.1366	.1540	.1714	.1888	50
52	.0151	.0326	.0500	.0675	.0849	.1023	.1198	.1372	.1546	.1720	.1894	52
54	.0157	.0332	.0506	.0681	.0855	.1029	.1204	.1378	.1552	.1726	.1900	54
56	.0163	.0337	.0512	.0686	.0861	.1035	.1209	.1384	.1558	.1732	.1905	56
58	.0169	.0343	.0518	.0692	.0867	.1041	.1215	.1389	.1563	.1737	.1911	58
60	.0175	.0349	.0524	.0698	.0872	.1047	.1221	.1395	.1569	.1743	.1917	60

Table of Chords, in parts of a radius 1; for protracting.
(Continued.)

Minutes	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	Minutes
0	.1917	.2091	.2264	.2437	.2611	.2783	.2956	.3129	.3301	.3473	0
2	.1923	.2096	.2270	.2443	.2616	.2789	.2962	.3134	.3307	.3479	2
4	.1928	.2102	.2276	.2449	.2622	.2795	.2968	.3140	.3312	.3484	4
6	.1934	.2108	.2281	.2455	.2628	.2801	.2973	.3146	.3318	.3490	6
8	.1940	.2114	.2287	.2460	.2634	.2807	.2979	.3152	.3324	.3496	8
10	.1946	.2119	.2293	.2466	.2639	.2812	.2985	.3157	.3330	.3502	10
12	.1952	.2125	.2299	.2472	.2645	.2818	.2991	.3163	.3335	.3507	12
14	.1957	.2131	.2305	.2478	.2651	.2824	.2996	.3169	.3341	.3513	14
16	.1963	.2137	.2310	.2484	.2657	.2830	.3002	.3175	.3347	.3519	16
18	.1969	.2143	.2316	.2489	.2662	.2835	.3008	.3180	.3353	.3525	18
20	.1975	.2148	.2322	.2495	.2668	.2841	.3014	.3186	.3358	.3530	20
22	.1981	.2154	.2328	.2501	.2674	.2847	.3019	.3192	.3364	.3536	22
24	.1986	.2160	.2333	.2507	.2680	.2853	.3025	.3198	.3370	.3542	24
26	.1992	.2166	.2339	.2512	.2685	.2858	.3031	.3203	.3376	.3547	26
28	.1998	.2172	.2345	.2518	.2691	.2864	.3037	.3209	.3381	.3553	28
30	.2004	.2177	.2351	.2524	.2697	.2870	.3042	.3215	.3387	.3559	30
32	.2010	.2183	.2357	.2530	.2703	.2876	.3048	.3221	.3393	.3565	32
34	.2015	.2189	.2362	.2536	.2709	.2881	.3054	.3226	.3398	.3570	34
36	.2021	.2195	.2368	.2541	.2714	.2887	.3060	.3232	.3404	.3576	36
38	.2027	.2200	.2374	.2547	.2720	.2893	.3065	.3238	.3410	.3582	38
40	.2033	.2206	.2380	.2553	.2726	.2899	.3071	.3244	.3416	.3587	40
42	.2038	.2212	.2385	.2559	.2732	.2904	.3077	.3249	.3421	.3593	42
44	.2044	.2218	.2391	.2564	.2737	.2910	.3083	.3255	.3427	.3599	44
46	.2050	.2224	.2397	.2570	.2743	.2916	.3088	.3261	.3433	.3605	46
48	.2056	.2229	.2403	.2576	.2749	.2922	.3094	.3267	.3439	.3610	48
50	.2062	.2235	.2409	.2582	.2755	.2927	.3100	.3272	.3444	.3616	50
52	.2067	.2241	.2414	.2587	.2760	.2933	.3106	.3278	.3450	.3622	52
54	.2073	.2247	.2420	.2593	.2766	.2939	.3111	.3284	.3456	.3628	54
56	.2079	.2253	.2426	.2599	.2772	.2945	.3117	.3289	.3462	.3633	56
58	.2085	.2258	.2432	.2605	.2778	.2950	.3123	.3295	.3467	.3639	58
60	.2091	.2264	.2437	.2611	.2783	.2956	.3129	.3301	.3473	.3645	60

Table of Chords, in parts of a radius 1; for protracting.

(Continued.)

Minutes	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°	Minutes
0	.3645	.3816	.3987	.4158	.4329	.4499	.4669	.4838	.5008	.5176	0
2	.3650	.3822	.3993	.4164	.4334	.4505	.4675	.4844	.5013	.5182	2
4	.3656	.3828	.3999	.4170	.4340	.4510	.4680	.4850	.5019	.5188	4
6	.3662	.3833	.4004	.4175	.4346	.4516	.4686	.4855	.5024	.5193	6
8	.3668	.3839	.4010	.4181	.4352	.4522	.4692	.4861	.5030	.5199	8
10	.3673	.3845	.4016	.4187	.4357	.4527	.4697	.4867	.5036	.5204	10
12	.3679	.3850	.4022	.4192	.4363	.4533	.4703	.4872	.5041	.5210	12
14	.3685	.3856	.4027	.4198	.4369	.4539	.4708	.4878	.5047	.5216	14
16	.3690	.3862	.4033	.4204	.4374	.4544	.4714	.4884	.5053	.5221	16
18	.3696	.3868	.4039	.4209	.4380	.4550	.4720	.4889	.5058	.5227	18
20	.3702	.3873	.4044	.4215	.4386	.4556	.4725	.4895	.5064	.5233	20
22	.3708	.3879	.4050	.4221	.4391	.4561	.4731	.4901	.5070	.5238	22
24	.3713	.3885	.4056	.4226	.4397	.4567	.4737	.4906	.5075	.5244	24
26	.3719	.3890	.4061	.4232	.4403	.4573	.4742	.4912	.5081	.5249	26
28	.3725	.3896	.4067	.4238	.4408	.4578	.4748	.4917	.5086	.5255	28
30	.3730	.3902	.4073	.4244	.4414	.4584	.4754	.4923	.5092	.5261	30
32	.3736	.3908	.4079	.4249	.4420	.4590	.4759	.4929	.5098	.5266	32
34	.3742	.3913	.4084	.4255	.4425	.4595	.4765	.4934	.5103	.5272	34
36	.3748	.3919	.4090	.4261	.4431	.4601	.4771	.4940	.5109	.5277	36
38	.3753	.3925	.4096	.4266	.4437	.4607	.4776	.4946	.5115	.5283	38
40	.3759	.3930	.4101	.4272	.4442	.4612	.4782	.4951	.5120	.5289	40
42	.3765	.3936	.4107	.4278	.4448	.4618	.4788	.4957	.5126	.5294	42
44	.3770	.3942	.4113	.4283	.4454	.4624	.4793	.4963	.5131	.5300	44
46	.3776	.3947	.4118	.4289	.4459	.4629	.4799	.4968	.5137	.5306	46
48	.3782	.3953	.4124	.4295	.4465	.4635	.4805	.4974	.5143	.5311	48
50	.3788	.3959	.4130	.4300	.4471	.4641	.4810	.4979	.5148	.5317	50
52	.3793	.3965	.4135	.4306	.4476	.4646	.4816	.4985	.5154	.5322	52
54	.3799	.3970	.4141	.4312	.4482	.4652	.4822	.4991	.5160	.5328	54
56	.3805	.3976	.4147	.4317	.4488	.4658	.4827	.4996	.5165	.5334	56
58	.3810	.3982	.4153	.4323	.4493	.4663	.4833	.5002	.5171	.5339	58
60	.3816	.3987	.4158	.4329	.4499	.4669	.4838	.5008	.5176	.5345	60

Table of Chords, in parts of a radius 1; for protracting.
(*Continued.*)

Minutes	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	Minutes
0	.5345	.5513	.5680	.5847	.6014	.6180	.6346	.6511	.6676	.6840	0
2	.5350	.5518	.5686	.5853	.6020	.6186	.6352	.6517	.6682	.6846	2
4	.5356	.5524	.5691	.5859	.6025	.6191	.6357	.6522	.6687	.6851	4
6	.5362	.5530	.5697	.5864	.6031	.6197	.6363	.6528	.6693	.6857	6
8	.5367	.5535	.5703	.5870	.6036	.6202	.6368	.6533	.6698	.6862	8
10	.5373	.5541	.5708	.5875	.6042	.6208	.6374	.6539	.6704	.6868	10
12	.5378	.5546	.5714	.5881	.6047	.6214	.6379	.6544	.6709	.6873	12
14	.5384	.5552	.5719	.5886	.6053	.6219	.6385	.6550	.6715	.6879	14
16	.5390	.5557	.5725	.5892	.6058	.6225	.6390	.6555	.6720	.6884	16
18	.5395	.5563	.5730	.5897	.6064	.6230	.6396	.6561	.6725	.6890	18
20	.5401	.5569	.5736	.5903	.6070	.6236	.6401	.6566	.6731	.6895	20
22	.5406	.5574	.5742	.5909	.6075	.6241	.6407	.6572	.6736	.6901	22
24	.5412	.5580	.5747	.5914	.6081	.6247	.6412	.6577	.6742	.6906	24
26	.5418	.5585	.5753	.5920	.6086	.6252	.6418	.6583	.6747	.6911	26
28	.5423	.5591	.5758	.5925	.6092	.6258	.6423	.6588	.6753	.6917	28
30	.5429	.5597	.5764	.5931	.6097	.6263	.6429	.6594	.6758	.6922	30
32	.5434	.5602	.5769	.5936	.6103	.6269	.6434	.6599	.6764	.6928	32
34	.5440	.5608	.5775	.5942	.6108	.6274	.6440	.6605	.6769	.6933	34
36	.5446	.5613	.5781	.5947	.6114	.6280	.6445	.6610	.6775	.6939	36
38	.5451	.5619	.5786	.5953	.6119	.6285	.6451	.6616	.6780	.6944	38
40	.5457	.5625	.5792	.5959	.6125	.6291	.6456	.6621	.6786	.6950	40
42	.5462	.5630	.5797	.5964	.6130	.6296	.6462	.6627	.6791	.6955	42
44	.5468	.5636	.5803	.5970	.6136	.6302	.6467	.6632	.6797	.6961	44
46	.5474	.5641	.5808	.5975	.6142	.6307	.6473	.6638	.6802	.6966	46
48	.5479	.5647	.5814	.5981	.6147	.6313	.6478	.6643	.6808	.6971	48
50	.5485	.5652	.5820	.5986	.6153	.6318	.6484	.6649	.6813	.6977	50
52	.5490	.5658	.5825	.5992	.6158	.6324	.6489	.6654	.6819	.6982	52
54	.5496	.5664	.5831	.5997	.6164	.6330	.6495	.6660	.6824	.6988	54
56	.5502	.5669	.5836	.6003	.6169	.6335	.6500	.6665	.6829	.6993	56
58	.5507	.5675	.5842	.6009	.6175	.6341	.6506	.6671	.6835	.6999	58
60	.5513	.5680	.5847	.6014	.6180	.6346	.6511	.6676	.6840	.7004	60

