Encyclopaedia Britannica, 11th Edition, "Destructors" to "Diameter"

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THE ENCYCLOPÆDIA BRITANNICA

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ELEVENTH EDITION

VOLUME VIII slice III

Destructor to Diameter

DESTRUCTOR (*continued from volume 8 slice 2 page 108.*)

... in main flues, &c. (g) The chimney draught must be assisted with forced draught from fans or steam jet to a pressure of 1½ in. to 2 in. under grates by water-gauge. (h) Where a destructor is required to work without risk of nuisance to the neighbouring inhabitants, its efficiency as a refuse destructor plant must be primarily kept in view in designing the works, steam-raising being regarded as a secondary consideration. Boilers should not be placed immediately over a furnace so as to present a large cooling surface, whereby the temperature of the gases is reduced before the organic matter has been thoroughly burned. (i) Where steam-power and a high fuel efficiency are desired a large percentage of CO_2 should be sought in the furnaces with as little excess of air as possible, and the flue gases should be utilized in heating the air-supply to the grates, and the feed-water to the boilers. (j) Ample boiler capacity and hot-water storage feed-tanks should be included in the design where steam-power is required.

Cost.

As to the initial cost of the erection of refuse destructors, few trustworthy data can be given. The outlay necessarily depends, amongst other things, upon the difficulty of preparing the site, upon the nature of the foundations required, the height of the chimney-shaft, the length of the inclined or approach roadway, and the varying prices of labour and materials in different localities. As an example may be mentioned the case of Bristol, where, in 1892, the total cost of constructing a 16-cell Fryer destructor was £11,418, of which £2909 was expended on foundations, and £1689 on the chimney-shaft; the cost of the destructor proper, buildings and approach road was therefore £6820, or about £426 per cell. The cost per ton of burning refuse in destructors depends mainly upon—(a) The price of labour in the locality, and the number of "shifts" or changes of workmen per day; (b) the type of furnace adopted; (c) the nature of the material to be consumed; (d) the interest on and repayment of capital outlay. The cost of burning ton for ton consumed, in high-temperature furnaces, including labour and repairs, is not greater than in slow-combustion destructors. The average cost of burning refuse at twenty-four different towns throughout England, exclusive of interest on the cost of the works, is 1s. 1½d. per ton burned; the minimum cost is 6d. per ton at Bradford, and the maximum cost 2s. 10d. per ton at Battersea. At Shoreditch the cost per ton for the year ending on the 25th of March 1899, including labour, supervision, stores, repairs, &c. (but exclusive of interest on cost of works), was 2s. 6.9d. The quantity of refuse burned per cell per day of 24 hours varies from about 4 tons up to 20 tons. The ordinary low-temperature destructor, with 25 sq. ft. grate area, burns about 20 lb. of refuse per square foot of grate area per hour, or between 5 and 6 tons per cell per 24 hours. The Meldrum destructor furnaces at Rochdale burn as much as 66 lb. per square foot of grate area per hour, and the Beaman and Deas destructor at Llandudno 71.7 lb. per square foot per hour. The amount, however, always depends materially on the care observed in stoking, the nature of the material, the frequency of removal of clinker, and on the question whether the whole of the refuse passed into the furnace is thoroughly cremated.

Residues:

The amount of residue in the shape of clinker and fine ash varies from 22 to 37% of the bulk dealt with. From 25 to 30% is a very usual amount. At Shoreditch, where the refuse consists of about 8% of straw, paper, shavings, &c., the residue contains about 29% clinker, 2.7% fine ash, .5% flue dust, and .6% old tins, making a total residue of 32.8%. As the residuum amounts to from one-fourth to one-third of the total bulk of the refuse dealt with, it is a question of the utmost importance that some profitable, or at least inexpensive, means should be devised for its regular disposal. Among other purposes, it has been used for bottoming for macadamized roads, for the manufacture of concrete, for making paving slabs, for forming suburban footpaths or cinder footwalks, and for the manufacture of mortar. The last is a very general, and in many places profitable, mode of disposal. An entirely new outlet has also arisen for the disposal of good well-vitrified destructor clinker in connexion with the construction of bacteria beds for sewage disposal, and in many districts its value has, by this means, become greatly enhanced.

Through defects in the design and management of many of the early destructors complaints of nuisance frequently arose, and these have, to some extent, brought destructor installations into disrepute. Although some of the older furnaces were decided offenders in this respect, that is by no means the case with the modern improved type of high-temperature furnace; and often, were it not for the great prominence in the landscape of a tall chimney-shaft, the existence of a refuse destructor in a neighbourhood would not be generally known to the inhabitants. A modern furnace, properly designed and worked, will give rise to no nuisance, and may be safely erected in the midst of a populous neighbourhood. To ensure the perfect cremation of the refuse and of the gases given off,

Forced draught.

forced draught is essential. This is supplied either as air draught delivered from a rapidly revolving fan, or as steam blast, as in the Horsfall steam jet or the Meldrum blower. With a forced blast less air is required to obtain complete combustion than by chimney draught. The forced draught grate requires little more than the quantity theoretically necessary, while with chimney draught more than double the theoretical amount of air must be supplied. With forced draught, too, a much higher temperature is attained, and if it is properly worked, little or no cold air will enter the furnaces during stoking operations. As far as possible a balance of pressure in the cells during clinkering should be maintained just sufficient to prevent an inrush of cold air through the flues. The forced draught pressure should not exceed 2 in. water-gauge. The efficiency of the combustion in the furnace is conveniently measured by the "Econometer," which registers continuously and automatically the proportion of CO_2 passing away in the waste gases; the higher the percentage of CO_2 the more efficient the furnace, provided there is no formation of CO, the presence of which would indicate incomplete combustion. The theoretical maximum of CO_2 for refuse burning is about 20%; and, by maintaining an even clean fire, by admitting secondary air over the fire, and by regulating the dampers or the air-pressure in the ash-pit, an amount approximating to this percentage may be attained in a well-designed furnace if properly worked. If the proportion of free oxygen (i.e. excess of air) is large, more air is passed through the furnace than is required for complete combustion, and the heating of this excess is clearly a waste of heat. The position of the econometer in testing should be as near the furnace as possible, as there may be considerable air leakage through the brickwork of the flues.

The air supply to modern furnaces is usually delivered hot, the inlet air being first passed through an air-heater the temperature of which is maintained by the waste gases in the main flue.

Calorific value.

The modern high-temperature destructor, to render the refuse and gases perfectly innocuous and harmless, is worked at a temperature varying from 1250° to 2000° F., and the maintenance of such temperatures has very naturally suggested the possibility of utilizing this heat-energy for the production of steam-power. Experience shows that a considerable amount of energy may be derived from steam-raising destructor stations, amply justifying a reasonable increase of expenditure on plant and labour. The actual calorific value of the refuse material necessarily varies, but, as a general average, with suitably designed and properly managed plant, an evaporation of 1 lb. of water per pound of refuse burned is a result which may be readily attained, and affords a basis of calculation which engineers may safely adopt in practice. Many destructor steam-raising plants, however, give considerably higher results, evaporations approaching 2 lb. of water per pound of refuse being often met with under favourable conditions.

From actual experience it may be accepted, therefore, that the calorific value of unscreened house refuse varies from 1 to 2 lb. of water evaporated per pound of refuse burned, the exact proportion depending upon the quality and condition of the material dealt with. Taking the evaporative power of coal at 10 lb. of water per pound of coal, this gives for domestic house refuse a value of from $\frac{1}{10}$ to $\frac{1}{5}$ that of coal; or, with coal at 20s. per ton, refuse has a commercial value of from 2s. to 4s. per ton. In London the quantity of house refuse amounts to about 1¼ million tons per annum, which is equivalent to from 4 cwt. to 5 cwt. per head per annum. If it be burned in furnaces giving an evaporation of 1 lb. of water per pound of refuse, it would yield a total power annually of about 138 million brake horse-power hours, and equivalent cost of coal at 20s. per ton for this amount of power even when calculated upon the very low estimate of 2 lb.[1] of coal per brake horse-power hour, works out at over £123,000. On the same basis, the refuse of a medium-sized town, with, say, a population of 70,000 yielding refuse at the rate of 5 cwt. per head per annum, would afford 112 indicated horse-power per ton burned, and the total indicated horse-power hours per annum would be

$$\frac{70{,}000 \times 5 \text{ cwt.}}{20} \times 112 = 1{,}960{,}000 \text{ I.H.P. hours annually.}$$

If this were applied to the production of electric energy, the electrical horse-power hours would be (with a dynamo efficiency of 90%)

$$\frac{1{,}960{,}000 \times 90}{100} = 1{,}764{,}000 \text{ E.H.P. hours per annum;}$$

and the watt-hours per annum at the central station would be

$$1{,}764{,}000 \times 746 = 1{,}315{,}944{,}000.$$

Allowing for a loss of 10% in distribution, this would give 1,184,349,600 watt-hours available in lamps, or with 8-candle-power lamps taking 30 watts of current per lamp, we should have

$$\frac{\text{1,184,349,600 watt-hours}}{\text{30 watts}} = \text{39,478,320 8-c.p. lamp-hours per annum;}$$

$$\text{that is, } \frac{\text{39,478,320}}{\text{70,000 population}} \text{563 8-c.p. lamp hours per annum per head of population.}$$

Taking the loss due to the storage which would be necessary at 20% on three-quarters of the total or 15% upon the whole, there would be 478 8-c.p. lamp-hours per annum per head of the population: i.e. if the power developed from the refuse were fully utilized, it would supply electric light at the rate of one 8-c.p. lamp per head of the population for about $1\frac{1}{3}$ hours for every night of the year.

Difficulties.

In actual practice, when the electric energy is for the purposes of lighting only, difficulty has been experienced in fully utilizing the thermal energy from a destructor plant owing to the want of adequate means of storage either of the thermal or of the electric energy. A destructor station usually yields a fairly definite amount of thermal energy uniformly throughout the 24 hours, while the consumption of electric-lighting current is extremely irregular, the maximum demand being about four times the mean demand. The period during which the demand exceeds the mean is comparatively short, and does not exceed about 6 hours out of the 24, while for a portion of the time the demand may not exceed $\frac{1}{20}$th of the maximum. This difficulty, at first regarded as somewhat grave, is substantially minimized by the provision of ample boiler capacity, or by the introduction of feed thermal storage vessels in which hot feed-water may be stored during the hours of light load (say 18 out of the 24), so that at the time of maximum load the boiler may be filled directly from these vessels, which work at the same pressure and temperature as the boiler. Further, the difficulty above mentioned will disappear entirely at stations where there is a fair day load which practically ceases at about the hour when the illuminating load comes on, thus equalizing the demand upon both destructor and electric plant throughout the 24 hours. This arises in cases where current is consumed during the day for motors, fans, lifts, electric tramways, and other like purposes, and, as the employment of electric energy for these services is rapidly becoming general, no difficulty need be anticipated in the successful working of combined destructor and electric plants where these conditions prevail. The more uniform the electrical demand becomes, the more fully may the power from a destructor station be utilized.

In addition to combination with electric-lighting works, refuse destructors are now very commonly installed in conjunction with various other classes of power-using undertakings, including tramways, water-works, sewage-pumping, artificial slab-making and clinker-crushing works and others; and the increasingly large sums which are being yearly expended in combined undertakings of this character is perhaps the strongest evidence of the practical value of such combinations where these several classes of work must be carried on.

For further information on the subject, reference should be made to William H. Maxwell, *Removal and Disposal of Town Refuse, with an exhaustive treatment of Refuse Destructor Plants* (London, 1899), with a special *Supplement* embodying later results (London, 1905).

See also the *Proceedings of the Incorporated Association of Municipal and County Engineers*, vols. xiii. p. 216, xxii. p. 211, xxiv. p. 214 and xxv. p. 138; also the *Proceedings of the Institution of Civil Engineers*, vols. cxxii. p. 443, cxxiv. p. 469, cxxxi. p. 413, cxxxviii. p. 508, cxxix. p. 434, cxxx. pp. 213 and 347, cxxiii. pp. 369 and 498, cxxviii. p. 293 and cxxxv. p. 300.

(W. H. MA.)

[1] With medium-sized steam plants, a consumption of 4 lb. of coal per brake horse-power per hour is a very usual performance.

DE TABLEY, JOHN BYRNE LEICESTER WARREN, 3RD BARON (1835-1895), English poet, eldest son of George Fleming Leicester (afterwards Warren), 2nd Baron De Tabley, was born on the 26th of April 1835. He was educated at Eton and Christ Church, Oxford, where he took his degree in 1856 with second classes in classics and in law and modern history. In the autumn of 1858 he went to Turkey as unpaid attaché to Lord Stratford de Redcliffe, and two years later was called to the bar. He became an officer in the Cheshire Yeomanry, and unsuccessfully contested Mid-Cheshire in 1868 as a Liberal. After his father's second marriage in 1871 he removed to London, where he became a close friend of Tennyson for several years. From 1877 till his succession to the title in 1887 he was lost to his friends, assuming the life of a recluse. It was not till 1892 that he returned to London life, and enjoyed a sort of renaissance of reputation and friendship. During the later years of his life Lord De Tabley made many new friends, besides reopening old associations, and he almost seemed to be gathering around him a small literary company when his health broke, and he died on the 22nd of November 1895 at Ryde, in his sixty-first year. He was buried at Little Peover in Cheshire. Although his reputation will live almost exclusively as that of a poet, De Tabley was a man of many studious tastes. He was at one time an authority on numismatics; he wrote two novels; published *A Guide to the Study of Book Plates* (1880); and the fruit of his careful researches in botany was printed posthumously in his elaborate *Flora of Cheshire* (1899). Poetry, however, was his first and last passion, and to that he devoted the best energies of his life. De Tabley's first impulse towards poetry came from his friend George Fortescue, with whom he shared a close companionship during his Oxford days, and whom he lost, as Tennyson lost Hallam, within a few years of their taking their degrees. Fortescue was killed by falling from the mast of Lord Drogheda's yacht in November 1859, and this gloomy event plunged De Tabley into deep depression. Between 1859 and 1862 De Tabley issued four little volumes of pseudonymous verse (by G. F. Preston), in the production of which he had been greatly stimulated by the sympathy of Fortescue. Once more he assumed a pseudonym—his *Praeterita* (1863) bearing the name of William Lancaster. In the next year he published *Eclogues and Monodramas*, followed in 1865 by *Studies in Verse*. These volumes all displayed technical grace and much natural beauty; but it was not till the publication of *Philoctetes* in 1866 that De Tabley met with any wide recognition. *Philoctetes* bore the initials "M.A.," which, to the author's dismay, were interpreted as meaning Matthew Arnold. He at once disclosed his identity, and received the congratulations of his friends, among whom were Tennyson, Browning and Gladstone. In 1867 he published *Orestes*, in 1870 *Rehearsals* and in 1873 *Searching the Net*. These last two bore his own name, John Leicester Warren. He was somewhat disappointed by their lukewarm reception, and when in 1876 *The Soldier of Fortune*, a drama on which he had bestowed much careful labour, proved a complete failure, he retired altogether from the literary arena. It was not until 1893 that he was persuaded to return, and the immediate success in that year of his *Poems, Dramatic and Lyrical*, encouraged him to publish a second series in 1895, the year of his death. The genuine interest with which these volumes were welcomed did much to lighten the last years of a somewhat sombre and solitary life. His posthumous poems were collected in 1902. The characteristics of De Tabley's poetry are pre-eminently magnificence of style, derived from close study of Milton, sonority, dignity, weight and colour. His passion for detail was both a strength and a weakness: it lent a loving fidelity to his description of natural objects, but it sometimes involved him in a loss of simple effect from over-elaboration of treatment. He was always a student of the classic poets, and drew much of his inspiration directly from them. He was a true and a whole-hearted artist, who, as a brother poet well said, "still climbed the clear cold altitudes of song." His ambition was always for the heights, a region naturally ice-bound at periods, but always a country of clear atmosphere and bright, vivid outlines.

See an excellent sketch by E. Gosse in his *Critical Kit-Kats* (1896).

(A. Wa.)

DETAILLE, JEAN BAPTISTE ÉDOUARD (1848-), French painter, was born in Paris on the 5th of October 1848. After working as a pupil of Meissonier's, he first exhibited, in the Salon of 1867, a picture representing "A Corner of Meissonier's Studio." Military life was from the first a principal attraction to the young painter, and he gained his reputation by depicting the scenes of a soldier's life with every detail truthfully rendered. He exhibited "A Halt" (1868); "Soldiers at rest, during the Manœuvres at the Camp of Saint Maur" (1869); "Engagement between Cossacks and the Imperial Guard, 1814" (1870). The war of 1870-71 furnished him with a series of subjects which gained him repeated successes. Among his more important pictures may be named "The Conquerors" (1872); "The Retreat" (1873); "The Charge of the 9th Regiment of Cuirassiers in the Village of Morsbronn, 6th August 1870" (1874); "The Marching Regiment, Paris, December 1874" (1875); "A Reconnaissance" (1876); "Hail to the Wounded!" (1877); "Bonaparte in Egypt" (1878); the "Inauguration of the New Opera House"—a water-colour; the "Defence of Champigny by Faron's Division" (1879). He also worked with Alphonse de Neuville on the panorama of Rezonville. In 1884 he exhibited at the Salon the "Evening at Rezonville," a panoramic study, and "The Dream" (1888), now in the Luxemburg. Detaille recorded other events in the military history of his country: the "Sortie of the Garrison of Huningue" (now in the Luxemburg), the "Vincendon Brigade," and "Bizerte," reminiscences of the expedition to Tunis. After a visit to Russia, Detaille exhibited "The Cossacks of the Ataman" and "The Hereditary Grand Duke at the Head of the Hussars of the Guard." Other important works are: "Victims to Duty," "The Prince of Wales and the Duke of Connaught" and "Pasteur's Funeral." In his picture of "Châlons, 9th October 1896," exhibited in the Salon, 1898, Detaille painted the emperor and empress of Russia at a review, with M. Félix Faure. Detaille became a member of the French Institute in 1898.

See Marius Vachon, *Detaille* (Paris, 1898); Frédéric Masson, *Édouard Detaille and his work* (Paris and London, 1891); J. Claretie, *Peintres et sculpteurs contemporains* (Paris, 1876); G. Goetschy, *Les*

Jeunes peintres militaires (Paris, 1878).

DETAINER (from *detain*, Lat. *detinere*), in law, the act of keeping a person against his will, or the wrongful keeping of a person's goods, or other real or personal property. A writ of detainer was a form for the beginning of a personal action against a person already lodged within the walls of a prison; it was superseded by the Judgment Act 1838.

DETERMINANT, in mathematics, a function which presents itself in the solution of a system of simple equations.

1. Considering the equations

$$\begin{aligned} ax + by + cz &= d, \\ a'x + b'y + c'z &= d', \\ a''x + b''y + c''z &= d'', \end{aligned}$$

and proceeding to solve them by the so-called method of cross multiplication, we multiply the equations by factors selected in such a manner that upon adding the results the whole coefficient of y becomes = 0, and the whole coefficient of z becomes = 0; the factors in question are $b'c'' - b''c'$, $b''c - bc''$, $bc' - b'c$ (values which, as at once seen, have the desired property); we thus obtain an equation which contains on the left-hand side only a multiple of x, and on the right-hand side a constant term; the coefficient of x has the value

$$a(b'c'' - b''c') + a'(b''c - bc'') + a''(bc' - b'c),$$

and this function, represented in the form

$$\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix},$$

is said to be a determinant; or, the number of elements being 3^2, it is called a determinant of the third order. It is to be noticed that the resulting equation is

$$\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} x = \begin{vmatrix} d, & b, & c \\ d', & b', & c' \\ d'', & b'', & c'' \end{vmatrix}$$

where the expression on the right-hand side is the like function with d, d′, d″ in place of a, a′, a″ respectively, and is of course also a determinant. Moreover, the functions $b'c'' - b''c'$, $b''c - bc''$, $bc' -$

$b'c$ used in the process are themselves the determinants of the second order

$$\begin{vmatrix} b', & c' \\ b'', & c'' \end{vmatrix}, \begin{vmatrix} b'', & c'' \\ b, & c \end{vmatrix}, \begin{vmatrix} b, & c \\ b', & c' \end{vmatrix}.$$

We have herein the suggestion of the rule for the derivation of the determinants of the orders 1, 2, 3, 4, &c., each from the preceding one, viz. we have

$$\begin{vmatrix} a \end{vmatrix} = a,$$

$$\begin{vmatrix} a, & b \\ a', & b' \end{vmatrix} = a\begin{vmatrix} b' \end{vmatrix} - a'\begin{vmatrix} b \end{vmatrix}.$$

$$\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} = a\begin{vmatrix} b', & c' \\ b'', & c'' \end{vmatrix} + a'\begin{vmatrix} b'', & c'' \\ b, & c \end{vmatrix} + a''\begin{vmatrix} b, & c \\ b', & c' \end{vmatrix},$$

$$\begin{vmatrix} a, & b, & c, & d \\ a', & b', & c', & d' \\ a'', & b'', & c'', & d'' \\ a''', & b''', & c''', & d''' \end{vmatrix} = a\begin{vmatrix} b', & c', & d' \\ b'', & c'', & d'' \\ b''', & c''', & d''' \end{vmatrix} - a'\begin{vmatrix} b'', & c'', & d'' \\ b''', & c''', & d''' \\ b, & c, & d; \end{vmatrix} + a''\begin{vmatrix} b''', & c''', & d''' \\ b, & c, & d \\ b', & c', & d' \end{vmatrix} - a'''\begin{vmatrix} b, & c, & d \\ b', & c', & d' \\ b'', & c'', & d'' \end{vmatrix},$$

and so on, the terms being all + for a determinant of an odd order, but alternately + and - for a determinant of an even order.

2. It is easy, by induction, to arrive at the general results:—

A determinant of the order n is the sum of the 1.2.3...n products which can be formed with n elements out of n^2 elements arranged in the form of a square, no two of the n elements being in the same line or in the same column, and each such product having the coefficient ± unity.

The products in question may be obtained by permuting in every possible manner the columns (or the lines) of the determinant, and then taking for the factors the n elements in the dexter diagonal. And we thence derive the rule for the signs, viz. considering the primitive arrangement of the columns as positive, then an arrangement obtained therefrom by a single interchange (inversion, or derangement) of two columns is regarded as negative; and so in general an arrangement is positive or negative according as it is derived from the primitive arrangement by an even or an odd number of interchanges. [This implies the theorem that a given arrangement can be derived from the primitive arrangement only by an odd number, or else only by an even number of interchanges,—a theorem the verification of which may be easily obtained from the theorem (in fact a particular case of the general one), an arrangement can be derived from itself only by an even number of interchanges.] And this being so, each product has the sign belonging to the corresponding arrangement of the columns; in particular, a determinant contains with the sign + the product of the elements in its dexter diagonal. It is to be observed that the rule gives as many positive as negative arrangements, the number of each being = ½ 1.2...n.

The rule of signs may be expressed in a different form. Giving to the columns in the primitive arrangement the numbers 1, 2, 3 ... n, to obtain the sign belonging to any other arrangement we take, as often as a lower number succeeds a higher one, the sign -, and, compounding together all these minus signs, obtain the proper sign, + or - as the case may be.

Thus, for three columns, it appears by either rule that 123, 231, 312 are positive; 213, 321, 132 are negative; and the developed expression of the foregoing determinant of the third order is

$$= ab'c'' - ab''c' + a'b''c - a'bc'' + a''bc' - a''b'c.$$

3. It further appears that a determinant is a linear function[1] of the elements of each column thereof, and also a linear function of the elements of each line thereof; moreover, that the determinant retains the same value, only its sign being altered, when any two columns are interchanged, or when any two lines are interchanged; more generally, when the columns are permuted in any manner, or when the lines are permuted in any manner, the determinant retains its original value, with the sign + or - according as the new arrangement (considered as derived from the primitive arrangement) is positive or negative according to the foregoing rule of signs. It at once follows that, if two columns are identical, or if two lines are identical, the value of the determinant is = 0. It may be added, that if the lines are converted into columns, and the columns into lines, in such a way as to leave the dexter diagonal unaltered, the value of the determinant is unaltered; the determinant is in this case said to be *transposed*.

4. By what precedes it appears that there exists a function of the n^2 elements, linear as regards the terms of each column (or say, for shortness, linear as to each column), and such that only the sign is altered when any two columns are interchanged; these properties completely determine the function, except as to a common factor which may multiply all the terms. If, to get rid of this arbitrary common factor, we assume that the product of the elements in the dexter diagonal has the coefficient +1, we have a complete definition of the determinant, and it is interesting to show how from these properties, assumed for the definition of the determinant, it at once appears that the determinant is a function serving for the solution of a system of linear equations. Observe that the properties show at once that if any column is = 0 (that is, if the elements in the column are each = 0), then the determinant is = 0; and further, that if any two columns are identical, then the determinant is = 0.

5. Reverting to the system of linear equations written down at the beginning of this article, consider the determinant

$$\begin{vmatrix} ax + by + cz - d, & b, & c \\ a'x + b'y + c'z - d', & b', & c' \\ a''x + b''y + c''z - d'', & b'', & c'' \end{vmatrix};$$

it appears that this is

$$= x\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} + y\begin{vmatrix} b, & b, & c \\ b', & b', & c' \\ b'', & b'', & c'' \end{vmatrix} + z\begin{vmatrix} c, & b, & c \\ c', & b', & c' \\ c'', & b'', & c'' \end{vmatrix} - \begin{vmatrix} d, & b, & c \\ d', & b', & c' \\ d'', & b'', & c'' \end{vmatrix};$$

viz. the second and third terms each vanishing, it is

$$= x\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} - \begin{vmatrix} d, & b, & c \\ d', & b', & c' \\ d'', & b'', & c'' \end{vmatrix}.$$

But if the linear equations hold good, then the first column of the original determinant is = 0, and therefore the determinant itself is = 0; that is, the linear equations give

$$x\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} - \begin{vmatrix} d, & b, & c \\ d', & b', & c' \\ d'', & b'', & c'' \end{vmatrix} = 0;$$

which is the result obtained above.

We might in a similar way find the values of y and z, but there is a more symmetrical process. Join to the original equations the new equation

$$\alpha x + \beta y + \gamma z = \delta;$$

a like process shows that, the equations being satisfied, we have

$$\begin{vmatrix} \alpha, & \beta, & \gamma, & \delta \\ a, & b, & c, & d \\ a', & b', & c', & d' \\ a'', & b'', & c'', & d'' \end{vmatrix} = 0;$$

or, as this may be written,

$$\begin{vmatrix} \alpha, & \beta, & \gamma, & \\ a, & b, & c, & d \\ a', & b', & c', & d' \\ a'', & b'', & c'', & d'' \end{vmatrix} - \delta\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} = 0;$$

which, considering δ as standing herein for its value $\alpha x + \beta y + \gamma z$, is a consequence of the original equations only: we have thus an expression for $\alpha x + \beta y + \gamma z$, an arbitrary linear function of the unknown quantities x, y, z; and by comparing the coefficients of α, β, γ on the two sides respectively, we have the values of x, y, z; in fact, these quantities, each multiplied by

$$\begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix},$$

are in the first instance obtained in the forms

$$\begin{vmatrix} 1 & & & \\ a, & b, & c, & d \\ a', & b', & c', & d' \\ a'', & b'', & c'', & d'' \end{vmatrix}, \quad \begin{vmatrix} & 1 & & \\ a, & b, & c, & d \\ a', & b', & c', & d' \\ a'', & b'', & c'', & d'' \end{vmatrix}, \quad \begin{vmatrix} & & 1 & \\ a, & b, & c, & d \\ a', & b', & c', & d' \\ a'', & b'', & c'', & d'' \end{vmatrix};$$

but these are

$$= \begin{vmatrix} b, & c, & d \\ b', & c', & d' \\ b'', & c'', & d'' \end{vmatrix}, - \begin{vmatrix} c, & d, & a \\ c', & d', & a' \\ c'', & d'', & a'' \end{vmatrix}, \begin{vmatrix} d, & a, & b \\ d', & a', & b' \\ d'', & a'', & b'' \end{vmatrix},$$

or, what is the same thing,

$$= \begin{vmatrix} b, & c, & d \\ b', & c', & d' \\ b'', & c'', & d'' \end{vmatrix}, \begin{vmatrix} c, & a, & d \\ c', & a', & d' \\ c'', & a'', & d'' \end{vmatrix}, \begin{vmatrix} a, & b, & d \\ a', & b', & d' \\ a'', & b'', & d'' \end{vmatrix}$$

respectively.

6. *Multiplication of two Determinants of the same Order.*—The theorem is obtained very easily from the last preceding definition of a determinant. It is most simply expressed thus—

$$\begin{array}{l|ccc|} & \underline{(\alpha, \alpha', \alpha''),} & \underline{(\beta, \beta', \beta''),} & \underline{(\gamma, \gamma', \gamma'')} \\ (a, b, c) & '' & '' & '' \\ (a', b', c') & '' & '' & '' \\ (a'', b'', c'') & '' & '' & '' \end{array} = \begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix} . \begin{vmatrix} \alpha, & \beta, & \gamma \\ \alpha', & \beta', & \gamma' \\ \alpha'', & \beta'', & \gamma'' \end{vmatrix},$$

where the expression on the left side stands for a determinant, the terms of the first line being (a, b, c)(α, α′, α″), that is, $a\alpha + b\alpha' + c\alpha''$, (a, b, c)(β, β′, β″), that is, $a\beta + b\beta' + c\beta''$, (a, b, c)(γ, γ′, γ″), that is $a\gamma + b\gamma' + c\gamma''$; and similarly the terms in the second and third lines are the life functions with (a′, b′, c′) and (a″, b″, c″) respectively.

There is an apparently arbitrary transposition of lines and columns; the result would hold good if on the left-hand side we had written (α, β, γ), (α′, β′, γ′), (α″, β″, γ″), or what is the same thing, if on the right-hand side we had transposed the second determinant; and either of these changes would, it might be thought, increase the elegance of the form, but, for a reason which need not be explained,[2] the form actually adopted is the preferable one.