Table of Chords, in parts of a radius 1; for protracting.
(*Continued.*)

Minutes	41°	42°	43°	44°	45°	46°	47°	48°	49°	50°	Minutes
0	.7004	.7167	.7330	.7492	.7654	.7815	.7975	.8135	.8294	.8452	0
2	.7010	.7173	.7335	.7498	.7659	.7820	.7980	.8140	.8299	.8458	2
4	.7015	.7178	.7341	.7503	.7664	.7825	.7986	.8145	.8304	.8463	4
6	.7020	.7184	.7346	.7508	.7670	.7831	.7991	.8151	.8310	.8468	6
8	.7026	.7189	.7352	.7514	.7675	.7836	.7996	.8156	.8315	.8473	8
10	.7031	.7195	.7357	.7519	.7681	.7841	.8002	.8161	.8320	.8479	10
12	.7037	.7200	.7362	.7524	.7686	.7847	.8007	.8167	.8326	.8484	12
14	.7042	.7205	.7368	.7530	.7691	.7852	.8012	.8172	.8331	.8489	14
16	.7048	.7211	.7373	.7535	.7697	.7857	.8018	.8177	.8336	.8495	16
18	.7053	.7216	.7379	.7541	.7702	.7863	.8023	.8183	.8341	.8500	18
20	.7059	.7222	.7384	.7546	.7707	.7868	.8028	.8188	.8347	.8505	20
22	.7064	.7227	.7390	.7551	.7713	.7873	.8034	.8193	.8352	.8510	22
24	.7069	.7232	.7395	.7557	.7718	.7879	.8039	.8198	.8357	.8516	24
26	.7075	.7238	.7400	.7562	.7723	.7884	.8044	.8204	.8363	.8521	26
28	.7080	.7243	.7406	.7568	.7729	.7890	.8050	.8209	.8368	.8526	28
30	.7086	.7249	.7411	.7573	.7734	.7895	.8055	.8214	.8373	.8531	30
32	.7091	.7254	.7417	.7578	.7740	.7900	.8060	.8220	.8378	.8537	32
34	.7097	.7260	.7422	.7584	.7745	.7906	.8066	.8225	.8384	.8542	34
36	.7102	.7265	.7427	.7589	.7750	.7911	.8071	.8230	.8389	.8547	36
38	.7108	.7270	.7433	.7595	.7756	.7916	.8076	.8236	.8394	.8552	38
40	.7113	.7276	.7438	.7600	.7761	.7922	.8082	.8241	.8400	.8558	40
42	.7118	.7281	.7443	.7605	.7766	.7927	.8087	.8246	.8405	.8563	42
44	.7124	.7287	.7449	.7611	.7772	.7932	.8092	.8251	.8410	.8568	44
46	.7129	.7292	.7454	.7616	.7777	.7938	.8098	.8257	.8415	.8573	46
48	.7135	.7298	.7460	.7621	.7782	.7943	.8103	.8262	.8421	.8579	48
50	.7140	.7303	.7465	.7627	.7788	.7948	.8108	.8267	.8426	.8584	50
52	.7146	.7308	.7471	.7632	.7793	.7954	.8113	.8273	.8431	.8589	52
54	.7151	.7314	.7476	.7638	.7799	.7959	.8119	.8278	.8437	.8594	54
56	.7156	.7319	.7481	.7643	.7804	.7964	.8124	.8283	.8442	.8600	56
58	.7162	.7325	.7487	.7648	.7809	.7970	.8129	.8289	.8447	.8605	58
60	.7167	.7330	.7492	.7654	.7815	.7975	.8135	.8294	.8452	.8610	60

Table of Chords, in parts of a radius 1; for protracting.
(*Continued.*)

Minutes	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°	Minutes
0	.8610	.8767	.8924	.9080	.9235	.9389	.9543	.9696	.9848	1.0000	0
2	.8615	.8773	.8929	.9085	.9240	.9395	.9548	.9701	.9854	1.0005	2
4	.8621	.8778	.8934	.9090	.9245	.9400	.9553	.9706	.9859	1.0010	4
6	.8626	.8783	.8940	.9095	.9250	.9405	.9559	.9711	.9864	1.0015	6
8	.8631	.8788	.8945	.9101	.9256	.9410	.9564	.9717	.9869	1.0020	8
10	.8636	.8794	.8950	.9106	.9261	.9415	.9569	.9722	.9874	1.0025	10
12	.8642	.8799	.8955	.9111	.9266	.9420	.9574	.9727	.9879	1.0030	12
14	.8647	.8804	.8960	.9116	.9271	.9425	.9579	.9732	.9884	1.0035	14
16	.8652	.8809	.8966	.9121	.9276	.9430	.9584	.9737	.9889	1.0040	16
18	.8657	.8814	.8971	.9126	.9281	.9436	.9589	.9742	.9894	1.0045	18
20	.8663	.8820	.8976	.9132	.9287	.9441	.9594	.9747	.9899	1.0050	20
22	.8668	.8825	.8981	.9137	.9292	.9446	.9599	.9752	.9904	1.0055	22
24	.8673	.8830	.8986	.9142	.9297	.9451	.9604	.9757	.9909	1.0060	24
26	.8678	.8835	.8992	.9147	.9302	.9456	.9610	.9762	.9914	1.0065	26
28	.8684	.8841	.8997	.9152	.9307	.9461	.9615	.9767	.9919	1.0070	28
30	.8689	.8846	.9002	.9157	.9312	.9466	.9620	.9772	.9924	1.0075	30
32	.8694	.8851	.9007	.9163	.9317	.9472	.9625	.9778	.9929	1.0080	32
34	.8699	.8856	.9012	.9168	.9323	.9477	.9630	.9783	.9934	1.0086	34
36	.8705	.8861	.9018	.9173	.9328	.9482	.9635	.9788	.9939	1.0091	36
38	.8710	.8867	.9023	.9178	.9333	.9487	.9640	.9793	.9945	1.0096	38
40	.8715	.8872	.9028	.9183	.9338	.9492	.9645	.9798	.9950	1.0101	40
42	.8720	.8877	.9033	.9188	.9343	.9497	.9650	.9803	.9955	1.0106	42
44	.8726	.8882	.9038	.9194	.9348	.9502	.9655	.9808	.9960	1.0111	44
46	.8731	.8887	.9044	.9199	.9353	.9507	.9661	.9813	.9965	1.0116	46
48	.8736	.8893	.9049	.9204	.9359	.9512	.9666	.9818	.9970	1.0121	48
50	.8741	.8898	.9054	.9209	.9364	.9518	.9671	.9823	.9975	1.0126	50
52	.8747	.8903	.9059	.9214	.9369	.9523	.9676	.9828	.9980	1.0131	52
54	.8752	.8908	.9064	.9219	.9374	.9528	.9681	.9833	.9985	1.0136	54
56	.8757	.8914	.9069	.9225	.9379	.9533	.9686	.9838	.9990	1.0141	56
58	.8762	.8919	.9075	.9230	.9384	.9538	.9691	.9843	.9995	1.0146	58
60	.8767	.8924	.9080	.9235	.9389	.9543	.9696	.9848	1.0000	1.0151	60

Table of Chords, in parts of a radius 1; for protracting.
(Continued.)