To indicate the method of proof, observe that the determinant on the left-hand side, *qua* linear function of its columns, may be broken up into a sum of (3^3 =) 27 determinants, each of which is either of some such form as

$$= \alpha\beta\gamma' \begin{vmatrix} a, & a, & b \\ a', & a', & b' \\ a'', & a'', & b'' \end{vmatrix},$$

where the term αβγ' is not a term of the αβγ-determinant, and its coefficient (as a determinant with two identical columns) vanishes; or else it is of a form such as

$$= \alpha\beta'\gamma'' \begin{vmatrix} a, & b, & c \\ a', & b', & c' \\ a'', & b'', & c'' \end{vmatrix},$$

that is, every term which does not vanish contains as a factor the abc-determinant last written down; the sum of all other factors ± αβ′γ″ is the αβγ-determinant of the formula; and the final result then is, that the determinant on the left-hand side is equal to the product on the right-hand side of the formula.

7. *Decomposition of a Determinant into complementary Determinants.*—Consider, for simplicity, a determinant of the fifth order, 5 = 2 + 3, and let the top two lines be

$$\begin{matrix} a, & b, & c, & d, & e \\ a', & b', & c', & d', & e' \end{matrix}$$

then, if we consider how these elements enter into the determinant, it is at once seen that they enter only through the determinants of the second order

$$\begin{vmatrix} a, & b \\ a', & b' \end{vmatrix},$$

&c., which can be formed by selecting any two columns at pleasure. Moreover, representing the remaining three lines by

$$\begin{matrix} a'', & b'', & c'', & d'', & e'' \\ a''', & b''', & c''', & d''', & e''' \end{matrix}$$

$$a'''', b'''', c'''', d'''', e''''$$

it is further seen that the factor which multiplies the determinant formed with any two columns of the first set is the determinant of the third order formed with the complementary three columns of the second set; and it thus appears that the determinant of the fifth order is a sum of all the products of the form

$$\begin{vmatrix} a, & b \\ a', & b'' \end{vmatrix} \begin{vmatrix} c'', & d'', & e'' \\ c''', & d''', & e''' \\ c'''', & d'''', & e'''' \end{vmatrix},$$

the sign ± being in each case such that the sign of the term $\pm ab'c''d'''e''''$ obtained from the diagonal elements of the component determinants may be the actual sign of this term in the determinant of the fifth order; for the product written down the sign is obviously +.

Observe that for a determinant of the n-th order, taking the decomposition to be 1 + (n - 1), we fall back upon the equations given at the commencement, in order to show the genesis of a determinant.

8. Any determinant $\begin{vmatrix} a, & b \\ a', & b' \end{vmatrix}$ formed out of the elements of the original determinant, by selecting the lines and columns at pleasure, is termed a *minor* of the original determinant; and when the number of lines and columns, or order of the determinant, is n-1, then such determinant is called a *first minor*; the number of the first minors is = n^2, the first minors, in fact, corresponding to the several elements of the determinant—that is, the coefficient therein of any term whatever is the corresponding first minor. The first minors, each divided by the determinant itself, form a system of elements *inverse* to the elements of the determinant.

A determinant is *symmetrical* when every two elements symmetrically situated in regard to the dexter diagonal are equal to each other; if they are equal and opposite (that is, if the sum of the two elements be = 0), this relation not extending to the diagonal elements themselves, which remain arbitrary, then the determinant is *skew*; but if the relation does extend to the diagonal terms (that is, if these are each = 0), then the determinant is *skew symmetrical*; thus the determinants

$$\begin{vmatrix} a, & h, & g \\ h, & b, & f \\ g, & f, & c \end{vmatrix}; \quad \begin{vmatrix} a, & \nu, & -\mu \\ -\nu, & b, & \lambda \\ \mu, & -\lambda, & c \end{vmatrix}; \quad \begin{vmatrix} 0, & \nu, & -\mu \\ -\nu, & 0, & \lambda \\ \mu, & -\lambda, & 0 \end{vmatrix}$$

are respectively symmetrical, skew and skew symmetrical: The theory admits of very extensive algebraic developments, and applications in algebraical geometry and other parts of mathematics. For further developments of the theory of determinants see ALGEBRAIC FORMS.

(A. CA.)

9. *History.*—These functions were originally known as "resultants," a name applied to them by Pierre Simon Laplace, but now replaced by the title "determinants," a name first applied to certain

forms of them by Carl Friedrich Gauss. The germ of the theory of determinants is to be found in the writings of Gottfried Wilhelm Leibnitz (1693), who incidentally discovered certain properties when reducing the eliminant of a system of linear equations. Gabriel Cramer, in a note to his *Analyse des lignes courbes algébriques* (1750), gave the rule which establishes the sign of a product as *plus* or *minus* according as the number of displacements from the typical form has been even or odd. Determinants were also employed by Étienne Bezout in 1764, but the first connected account of these functions was published in 1772 by Charles Auguste Vandermonde. Laplace developed a theorem of Vandermonde for the expansion of a determinant, and in 1773 Joseph Louis Lagrange, in his memoir on *Pyramids*, used determinants of the third order, and proved that the square of a determinant was also a determinant. Although he obtained results now identified with determinants, Lagrange did not discuss these functions systematically. In 1801 Gauss published his *Disquisitiones arithmeticae*, which, although written in an obscure form, gave a new impetus to investigations on this and kindred subjects. To Gauss is due the establishment of the important theorem, that the product of two determinants both of the second and third orders is a determinant. The formulation of the general theory is due to Augustin Louis Cauchy, whose work was the forerunner of the brilliant discoveries made in the following decades by Hoëné-Wronski and J. Binet in France, Carl Gustav Jacobi in Germany, and James Joseph Sylvester and Arthur Cayley in England. Jacobi's researches were published in *Crelle's Journal* (1826-1841). In these papers the subject was recast and enriched by new and important theorems, through which the name of Jacobi is indissolubly associated with this branch of science. The far-reaching discoveries of Sylvester and Cayley rank as one of the most important developments of pure mathematics. Numerous new fields were opened up, and have been diligently explored by many mathematicians. Skew-determinants were studied by Cayley; axisymmetric-determinants by Jacobi, V. A. Lebesque, Sylvester and O. Hesse, and centro-symmetric determinants by W. R. F. Scott and G. Zehfuss. Continuants have been discussed by Sylvester; alternants by Cauchy, Jacobi, N. Trudi, H. Nagelbach and G. Garbieri; circulants by E. Catalan, W. Spottiswoode and J. W. L. Glaisher, and Wronskians by E. B. Christoffel and G. Frobenius. Determinants composed of binomial coefficients have been studied by V. von Zeipel; the expression of definite integrals as determinants by A. Tissot and A. Enneper, and the expression of continued fractions as determinants by Jacobi, V. Nachreiner, S. Günther and E. Fürstenau. (See T. Muir, *Theory of Determinants*, 1906).

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[1] The expression, a linear function, is here used in its narrowest sense, a linear function without constant term; what is meant is that the determinant is in regard to the elements a, a′, a″, ... of any column or line thereof, a function of the form Aa + A′a′ + A″a″ + ... without any term independent of a, a′, a″ ...

[2] The reason is the connexion with the corresponding theorem for the multiplication of two matrices.

DETERMINISM (Lat. *determinare*, to prescribe or limit), in ethics, the name given to the theory that all moral choice, so called, is the determined or necessary result of psychological and other conditions. It is opposed to the various doctrines of Free-Will, known as voluntarism, libertarianism, indeterminism, and is from the ethical standpoint more or less akin to necessitarianism and fatalism. There are various degrees of determinism. It may be held that every action is causally connected not only externally with the sum of the agent's environment, but also internally with his motives and impulses. In other words, if we could know exactly all these conditions, we should be able to forecast with mathematical certainty the course which the agent would pursue. In this theory the agent cannot be held responsible for his action in any sense. It is the extreme antithesis of Indeterminism or Indifferentism, the doctrine that a man is absolutely free to choose between alternative courses (the *liberum arbitrium indifferentiae*). Since, however, the evidence of ordinary consciousness almost always goes to prove that the individual, especially in relation to future acts, regards himself as being free within certain limitations to make his own choice of alternatives, many determinists go so far as to admit that there may be in any action which is neither reflex nor determined by external causes solely an element of freedom. This view is corroborated by the phenomenon of remorse, in which the agent feels that he ought to, and could, have chosen a different course of action. These two kinds of determinism are sometimes distinguished as "hard" and "soft" determinism. The controversy between determinism and libertarianism hinges largely on the significance of the word "motive"; indeed in no other philosophical controversy has so much difficulty been caused by purely verbal disputation and ambiguity of expression. How far, and in what sense, can action which is determined by motives be said to be free? For a long time the advocates of free-will, in their eagerness to preserve moral responsibility, went so far as to deny all motives as influencing moral action. Such a contention, however, clearly defeats its own object by reducing all action to chance. On the other hand, the scientific doctrine of evolution has gone far towards obliterating the distinction between external and internal compulsion, e.g. motives, character and the like. In so far as man can be shown to be the product of, and a link in, a long chain of causal development, so far does it become impossible to regard him as self-determined. Even in his motives and his impulses, in his mental attitude towards outward surroundings, in his appetites and aversions, inherited tendency and environment have been found to play a very large part; indeed many thinkers hold that the whole of a man's development, mental as well as physical, is determined by external conditions.

In the Bible the philosophical-religious problem is nowhere discussed, but Christian ethics as set forth in the New Testament assumes throughout the freedom of the human will. It has been argued by theologians that the doctrine of divine fore-knowledge, coupled with that of the divine origin of all things, necessarily implies that all human action was fore-ordained from the beginning of the world. Such an inference is, however, clearly at variance with the whole doctrine of sin, repentance and the atonement, as also with that of eternal reward and punishment, which postulates a real measure of human responsibility.

For the history of the free-will controversy see the articles, Will, Predestination (for the theological problems), Ethics.

DETINUE (O. Fr. *detenue*, from *detenir*, to hold back), in law, an action whereby one who has an absolute or a special property in goods seeks to recover from another who is in actual possession and refuses to redeliver them. If the plaintiff succeeds in an action of detinue, the judgment is that he recover the chattel or, if it cannot be had, its value, which is assessed by the judge and jury, and also certain damages for detaining the same. An order for the restitution of the specific goods may be enforced by a special writ of execution, called a writ of delivery. (See Contract; Trover.)

DETMOLD, a town of Germany, capital of the principality of Lippe-Detmold, beautifully situated on the east slope of the Teutoburger Wald, 25 m. S. of Minden, on the Herford-Altenbeken line of the Prussian state railways. Pop. (1905) 13,164. The residential château of the princes of Lippe-Detmold (1550), in the Renaissance style, is an imposing building, lying with its pretty gardens nearly in the centre of the town; whilst at the entrance to the large park on the south is the New Palace (1708-1718), enlarged in 1850, used as the dower-house. Detmold possesses a natural history museum, theatre, high school, library, the house in which the poet Ferdinand Freiligrath (1810-1876) was born, and that in which the dramatist Christian Dietrich Grabbe (1801-1836), also a native, died. The leading industries are linen-weaving, tanning, brewing, horse-dealing and the quarrying of marble and gypsum. About 3 m. to the south-west of the town is the Grotenburg, with Ernst von Bandel's colossal statue of Hermann or Arminius, the leader of the Cherusci. Detmold (Thiatmelli) was in 783 the scene of a conflict between the Saxons and the troops of Charlemagne.

DETROIT, the largest city of Michigan, U.S.A., and the county-seat of Wayne county, on the Detroit river opposite Windsor, Canada, about 4 m. W. from the outlet of Lake St Clair and 18 m. above Lake Erie. Pop. (1880) 116,340; (1890) 205,876; (1900) 285,704, of whom 96,503 were foreign-born and 4111 were negroes; (1910 census) 465,766. Of the foreign-born in 1900, 32,027 were Germans and 10,703 were German Poles, 25,403 were English Canadians and 3541 French Canadians, 6347 were English and 6412 were Irish. Detroit is served by the Michigan Central, the Lake Shore & Michigan Southern, the Wabash, the Grand Trunk, the Père Marquette, the Detroit & Toledo Shore Line, the Detroit, Toledo & Ironton and the Canadian Pacific railways. Two belt lines, one 2 m. to 3 m., and the other 6 m. from the centre of the city, connect the factory districts with the main railway lines. Trains are ferried across the river to Windsor, and steamboats make daily trips to Cleveland, Wyandotte, Mount Clemens, Port Huron, to less important places between, and to several Canadian ports. Detroit is also the S. terminus for several lines to more remote lake ports, and electric lines extend from here to Port Huron, Flint, Pontiac, Jackson, Toledo and Grand Rapids.

The city extended in 1907 over about 41 sq. m., an increase from 29 sq. m. in 1900 and 36 sq. m. in 1905. Its area in proportion to its population is much greater than that of most of the larger cities of the United States. Baltimore, for example, had in 1904 nearly 70% more inhabitants (estimated), while its area at that time was a little less and in 1907 was nearly one-quarter less than that of Detroit. The ground within the city limits as well as that for several miles farther back is quite level, but rises gradually from the river bank, which is only a few feet in height. The Detroit river, along which the city extends for about 10 m., is here ½ m. wide and 30 ft. to 40 ft. deep; its current is quite rapid; its water, a beautiful clear blue; at its mouth it has a width of about 10 m., and in the river there are a number of islands, which during the summer are popular resorts. The city has a 3 m. frontage on the river Rouge, an estuary of the Detroit, with a 16 ft. channel. Before the fire by which the city was destroyed in 1805, the streets were only 12 ft. wide and were unpaved and extremely dirty. But when the rebuilding began, several avenues from 100 ft. to 200 ft. wide were—through the influence of Augustus B. Woodward (c. 1775-1827), one of the territorial judges at the time and an admirer of the plan of the city of Washington—made to radiate from two central points. From a half circle called the Grand Circus there radiate avenues 120 ft. and 200 ft. wide. About ¼ m. toward the river from this was established another focal point called the Campus Martius, 600 ft. long and 400 ft. wide, at which commence radiating or cross streets 80 ft. and 100 ft. wide. Running north from the river through the Campus Martius and the Grand Circus is Woodward Avenue, 120 ft. wide, dividing the present city, as it did the old town, into nearly equal parts. Parallel with the river is Jefferson Avenue, also 120 ft. wide. The first of these avenues is the principal retail street along its lower portion, and is a residence avenue for 4 m. beyond this. Jefferson is the principal wholesale street at the lower end, and a fine residence avenue E. of this. Many of the other residence streets are 80 ft. wide. The setting of shade trees was early encouraged, and large elms and maples abound. The intersections of the diagonal streets left a number of small, triangular parks, which, as well as the larger ones, are well shaded. The streets are paved mostly with asphalt and brick, though cedar and stone have been much used, and kreodone block to some extent. In few, if any, other American cities of equal size are the streets and avenues kept so clean. The Grand Boulevard, 150 ft. to 200 ft. in width and 12 m. in length, has been constructed around the city except along the river front. A very large proportion of the inhabitants of Detroit own their homes: there are no large congested tenement-house districts; and many streets in various parts of the city are faced with rows of low and humble cottages often having a garden plot in front.

Of the public buildings the city hall (erected 1868-1871), overlooking the Campus Martius, is in Renaissance style, in three storeys; the flagstaff from the top of the tower reaches a height of 200 ft. On the four corners above the first section of the tower are four figures, each 14 ft. in height, to represent Justice, Industry, Art and Commerce, and on the same level with these is a clock weighing 7670 lb—one of the largest in the world. In front of the building stands the Soldiers' and Sailors' monument, 60 ft. high, designed by Randolph Rogers (1825-1892) and unveiled in 1872. At each of the four corners in each of three sections rising one above the other are bronze eagles and figures representing the United States Infantry, Marine, Cavalry and Artillery, also Victory, Union, Emancipation and History; the figure by which the monument is surmounted was designed to symbolize Michigan. A larger and more massive and stately building than the city hall is the county court house, facing Cadillac Square, with a lofty tower surmounted by a gilded dome. The Federal building is a massive granite structure, finely decorated in the interior. Among the churches of greatest architectural beauty are the First Congregational, with a fine Byzantine interior, St John's Episcopal, the Woodward Avenue Baptist and the First Presbyterian, all on Woodward Avenue, and St. Anne's and Sacred Heart of Mary, both Roman Catholic. The municipal museum of art, in Jefferson Avenue, contains some unusually interesting Egyptian and Japanese collections, the Scripps' collection of old masters, other valuable paintings, and a small library; free lectures on art are given here through the winter. The public library had 228,500 volumes in 1908, including one of the best collections of state and town histories in the country. A large private collection, owned by C. M. Burton and relating principally to the history of Detroit, is also open to the public. The city is not rich in outdoor works of art. The principal ones are the Merrill fountain and the soldiers' monument on the Campus Martius, and a statue of Mayor Pingree in West Grand Circus Park.

The parks of Detroit are numerous and their total area is about 1200 acres. By far the most attractive is Belle Isle, an island in the river at the E. end of the city, purchased in 1879 and having an area of more than 700 acres. The Grand Circus Park of 4½ acres, with its trees, flowers and fountains, affords a pleasant resting place in the busiest quarter of the city. Six miles farther out on Woodward Avenue is Palmer Park of about 140 acres, given to the city in 1894 and named in honour of the donor. Clark Park (28 acres) is in the W. part of the city, and there are various smaller parks. The principal cemeteries are Elmwood (Protestant) and Mount Elliott (Catholic), which lie adjoining in the E. part of the city; Woodmere in the W. and Woodlawn in the N. part of the city.

Charity and Education.—Among the charitable institutions are the general hospitals (Harper, Grace and St Mary's); the Detroit Emergency, the Children's Free and the United States Marine hospitals; St Luke's hospital, church home, and orphanage; the House of Providence (a maternity hospital and infant asylum); the Woman's hospital and foundling's home; the Home for convalescent children, &c. In 1894 the mayor, Hazen Senter Pingree (1842-1901), instituted the practice of preparing, through municipal aid and supervision, large tracts of vacant land in and about the city for the growing of potatoes and other vegetables and then, in conjunction with the board of poor commissioners, assigning it in small lots to families of the unemployed, and furnishing them with seed for planting. This plan served an admirable purpose through three years of industrial depression, and was copied in other cities; it was abandoned when, with the renewal of industrial activity, the necessity for it ceased. The leading penal institution of the city is the Detroit House of Correction, noted for its efficient reformatory work; the inmates are employed ten hours a day, chiefly in making furniture. The house of correction pays the city a profit of $35,000 to $40,000 a year. The educational institutions, in addition to those of the general public school system, include several parochial schools, schools of art and of music, and commercial colleges; Detroit College (Catholic), opened in 1877; the Detroit College of Medicine, opened in 1885; the Michigan College of Medicine and Surgery, opened in 1888; the Detroit College of law, founded in 1891, and a city normal school.

Commerce.—Detroit's location gives to the city's shipping and shipbuilding interests a high importance. All the enormous traffic between the upper and lower lakes passes through the Detroit river. In 1907 the number of vessels recorded was 34,149, with registered tonnage of 53,959,769, carrying 71,226,895 tons of freight, valued at $697,311,302. This includes vessels which delivered part or all of their cargo at Detroit. The largest item in the freights is iron ore on vessels bound down. The next is coal on vessels up bound. Grain and lumber are the next largest items. Detroit is a port of entry, and its foreign commerce, chiefly with Canada, is of growing importance. The city's exports increased from $11,325,807 in 1896 to $37,085,027 in 1909. The imports were $3,153,609 in 1896 and $7,100,659 in 1909.

As a manufacturing city, Detroit holds high rank. The total number of manufacturing establishments in 1890 was 1746, with a product for the year valued at $77,351,546; in 1900 there were 2847 establishments with a product for the year valued at $100,892,838; or an increase of 30.4% in the decade. In 1900 the establishments under the factory system, omitting the hand trades and neighbourhood industries, numbered 1259 and produced goods valued at $88,365,924; in 1904 establishments under the factory system numbered 1363 and the product had increased 45.7% to $128,761,658. In the district subsequently annexed the product in 1904 was about $12,000,000, making a total of $140,000,000. The output for 1906 was estimated at $180,000,000. The state factory inspectors in 1905 visited 1721 factories having 83,231 employees. In 1906 they inspected 1790 factories with 93,071 employees. Detroit is the leading city in the country in the manufacture of automobiles. In 1904 the value of its product was one-fifth that for the whole country. In 1906 the city had twenty automobile factories, with an output of 11,000 cars, valued at $12,000,000. Detroit is probably the largest manufacturer in the country of freight cars, stoves, pharmaceutical preparations, varnish, soda ash and similar alkaline products. Other important manufactures are ships, paints, foundry and machine shop products, brass goods, furniture, boots and shoes, clothing, matches, cigars, malt liquors and fur goods; and slaughtering and meat packing is an important industry.

The Detroit Board of Commerce, organized in 1903, brought into one association the members of three former bodies, making a compact organization with civic as well as commercial aims. The board has brought into active co-operation nearly all the leading business men of the city and many of the professional men. Their united efforts have brought many new industries to the city, have improved industrial conditions, and have exerted a beneficial influence upon the municipal administration. Other business organizations are the Board of Trade, devoted to the grain trade and kindred lines, the Employers' Association, which seeks to maintain satisfactory relations between employer and employed, the Builders' & Traders' Exchange, and the Credit Men's Association.

Administration.—Although the city received its first charter in 1806, and another in 1815, the real power rested in the hands of the governor and judges of the territory until 1824; the charters of 1824 and 1827 centred the government in a council and made the list of elective officers long; the charter of 1827 was revised in 1857 and again in 1859 and the present charter dates from 1883. Under this charter only three administrative officers are elected,—the mayor, the city clerk and the city treasurer,—elections being biennial. The administration of the city departments is largely in the hands of commissions. There is one commissioner each, appointed by the mayor, for the parks and boulevards, police and public works departments. The four members of the health board are nominated by the governor and confirmed by the state senate. The school board is an independent body, consisting of one elected member from each ward holding office for four years, but the mayor has the veto power over its proceedings as well as those of the common council. In each case a two-thirds vote overrules his veto. The other principal officers and commissions, appointed by the mayor and confirmed by the council, are controller, corporation counsel, board of three assessors, fire commission (four members), public lighting commission (six members), water commission (five members), poor commission (four members), and inspectors of the house of correction (four in number). The members of the public library commission, six in number, are elected by the board of education. Itemized estimates of expenses for the next fiscal year are furnished by the different departments to the controller in February. He transmits them to the common council with his recommendations. The council has four weeks in which to consider them. It may reduce or increase the amounts asked, and may add new items. The budget then goes to the board of estimates, which has a month for its consideration. This body consists of two members elected from each ward and five elected at large. The mayor and heads of departments are advisory members, and may speak but not vote. The members of the board of estimates can hold no other office and they have no appointing power, the intention being to keep them as free as possible from all political motives and influences. They may reduce or cut out any estimates submitted, but cannot increase any or add new ones. No bonds can be issued without the assent of the board of estimates. The budget is apportioned among twelve committees which have almost invariably given close and conscientious examination to the actual needs of the departments. A reduction of $1,000,000 to $1,500,000, without impairing the service, has been a not unusual result of their deliberations. Prudent management under this system has placed the city in the highest rank financially. Its debt limit is 2% on the assessed valuation, and even that low maximum is not often reached. The debt in 1907 was only about $5,500,000, a smaller *per capita* debt than that of any other city of over 100,000 inhabitants in the country; the assessed valuation was $330,000,000; the city tax, $14.70 on the thousand dollars of assessed valuation. Both the council and the estimators are hampered in their work by legislative interference. Nearly all the large salaries and many of those of the second grade are made mandatory by the legislature, which has also determined many affairs of a purely administrative character.

Detroit has made three experiments with municipal ownership. On account of inadequate and unsatisfactory service by a private company, the city bought the water-works as long ago as 1836. The works have been twice moved and enlargements have been made in advance of the needs of the city. In 1907 there were six engines in the works with a pumping capacity of 152,000,000 gallons daily. The daily average of water used during the preceding year was 61,357,000 gallons. The water is pumped from Lake St Clair and is of exceptional purity. The city began its own public lighting in April 1895, having a large plant on the river near the centre of the city. It lights the streets and public buildings, but makes no provision for commercial business. The lighting is excellent, and the cost is probably less than could be obtained from a private company. The street lighting is done partly from pole and arm lights, but largely from steel towers from 100 ft. to 180 ft. in height, with strong reflected lights at the top. The city also owns two portable asphalt plants, and thus makes a saving in the cost of street repairing and resurfacing. With a view of effecting the reduction of street car fares to three cents, the state legislature in 1899 passed an act for purchasing or leasing the street railways of the city, but the Supreme Court pronounced this act unconstitutional on the ground that, as the constitution prohibited the state from engaging in a work of internal improvement, the state could not empower a municipality to do so. Certain test votes indicated an almost even division on the question of municipal ownership of the railways.

History.—Detroit was founded in 1701 by Antoine Laumet de la Mothe Cadillac (c. 1661-1730), who had pointed out the importance of the place as a strategic point for determining the control of the fur trade and the possession of the North-west and had received assistance from the French government soon after Robert Livingston (1654-1725), the secretary of the Board of Indian Commissioners in New York, had urged the English government to establish a fort at the same place. Cadillac arrived on the 24th of July with about 100 followers. They at once built a palisade fort about 200 ft. square S. of what is now Jefferson Avenue and between Griswold and Shelby streets, and named it Fort Pontchartrain in honour of the French colonial minister. Indians at once came to the place in large numbers, but they soon complained of the high price of French goods; there was serious contention between Cadillac and the French Canadian Fur Company, to which a monopoly of the trade had been granted, as well as bitter rivalry between him and the Jesuits. After the several parties had begun to complain to the home government the monopoly of the fur trade was transferred to Cadillac and he was exhorted to cease quarrelling with the Jesuits. Although the inhabitants then increased to 200 or more, dissatisfaction with the paternal rule of the founder increased until 1710, when he was made governor of Louisiana. The year before, the soldiers had been withdrawn; by the second year after there was serious trouble with the Indians, and for several years following the population was greatly reduced and the post threatened with extinction. But in 1722, when the Mississippi country was opened, the population once more increased, and again in 1748, when the settlement of the Ohio Valley began, the governor-general of Canada offered special inducements to Frenchmen to settle at Detroit, with the result that the population was soon more than 1000 and the cultivation of farms in the vicinity was begun. In 1760, however, the place was taken by the British under Colonel Robert Rogers and an English element was introduced into the population which up to this time had been almost exclusively French. Three years later, during the conspiracy of Pontiac, the fort first narrowly escaped capture and then suffered from a siege lasting from the 9th of May until the 12th of October. Under English rule it continued from this time on as a military post with its population usually reduced to less than 500. In 1778 a new fort was built and named Fort Lernault, and during the War of Independence the British sent forth from here several Indian expeditions to ravage the frontiers. With the ratification of the treaty which concluded that war the title to the post passed to the United States in 1783, but the post itself was not surrendered until the 11th of January 1796, in accordance with Jay's Treaty of 1794. It was then named Fort Shelby; but in 1802 it was incorporated as a town and received its present name. In 1805 all except one or two buildings were destroyed by fire. General William Hull (1753-1825), a veteran of the War of American Independence, governor of Michigan territory in 1805-1812, as commander of the north-western army in 1812 occupied the city. Failing to hear immediately of the declaration of war between the United States and Great Britain, he was cut off from his supplies shipped by Lake Erie. He made from Detroit on the 12th of July an awkward and futile advance into Canada, which, if more vigorous, might have resulted in the capture of Malden and the establishment of American troops in Canada, and then retired to his fortifications. On the 16th of August 1812, without any resistance and without consulting his officers, he surrendered the city to General Brock, for reasons of humanity, and afterwards attempted to justify himself by criticism of the War Department in general and in particular of General Henry Dearborn's armistice with Prevost, which had not included in its terms Hull, whom Dearborn had been sent out to reinforce.[1] After Perry's victory on the 14th of September on Lake Erie, Detroit on the 29th of September was again occupied by the forces of the United States. Its growth was rather slow until 1830, but since then its progress has been unimpeded. Detroit was the capital of Michigan from 1805 to 1847.

Authorities.—Silas Farmer, *The History of Detroit and Michigan* (Detroit, 1884 and 1889), and "Detroit, the Queen City," in L. P. Powell's *Historic Towns of the Western States* (New York and London, 1901); D. F. Wilcox, "Municipal Government in Michigan and Ohio," in *Columbia University Studies* (New York, 1896); C. M. Burton, *"Cadillac's Village" or Detroit under Cadillac* (Detroit, 1896); Francis Parkman, *A Half Century of Conflict* (Boston, 1897); and *The Conspiracy of Pontiac* (Boston, 1898); and the annual *Reports* of the Detroit Board of Commerce (1904 sqq.).

[1] Hull was tried at Albany in 1814 by court martial, General Dearborn presiding, was found guilty of treason, cowardice, neglect of duty and unofficerlike conduct, and was sentenced to be shot; the president remitted the sentence because of Hull's services in the Revolution.

DETTINGEN, a village of Germany in the kingdom of Bavaria, on the Main, and on the Frankfort-on-Main-Aschaffenburg railway, 10 m. N.W. of Aschaffenburg. It is memorable as the scene of a decisive battle on the 27th of June 1743, when the English, Hanoverians and Austrians (the "Pragmatic army"), 42,000 men under the command of George II. of England, routed the numerically superior French forces under the duc de Noailles. It was in memory of this victory that Handel composed his *Dettingen Te Deum*.

DEUCALION, in Greek legend, son of Prometheus, king of Phthia in Thessaly, husband of Pyrrha, and father of Hellen, the mythical ancestor of the Hellenic race. When Zeus had resolved to destroy all mankind by a flood, Deucalion constructed a boat or ark, in which, after drifting nine days and nights, he landed on Mount Parnassus (according to others, Othrys, Aetna or Athos) with his wife. Having offered sacrifice and inquired how to renew the human race, they were ordered to cast behind them the "bones of the great mother," that is, the stones from the hillside. The stones thrown by Deucalion became men, those thrown by Pyrrha, women.