Minutes	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°	Minutes
0	1.0151	1.0301	1.0450	1.0598	1.0746	1.0893	1.1039	1.1184	1.1328	1.1472	0
2	1.0156	1.0306	1.0455	1.0603	1.0751	1.0898	1.1044	1.1189	1.1333	1.1476	2
4	1.0161	1.0311	1.0460	1.0608	1.0756	1.0903	1.1048	1.1194	1.1338	1.1481	4
6	1.0166	1.0316	1.0465	1.0613	1.0761	1.0907	1.1053	1.1198	1.1342	1.1486	6
8	1.0171	1.0321	1.0470	1.0618	1.0766	1.0912	1.1058	1.1203	1.1347	1.1491	8
10	1.0176	1.0326	1.0475	1.0623	1.0771	1.0917	1.1063	1.1208	1.1352	1.1495	10
12	1.0181	1.0331	1.0480	1.0628	1.0775	1.0922	1.1068	1.1213	1.1357	1.1500	12
14	1.0186	1.0336	1.0485	1.0633	1.0780	1.0927	1.1073	1.1218	1.1362	1.1505	14
16	1.0191	1.0341	1.0490	1.0638	1.0785	1.0932	1.1078	1.1222	1.1366	1.1510	16
18	1.0196	1.0346	1.0495	1.0643	1.0790	1.0937	1.1082	1.1227	1.1371	1.1514	18
20	1.0201	1.0351	1.0500	1.0648	1.0795	1.0942	1.1087	1.1232	1.1376	1.1519	20
22	1.0206	1.0356	1.0504	1.0653	1.0800	1.0946	1.1092	1.1237	1.1381	1.1524	22
24	1.0211	1.0361	1.0509	1.0658	1.0805	1.0951	1.1097	1.1242	1.1386	1.1529	24
26	1.0216	1.0366	1.0514	1.0662	1.0810	1.0956	1.1102	1.1246	1.1390	1.1533	26
28	1.0221	1.0370	1.0519	1.0667	1.0815	1.0961	1.1107	1.1251	1.1395	1.1538	28
30	1.0226	1.0375	1.0524	1.0672	1.0820	1.0966	1.1111	1.1256	1.1400	1.1543	30
32	1.0231	1.0380	1.0529	1.0677	1.0824	1.0971	1.1116	1.1261	1.1405	1.1548	32
34	1.0236	1.0385	1.0534	1.0682	1.0829	1.0976	1.1121	1.1266	1.1409	1.1552	34
36	1.0241	1.0390	1.0539	1.0687	1.0834	1.0980	1.1126	1.1271	1.1414	1.1557	36
38	1.0246	1.0395	1.0544	1.0692	1.0839	1.0985	1.1131	1.1275	1.1419	1.1562	38
40	1.0251	1.0400	1.0549	1.0697	1.0844	1.0990	1.1136	1.1280	1.1424	1.1567	40
42	1.0256	1.0405	1.0554	1.0702	1.0849	1.0995	1.1140	1.1285	1.1429	1.1571	42
44	1.0261	1.0410	1.0559	1.0707	1.0854	1.1000	1.1145	1.1290	1.1433	1.1576	44
46	1.0266	1.0415	1.0564	1.0712	1.0859	1.1005	1.1150	1.1295	1.1438	1.1581	46
48	1.0271	1.0420	1.0569	1.0717	1.0863	1.1010	1.1155	1.1299	1.1443	1.1586	48
50	1.0276	1.0425	1.0574	1.0721	1.0868	1.1014	1.1160	1.1304	1.1448	1.1590	50
52	1.0281	1.0430	1.0579	1.0726	1.0873	1.1019	1.1165	1.1309	1.1452	1.1595	52
54	1.0286	1.0435	1.0584	1.0731	1.0878	1.1024	1.1169	1.1314	1.1457	1.1600	54
56	1.0291	1.0440	1.0589	1.0736	1.0883	1.1029	1.1174	1.1319	1.1462	1.1605	56
58	1.0296	1.0445	1.0593	1.0741	1.0888	1.1034	1.1179	1.1323	1.1467	1.1609	58
60	1.0301	1.0450	1.0598	1.0746	1.0893	1.1039	1.1184	1.1328	1.1472	1.1614	60

Table of Chords, in parts of a radius 1; for protracting.
(Continued.)

Minutes	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	Minutes
0	1.1614	1.1756	1.1896	1.2036	1.2175	1.2313	1.2450	1.2586	1.2722	1.2856	0
2	1.1619	1.1760	1.1901	1.2041	1.2180	1.2318	1.2455	1.2591	1.2726	1.2860	2
4	1.1624	1.1765	1.1906	1.2046	1.2184	1.2322	1.2459	1.2595	1.2731	1.2865	4
6	1.1628	1.1770	1.1910	1.2050	1.2189	1.2327	1.2464	1.2600	1.2735	1.2869	6
8	1.1633	1.1775	1.1915	1.2055	1.2194	1.2332	1.2468	1.2604	1.2740	1.2874	8
10	1.1638	1.1779	1.1920	1.2060	1.2198	1.2336	1.2473	1.2609	1.2744	1.2878	10
12	1.1642	1.1784	1.1924	1.2064	1.2203	1.2341	1.2478	1.2614	1.2748	1.2882	12
14	1.1647	1.1789	1.1929	1.2069	1.2208	1.2345	1.2482	1.2618	1.2753	1.2887	14
16	1.1652	1.1793	1.1934	1.2073	1.2212	1.2350	1.2487	1.2623	1.2757	1.2891	16
18	1.1657	1.1798	1.1938	1.2078	1.2217	1.2354	1.2491	1.2627	1.2762	1.2896	18
20	1.1661	1.1803	1.1943	1.2083	1.2221	1.2359	1.2496	1.2632	1.2766	1.2900	20
22	1.1666	1.1807	1.1948	1.2087	1.2226	1.2364	1.2500	1.2636	1.2771	1.2905	22
24	1.1671	1.1812	1.1952	1.2092	1.2231	1.2368	1.2505	1.2641	1.2775	1.2909	24
26	1.1676	1.1817	1.1957	1.2097	1.2235	1.2373	1.2509	1.2645	1.2780	1.2914	26
28	1.1680	1.1821	1.1962	1.2101	1.2240	1.2377	1.2514	1.2650	1.2784	1.2918	28
30	1.1685	1.1826	1.1966	1.2106	1.2244	1.2382	1.2518	1.2654	1.2789	1.2922	30
32	1.1690	1.1831	1.1971	1.2111	1.2249	1.2386	1.2523	1.2659	1.2793	1.2927	32
34	1.1694	1.1836	1.1976	1.2115	1.2254	1.2391	1.2528	1.2663	1.2798	1.2931	34
36	1.1699	1.1840	1.1980	1.2120	1.2258	1.2396	1.2532	1.2668	1.2802	1.2936	36
38	1.1704	1.1845	1.1985	1.2124	1.2263	1.2400	1.2537	1.2672	1.2807	1.2940	38
40	1.1709	1.1850	1.1990	1.2129	1.2267	1.2405	1.2541	1.2677	1.2811	1.2945	40
42	1.1713	1.1854	1.1994	1.2134	1.2272	1.2409	1.2546	1.2681	1.2816	1.2949	42
44	1.1718	1.1859	1.1999	1.2138	1.2277	1.2414	1.2550	1.2686	1.2820	1.2954	44
46	1.1723	1.1864	1.2004	1.2143	1.2281	1.2418	1.2555	1.2690	1.2825	1.2958	46
48	1.1727	1.1868	1.2008	1.2148	1.2286	1.2423	1.2559	1.2695	1.2829	1.2962	48
50	1.1732	1.1873	1.2013	1.2152	1.2290	1.2428	1.2564	1.2699	1.2833	1.2967	50
52	1.1737	1.1878	1.2018	1.2157	1.2295	1.2432	1.2568	1.2704	1.2838	1.2971	52
54	1.1742	1.1882	1.2022	1.2161	1.2299	1.2437	1.2573	1.2708	1.2842	1.2976	54
56	1.1746	1.1887	1.2027	1.2166	1.2304	1.2441	1.2577	1.2713	1.2847	1.2980	56
58	1.1751	1.1892	1.2032	1.2171	1.2309	1.2446	1.2582	1.2717	1.2851	1.2985	58
60	1.1756	1.1896	1.2036	1.2175	1.2313	1.2450	1.2586	1.2722	1.2856	1.2989	60

Table of Chords, in parts of a radius 1; for protracting.
(Continued.)

Minutes	81°	82°	83°	84°	85°	86°	87°	88°	89°	Minutes
0	1.2989	1.3121	1.3252	1.3383	1.3512	1.3640	1.3767	1.3893	1.4018	0
2	1.2993	1.3126	1.3257	1.3387	1.3516	1.3644	1.3771	1.3897	1.4022	2
4	1.2998	1.3130	1.3261	1.3391	1.3520	1.3648	1.3776	1.3902	1.4026	4
6	1.3002	1.3134	1.3265	1.3396	1.3525	1.3653	1.3780	1.3906	1.4031	6
8	1.3007	1.3139	1.3270	1.3400	1.3529	1.3657	1.3784	1.3910	1.4035	8
10	1.3011	1.3143	1.3274	1.3404	1.3533	1.3661	1.3788	1.3914	1.4039	10
12	1.3015	1.3147	1.3279	1.3409	1.3538	1.3665	1.3792	1.3918	1.4043	12
14	1.3020	1.3152	1.3283	1.3413	1.3542	1.3670	1.3797	1.3922	1.4047	14
16	1.3024	1.3156	1.3287	1.3417	1.3546	1.3674	1.3801	1.3927	1.4051	16
18	1.3029	1.3161	1.3292	1.3421	1.3550	1.3678	1.3805	1.3931	1.4055	18
20	1.3033	1.3165	1.3296	1.3426	1.3555	1.3682	1.3809	1.3935	1.4060	20
22	1.3038	1.3169	1.3300	1.3430	1.3559	1.3687	1.3813	1.3939	1.4064	22
24	1.3042	1.3174	1.3305	1.3434	1.3563	1.3691	1.3818	1.3943	1.4068	24
26	1.3046	1.3178	1.3309	1.3439	1.3567	1.3695	1.3822	1.3947	1.4072	26
28	1.3051	1.3183	1.3313	1.3443	1.3572	1.3699	1.3826	1.3952	1.4076	28
30	1.3055	1.3187	1.3318	1.3447	1.3576	1.3704	1.3830	1.3956	1.4080	30
32	1.3060	1.3191	1.3322	1.3452	1.3580	1.3708	1.3834	1.3960	1.4084	32
34	1.3064	1.3196	1.3326	1.3456	1.3585	1.3712	1.3839	1.3964	1.4089	34
36	1.3068	1.3200	1.3331	1.3460	1.3589	1.3716	1.3843	1.3968	1.4093	36
38	1.3073	1.3204	1.3335	1.3465	1.3593	1.3721	1.3847	1.3972	1.4097	38
40	1.3077	1.3209	1.3339	1.3469	1.3597	1.3725	1.3851	1.3977	1.4101	40
42	1.3082	1.3213	1.3344	1.3473	1.3602	1.3729	1.3855	1.3981	1.4105	42
44	1.3086	1.3218	1.3348	1.3477	1.3606	1.3733	1.3860	1.3985	1.4109	44
46	1.3090	1.3222	1.3352	1.3482	1.3610	1.3738	1.3864	1.3989	1.4113	46
48	1.3095	1.3226	1.3357	1.3486	1.3614	1.3742	1.3868	1.3993	1.4117	48
50	1.3099	1.3231	1.3361	1.3490	1.3619	1.3746	1.3872	1.3997	1.4122	50
52	1.3104	1.3235	1.3365	1.3495	1.3623	1.3750	1.3876	1.4002	1.4126	52
54	1.3108	1.3239	1.3370	1.3499	1.3627	1.3754	1.3881	1.4006	1.4130	54
56	1.3112	1.3244	1.3374	1.3503	1.3631	1.3759	1.3885	1.4010	1.4134	56
58	1.3117	1.3248	1.3378	1.3508	1.3636	1.3763	1.3889	1.4014	1.4138	58
60	1.3121	1.3252	1.3383	1.3512	1.3640	1.3767	1.3893	1.4018	1.4142	60

APPENDIX.

Table giving the circumference and area of a circle corresponding to a given diameter.*

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
10	31.416	78.5398	40	125.66	1256.64	70	219.91	3848.45
11	34.558	95.0332	41	128.81	1320.25	71	223.05	3959.19
12	37.699	113.097	42	131.95	1385.44	72	226.19	4071.50
13	40.841	132.732	43	135.09	1452.20	73	229.34	4185.39
14	43.982	153.938	44	138.23	1520.53	74	232.48	4300.84
15	47.124	176.715	45	141.37	1590.43	75	235.62	4417.86
16	50.265	201.062	46	144.51	1661.90	76	238.76	4536.46
17	53.407	226.980	47	147.65	1734.94	77	241.90	4656.63
18	56.549	254.469	48	150.80	1809.56	78	245.04	4778.36
19	59.690	283.529	49	153.94	1885.74	79	248.19	4901.67
20	62.832	314.159	50	157.08	1963.50	80	251.33	5026.55
21	65.973	346.361	51	160.22	2042.82	81	254.47	5153.00
22	69.115	380.133	52	163.36	2123.72	82	257.61	5281.02
23	72.257	415.476	53	166.50	2206.18	83	260.75	5410.61
24	75.398	452.389	54	169.65	2290.22	84	263.89	5541.77
25	78.540	490.874	55	172.79	2375.83	85	267.04	5674.50
26	81.681	530.929	56	175.93	2463.01	86	270.18	5808.80
27	84.823	572.555	57	179.07	2551.76	87	273.32	5944.68
28	87.965	615.752	58	182.21	2642.08	88	276.46	6082.12
29	91.106	660.520	59	185.35	2733.97	89	279.60	6221.14
30	94.248	706.858	60	188.50	2827.43	90	282.74	6361.73
31	97.389	754.768	61	191.64	2922.47	91	285.88	6503.88
32	100.53	804.248	62	194.78	3019.07	92	289.03	6647.61
33	103.67	855.299	63	197.92	3117.25	93	292.17	6792.91
34	106.81	907.920	64	201.06	3216.99	94	295.31	6939.78
35	109.96	962.113	65	204.20	3318.31	95	298.45	7088.22
36	113.10	1017.88	66	207.35	3421.19	96	301.59	7238.23
37	116.24	1075.21	67	210.49	3525.65	97	304.73	7389.81
38	119.38	1134.11	68	213.63	3631.68	98	307.88	7542.96
39	122.52	1194.59	69	216.77	3739.28	99	311.02	7697.69

* From *The Smithsonian Geographical Tables*, Washington, 1906, p. 23.

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000.*

In the roots, wherever the effect of a fifth decimal would be to add 1 to the fourth and final decimal, the addition has been made.

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
1	1	1	1.	1.	51	2601	132651	7.1414	3.7084
2	4	8	1.4142	1.2599	52	2704	140608	7.2111	3.7325
3	9	27	1.7321	1.4422	53	2809	148877	7.2801	3.7563
4	16	64	2.	1.5874	54	2916	157464	7.3485	3.7798
5	25	125	2.2361	1.7100	55	3025	166375	7.4162	3.8030
6	36	216	2.4495	1.8171	56	3136	175616	7.4833	3.8259
7	49	343	2.6458	1.9129	57	3249	185193	7.5498	3.8485
8	64	512	2.8284	2.	58	3364	195112	7.6158	3.8709
9	81	729	3.	2.0801	59	3481	205379	7.6811	3.8930
10	100	1000	3.1623	2.1544	60	3600	216000	7.7460	3.9149
11	121	1331	3.3166	2.2240	61	3721	226981	7.8102	3.9365
12	144	1728	3.4641	2.2894	62	3844	238328	7.8740	3.9579
13	169	2197	3.6056	2.3513	63	3969	250047	7.9373	3.9791
14	196	2744	3.7417	2.4101	64	4096	262144	8.	4.
15	225	3375	3.8730	2.4662	65	4225	274625	8.0623	4.0207
16	256	4096	4.	2.5198	66	4356	287496	8.1240	4.0412
17	289	4913	4.1231	2.5713	67	4489	300763	8.1854	4.0615
18	324	5832	4.2426	2.6207	68	4624	314432	8.2462	4.0817
19	361	6859	4.3589	2.6684	69	4761	328509	8.3066	4.1016
20	400	8000	4.4721	2.7144	70	4900	343000	8.3666	4.1213
21	441	9261	4.5826	2.7589	71	5041	357911	8.4261	4.1408
22	484	10648	4.6904	2.8020	72	5184	373248	8.4853	4.1602
23	529	12167	4.7958	2.8439	73	5329	389017	8.5440	4.1793
24	576	13824	4.8990	2.8845	74	5476	405224	8.6023	4.1983
25	625	15625	5.	2.9240	75	5625	421875	8.6603	4.2172
26	676	17576	5.0990	2.9625	76	5776	438976	8.7178	4.2358
27	729	19683	5.1962	3.	77	5929	456533	8.7750	4.2543
28	784	21952	5.2915	3.0366	78	6084	474552	8.8318	4.2727
29	841	24389	5.3852	3.0723	79	6241	493039	8.8882	4.2908
30	900	27000	5.4772	3.1072	80	6400	512000	8.9443	4.3089
31	961	29791	5.5678	3.1414	81	6561	531441	9.	4.3267
32	1024	32768	5.6569	3.1748	82	6724	551368	9.0554	4.3445
33	1089	35937	5.7446	3.2075	83	6889	571787	9.1104	4.3621
34	1156	39304	5.8310	3.2396	84	7056	592704	9.1652	4.3795
35	1225	42875	5.9161	3.2711	85	7225	614125	9.2195	4.3968
36	1296	46656	6.	3.3019	86	7396	636056	9.2736	4.4140
37	1369	50653	6.0828	3.3322	87	7569	658503	9.3274	4.4310
38	1444	54872	6.1644	3.3620	88	7744	681472	9.3808	4.4480
39	1521	59319	6.2450	3.3912	89	7921	704969	9.4340	4.4647
40	1600	64000	6.3246	3.4200	90	8100	729000	9.4868	4.4814
41	1681	68921	6.4031	3.4482	91	8281	753571	9.5394	4.4979
42	1764	74088	6.4807	3.4760	92	8464	778688	9.5917	4.5144
43	1849	79507	6.5574	3.5034	93	8649	804357	9.6437	4.5307
44	1936	85184	6.6332	3.5303	94	8836	830584	9.6954	4.5468
45	2025	91125	6.7082	3.5569	95	9025	857375	9.7468	4.5629
46	2116	97336	6.7823	3.5830	96	9216	884736	9.7980	4.5789
47	2209	103823	6.8557	3.6088	97	9409	912673	9.8489	4.5947
48	2304	110592	6.9282	3.6342	98	9604	941192	9.8995	4.6104
49	2401	117649	7.	3.6593	99	9801	970299	9.9499	4.6261
50	2500	125000	7.0711	3.6840	100	10000	1000000	10.	4.6416

* From *Smithsonian Geographical Tables*, Washington, 1906, checked by comparison with a similar table in *The Civil Engineer's Pocket-book*, Trautwine, New York, 1900.

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
101	10201	1030301	10.0499	4.6570	151	22801	3442951	12.2882	5.3251
102	10404	1061208	10.0995	4.6723	152	23104	3511808	12.3288	5.3368
103	10609	1092727	10.1489	4.6875	153	23409	3581577	12.3693	5.3485
104	10816	1124864	10.1980	4.7027	154	23716	3652264	12.4097	5.3601
105	11025	1157625	10.2470	4.7177	155	24025	3723875	12.4499	5.3717
106	11236	1191016	10.2956	4.7326	156	24336	3796416	12.4900	5.3832
107	11449	1225043	10.3441	4.7475	157	24649	3869893	12.5300	5.3947
108	11664	1259712	10.3923	4.7622	158	24964	3944312	12.5698	5.4061
109	11881	1295029	10.4403	4.7769	159	25281	4019679	12.6095	5.4175
110	12100	1331000	10.4881	4.7914	160	25600	4096000	12.6491	5.4288
111	12321	1367631	10.5357	4.8059	161	25921	4173281	12.6886	5.4401
112	12544	1404928	10.5830	4.8203	162	26244	4251528	12.7279	5.4514
113	12769	1442897	10.6301	4.8346	163	26569	4330747	12.7671	5.4626
114	12996	1481544	10.6771	4.8488	164	26896	4410944	12.8062	5.4737
115	13225	1520875	10.7238	4.8629	165	27225	4492125	12.8452	5.4848
116	13456	1560896	10.7703	4.8770	166	27556	4574296	12.8841	5.4959
117	13689	1601613	10.8167	4.8910	167	27889	4657463	12.9228	5.5069
118	13924	1643032	10.8628	4.9049	168	28224	4741632	12.9615	5.5178
119	14161	1685159	10.9087	4.9187	169	28561	4826809	13.	5.5288
120	14400	1728000	10.9545	4.9324	170	28900	4913000	13.0384	5.5397
121	14641	1771561	11.	4.9461	171	29241	5000211	13.0767	5.5505
122	14884	1815848	11.0454	4.9597	172	29584	5088448	13.1149	5.5613
123	15129	1860867	11.0905	4.9732	173	29929	5177717	13.1529	5.5721
124	15376	1906624	11.1355	4.9866	174	30276	5268024	13.1909	5.5828
125	15625	1953125	11.1803	5.	175	30625	5359375	13.2288	5.5934
126	15876	2000376	11.2250	5.0133	176	30976	5451776	13.2665	5.6041
127	16129	2048383	11.2694	5.0265	177	31329	5545233	13.3041	5.6147
128	16384	2097152	11.3137	5.0397	178	31684	5639752	13.3417	5.6252
129	16641	2146689	11.3578	5.0528	179	32041	5735339	13.3791	5.6357
130	16900	2197000	11.4018	5.0658	180	32400	5832000	13.4164	5.6462
131	17161	2248091	11.4455	5.0788	181	32761	5929741	13.4536	5.6567
132	17424	2299968	11.4891	5.0916	182	33124	6028568	13.4907	5.6671
133	17689	2352637	11.5326	5.1045	183	33489	6128487	13.5277	5.6774
134	17956	2406104	11.5758	5.1172	184	33856	6229504	13.5647	5.6877
135	18225	2460375	11.6190	5.1299	185	34225	6331625	13.6015	5.6980
136	18496	2515456	11.6619	5.1426	186	34596	6434856	13.6382	5.7083
137	18769	2571353	11.7047	5.1551	187	34969	6539203	13.6748	5.7185
138	19044	2628072	11.7473	5.1676	188	35344	6644672	13.7113	5.7287
139	19321	2685619	11.7898	5.1801	189	35721	6751269	13.7477	5.7388
140	19600	2744000	11.8322	5.1925	190	36100	6859000	13.7840	5.7489
141	19881	2803221	11.8743	5.2048	191	36481	6967871	13.8203	5.7590
142	20164	2863288	11.9164	5.2171	192	36864	7077888	13.8564	5.7690
143	20449	2924207	11.9583	5.2293	193	37249	7189057	13.8924	5.7790
144	20736	2985984	12.	5.2415	194	37636	7301384	13.9284	5.7890
145	21025	3048625	12.0416	5.2536	195	38025	7414875	13.9642	5.7989
146	21316	3112136	12.0830	5.2656	196	38416	7529536	14.	5.8088
147	21609	3176523	12.1244	5.2776	197	38809	7645373	14.0357	5.8186
148	21904	3241792	12.1655	5.2896	198	39204	7762392	14.0712	5.8285
149	22201	3307949	12.2066	5.3015	199	39601	7880599	14.1067	5.8383
150	22500	3375000	12.2474	5.3133	200	40000	8000000	14.1421	5.8480