See Apollodorus i. 7, 2; Ovid, *Metam*. i. 243-415; Apollonius Rhodius iii. 1085 ff.; H. Usener, *Die Sintflutsagen* (1899).

DEUCE (a corruption of the Fr. *deux*, two), a term applied to the "two" of any suit of cards, or of dice. It is also a term used in tennis when both sides have each scored three points in a game, or five games in a set; to win the game or set two points or games must then be won consecutively. The earliest instances in English of the use of the slang expression "the deuce," in exclamations and the like, date from the middle of the 17th century. The meaning was similar to that of "plague" or "mischief" in such phrases as "plague on you," "mischief take you" and the like. The use of the word as an euphemism for "the devil" is later. According to the *New English Dictionary* the most probable derivation is from a Low German *das daus*, i.e. the "deuce" in dice, the lowest and therefore the most unlucky throw. The personification, with a consequent change of gender, to *der daus*, came later. The word has also been identified with the name of a giant or goblin in Teutonic mythology.

DEUS, JOÃO DE (1830-1896), the greatest Portuguese poet of his generation, was born at San Bartholomeu de Messines in the province of Algarve on the 8th of March 1830. Matriculating in the faculty of law at the university of Coimbra, he did not proceed to his degree but settled in the city, dedicating himself wholly to the composition of verses, which circulated among professors and undergraduates in manuscript copies. In the volume of his art, as in the conduct of life, he practised a rigorous self-control. He printed nothing previous to 1855, and the first of his poems to appear in a separate form was *La Lata*, in 1860. In 1862 he left Coimbra for Beja, where he was appointed editor of *O Bejense*, the chief newspaper in the province of Alemtejo, and four years later he edited the *Folha do Sul*. As the pungent satirical verses entitled *Eleições* prove, he was not an ardent politician, and, though he was returned as Liberal deputy for the constituency of Silves in 1869, he acted independently of all political parties and promptly resigned his mandate. The renunciation implied in the act, which cut him off from all advancement, is in accord with nearly all that is known of his lofty character. In the year of his election as deputy, his friend José Antonio Garcia Blanco collected from local journals the series of poems, *Flores do campo*, which is supplemented by the *Ramo de flores* (1869). This is João de Deus's masterpiece. *Pires de Marmalada* (1869) is an improvisation of no great merit. The four theatrical pieces—*Amemos o nosso proximo*, *Ser apresentado*, *Ensaio de Casamento*, and *A Viúva inconsolavel*—are prose translations from Méry, cleverly done, but not worth the doing. *Horacio e Lydia* (1872), a translation from Ronsard, is a good example of artifice in manipulating that dangerously monotonous measure, the Portuguese couplet. As an indication of a strong spiritual reaction three prose fragments (1873)—*Anna, Mãe de Maria*, *A Virgem Maria* and *A Mulher do Levita de Ephrain*—translated from Darboy's *Femmes de la Bible*, are full of significance. The *Folhas soltas* (1876) is a collection of verse in the manner of *Flores do campo*, brilliantly effective and exquisitely refined. Within the next few years the writer turned his attention to educational problems, and in his *Cartilha maternal* (1876) first expressed the conclusions to which his study of Pestalozzi and Fröbel had led him. This patriotic, pedagogical apostolate was a misfortune for Portuguese literature; his educational mission absorbed João de Deus completely, and is responsible for numerous controversial letters, for a translation of Théodore-Henri Barrau's treatise, *Des devoirs des enfants envers leurs parents*, for a prosodic dictionary and for many other publications of no literary value. A copy of verses in Antonio Vieira's *Grinalda de Maria* (1877), the *Loas á Virgem* (1878) and the *Proverbios de Salomão* are evidence of a complete return to orthodoxy during the poet's last years. By a lamentable error of judgment some worthless pornographic verses entitled *Cryptinas* have been inserted in the completest edition of João de Deus's poems—*Campo de Flores* (Lisbon, 1893). He died at Lisbon on the 11th of January 1896, was accorded a public funeral and was buried in the National Pantheon, the Jeronymite church at Belem, where repose the remains of Camoens, Herculano and Garrett. His scattered minor prose writings and correspondence have been posthumously published by Dr Theophilo Braga (Lisbon, 1898).

Next to Camoens and perhaps Garrett, no Portuguese poet has been more widely read, more profoundly admired than João de Deus; yet no poet in any country has been more indifferent to public opinion and more deliberately careless of personal fame. He is not responsible for any single edition of his poems, which were put together by pious but ill-informed enthusiasts, who ascribed to him verses that he had not written; he kept no copies of his compositions, seldom troubled to write them himself, and was content for the most part to dictate them to others. He has no great intellectual force, no philosophic doctrine, is limited in theme as in outlook, is curiously uncertain in his touch, often marring a fine poem with a slovenly rhyme or with a misplaced accent; and, on the only occasion when he was induced to revise a set of proofs, his alterations were nearly all for the worse. And yet, though he never appealed to the patriotic spirit, though he wrote nothing at all comparable in force or majesty to the restrained splendour of *Os Lusiadas*, the popular instinct which links his name with that of his great predecessor is eminently just. For Camoens was his model; not the Camoens of the epic, but the Camoens of the lyrics and the sonnets, where the passion of tenderness finds its supreme utterance. Braga has noted five stages of development in João de Deus's artistic life—the imitative, the idyllic, the lyric, the pessimistic and the devout phases. Under each of these divisions is included much that is of extreme interest, especially to contemporaries who have passed through the same succession of emotional experience, and it is highly probable that *Caturras* and *Gaspar*, pieces as witty as anything in Bocage but free from Bocage's coarse impiety, will always interest literary students. But it is as the singer of love that João de Deus will delight posterity as he delighted his own generation. The elegiac music of *Rachel* and of *Marina*, the melancholy of *Adeus* and of *Remoinho*, the tenderness and sincerity of *Meu casta lirio*, of *Lagrima celeste*, of *Descalça* and a score more songs are distinguished by the large, vital simplicity which withstands time. It is precisely in the quality of unstudied simplicity that João de Deus is incomparably strong. The temptations to a display of virtuosity are almost irresistible for a Portuguese poet; he has the tradition of virtuosity in his blood, he has before him the example of all contemporaries, and he has at hand an instrument of wonderful sonority and compass. Yet not once is João de Deus clamorous or rhetorical, not once does he indulge in idle ornament. His prevailing note is that of exquisite sweetness and of reverent purity; yet with all his caressing softness he is never sentimental, and, though he has not the strength for a long fight, emotion has seldom been set to more delicate music. Had he included among his other gifts the gift of selection, had he continued the poetic discipline of his youth instead of dedicating his powers to a task which, well as he performed it, might have been done no less well by a much lesser man, there is scarcely any height to which he might not have risen.

See also Maxime Formont, *Le Mouvement poétique contemporain en Portugal* (Lyon, 1892).

(J. F.-K.)

DEUTERONOMY, the name of one of the books of the Old Testament. This book was long the storm-centre of Pentateuchal criticism, orthodox scholars boldly asserting that any who questioned its Mosaic authorship reduced it to the level of a pious fraud. But Biblical facts have at last triumphed over tradition, and the non-Mosaic authorship of Deuteronomy is now a commonplace of criticism. It is still instructive, however, to note the successive phases through which scholarly opinion regarding the composition and date of his book has passed.

In the 17th century the characteristics which so clearly mark off Deuteronomy from the other four books of the Pentateuch were frankly recognized, but the most advanced critics of that age were inclined to pronounce it the earliest and most authentic of the five. In the beginning of the 19th century de Wette startled the religious world by declaring that Deuteronomy, so far from being Mosaic, was not known till the time of Josiah. This theory he founded on 2 Kings xxii.; and ever since, this chapter has been one of the recognized foci of Biblical criticism. The only other single chapter of the Bible which is responsible for having brought about a somewhat similar revolution in critical opinion is Ezek. xliv. From this chapter, some seventy years after de Wette's discovery, Wellhausen with equal acumen inferred that Leviticus was not known to Ezekiel, the priest, and therefore could not have been in existence in his day; for had Leviticus been the recognized Law-book of his nation Ezekiel could not have represented as a degradation the very position which that Law-book described as a special honour conferred on the Levites by Yahweh himself. Hence Leviticus, so far from belonging to an earlier stratum of the Pentateuch than Deuteronomy, as de Wette thought, must belong to a much later stratum, and be at least exilic, if not post-exilic.

The title "Deuteronomy" is due to a mistranslation by the Septuagint of the clause in chap. xvii. 18, rendered "and he shall write out for himself this Deuteronomy." The Hebrew really means "and he [the king] shall write out for himself a copy of this law," where there is not the slightest suggestion that the author intended to describe "this law" delivered on the plains of Moab as a second code in contradistinction to the first code given on Sinai thirty-eight years earlier. Moreover the phrase "this law" is so ambiguous as to raise a much greater difficulty than that caused by the Greek mistranslation of the Hebrew word for "copy." How much does "this law" include? It was long supposed to mean the whole of our present Deuteronomy; indeed, it is on that supposition that the traditional view of the Mosaic authorship is based. But the context alone can determine the question; and that is often so ambiguous that a sure inference is impossible. We may safely assert, however, that nowhere need "this law" mean the whole book. In fact, it invariably means very much less, and sometimes, as in xxvii. 3, 8, so little that it could all be engraved in large letters on a few plastered stones set up beside an altar.

Deuteronomy is not the work of any single writer but the result of a long process of development. The fact that it is legislative as well as hortatory is enough to prove this, for most of the laws it contains are found elsewhere in the Pentateuch, sometimes in less developed, sometimes in more developed forms, a fact which is conclusive proof of prolonged historical development. According to the all-pervading law of evolution, the less complex form must have preceded the more complex. Still, the book does bear the stamp of one master-mind. Its style is as easily recognized as that of

Deutero-Isaiah, being as remarkable for its copious diction as for its depths of moral and religious feeling.

The original Deuteronomy, D, read to King Josiah, cannot have been so large as our present book, for not only could it be read at a single sitting, but it could be easily read twice in one day. On the day it was found, Shaphan first read it himself, and then went to the king and read it aloud to him. But perhaps the most conclusive proof of its brevity is that it was read publicly to the assembled people immediately before they, as well as their king, pledged themselves to obey it; and not a word is said as to the task of reading it aloud, so as to be heard by such a great multitude, being long or difficult.

The legislative part of D consists of fifteen chapters (xii.-xxvi.), which, however, contain many later insertions. But the impression made upon Josiah by what he heard was far too deep to have been produced by the legislative part alone. The king must have listened to the curses as well as the blessings in chap, xxviii., and no doubt also to the exhortations in chaps. v.-xi. Hence we may conclude that the original book consisted of a central mass of religious, civil and social laws, preceded by a hortatory introduction and followed by an effective peroration. The book read to Josiah must therefore have comprised most of what is found in Deut. v.-xxvi., xxvii. 9, 10 and xxviii. But something like two centuries elapsed before the book reached its present form, for in the closing chapter, as well as elsewhere, e.g. i. 41-43 (where the joining is not so deftly done as usual) and xxxii. 48-52, there are undoubted traces of the Priestly Code, P, which is generally acknowledged to be post-exilic.

The following is an analysis of the main divisions of the book as we now have it. There are two introductions, the first i.-iv. 44, more historical than hortatory; the second v.-xi., more hortatory than historical. These may at first have been prefixed to separate editions of the legislative portion, but were eventually combined. Then, before D was united to P, five appendices of very various dates and embracing poetry as well as prose, were added so as to give a fuller account of the last days of Moses and thus lead up to the narrative of his death with which the book closes. (1) Chap. xxvii., where the elders of Israel are introduced for the first time as acting along with Moses (xxvii. 1) and then the priests, the Levites (xxvii. 9). Some of the curses refer to laws given not in D but in Lev. xxx., so that the date of this chapter must be later than Leviticus or at any rate than the laws codified in the Law of Holiness (Lev. xvii.-xxvi.). (2) The second appendix, chaps, xxix.-xxxi. 29, xxxii. 45-47, gives us the farewell address of Moses and is certainly later than D. Moses is represented as speaking not with any hope of preventing Israel's apostasy but because he knows that the people will eventually prove apostate (xxxi. 29), a point of view very different from D's. (3) The Song of Moses, chap. xxxii. That this didactic poem must have been written late in the nation's history, and not at its very beginning, is evident from v. 7: "Remember the days of old, Consider the years of many generations." Such words cannot be interpreted so as to fit the lips of Moses. It must have been composed in a time of natural gloom and depression, after Yahweh's anger had been provoked by "a very froward generation," certainly not before the Assyrian Empire had loomed up against the political horizon, aggressive and menacing. Some critics bring the date down even to the time of Jeremiah and Ezekiel. (4) The Blessing of Moses, chap, xxxiii. The first line proves that this poem is not by D, who speaks invariably of Horeb, never of Sinai. The situation depicted is in striking contrast with that of the Song. Everything is bright because of promises fulfilled, and the future bids fair to be brighter still. Bruston maintains with reason that the Blessing, strictly so called, consists only of vv. 6-25, and has been inserted in a Psalm celebrating the goodness of Jehovah to his people on their entrance into Canaan (vv. 1-5, 26-29). The special prominence given to Joseph (Ephraim and Manasseh) in vv. 13-17 has led many critics to assign this poem to the time of the greatest warrior-king of Northern Israel, Jeroboam II. (5) The account of Moses' death, chap. xxxiv. This appendix, containing, as it does, manifest traces of P, proves that even Deuteronomy was not put into its present form until after the exile.

From the many coincidences between D and the Book of the Covenant (Ex. xx.-xxiii.) it is clear that D was acquainted with E, the prophetic narrative of the Northern kingdom; but it is not quite clear whether D knew E as an independent work, or after its combination with J, the somewhat earlier prophetic narrative of the Southern kingdom, the combined form of which is now indicated by the symbol JE. Kittel certainly puts it too strongly when he asserts that D quotes always from E and never from J, for some of the passages alluded to in D may just as readily be ascribed to J as to E, cf. Deut. i. 7 and Gen. xv. 18; Deut. x. 14 and Ex. xxxiv. 1-4. Consequently D must have been written certainly after E and possibly after E was combined with J.

In Amos, Hosea and Isaiah there are no traces of D's ideas, whereas in Jeremiah and Ezekiel their influence is everywhere manifest. Hence this school of thought arose between the age of Isaiah and that of Jeremiah; but how long D itself may have been in existence before it was read in 622 to Josiah cannot be determined with certainty. Many argue that D was written immediately before it was found and that, in fact, it was put into the temple for the purpose of being "found." This theory gives some plausibility to the charge that the book is a pious fraud. But the narrative in 2 Kings xxii. warrants no such inference. The more natural explanation is that it was written not in the early years of Josiah's reign, and with the cognizance of the temple priests then in office, but some time during the long reign of Manasseh, probably when his policy was most reactionary and when he favoured the worship of the "host of heaven" and set up altars to strange gods in Jerusalem itself. This explains why the author did not publish his work immediately, but placed it where he hoped it would be safely preserved till opportunity should arise for its publication. One need not suppose that he actually foresaw how favourable that opportunity would prove, and that, as soon as discovered, his work would be promulgated as law by the king and willingly accepted by the people. The author believed that everything he wrote was in full accordance with the mind of Moses, and would contribute to the national weal of Yahweh's covenant people, and therefore he did not scruple to represent Moses as the speaker. It is not to be expected that modern scholars should be able to fix the exact year or even decade in which such a book was written. It is enough to determine with something like probability the century or half-century which best fits its historical data; and these appear to point to the reign of Manasseh.