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
201	40401	8120601	14.1774	5.8578	**251**	63001	15813251	15.8430	6.3080
202	40804	8242408	14.2127	5.8675	252	63504	16003008	15.8745	6.3164
203	41209	8365427	14.2478	5.8771	253	64009	16194277	15.9060	6.3247
204	41616	8489664	14.2829	5.8868	254	64516	16387064	15.9374	6.3330
205	42025	8615125	14.3178	5.8964	255	65025	16581375	15.9687	6.3413
206	42436	8741816	14.3527	5.9059	**256**	65536	16777216	16.	6.3496
207	42849	8869743	14.3875	5.9155	257	66049	16974593	16.0312	6.3579
208	43264	8998912	14.4222	5.9250	258	66564	17173512	16.0624	6.3661
209	43681	9129329	14.4568	5.9345	259	67081	17373979	16.0935	6.3743
210	44100	9261000	14.4914	5.9439	260	67600	17576000	16.1245	6.3825
211	44521	9393931	14.5258	5.9533	**261**	68121	17779581	16.1555	6.3907
212	44944	9528128	14.5602	5.9627	262	68644	17984728	16.1864	6.3988
213	45369	9663597	14.5945	5.9721	263	69169	18191447	16.2173	6.4070
214	45796	9800344	14.6287	5.9814	264	69696	18399744	16.2481	6.4151
215	46225	9938375	14.6629	5.9907	265	70225	18609625	16.2788	6.4232
216	46656	10077696	14.6969	6.	**266**	70756	18821096	16.3095	6.4312
217	47089	10218313	14.7309	6.0092	267	71289	19034163	16.3401	6.4393
218	47524	10360232	14.7648	6.0185	268	71824	19248832	16.3707	6.4473
219	47961	10503459	14.7986	6.0277	269	72361	19465109	16.4012	6.4553
220	48400	10648000	14.8324	6.0368	270	72900	19683000	16.4317	6.4633
221	48841	10793861	14.8661	6.0459	**271**	73441	19902511	16.4621	6.4713
222	49284	10941048	14.8997	6.0550	272	73984	20123648	16.4924	6.4792
223	49729	11089567	14.9332	6.0641	273	74529	20346417	16.5227	6.4872
224	50176	11239424	14.9666	6.0732	274	75076	20570824	16.5529	6.4951
225	50625	11390625	15.	6.0822	275	75625	20796875	16.5831	6.5030
226	51076	11543176	15.0333	6.0912	**276**	76176	21024576	16.6132	6.5108
227	51529	11697083	15.0665	6.1002	277	76729	21253933	16.6433	6.5187
228	51984	11852352	15.0997	6.1091	278	77284	21484952	16.6733	6.5265
229	52441	12008989	15.1327	6.1180	279	77841	21717639	16.7033	6.5343
230	52900	12167000	15.1658	6.1269	280	78400	21952000	16.7332	6.5421
231	53361	12326391	15.1987	6.1358	**281**	78961	22188041	16.7631	6.5499
232	53824	12487168	15.2315	6.1446	282	79524	22425768	16.7929	6.5577
233	54289	12649337	15.2643	6.1534	283	80089	22665187	16.8226	6.5654
234	54756	12812904	15.2971	6.1622	284	80656	22906304	16.8523	6.5731
235	55225	12977875	15.3297	6.1710	285	81225	23149125	16.8819	6.5808
236	55696	13144256	15.3623	6.1797	**286**	81796	23393656	16.9115	6.5885
237	56169	13312053	15.3948	6.1885	287	82369	23639903	16.9411	6.5962
238	56644	13481272	15.4272	6.1972	288	82944	23887872	16.9706	6.6039
239	57121	13651919	15.4596	6.2058	289	83521	24137569	17.	6.6115
240	57600	13824000	15.4919	6.2145	290	84100	24389000	17.0294	6.6191
241	58081	13997521	15.5242	6.2231	**291**	84681	24642171	17.0587	6.6267
242	58564	14172488	15.5563	6.2317	292	85264	24897088	17.0880	6.6343
243	59049	14348907	15.5885	6.2403	293	85849	25153757	17.1172	6.6419
244	59536	14526784	15.6205	6.2488	294	86436	25412184	17.1464	6.6494
245	60025	14706125	15.6525	6.2573	295	87025	25672375	17.1756	6.6569
246	60516	14886936	15.6844	6.2658	**296**	87616	25934336	17.2047	6.6644
247	61009	15069223	15.7162	6.2743	297	88209	26198073	17.2337	6.6719
248	61504	15252992	15.7480	6.2828	298	88804	26463592	17.2627	6.6794
249	62001	15438249	15.7797	6.2912	299	89401	26730899	17.2916	6.6869
250	62500	15625000	15.8114	6.2996	300	90000	27000000	17.3205	6.6943

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
301	90601	27270901	17.3494	6.7018	**351**	123201	43243551	18.7350	7.0540
302	91204	27543608	17.3781	6.7092	352	123904	43614208	18.7617	7.0607
303	91809	27818127	17.4069	6.7166	353	124609	43986977	18.7883	7.0674
304	92416	28094464	17.4356	6.7240	354	125316	44361864	18.8149	7.0740
305	93025	28372625	17.4642	6.7313	355	126025	44738875	18.8414	7.0807
306	93636	28652616	17.4929	6.7387	**356**	126736	45118016	18.8680	7.0873
307	94249	28934443	17.5214	6.7460	357	127449	45499293	18.8944	7.0940
308	94864	29218112	17.5499	6.7533	358	128164	45882712	18.9209	7.1006
309	95481	29503629	17.5784	6.7606	359	128881	46268279	18.9473	7.1072
310	96100	29791000	17.6068	6.7679	360	129600	46656000	18.9737	7.1138
311	96721	30080231	17.6352	6.7752	**361**	130321	47045881	19.	7.1204
312	97344	30371328	17.6635	6.7824	362	131044	47437928	19.0263	7.1269
313	97969	30664297	17.6918	6.7897	363	131769	47832147	19.0526	7.1335
314	98596	30959144	17.7200	6.7969	364	132496	48228544	19.0788	7.1400
315	99225	31255875	17.7482	6.8041	365	133225	48627125	19.1050	7.1466
316	99856	31554496	17.7764	6.8113	**366**	133956	49027896	19.1311	7.1531
317	100489	31855013	17.8045	6.8185	367	134689	49430863	19.1572	7.1596
318	101124	32157432	17.8326	6.8256	368	135424	49836032	19.1833	7·1661
319	101761	32461759	17.8606	6.8328	369	136161	50243409	19.2094	7.1726
320	102400	32768000	17.8885	6.8399	370	136900	50653000	19.2354	7.1791
321	103041	33076161	17.9165	6.8470	**371**	137641	51064811	19.2614	7.1855
322	103684	33386248	17.9444	6.8541	372	138384	51478848	19.2873	7.1920
323	104329	33698267	17.9722	6.8612	373	139129	51895117	19.3132	7.1984
324	104976	34012224	18.	6.8683	374	139876	52313624	19.3391	7.2048
325	105625	34328125	18.0278	6.8753	375	140625	52734375	19.3649	7.2112
326	106276	34645976	18.0555	6.8824	**376**	141376	53157376	19.3907	7.2177
327	106929	34965783	18.0831	6.8894	377	142129	53582633	19.4165	7.2240
328	107584	35287552	18.1108	6.8964	378	142884	54010152	19.4422	7.2304
329	108241	35611289	18.1384	6.9034	379	143641	54439939	19.4679	7.2368
330	108900	35937000	18.1659	6.9104	380	144400	54872000	19.4936	7.2432
331	109561	36264691	18.1934	6.9174	**381**	145161	55306341	19.5192	7.2495
332	110224	36594368	18.2209	6.9244	382	145924	55742968	19.5448	7.2558
333	110889	36926037	18.2483	6.9313	383	146689	56181887	19.5704	7.2622
334	111556	37259704	18.2757	6.9382	384	147456	56623104	19.5959	7.2685
335	112225	37595375	18.3030	6.9451	385	148225	57066625	19.6214	7.2748
336	112896	37933056	18.3303	6.9521	**386**	148996	57512456	19.6469	7.2811
337	113569	38272753	18.3576	6.9589	387	149769	57960603	19.6723	7.2874
338	114244	38614472	18.3848	6.9658	388	150544	58411072	19.6977	7.2936
339	114921	38958219	18.4120	6.9727	389	151321	58863869	19.7231	7.2999
340	115600	39304000	18.4391	6.9795	390	152100	59319000	19.7484	7.3061
341	116281	39651821	18.4662	6.9864	**391**	152881	59776471	19.7737	7.3124
342	116964	40001688	18.4932	6.9932	392	153664	60236288	19.7990	7.3186
343	117649	40353607	18.5203	7.	393	154449	60698457	19.8242	7.3248
344	118336	40707584	18.5472	7.0068	394	155236	61162984	19.8494	7.3310
345	119025	41063625	18.5742	7.0136	395	156025	61629875	19.8746	7.3372
346	119716	41421736	18.6011	7.0203	**396**	156816	62099136	19.8997	7.3434
347	120409	41781923	18.6279	7.0271	397	157609	62570773	19.9249	7.3496
348	121104	42144192	18.6548	7.0338	398	158404	63044792	19.9499	7.3558
349	121801	42508549	18.6815	7.0406	399	159201	63521199	19.9750	7.3619
350	122500	42875000	18.7083	7.0473	400	160000	64000000	20.	7.3681