Between D and P there are no verbal parallels; but in the historical résumés JE is followed closely, whole clauses and even verses being copied practically verbatim. As Dr Driver points out in his careful analysis, there are only three facts in D which are not also found in JE, viz. the number of the spies, the number of souls that went down into Egypt with Jacob, and the ark being made of acacia wood. But even these may have been in J or E originally, and left out when JE was combined with P. Steuernagel divides the legal as well as the hortatory parts of D between two authors, one of whom uses the 2nd person plural when addressing Israel, and the other the 2nd person singular; but as a similar alternation is constantly found in writings universally acknowledged to be by the same author, this clue seems anything but trustworthy, depending as it does on the presence or absence of a single Hebrew letter, and resulting, as it frequently does, in the division of verses which otherwise seem to be from the same pen (cf. xx. 2). The inference as to diversity of authorship is much more conclusive when difference of standpoint can be proved, cf. v. 3, xi. 2 ff. with viii. 2. The first two passages represent Moses as addressing the generation that was alive at Horeb, whereas the last represents him as speaking to those who were about to pass over Jordan a full generation later; and it may well be that the one author may, in the historical and hortatory parts, have preferred the 2nd plural and the other the 2nd singular; without the further inference being justified that every law in which the 2nd singular is used must be assigned to the latter, and every law in which the 2nd plural occurs must be due to the former.

The law of the Single Sanctuary, one of D's outstanding characteristics, is, for him, an innovation, but an innovation towards which events had long been tending. 2 Kings xxiii. 9 shows that even the zeal of Josiah could not carry out the instructions laid down in D xviii. 6-8. Josiah's acceptance of D made it the first canonical book of scripture. Thus the religion of Judah became henceforward a religion which enabled its adherents to learn from a book exactly what was required of them. D requires the destruction not only of the high places and the idols, but of the Asheras (wooden posts) and the Mazzebas (stone pillars) often set up beside the altar of Jehovah (xvi. 21). These reforms made too heavy demands upon the people, as was proved by the reaction which set in at Josiah's death. Indeed the country people would look on the destruction of the high places with their Asheras and Mazzebas as sacrilege and would consider Josiah's death in battle as a divine punishment for his sacrilegious deeds. On the other hand, the destruction of Jerusalem and the exile of the people would appear to those who had obeyed D's instructions as a well-merited punishment for national apostasy.

Moreover, D regarded religion as of the utmost moment to each individual Israelite; and it is certainly not by accident that the declaration of the individual's duty towards God immediately follows the emphatic intimation to Israel of Yahweh's unity. "Hear, O Israel, Yahweh is our God, Yahweh is one: and thou shalt love Yahweh thy God with all thine heart and with all thy soul and with all thy strength" (vi. 4, 5).

In estimating the religious value of Deuteronomy it should never be forgotten that upon this passage the greatest eulogy ever pronounced on any scripture was pronounced by Christ himself, when he said "on these words hang all the law and the prophets," and it is also well to remember that when tempted in the wilderness he repelled each suggestion of the Tempter by a quotation from Deuteronomy.

Nevertheless even such a writer as D could not escape the influence of the age and atmosphere in which he lived; and despite the spirit of love which breathes so strongly throughout the book, especially for the poor, the widow and the fatherless, the stranger and the homeless Levite (xxiv. 10-22), and the humanity shown towards both beasts and birds (xxii. 1, 4, 6 f., xxv. 4), there are elements in D which go far to explain the intense exclusiveness and the religious intolerance characteristic of Judaism. Should a man's son or friend dear to him as his own soul seek to tempt him from the faith of his fathers, D's pitiless order to that man is "Thou shalt surely kill him; thine hand shall be first upon him to put him to death." From this single instance we see not only how far mankind has travelled along the path of religious toleration since Deuteronomy was written, but also how very far the criticism implied in Christ's method of dealing with what "was said to them of old time" may be legitimately carried.

(J. A. P.*)

DEUTSCH, IMMANUEL OSCAR MENAHEM (1829-1873), German oriental scholar, was born on the 28th of October 1829, at Neisse in Prussian Silesia, of Jewish extraction. On reaching his sixteenth year he began his studies at the university of Berlin, paying special attention to theology and the Talmud. He also mastered the English language and studied English literature. In 1855 Deutsch was appointed assistant in the library of the British Museum. He worked intensely on the Talmud and contributed no less than 190 papers to *Chambers's Encyclopaedia*, in addition to essays in Kitto's and Smith's Biblical Dictionaries, and articles in periodicals. In October 1867 his article on "The Talmud," published in the *Quarterly Review*, made him known. It was translated into French, German, Russian, Swedish, Dutch and Danish. He died at Alexandria on the 12th of May 1873.

His *Literary Remains*, edited by Lady Strangford, were published in 1874, consisting of nineteen papers on such subjects as "The Talmud," "Islam," "Semitic Culture," "Egypt, Ancient and Modern," "Semitic Languages," "The Targums," "The Samaritan Pentateuch," and "Arabic Poetry."

DEUTSCHKRONE, a town of Germany, kingdom of Prussia, between the two lakes of Arens and Radau, 15 m. N.W. of Schneidemühl, a railway junction 60 m. north of Posen. Pop. (1905) 7282. It is the seat of the public offices for the district, possesses an Evangelical and a Roman Catholic church, a synagogue, and a gymnasium established in the old Jesuit college, and has manufactures of machinery, woollens, tiles, brandy and beer.

DEUTZ (anc. *Divitio*), formerly an independent town of Germany, in the Prussian Rhine Province, on the right bank of the Rhine, opposite to Cologne, with which it has been incorporated since 1888. It contains the church of St Heribert, built in the 17th century, cavalry barracks, artillery magazines, and gas, porcelain, machine and carriage factories. It has a handsome railway station on the banks of the Rhine, negotiating the local traffic with Elberfeld and Königswinter. The fortifications of the town form part of the defences of Cologne. To the east is the manufacturing suburb of Kalk.

The old castle in Deutz was in 1002 made a Benedictine monastery by Heribert, archbishop of Cologne. Permission to fortify the town was in 1230 granted to the citizens by the archbishop of Cologne, between whom and the counts of Berg it was in 1240 divided. It was burnt in 1376, 1445 and 1583; and in 1678, after the peace of Nijmwegen, the fortifications were dismantled; rebuilt in 1816, they were again razed in 1888.

DEUX-SÈVRES, an inland department of western France, formed in 1790 mainly of the three districts of Poitou, Thouarsais, Gâtine and Niortais, added to a small portion of Saintonge and a still smaller portion of Aunis. Area, 2337 sq. m. Pop. (1906) 339,466. It is bounded N. by Maine-et-Loire, E. by Vienne, S.E. by Charente, S. by Charente-Inférieure and W. by Vendée. The department takes its name from two rivers—the Sèvre of Niort which traverses the southern portion, and the Sèvre of Nantes (an affluent of the Loire) which drains the north-west. There are three regions—the Gâtine, occupying the north and centre of the department, the Plaine in the south and the Marais,—distinguished by their geological character and their general physical appearance. The Gâtine, formed of primitive rocks (granite and schists), is the continuation of the "Bocage" of Vendée and Maine-et-Loire. Its surface is irregular and covered with hedges and clumps of wood or forests. The systematic application of lime has much improved the soil, which is naturally poor. The Plaine, resting on oolite limestone, is treeless but fertile. The Marais, a low-lying district in the extreme southwest, consists of alluvial clays which also are extremely productive when properly drained. The highest points, several of which exceed 700 ft., are found in a line of hills which begins in the centre of the department, to the south of Parthenay, and stretches north-west into the neighbouring department of Vendée. It divides the region drained by the Sèvre Nantaise and the Thouet (both affluents of the Loire) in the north from the basins of the Sèvre Niortaise and the Charente in the south. The climate is mild, the annual temperature at Niort being 54° Fahr., and the rainfall nearly 25 in. The winters are colder in the Gâtine, the summers warmer in the Plaine.

Three-quarters of the entire area of Deux-Sèvres, which is primarily an agricultural department, consists of arable land. Wheat and oats are the main cereals. Potatoes and mangold-wurzels are the chief root-crops. Niort is a centre for the growing Of vegetables (onions, asparagus, artichokes, &c.) and of angelica. Considerable quantities of beetroot are raised to supply the distilleries of Melle. Colza, hemp, rape and flax are also cultivated. Vineyards are numerous in the neighbourhood of Bressuire in the north, and of Niort and Melle in the south. The department is well known for the Parthenay breed of cattle and the Poitou breed of horses; and the mules reared in the southern arrondissements are much sought after both in France and in Spain. The system of co-operative dairying is practised in some localities. The apple-trees of the Gâtine and the walnut-trees of the Plaine bring a good return. Coal is mined, and the department produces building-stone and lime. A leading industry is the manufacture of textiles (serges, druggets, linen, handkerchiefs, flannels, swanskins and knitted goods). Tanning and leather-dressing are carried on at Niort and other places, and gloves are made at Niort. Wool and cotton spinning, hat and shoe making, distilling, brewing, flour-milling and oil-refining are also main industries. The department exports cattle and sheep to Paris and Poitiers; also cereals, oils, wines, vegetables and its industrial products.

The Sèvre Niortaise and its tributary the Mignon furnish 19 m. of navigable waterway. The department is served by the Ouest-État railway. It contains a large proportion of Protestants, especially in the south-east. The four arrondissements are Niort, Bressuire, Melle and Parthenay; the cantons number 31, and the communes 356. Deux-Sèvres is part of the region of the IX. army corps, and of the diocese and the académie (educational circumscription) of Poitiers, where also is its court of appeal.

Niort (the capital), Bressuire, Melle, Parthenay, St Maixent, Thouars and Oiron are the principal places in the department. Several other towns contain features of interest. Among these are Airvault, where there is a church of the 12th and 14th centuries which once belonged to the abbey of St Pierre, and an ancient bridge built by the monks; Celles-sur-Belle, where there is an old church rebuilt by Louis XI., and again in the 17th century; and St Jouin-de-Marnes, with a fine Romanesque church with Gothic restoration, which belonged to one of the most ancient abbeys of Gaul.

DEVA (Sanskrit "heavenly"), in Hindu and Buddhist mythology, spirits of the light and air, and minor deities generally beneficent. In Persian mythology, however, the word is used for evil spirits or demons. According to Zoroaster the devas were created by Ahriman.

DEVA (mod. *Chester*), a Roman legionary fortress in Britain on the Dee. It was occupied by Roman troops about A.D. 48 and held probably till the end of the Roman dominion. Its garrison was the Legio XX. Valeria Victrix, with which another legion (II. Adjutrix) was associated for a few years, about A.D. 75-85. It never developed, like many Roman legionary fortresses, into a town, but remained military throughout. Parts of its north and east walls (from Morgan's Mount to Peppergate) and numerous inscriptions remain to indicate its character and area.

See F. J. Haverfield, *Catalogue of the Grosvenor Museum, Chester* (Chester, 1900), Introduction.

DEVADATTA, the son of Suklodana, who was younger brother to the father of the Buddha (*Mahāvastu*, iii. 76). Both he and his brother Ānanda, who were considerably younger than the Buddha, joined the brotherhood in the twentieth year of the Buddha's ministry. Four other cousins of theirs, chiefs of the Sākiya clan, and a barber named Upāli, were admitted to the order at the same time; and at their own request the barber was admitted first, so that as their senior in the order he should take precedence of them (*Vinaya Texts*, iii. 228). All the others continued loyal disciples, but

Devadatta, fifteen years afterwards, having gained over the crown prince of Magadha, Ajātasattu, to his side, made a formal proposition, at the meeting of the order, that the Buddha should retire, and hand over the leadership to him, Devadatta (*Vinaya Texts*, iii. 238; *Jātaka*, i. 142). This proposal was rejected, and Devadatta is said in the tradition to have successfully instigated the prince to the execution of his aged father and to have made three abortive attempts to bring about the death of the Buddha (*Vinaya Texts*, iii. 241-250; *Jātaka*, vi. 131), shortly afterwards, relying upon the feeling of the people in favour of asceticism, he brought forward four propositions for ascetic rules to be imposed on the order. These being refused, he appealed to the people, started an order of his own, and gained over 500 of the Buddha's community to join in the secession. We hear nothing further about the success or otherwise of the new order, but it may possibly be referred to under the name of the Gotamakas, in the *Anguttara* (see *Dialogues of the Buddha* i. 222), for Devadatta's family name was Gotama. But his community was certainly still in existence in the 4th century A.D., for it is especially mentioned by Fa Hien, the Chinese pilgrim (Legge's translation, p. 62). And it possibly lasted till the 7th century, for Hsüan Tsang mentions that in a monastery in Bengal the monks then followed a certain regulation of Devadatta's (T. Watters, *On Yuan Chwang*, ii. 191). There is no mention in the canon as to how or when Devadatta died; but the commentary on the *Jātaka*, written in the 5th century A.D., has preserved a tradition that he was swallowed up by the earth near Sāvatthi, when on his way to ask pardon of the Buddha (*Jātaka*, iv. 158). The spot where this occurred was shown to both the pilgrims just mentioned (Fa Hien, loc. cit. p. 60; and T. Watters, *On Yuan Chwang*, i. 390). It is a striking example of the way in which such legends grow, that it is only the latest of these authorities, Hsüan Tsang, who says that, though ostensibly approaching the Buddha with a view to reconciliation, Devadatta had concealed poison in his nail with the object of murdering the Buddha.

Authorities.—*Vinaya Texts*, translated by Rhys Davids and H. Oldenberg (3 vols., Oxford, 1881-1885); *The Jātaka*, edited by V. Fausböll (7 vols., London, 1877-1897); T. Watters, *On Yuan Chwang* (ed. Rhys Davids and Bushell, 2 vols., London, 1904-1905); *Fa Hian*, translated by J. Legge (Oxford, 1886); *Mahāvastu* (ed. Tenant, 3 vols., Paris, 1882-1897).

(T. W. R. D.)

DEVAPRAYAG (Deoprayag), a village in Tehri State of the United Provinces, India. It is situated at the spot where the rivers Alaknanda and Bhagirathi unite and form the Ganges, and as one of the five sacred confluences in the hills is a great place of pilgrimage for devout Hindus. Devaprayag stands at an elevation of 2265 ft. on the side of a hill which rises above it 800 ft. On a terrace in the upper part of the village is the temple of Raghunath, built of huge uncemented stones, pyramidical in form and capped by a white cupola.

DEVENS, CHARLES (1820-1891), American lawyer and jurist, was born in Charlestown, Massachusetts, on the 4th of April 1820. He graduated at Harvard College in 1838, and at the

Harvard law school in 1840, and was admitted to the bar in Franklin county, Mass., where he practised from 1841 to 1849. In the year 1848 he was a Whig member of the state senate, and from 1849 to 1853 was United States marshal for Massachusetts, in which capacity he was called upon in 1851 to remand the fugitive slave, Thomas Sims, to slavery. This he felt constrained to do, much against his personal desire; and subsequently he attempted in vain to purchase Sims's freedom, and many years later appointed him to a position in the department of justice at Washington. Devens practised law at Worcester from 1853 until 1861, and throughout the Civil War served in the Federal army, becoming colonel of volunteers in July 1861 and brigadier-general of volunteers in April 1862. At the battle of Ball's Bluff (1861) he was severely wounded; he was again wounded at Fair Oaks (1862) and at Chancellorsville (1863), where he commanded a division. He later distinguished himself at Cold Harbor, and commanded a division in Grant's final campaign in Virginia (1864-65), his troops being the first to occupy Richmond after its fall. Breveted major-general in 1865, he remained in the army for a year as commander of the military district of Charleston, South Carolina. He was a judge of the Massachusetts superior court from 1867 to 1873, and was an associate justice of the supreme court of the state from 1873 to 1877, and again from 1881 to 1891. From 1877 to 1881 he was attorney-general of the United States in the cabinet of President Hayes. He died at Boston, Mass., on the 7th of January 1891.

See his *Orations and Addresses*, with a memoir by John Codman Ropes (Boston, 1891).

DEVENTER, a town in the province of Overysel, Holland, on the right bank of the Ysel, at the confluence of the Schipbeek, and a junction station 10 m. N. of Zutphen by rail. It is also connected by steam tramway S.E. with Brokulo. Pop. (1900) 26,212. Deventer is a neat and prosperous town situated in the midst of prettily wooded environs, and containing many curious old buildings. There are three churches of special interest: the Groote Kerk (St Lebuinus), which dates from 1334, and occupies the site of an older structure of which the 11th-century crypt remains; the Roman Catholic Broederkerk, or Brothers' Church, containing among its relics three ancient gospels said to have been written by St Lebuinus (Lebwin), the English apostle of the Frisians and Westphalians (d. c. 773); and the Bergkerk, dedicated in 1206, which has two late Romanesque towers. The town hall (1693) contains a remarkable painting of the town council by Terburg. In the fine square called the Brink is the old weigh-house, now a school (gymnasium), built in 1528, with a large external staircase (1644). The gymnasium is descended from the Latin school of which the celebrated Alexander Hegius was master in the third quarter of the 15th century, when the young Erasmus was sent to it, and at which Adrian Floreizoon, afterwards Pope Adrian VI., is said to have been a pupil about the same time. Another famous educational institution was the "Athenaeum" or high school, founded in 1630, at which Henri Renery (d. 1639) taught philosophy, while Johann Friedrich Gronov (Gronovius) (1611-1671) taught rhetoric and history in the middle of the same century. The "Athenaeum" disappeared in 1876. In modern times Deventer possessed a famous teacher in Dr Burgersdyk (d. 1900), the Dutch translator of Shakespeare. The town library, also called the library of the Athenaeum, includes many MSS. and *incunabula*, and a 13th-century copy of *Reynard the Fox*. The archives of the town are of considerable value. Besides a considerable agricultural trade, Deventer has important iron foundries and carpet factories (the royal manufactory of Smyrna carpets being especially famous); while cotton-printing, rope-making and the weaving of woollens and silks are also carried on. A public official is appointed to supervise the proper making of a form of gingerbread known as "*Deventer Koek*," which has a reputation throughout Holland. In the church of Bathmen, a village 5 m. E. of Deventer, some 14th-century frescoes were discovered in 1870.

In the 14th century Deventer was the centre of the famous religious and educational movement associated with the name of Gerhard Groot (q.v.), who was a native of the town (see BROTHERS OF COMMON LIFE.).

DE VERE, AUBREY THOMAS (1814-1902), Irish poet and critic, was born at Curragh Chase, Co. Limerick, on the 10th of January 1814, being the third son of Sir Aubrey de Vere Hunt (1788-1846). In 1832 his father dropped the final name by royal licence. Sir Aubrey was himself a poet. Wordsworth called his sonnets the "most perfect of the age." These and his drama, *Mary Tudor*, were published by his son in 1875 and 1884. Aubrey de Vere was educated at Trinity College, Dublin, and in his twenty-eighth year published *The Waldenses*, which he followed up in the next year by *The Search after Proserpine*. Thenceforward he was continually engaged, till his death on the 20th of January 1902, in the production of poetry and criticism. His best-known works are: in verse, *The Sisters* (1861); *The Infant Bridal* (1864); *Irish Odes* (1869); *Legends of St Patrick* (1872); and *Legends of the Saxon Saints* (1879); and in prose, *Essays chiefly on Poetry* (1887); and *Essays chiefly Literary and Ethical* (1889). He also wrote a picturesque volume of travel-sketches, and two dramas in verse, *Alexander the Great* (1874); and *St Thomas of Canterbury* (1876); both of which, though they contain fine passages, suffer from diffuseness and a lack of dramatic spirit. The characteristics of Aubrey de Vere's poetry are "high seriousness" and a fine religious enthusiasm. His research in questions of faith led him to the Roman Church; and in many of his poems, notably in the volume of sonnets called *St Peter's Chains* (1888), he made rich additions to devotional verse. He was a disciple of Wordsworth, whose calm meditative serenity he often echoed with great felicity; and his affection for Greek poetry, truly felt and understood, gave dignity and weight to his own versions of mythological idylls. But perhaps he will be chiefly remembered for the impulse which he gave to the study of Celtic legend and literature. In this direction he has had many followers, who have sometimes assumed the appearance of pioneers; but after Matthew Arnold's fine lecture on "Celtic Literature," nothing perhaps did more to help the Celtic revival than Aubrey de Vere's tender insight into the Irish character, and his stirring reproductions of the early Irish epic poetry.

A volume of *Selections* from his poems was edited in 1894 (New York and London) by G. E. Woodberry.

DEVICE, a scheme, plan, simple mechanical contrivance; also a pattern or design, particularly an heraldic design or emblem, often combined with a motto or legend. "Device" and its doublet "devise" come from the two Old French forms *devis* and *devise* of the Latin *divisa*, things divided, from *dividere*, to separate, used in the sense of to arrange, set out, apportion. "Devise," as a substantive, is now only used as a legal term for a disposition of property by will, by a modern convention restricted to a disposition of real property, the term "bequest" being used of personalty (see WILL). This use is directly due to the Medieval Latin meaning of *dividere* = *testamento disponere*. In its verbal form, "devise" is used not only in the legal sense, but also in the sense of to plan, arrange, scheme.

DEVIL (Gr. διάβολος, "slanderer," from διαβάλλειν, to slander), the generic name for a spirit of evil, especially the supreme spirit of evil, the foe of God and man. The word is used for minor evil spirits in much the same sense as "demon." From the various characteristics associated with this idea, the term has come to be applied by analogy in many different senses. From the idea of evil as degraded, contemptible and doomed to failure, the term is applied to persons in evil plight, or of slight consideration. In English legal phraseology "devil" and "devilling" are used of barristers who act as substitutes for others. Any remuneration which the legal "devil" may receive is purely a matter of private arrangement between them. In the chancery division such remuneration is generally in the proportion of one half of the fee which the client pays; "in the king's bench division remuneration for 'devilling' of briefs or assisting in drafting and opinions is not common" (see *Annual Practice*, 1907, p. 717). In a similar sense an author may have his materials collected and arranged by a literary hack or "devil." The term "printer's devil" for the errand boy in a printing office probably combines this idea with that of his being black with ink. The common notions of the devil as black, ill-favoured, malicious, destructive and the like, have occasioned the application of the term to certain animals (the Tasmanian devil, the devil-fish, the coot), to mechanical contrivances (for tearing up cloth or separating wool), to pungent, highly seasoned dishes, broiled or fried. In this article we are concerned with the primary sense of the word, as used in mythology and religion.

The primitive philosophy of animism involves the ascription of all phenomena to personal agencies. As phenomena are good or evil, produce pleasure or pain, cause weal or woe, a distinction in the character of these agencies is gradually recognized; the agents of good become gods, those of evil, demons. A tendency towards the simplification and organization of the evil as of the good forces, leads towards belief in outstanding leaders among the forces of evil. When the divine is most completely conceived as unity, the demonic is also so conceived; and over against God stands Satan, or the devil.

Although it is in connexion with Hebrew and Christian monotheism that this belief in the devil has been most fully developed, yet there are approaches to the doctrine in other religions. In Babylonian mythology "the old serpent goddess 'the lady Nina' was transformed into the embodiment of all that was hostile to the powers of heaven" (Sayce's *Hibbert Lectures*, p. 283), and was confounded with the dragon Tiamat, "a terrible monster, reappearing in the Old Testament writings as Rahab and

Leviathan, the principle of chaos, the enemy of God and man" (Tennant's *The Fall and Original Sin*, p. 43), and according to Gunkel (*Schöpfung und Chaos*, p. 383) "the original of the 'old serpent' of Rev. xii. 9." In Egyptian mythology the serpent Apap with an army of monsters strives daily to arrest the course of the boat of the luminous gods. While the Greek mythology described the Titans as "enchained once for all in their dark dungeons" yet Prometheus' threat remained to disturb the tranquillity of the Olympian Zeus. In the German mythology the army of darkness is led by Hel, the personification of twilight, sunk to the goddess who enchains the dead and terrifies the living, and Loki, originally the god of fire, but afterwards "looked upon as the father of the evil powers, who strips the goddess of earth of her adornments, who robs Thor of his fertilizing hammer, and causes the death of Balder the beneficent sun." In Hindu mythology the Maruts, Indra, Agni and Vishnu wage war with the serpent Ahi to deliver the celestial cows or spouses, the waters held captive in the caverns of the clouds. In the *Trimurti*, Brahmă (the impersonal) is manifested as Brahmā (the personal creator), Vishnu (the preserver), and Siva (the destroyer). In Siva is perpetuated the belief in the god of Vedic times Rudra, who is represented as "the wild hunter who storms over the earth with his bands, and lays low with arrows the men who displease him" (Chantepie de la Saussaye's *Religionsgeschichte*, 2nd ed., vol. ii. p. 25). The evil character of Siva is reflected in his wife, who as Kali (the black) is the wild and cruel goddess of destruction and death. The opposition of good and evil is most fully carried out in Zoroastrianism. Opposed to Ormuzd, the author of all good, is Ahriman, the source of all evil; and the opposition runs through the whole universe (D'Alviella's *Hibbert Lectures*, pp. 158-164).

The conception of *Satan* (Heb. שטן, the adversary, Gr. Σατανᾶς, or Σατᾶν, 2 Cor. xii. 7) belongs to the post-exilic period of Hebrew development, and probably shows traces of the influence of Persian on Jewish thought, but it has also its roots in much older beliefs. An "evil spirit" possesses Saul (1 Sam. xvi. 14), but it is "from the Lord." The same agency produces discord between Abimelech and the Shechemites (Judges ix. 23). "A lying spirit in the mouth of all his prophets" as Yahweh's messenger entices Ahab to his doom (1 Kings xxii. 22). Growing human corruption is traced to the fleshy union of angels and women (Gen. vi. 1-4). But generally evil, whether as misfortune or as sin, is assigned to divine causality (1 Sam. xviii. 10; 2 Sam. xxiv. 1; 1 Kings xxii. 20; Isa. vi. 10, lxiii. 17). After the Exile there is a tendency to protect the divine transcendence by the introduction of mediating angelic agency, and to separate all evil from God by ascribing its origin to Satan, the enemy of God and man. In the prophecy of Zechariah (iii. 1-2) he stands as the adversary of Joshua, the high priest, and is rebuked by Yahweh for desiring that Jerusalem should be further punished. In the book of Job he presents himself before the Lord among the sons of God (ii. 1), yet he is represented both as accuser and tempter. He disbelieves in Job's integrity, and desires him to be so tried that he may fall into sin. While, according to 2 Sam. xxiv. 1, God himself tests David in regard to the numbering of the people, according to 1 Chron. xxi. 1 it is Satan who tempts him.

The development of the conception continued in later Judaism, which was probably more strongly influenced by Persian dualism. It is doubtful, however, whether the Asmodeus (q.v.) of the book of Tobit is the same as the Aēshma Daēwa of the Bundahesh. He is the evil spirit who slew the seven husbands of Sara (iii. 8), and the name probably means "Destroyer." In the book of Enoch Satan is represented as the ruler of a rival kingdom of evil, but here are also mentioned Satans, who are distinguished from the fallen angels and who have a threefold function, to tempt, to accuse and to punish. Satan possesses the ungodly (Ecclesiasticus xxi. 27), is identified with the serpent of Gen. iii. (Wisdom ii. 24), and is probably also represented by Asmodeus, to whom lustful qualities are assigned (Tobit vi. 14); Gen. iii. is probably referred to in Psalms of Solomon xvii. 49, "a serpent speaking with the words of transgressors, words of deceit to pervert wisdom." The *Book of the Secrets of Enoch* not only identifies Satan with the Serpent, but also describes his revolt against God, and expulsion from heaven. In the Jewish *Targums* Sammael, "the highest angel that stands before God's throne, caused the serpent to seduce the woman"; he coalesces with Satan, and has inferior Satans as his servants. The birth of Cain is ascribed to a union of Satan with Eve. As accuser affecting man's standing before God he is greatly feared.

This doctrine, stripped of much of its grossness, is reproduced in the New Testament. Satan is the διάβολος (Matt. xiii. 39; John xiii. 2; Eph. iv. 27; Heb. ii. 14; Rev. ii. 10), slanderer or accuser, the πειράζων (Matt. iv. 3; 1 Thess. iii. 5), the tempter, the πονηρός (Matt. v. 37; John xvii. 15; Eph. vi. 16), the evil one, and the ἐχθρός (Matt. xiii. 39), the enemy. He is apparently identified with Beelzebub (or Beelzebul) in Matt. xii. 26, 27. Jesus appears to recognize the existence of demons belonging to a kingdom of evil under the leadership of Satan "the prince of demons" (Matt. xii. 24, 26, 27), whose works in demonic possessions it is his function to destroy (Mark i. 34, iii. 11, vi. 7; Luke x. 17-20). But he himself conquers Satan in resisting his temptations (Matt. iv. 1-11). Simon is warned against him, and Judas yields to him as tempter (Luke xxii. 31; John xiii. 27). Jesus's cures are represented as a triumph over Satan (Luke x. 18). This Jewish doctrine is found in Paul's letters also. Satan rules over a world of evil, supernatural agencies, whose dwelling is in the lower heavens (Eph. vi. 12): hence he is the "prince of the power of the air" (ii. 2). He is the tempter (1 Thess. iii. 5; 1 Cor. vii. 5), the destroyer (x. 10), to whom the offender is to be handed over for bodily destruction (v. 5), identified with the serpent (Rom. xvi. 20; 2 Cor. xi. 3), and probably with Beliar or Belial (vi. 15); and the surrender of man to him brought death into the world (Rom. v. 17). Paul's own "stake in the flesh" is Satan's messenger (2 Cor. xii. 7). According to Hebrews Satan's power over death Jesus destroys by dying (ii. 14). Revelation describes the war in heaven between God with his angels and Satan or the dragon, the "old serpent," the deceiver of the whole world (xii. 9), with his hosts of darkness. After the overthrow of the Beast and the kings of the earth, Satan is imprisoned in the bottomless pit a thousand years (xx. 2). Again loosed to deceive the nations, he is finally cast into the lake of fire and brimstone (xx. 10; cf. Enoch liv. 5, 6; 2 Peter ii. 4). In John's Gospel and Epistles Satan is opposed to Christ. Sinner and murderer from the beginning (1 John iii. 8) and liar by nature (John viii. 44), he enslaves men to sin (viii. 34), causes death (verse 44), rules the present world (xiv. 30), but has no power over Christ or those who are his (xiv. 30, xvi. 11; 1 John v. 18). He will be destroyed by Christ with all his works (John xvi. 33; 1 John iii. 8).