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
401	160801	64481201	20.0250	7.3742	**451**	203401	91733851	21.2368	7.6688
402	161604	64964808	20.0499	7.3803	452	204304	92345408	21.2603	7.6744
403	162409	65450827	20.0749	7.3864	453	205209	92959677	21.2838	7.6801
404	163216	65939264	20.0998	7.3925	454	206116	93576664	21.3073	7.6857
405	164025	66430125	20.1246	7.3986	455	207025	94196375	21.3307	7.6914
406	164836	66923416	20.1494	7.4047	**456**	207936	94818816	21.3542	7.6970
407	165649	67419143	20.1742	7.4108	457	208849	95443993	21.3776	7.7026
408	166464	67917312	20.1990	7.4169	458	209764	96071912	21.4009	7.7082
409	167281	68417929	20.2237	7.4229	459	210681	96702579	21.4243	7.7138
410	168100	68921000	20.2485	7.4290	460	211600	97336000	21.4476	7.7194
411	168921	69426531	20.2731	7.4350	**461**	212521	97972181	21.4709	7.7250
412	169744	69934528	20.2978	7.4410	462	213444	98611128	21.4942	7.7306
413	170569	70444997	20.3224	7.4470	463	214369	99252847	21.5174	7.7362
414	171396	70957944	20.3470	7.4530	464	215296	99897344	21.5407	7.7418
415	172225	71473375	20.3715	7.4590	465	216225	100544625	21.5639	7.7473
416	173056	71991296	20.3961	7.4650	**466**	217156	101194696	21.5870	7.7529
417	173889	72511713	20.4206	7.4710	467	218089	101847563	21.6102	7.7584
418	174724	73034632	20.4450	7.4770	468	219024	102503232	21.6333	7.7639
419	175561	73560059	20.4695	7.4829	469	219961	103161709	21.6564	7.7695
420	176400	74088000	20.4939	7.4889	470	220900	103823000	21.6795	7.7750
421	177241	74618461	20.5183	7.4948	**471**	221841	104487111	21.7025	7.7805
422	178084	75151448	20.5426	7.5007	472	222784	105154048	21.7256	7.7860
423	178929	75686967	20.5670	7.5067	473	223729	105823817	21.7486	7.7915
424	179776	76225024	20.5913	7.5126	474	224676	106496424	21.7715	7.7970
425	180625	76765625	20.6155	7.5185	475	225625	107171875	21.7945	7.8025
426	181476	77308776	20.6398	7.5244	**476**	226576	107850176	21.8174	7.8079
427	182329	77854483	20.6640	7.5302	477	227529	108531333	21.8403	7.8134
428	183184	78402752	20.6882	7.5361	478	228484	109215352	21.8632	7.8188
429	184041	78953589	20.7123	7.5420	479	229441	109902239	21.8861	7.8243
430	184900	79507000	20.7364	7.5478	480	230400	110592000	21.9089	7.8297
431	185761	80062991	20.7605	7.5537	**481**	231361	111284641	21.9317	7.8352
432	186624	80621568	20.7846	7.5595	482	232324	111980168	21.9545	7.8406
433	187489	81182737	20.8087	7.5654	483	233289	112678587	21.9773	7.8460
434	188356	81746504	20.8327	7.5712	484	234256	113379904	22.	7.8514
435	189225	82312875	20.8567	7.5770	485	235225	114084125	22.0227	7.8568
436	190096	82881856	20.8806	7.5828	**486**	236196	114791256	22.0454	7.8622
437	190969	83453453	20.9045	7.5886	487	237169	115501303	22.0681	7.8676
438	191844	84027672	20.9284	7.5944	488	238144	116214272	22.0907	7.8730
439	192721	84604519	20.9523	7.6001	489	239121	116930169	22.1133	7.8784
440	193600	85184000	20.9762	7.6059	490	240100	117649000	22.1359	7.8837
441	194481	85766121	21.	7.6117	**491**	241081	118370771	22.1585	7.8891
442	195364	86350888	21.0238	7.6174	492	242064	119095488	22.1811	7.8944
443	196249	86938307	21.0476	7.6232	493	243049	119823157	22.2036	7.8998
444	197136	87528384	21.0713	7.6289	494	244036	120553784	22.2261	7.9051
445	198025	88121125	21.0950	7.6346	495	245025	121287375	22.2486	7.9105
446	198916	88716536	21.1187	7.6403	**496**	246016	122023936	22.2711	7.9158
447	199809	89314623	21.1424	7.6460	497	247009	122763473	22.2935	7.9211
448	200704	89915392	21.1660	7.6517	498	248004	123505992	22.3159	7.9264
449	201601	90518849	21.1896	7.6574	499	249001	124251499	22.3383	7.9317
450	202500	91125000	21.2132	7.6631	500	250000	125000000	22.3607	7.9370

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
501	251001	125751501	22.3830	7.9423	**551**	303601	167284151	23.4734	8.1982
502	252004	126506008	22.4054	7.9476	552	304704	168196608	23.4947	8.2031
503	253009	127263527	22.4277	7.9528	553	305809	169112377	23.5160	8.2081
504	254016	128024064	22.4499	7.9581	554	306916	170031464	23.5372	8.2130
505	255025	128787625	22.4722	7.9634	555	308025	170953875	23.5584	8.2180
506	256036	129554216	22.4944	7.9686	**556**	309136	171879616	23.5797	8.2229
507	257049	130323843	22.5167	7.9739	557	310249	172808693	23.6008	8.2278
508	258064	131096512	22.5389	7.9791	558	311364	173741112	23.6220	8.2327
509	259081	131872229	22.5610	7.9843	559	312481	174676879	23.6432	8.2377
510	260100	132651000	22.5832	7.9896	560	313600	175616000	23.6643	8.2426
511	261121	133432831	22.6053	7.9948	**561**	314721	176558481	23.6854	8.2475
512	262144	134217728	22.6274	8.	562	315844	177504328	23.7065	8.2524
513	263169	135005697	22.6495	8.0052	563	316969	178453547	23.7276	8.2573
514	264196	135796744	22.6716	8.0104	564	318096	179406144	23.7487	8.2621
515	265225	136590875	22.6936	8.0156	565	319225	180362125	23.7697	8.2670
516	266256	137388096	22.7156	8.0208	**566**	320356	181321496	23.7908	8.2719
517	267289	138188413	22.7376	8.0260	567	321489	182284263	23.8118	8.2768
518	268324	138991832	22.7596	8.0311	568	322624	183250432	23.8328	8.2816
519	269361	139798359	22.7816	8.0363	569	323761	184220009	23.8537	8.2865
520	270400	140608000	22.8035	8.0415	570	324900	185193000	23.8747	8.2913
521	271441	141420761	22.8254	8.0466	**571**	326041	186169411	23.8956	8.2962
522	272484	142236648	22.8473	8.0517	572	327184	187149248	23.9165	8.3010
523	273529	143055667	22.8692	8.0569	573	328329	188132517	23.9374	8.3059
524	274576	143877824	22.8910	8.0620	574	329476	189119224	23.9583	8.3107
525	275625	144703125	22.9129	8.0671	575	330625	190109375	23.9792	8.3155
526	276676	145531576	22.9347	8.0723	**576**	331776	191102976	24.	8.3203
527	277729	146363183	22.9565	8.0774	577	332929	192100033	24.0208	8.3251
528	278784	147197952	22.9783	8.0825	578	334084	193100552	24.0416	8.3300
529	279841	148035889	23.	8.0876	579	335241	194104539	24.0624	8.3348
530	280900	148877000	23.0217	8.0927	580	336400	195112000	24.0832	8.3396
531	281961	149721291	23.0434	8.0978	**581**	337561	196122941	24.1039	8.3443
532	283024	150568768	23 0651	8.1028	582	338724	197137368	24.1247	8.3491
533	284089	151419437	23.0868	8.1079	583	339889	198155287	24.1454	8.3539
534	285156	152273304	23.1084	8.1130	584	341056	199176704	24.1661	8.3587
535	286225	153130375	23.1301	8.1180	585	342225	200201625	24.1868	8.3634
536	287296	153990656	23.1517	8.1231	**586**	343396	201230056	24.2074	8.3682
537	288369	154854153	23.1733	8.1281	587	344569	202262003	24.2281	8.3730
538	289444	155720872	23.1948	8.1332	588	345744	203297472	24.2487	8.3777
539	290521	156590819	23.2164	8.1382	589	346921	204336469	24.2693	8.3825
540	291600	157464000	23.2379	8.1433	590	348100	205379000	24.2899	8.3872
541	292681	158340421	23.2594	8.1483	**591**	349281	206425071	24.3105	8.3919
542	293764	159220088	23.2809	8.1533	592	350464	207474688	24.3311	8.3967
543	294849	160103007	23.3024	8.1583	593	351649	208527857	24.3516	8.4014
544	295936	160989184	23.3238	8.1633	594	352836	209584584	24.3721	8.4061
545	297025	161878625	23.3452	8.1683	595	354025	210644875	24.3926	8.4108
546	298116	162771336	23.3666	8.1733	**596**	355216	211708736	24.4131	8.4155
547	299209	163667323	23.3880	8.1783	597	356409	212776173	24.4336	8.4202
548	300304	164566592	23.4094	8.1833	598	357604	213847192	24.4540	8.4249
549	301401	165469149	23.4307	8.1882	599	358801	214921799	24.4745	8.4296
550	302500	166375000	23.4521	8.1932	600	360000	216000000	24.4949	8.4343

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
601	361201	217081801	24.5153	8.4390	**651**	423801	275894451	25.5147	8.6668
602	362404	218167208	24.5357	8.4437	652	425104	277167808	25.5343	8.6713
603	363609	219256227	24.5561	8.4484	653	426409	278445077	25.5539	8.6757
604	364816	220348864	24.5764	8.4530	654	427716	279726264	25.5734	8.6801
605	366025	221445125	24.5967	8.4577	655	429025	281011375	25.5930	8.6845
606	367236	222545016	24.6171	8.4623	**656**	430336	282300416	25.6125	8.6890
607	368449	223648543	24.6374	8.4670	657	431649	283593393	25.6320	8.6934
608	369664	224755712	24.6577	8.4716	658	432964	284890312	25.6515	8.6978
609	370881	225866529	24.6779	8.4763	659	434281	286191179	25.6710	8.7022
610	372100	226981000	24.6982	8.4809	660	435600	287496000	25.6905	8.7066
611	373321	228099131	24.7184	8.4856	**661**	436921	288804781	25.7099	8.7110
612	374544	229220928	24.7386	8.4902	662	438244	290117528	25.7294	8.7154
613	375769	230346397	24.7588	8.4948	663	439569	291434247	25.7488	8.7198
614	376996	231475544	24.7790	8.4994	664	440896	292754944	25.7682	8.7241
615	378225	232608375	24.7992	8.5040	665	442225	294079625	25.7876	8.7285
616	379456	233744896	24.8193	8.5086	**666**	443556	295408296	25.8070	8.7329
617	380689	234885113	24.8395	8.5132	667	444889	296740963	25.8263	8.7373
618	381924	236029032	24.8596	8.5178	668	446224	298077632	25.8457	8.7416
619	383161	237176659	24.8797	8.5224	669	447561	299418309	25.8650	8.7460
620	384400	238328000	24.8998	8.5270	670	448900	300763000	25.8844	8.7503
621	385641	239483061	24.9199	8.5316	**671**	450241	302111711	25.9037	8.7547
622	386884	240641848	24.9399	8.5362	672	451584	303464448	25.9230	8.7590
623	388129	241804367	24.9600	8.5408	673	452929	304821217	25.9422	8.7634
624	389376	242970624	24.9800	8.5453	674	454276	306182024	25.9615	8.7677
625	390625	244140625	25.	8.5499	675	455625	307546875	25.9808	8.7721
626	391876	245314376	25.0200	8.5544	**676**	456976	308915776	26.	8.7764
627	393129	246491883	25.0400	8.5590	677	458329	310288733	26.0192	8.7807
628	394384	247673152	25.0599	8.5635	678	459684	311665752	26.0384	8.7850
629	395641	248858189	25.0799	8.5681	679	461041	313046839	26.0576	8.7893
630	396900	250047000	25.0998	8.5726	680	462400	314432000	26.0768	8.7937
631	398161	251239591	25.1197	8.5772	**681**	463761	315821241	26.0960	8.7980
632	399424	252435968	25.1396	8.5817	682	465124	317214568	26.1151	8.8023
633	400689	253636137	25.1595	8.5862	683	466489	318611987	26.1343	8.8066
634	401956	254840104	25.1794	8.5907	684	467856	320013504	26.1534	8.8109
635	403225	256047875	25.1992	8.5952	685	469225	321419125	26.1725	8.8152
636	404496	257259456	25.2190	8.5997	**686**	470596	322828856	26.1916	8.8194
637	405769	258474853	25.2389	8.6043	687	471969	324242703	26.2107	8.8237
638	407044	259694072	25.2587	8.6088	688	473344	325660672	26.2298	8.8280
639	408321	260917119	25.2784	8.6132	689	474721	327082769	26.2488	8.8323
640	409600	262144000	25.2982	8.6177	690	476100	328509000	26.2679	8.8366
641	410881	263374721	25.3180	8.6222	**691**	477481	329939371	26.2869	8.8408
642	412164	264609288	25.3377	8.6267	692	478864	331373888	26.3059	8.8451
643	413449	265847707	25.3574	8.6312	693	480249	332812557	26.3249	8.8493
644	414736	267089984	25.3772	8.6357	694	481636	334255384	26.3439	8.8536
645	416025	268336125	25.3969	8.6401	695	483025	335702375	26.3629	8.8578
646	417316	269586136	25.4165	8.6446	**696**	484416	337153536	26.3818	8.8621
647	418609	270840023	25.4362	8.6490	697	485809	338608873	26.4008	8.8663
648	419904	272097792	25.4558	8.6535	698	487204	340068392	26.4197	8.8706
649	421201	273359449	25.4755	8.6579	699	488601	341532099	26.4386	8.8748
650	422500	274625000	25.4951	8.6624	700	490000	343000000	26.4575	8.8790

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
701	491401	344472101	26.4764	8.8833	**751**	564001	423564751	27.4044	9.0896
702	492804	345948408	26.4953	8.8875	752	565504	425259008	27.4226	9.0937
703	494209	347428927	26.5141	8.8917	753	567009	426957777	27.4408	9.0977
704	495616	348913664	26.5330	8.8959	754	568516	428661064	27.4591	9.1017
705	497025	350402625	26.5518	8.9001	755	570025	430368875	27.4773	9.1057
706	498436	351895816	26.5707	8.9043	**756**	571536	432081216	27.4955	9.1098
707	499849	353393243	26.5895	8.9085	757	573049	433798093	27.5136	9.1138
708	501264	354894912	26.6083	8.9127	758	574564	435519512	27.5318	9.1178
709	502681	356400829	26.6271	8.9169	759	576081	437245479	27.5500	9.1218
710	504100	357911000	26.6458	8.9211	760	577600	438976000	27.5681	9.1258
711	505521	359425431	26.6646	8.9253	**761**	579121	440711081	27.5862	9.1298
712	506944	360944128	26.6833	8.9295	762	580644	442450728	27.6043	9.1338
713	508369	362467097	26.7021	8.9337	763	582169	444194947	27.6225	9.1378
714	509796	363994344	26.7208	8.9378	764	583696	445943744	27.6405	9.1418
715	511225	365525875	26.7395	8.9420	765	585225	447697125	27.6586	9.1458
716	512656	367061696	26.7582	8.9462	**766**	586756	449455096	27.6767	9.1498
717	514089	368601813	26.7769	8.9503	767	588289	451217663	27.6948	9.1537
718	515524	370146232	26.7955	8.9545	768	589824	452984832	27.7128	9.1577
719	516961	371694959	26.8142	8.9587	769	591361	454756609	27.7308	9.1617
720	518400	373248000	26.8328	8.9628	770	592900	456533000	27.7489	9.1657
721	519841	374805361	26.8514	8.9670	**771**	594441	458314011	27.7669	9.1696
722	521284	376367048	26.8701	8.9711	772	595984	460099648	27.7849	9.1736
723	522729	377933067	26.8887	8.9752	773	597529	461889917	27.8029	9.1775
724	524176	379503424	26.9072	8.9794	774	599076	463684824	27.8209	9.1815
725	525625	381078125	26.9258	8.9835	775	600625	465484375	27.8388	9.1855
726	527076	382657176	26.9444	8.9876	**776**	602176	467288576	27.8568	9.1894
727	528529	384240583	26.9629	8.9918	777	603729	469097433	27.8747	9.1933
728	529984	385828352	26.9815	8.9959	778	605284	470910952	27.8927	9.1973
729	531441	387420489	27.	9.	779	606841	472729139	27.9106	9.2012
730	532900	389017000	27.0185	9.0041	780	608400	474552000	27.9285	9.2052
731	534361	390617891	27.0370	9.0082	**781**	609961	476379541	27.9464	9.2091
732	535824	392223168	27.0555	9.0123	782	611524	478211768	27.9643	9.2130
733	537289	393832837	27.0740	9.0164	783	613089	480048687	27.9821	9.2170
734	538756	395446904	27.0924	9.0205	784	614656	481890304	28.	9.2209
735	540225	397065375	37.1109	9.0246	785	616225	483736625	28.0179	9.2248
736	541696	398688256	27.1293	9.0287	**786**	617796	485587656	28.0357	9.2287
737	543169	400315553	27.1477	9.0328	787	619369	487443403	28.0535	9.2326
738	544644	401947272	27.1662	9.0369	788	620944	489303872	28.0713	9.2365
739	546121	403583419	27.1846	9.0410	789	622521	491169069	28.0891	9.2404
740	547600	405224000	27.2029	9.0450	790	624100	493039000	28.1069	9.2443
741	549081	406869021	27.2213	9.0491	**791**	625681	494913671	28.1247	9.2482
742	550564	408518488	27.2397	9.0532	792	627264	496793088	28.1425	9.2521
743	552049	410172407	27.2580	9.0572	793	628849	498677257	28.1603	9.2560
744	553536	411830784	27.2764	9.0613	794	630436	500566184	28.1780	9.2599
745	555025	413493625	27.2947	9.0654	795	632025	502459875	28.1957	9.2638
746	556516	415160936	27.3130	9.0694	**796**	633616	504358336	28.2135	9.2677
747	558009	416832723	27.3313	9.0735	797	635209	506261573	28.2312	9.2716
748	559504	418508992	27.3496	9.0775	798	636804	508169592	28.2489	9.2754
749	561001	420189749	27.3679	9.0816	799	638401	510082399	28.2666	9.2793
750	562500	421875000	27.3861	9.0856	800	640000	512000000	28.2843	9.2832

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
801	641601	513922401	28.3019	9.2870	**851**	724201	616295051	29.1719	9.4764
802	643204	515849608	28.3196	9.2909	852	725904	618470208	29.1890	9.4801
803	644809	517781627	28.3373	9.2948	853	727609	620650477	29.2062	9.4838
804	646416	519718464	28.3549	9.2986	854	729316	622835864	29.2233	9.4875
805	648025	521660125	28.3725	9.3025	855	731025	625026375	29.2404	9.4912
806	649636	523606616	28.3901	9.3063	**856**	732736	627222016	29.2575	9.4949
807	651249	525557943	28.4077	9.3102	857	734449	629422793	29.2746	9.4986
808	652864	527514112	28.4253	9.3140	858	736164	631628712	29.2916	9.5023
809	654481	529475129	28.4429	9.3179	859	737881	633839779	29.3087	9.5060
810	656100	531441000	28.4605	9.3217	860	739600	636056000	29.3258	9.5097
811	657721	533411731	28.4781	9.3255	**861**	741321	638277381	29.3428	9.5134
812	659344	535387328	28.4956	9.3294	862	743044	640503928	29.3598	9.5171
813	660969	537367797	28.5132	9.3332	863	744769	642735647	29.3769	9.5207
814	662596	539353144	28.5307	9.3370	864	746496	644972544	29.3939	9.5244
815	664225	541343375	28.5482	9.3408	865	748225	647214625	29.4109	9.5281
816	665856	543338496	28.5657	9.3447	**866**	749956	649461896	29.4279	9.5317
817	667489	545338513	28.5832	9.3485	867	751689	651714363	29.4449	9.5354
818	669124	547343432	28.6007	9.3523	868	753424	653972032	29.4618	9.5391
819	670761	549353259	28.6182	9.3561	869	755161	656234909	29.4788	9.5427
820	672400	551368000	28.6356	9.3599	870	756900	658503000	29.4958	9.5464
821	674041	553387661	28.6531	9.3637	**871**	758641	660776311	29.5127	9.5501
822	675684	555412248	28.6705	9.3675	872	760384	663054848	29.5296	9.5537
823	677329	557441767	28.6880	9.3713	873	762129	665338617	29.5466	9.5574
824	678976	559476224	28.7054	9.3751	874	763876	667627624	29.5635	9.5610
825	680625	561515625	28.7228	9.3789	875	765625	669921875	29.5804	9.5647
826	682276	563559976	28.7402	9.3827	**876**	767376	672221376	29.5973	9.5683
827	683929	565609283	28.7576	9.3865	877	769129	674526133	29.6142	9.5719
828	685584	567663552	28.7750	9.3902	878	770884	676836152	29.6311	9.5756
829	687241	569722789	28.7924	9.3940	879	772641	679151439	29.6479	9.5792
830	688900	571787000	28.8097	9.3978	880	774400	681472000	29.6648	9.5828
831	690561	573856191	28.8271	9.4016	**881**	776161	683797841	29.6816	9.5865
832	692224	575930368	28.8444	9.4053	882	777924	686128968	29.6985	9.5901
833	693889	578009537	28.8617	9.4091	883	779689	688465387	29.7153	9.5937
834	695556	580093704	28.8791	9.4129	884	781456	690807104	29.7321	9.5973
835	697225	582182875	28.8964	9.4166	885	783225	693154125	29.7489	9.6010
836	698896	584277056	28.9137	9.4204	**886**	784996	695506456	29.7658	9.6046
837	700569	586376253	28.9310	9.4241	887	786769	697864103	29.7825	9.6082
838	702244	588480472	28.9482	9.4279	888	788544	700227072	29.7993	9.6118
839	703921	590589719	28.9655	9.4316	889	790321	702595369	29.8161	9.6154
840	705600	592704000	28.9828	9.4354	890	792100	704969000	29.8329	9.6190
841	707281	594823321	29.	9.4391	**891**	793881	707347971	29.8496	9.6226
842	708964	596947688	29.0172	9.4429	892	795664	709732288	29.8664	9.6262
843	710649	599077107	29.0345	9.4466	893	797449	712121957	29.8831	9.6298
844	712336	601211584	29.0517	9.4503	894	799236	714516984	29.8998	9.6334
845	714025	603351125	29.0689	1.4541	895	801025	716917375	29.9166	9.6370
846	715716	605495736	29.0861	9.4578	**896**	802816	719323136	29.9333	9.6406
847	717409	607645423	29.1033	9.4615	897	804609	721734273	29.9500	9.6442
848	719104	609800192	29.1204	9.4652	898	806404	724150792	29.9666	9.6477
849	720801	611960049	29.1376	9.4690	899	808201	726572699	29.9833	9.6513
850	722500	614125000	29.1548	9.4727	900	810000	729000000	30.	9.6549

Table of Squares, Cubes, Square Roots, and Cube Roots of Numbers from 1 to 1000—*continued.*

No.	Square.	Cube.	Sq. Rt.	Cu. Rt.	No.	Square.	Cube.	Sq. Rt.	Cu. Rt.
901	811801	731432701	30.0167	9.6585	**951**	904401	860085351	30.8383	9.8339
902	813604	733870808	30.0333	9.6620	952	906304	862801408	30.8545	9.8374
903	815409	736314327	30.0500	9.6656	953	908209	865523177	30.8707	9.8408
904	817216	738763264	30.0666	9.6692	954	910116	868250664	30.8869	9.8443
905	819025	741217625	30.0832	9.6727	955	912025	870983875	30.9031	9.8477
906	820836	743677416	30.0998	9.6763	**956**	913936	873722816	30.9192	9.8511
907	822649	746142643	30.1164	9.6799	957	915849	876467493	30.9354	9.8546
908	824464	748613312	30.1330	9.6834	958	917764	879217912	30.9516	9.8580
909	826281	751089429	30.1496	9.6870	959	919681	881974079	30.9677	9.8614
910	828100	753571000	30.1662	9.6905	960	921600	884736000	30.9839	9.8648
911	829921	756058031	30.1828	9.6941	**961**	923521	887503681	31.	9.8683
912	831744	758550528	30.1993	9.6976	962	925444	890277128	31.0161	9.8717
913	833569	761048497	30.2159	9.7012	963	927369	893056347	31.0322	9.8751
914	835396	763551944	30.2324	9.7047	964	929296	895841344	31.0483	9.8785
915	837225	766060875	30.2490	9.7082	965	931225	898632125	31.0644	9.8819
916	839056	768575296	30.2655	9.7118	**966**	933156	901428696	31.0805	9.8854
917	840889	771095213	30.2820	9.7153	967	935089	904231063	31.0966	9.8888
918	842724	773620632	30.2985	9.7188	968	937024	907039232	31.1127	9.8922
919	844561	776151559	30.3150	9.7224	969	938961	909853209	31.1288	9.8956
920	846400	778688000	30.3315	9.7259	970	940900	912673000	31.1448	9.8990
921	848241	781229961	30.3480	9.7294	**971**	942841	915498611	31.1609	9.9024
922	850084	783777448	30.3645	9.7329	972	944784	918330048	31.1769	9.9058
923	851929	786330467	30.3809	9.7364	973	946729	921167317	31.1929	9.9092
924	853776	788889024	30.3974	9.7400	974	948676	924010424	31.2090	9.9126
925	855625	791453125	30.4138	9.7435	975	950625	926859375	31.2250	9.9160
926	857476	794022776	30.4302	9.7470	**976**	952576	929714176	31.2410	9.9194
927	859329	796597983	30.4467	9.7505	977	954529	932574833	31.2570	9.9227
928	861184	799178752	30.4631	9.7540	978	956484	935441352	31.2730	9.9261
929	863041	801765089	30.4795	9.7575	979	958441	938313739	31.2890	9.9295
930	864900	804357000	30.4959	9.7610	980	960400	941192000	31.3050	9.9329
931	866761	806954491	30.5123	9.7645	**981**	962361	944076141	31.3209	9.9363
932	868624	809557568	30.5287	9.7680	982	964324	946966168	31.3369	9.9396
933	870489	812166237	30.5450	9.7715	983	966289	949862087	31.3528	9.9430
934	872356	814780504	30.5614	9.7750	984	968256	952763904	31.3688	9.9464
935	874225	817400375	30.5778	9.7785	985	970225	955671625	31.3847	9.9497
936	876096	820025856	30.5941	9.7819	**986**	972196	958585256	31.4006	9.9531
937	877969	822656953	30.6105	9.7854	987	974169	961504803	31.4166	9.9565
938	879844	825293672	30.6268	9.7889	988	976144	964430272	31.4325	9.9598
939	881721	827936019	30.6431	9.7924	989	978121	967361669	31.4484	9.9632
940	883600	830584000	30.6594	9.7959	990	980100	970299000	31.4643	9.9666
941	885481	833237621	30.6757	9.7993	**991**	982081	973242271	31.4802	9.9699
942	887364	835896888	30.6920	9.8028	992	984064	976191488	31.4960	9.9733
943	889249	838561807	30.7083	9.8063	993	986049	979146657	31.5119	9.9766
944	891136	841232384	30.7246	9.8097	994	988036	982107784	31.5278	9.9800
945	893025	843908625	30.7409	9.8132	995	990025	985074875	31.5436	9.9833
946	894916	846590536	30.7571	9.8167	**996**	992016	988047936	31.5595	9.9866
947	896809	849278123	30.7734	9.8201	997	994009	991026973	31.5753	9.9900
948	898704	851971392	30.7896	9.8236	998	996004	994011992	31.5911	9.9933
949	900601	854670349	30.8058	9.8270	999	998001	997002999	31.6070	9.9967
950	902500	857375000	30.8221	9.8305	1000	1000000	1000000000	31.6228	10.

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