In the common faith of the Gentile churches after the Apostolic Age "the present dominion of evil demons, or of one evil demon, was just as generally presupposed as man's need of redemption, which was regarded as a result of that dominion. The tenacity of this belief may be explained among other things by the living impression of the polytheism that surrounded the communities on every side. By means of this assumption too, humanity seemed to be unburdened, and the presupposed capacity for redemption could, therefore, be justified in its widest range" (Harnack's *History of Dogma*, i. p. 181). While Christ's First Advent delivered believers from Satan's bondage, his overthrow would be completed only by the Second Advent. The Gnostics held that "the present world sprang from a fall of man, or from an undertaking hostile to God, and is, therefore, the product of an evil or intermediate being" (p. 257). Some taught that while the future had been assigned by God to Christ, the devil had received the present age (p. 309). The fathers traced all doctrines not held by the Catholic Church to the devil, and the virtues of heretics were regarded as an instance of the devil transforming himself into an angel of light (ii. 91). Irenaeus ascribes Satan's fall to "pride and arrogance and envy of God's creation"; and traces man's deliverance from Satan to Christ's victory in resisting his temptations; but also, guided by certain Pauline passages, represents the death of Christ "as a ransom paid to the 'apostasy' for men who had fallen into captivity" (ii. 290). He does not admit that Satan has any lawful claim on man, or that God practised a deceit on him, as later fathers taught. This theory of the *atonement* was formulated by Origen. "By his successful temptation the devil acquired a right over men. God offered Christ's soul for that of men. But the devil was duped, as Christ overcame both him and death" (p. 367). It was held by Gregory of Nyssa, Ambrose, who uses the phrase *pia fraus*, Augustine, Leo I., and Gregory I., who expresses it in its worst form. "The humanity of Christ was the bait; the fish, the devil, snapped at it, and was left hanging on the invisible hook, Christ's divinity" (iii. 307). In Athanasius the relation of the work of Christ to Satan retires into the background, Gregory of Nazianzus and John of Damascus felt scruples about this view. It is expressly repudiated by Anselm and Abelard. Peter the Lombard asserted it, disregarding these objections. Bernard represents man's bondage to Satan "as righteously permitted as a just retribution for sin," he being "the executioner of the divine justice." Another theory of Origen's found less acceptance. The devil, as a being resulting from God's will, cannot always remain a devil. The possibility of his redemption, however, was in the 5th century branded as a heresy. Persian dualism was brought into contact with Christian thought in the doctrine of Mani; and it is permissible to believe that the gloomy views of Augustine regarding man's condition are due in some measure to this influence. Mani taught that Satan with his demons, sprung from the kingdom of darkness, attacked the realm of light, the earth, defeated man sent against him by the God of light, but was overthrown by the God of light, who then delivered the primeval man (iii. 324). "During the middle ages," says Tulloch, "the belief in the devil was absorbing—saints conceived themselves and others to be in constant conflict with him." This superstition, perhaps at its strongest in the 13th to the 15th century, passed into Protestantism. Luther was always conscious of the presence and opposition of Satan. "As I found he was about to begin again," says Luther, "I gathered together my books, and got into bed. Another time in the night I heard him above my cell walking on the cloister, but as I knew it was the devil I paid no attention to him and went to sleep." He held that this world will pass away with its pleasures, as there can be no real improvement in it, for the devil continues in it to ply his daring and seductive devices (vii. 191). I. A. Dorner (*Christian Doctrine*, iii. p. 93) sums up

Protestant doctrine as follows:—"He is brought into relation with natural sinfulness, and the impulse to evil thoughts and deeds is ascribed to him. The dominion of evil over men is also represented as a slavery to Satan, and this as punishment. He has his full power in the extra-Christian world. But his power is broken by Christ, and by his word victory over him is to be won. The power of creating anything is also denied the devil, and only the power of corrupting substances is conceded to him. But it is only at the Last Judgment that his power is wholly annihilated; he is himself delivered up to eternal punishment." This belief in the devil was specially strong in Scotland among both clergy and laity in the 17th century. "The devil was always and literally at hand," says Buckle, "he was haunting them, speaking to them, and tempting them. Go where they would he was there."

In more recent times a great variety of opinions has been expressed on this subject. J. S. Semler denied the reality of demonic possession, and held that Christ in his language accommodated himself to the views of the sick whom he was seeking to cure. Kant regarded the devil as a personification of the radical evil in man. Daub in his *Judas Ishcarioth* argued that a finite evil presupposes an absolute evil, and the absolute evil as real must be in a person. Schelling regarded the devil as, not a person, but a real principle, a spirit let loose by the freedom of man. Schleiermacher was an uncompromising opponent of the common belief. "The problem remains to seek evil rather in self than in Satan, Satan only showing the limits of our self-knowledge." Dorner has formulated a theory which explains the development of the conception of Satan in the Holy Scriptures as in correspondence with an evolution in the character of Satan. "Satan appears in Scripture under four leading characters:—first as the tempter of freedom, who desires to bring to decision, secondly as the accuser, who by virtue of the law retorts criminality on man; thirdly as the instrument of the Divine, which brings evil and death upon men; fourthly and lastly he is described, especially in the New Testament, as the enemy of God and man." He supposes "a change in Satan in the course of the history of the divine revelation, in conflict with which he came step by step to be a sworn enemy of God and man, especially in the New Testament times, in which, on the other hand, his power is broken at the root by Christ." He argues that "the world-order, being in process as a moral order, permits breaches everywhere into which Satan can obtain entrance" (pp. 99, 102). H. L. Martensen gives even freer rein to speculation. "The evil principle," he says, "has in itself no personality, but attains a progressively universal personality in its kingdom; it has no individual personality, save only in individual creatures, who in an especial manner make themselves its organs; but among these is one creature in whom the principle is so hypostasized that he has become the centre and head of the kingdom of evil" (*Dogmatics*, p. 199). A. Ritschl gives no place in his constructive doctrine to the belief in the devil; but recognizes that the mutual action of individual sinners on one another constitutes a kingdom of sin, opposed to the Kingdom of God (A. E. Garvie, *The Ritschlian Theology*, p. 304). Kaftan affirms that a "doctrine about Satan can as little be established as about angels, as faith can say nothing about it, and nothing is gained by it for the dogmatic explanation of evil. This whole province must be left to the immediate world-view of the pious. The idea of Satan will on account of the Scriptures not disappear from it, and it would be arrogant to wish to set it aside. Only let everyone keep the thought that Satan also stands under the commission of the Almighty God, and that no one must suppose that by leading back his sins to a Satanic temptation he can get rid of his own guilt. To transgress these limits is to assail faith" (*Dogmatik*, p. 348). In the book entitled *Evil and Evolution* there is "an attempt to turn the light of modern science on to the ancient mystery of evil." The author contends that the existence of evil is best explained by assuming that God is confronted with Satan, who in the process of evolution interferes with the divine designs, an interference which the instability of such an evolving process makes not incredible. Satan is, however, held to be a creature who has by abuse of his freedom been estranged from, and opposed to his Creator, and who at last will be conquered by moral means. W. M. Alexander in his book on demonic possession maintains that "the confession of Jesus as the Messiah or Son of God is the classical criterion of genuine demonic possession" (p. 150), and argues that, as "the Incarnation indicated the establishment of the kingdom of heaven upon earth," there took place "a counter movement among the powers of darkness," of which "genuine demonic possession was one of the manifestations" (p. 249).

Interesting as these speculations are, it may be confidently affirmed that belief in Satan is not now generally regarded as an essential article of the Christian faith, nor is it found to be an indispensable element of Christian experience. On the one hand science has so explained many of the processes of outer nature and of the inner life of man as to leave no room for Satanic agency. On the other hand the modern view of the inspiration of the Scriptures does not necessitate the acceptance of the doctrine of the Scriptures on this subject as finally and absolutely authoritative. The teaching of Jesus even in this matter may be accounted for as either an accommodation to the views of those with whom he was dealing, or more probably as a proof of the limitation of knowledge which was a necessary condition of the Incarnation, for it cannot be contended that as revealer of God and redeemer of men it was imperative that he should either correct or confirm men's beliefs in this respect. The possibility of the existence of evil spirits, organized under one leader Satan to tempt man and oppose God, cannot be denied; the sufficiency of the evidence for such evil agency may, however, be doubted; the necessity of any such belief for Christian thought and life cannot, therefore, be affirmed. (See also Demonology; Possession.)

DEVIZES, a market town and municipal borough in the Devizes parliamentary division of Wiltshire, England, 86 m. W. by S. of London by the Great Western railway. Pop. (1901) 6532. Its castle was built on a tongue of land flanked by two deep ravines, and behind this the town grew up in a semicircle on a stretch of bare and exposed tableland. Its main streets, in which a few ancient timbered houses are left, radiate from the market place, where stands a Gothic cross, the gift of Lord Sidmouth in 1814. The Kennet and Avon Canal skirts the town on the N., passing over the high ground through a chain of thirty-nine locks. St John's church, one of the most interesting in Wiltshire, is cruciform, with a massive central tower, based upon two round and two pointed arches. It was originally Norman of the 12th century, and the chancel arch and low vaulted chancel, in this style, are very fine. In the interior several ancient monuments of the Suttons and Heathcotes are preserved, besides some beautiful carved stone work, and two rich ceilings of oak over the chapels. St Mary's, a smaller church, is partly Norman, but was rebuilt in the 15th and again in the 19th century. Its lofty clerestoried nave has an elaborately carved timber roof, and the south porch, though repaired in 1612, preserves its Norman mouldings. The woollen industries of Devizes have lost their prosperity; but there is a large grain trade, with engineering works, breweries, and manufactures of silk, snuff, tobacco and agricultural implements. The town is governed by a mayor, six aldermen and eighteen councillors. Area, 906 acres.

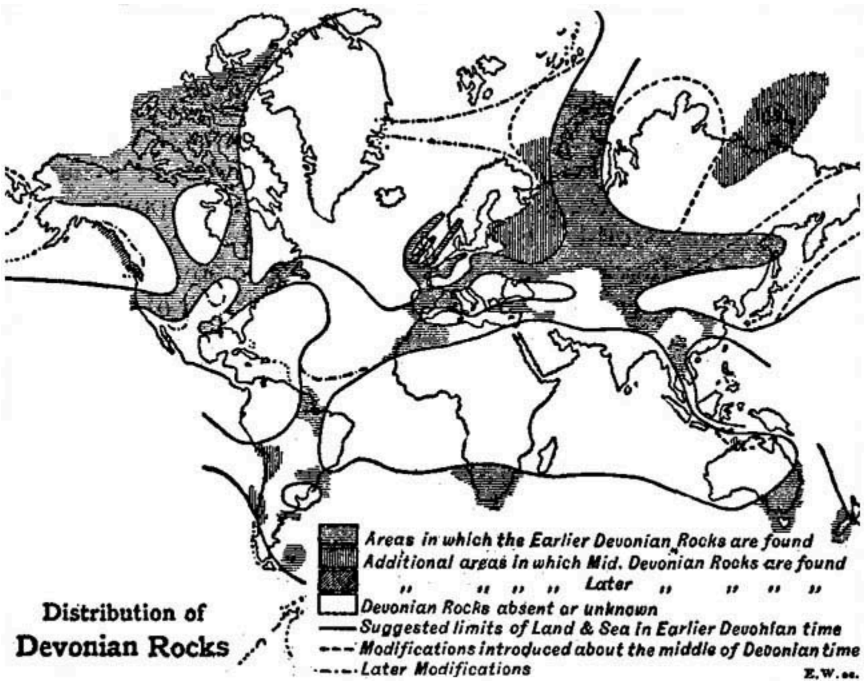
Devizes (*Divisis*, *la Devise*, *De Vies*) does not appear in any historical document prior to the reign of Henry I., when the construction of a castle of exceptional magnificence by Roger, bishop of Salisbury, at once constituted the town an important political centre, and led to its speedy development. After the disgrace of Roger in 1139 the castle was seized by the Crown; in the 14th century it formed part of the dowry of the queens of England, and figured prominently in history until its capture and demolition by Cromwell in the Civil War of the 17th century. Devizes became a borough by prescription, and the first charter from Matilda, confirmed by successive later sovereigns, merely grants exemption from certain tolls and the enjoyment of undisturbed peace. Edward III. added a clause conferring on the town the liberties of Marlborough, and Richard II. instituted a coroner. A gild merchant was granted by Edward I., Edward II. and Edward III., and in 1614 was divided into the three companies of drapers, mercers and leathersellers. The present governing charters were issued by James I. and Charles I., the latter being little more than a confirmation of the former, which instituted a common council consisting of a mayor, a town clerk and thirty-six capital burgesses. These charters were surrendered to Charles II., and a new one was conferred by James II., but abandoned three years later in favour of the original grant. Devizes returned two members to parliament from 1295, until deprived of one member by the Representation of the People Act of 1867, and of the other by the Redistribution Act of 1885. The woollen manufacture was the staple industry of the town from the reign of Edward III. until the middle of the 18th century, when complaints as to the decay of trade began to be prevalent. In the reign of Elizabeth the market was held on Monday, and there were two annual fairs at the feasts of the Purification of the Virgin and the Decollation of John the Baptist. The market was transferred to Thursday in the next reign, and the fairs in the 18th century had become seven in number.

See *Victoria County History, Wiltshire*; *History of Devizes* (Devizes, 1859).

DEVOLUTION, WAR OF (1667-68), the name applied to the war which arose out of Louis XIV.'s claims to certain Spanish territories in right of his wife Maria Theresa, upon whom the ownership was alleged to have "devolved." (See, for the military operations, Dutch Wars.) The war was ended by the treaty of Aix-la-Chapelle in 1668.

DEVON, EARLS OF. From the family of De Redvers (De Ripuariis; Riviers), who had been earls of Devon from about 1100, this title passed to Hugh de Courtenay (c. 1275-1340), the representative of a prominent family in the county (see Gibbon's "digression" in chap. lxi. of the *Decline and Fall*, ed. Bury), but was subsequently forfeited by Thomas Courtenay (1432-1462), a Lancastrian who was beheaded after the battle of Towton. It was revived in 1485 in favour of Edward Courtenay (d. 1509), whose son Sir William (d. 1511) married Catherine, daughter of Edward IV. Too great proximity to the throne led to his attainder, but his son Henry (c. 1498-1539) was restored in blood in 1517 as earl of Devon, and in 1525 was created marquess of Exeter; his second wife was a daughter of William Blount, 4th Lord Mountjoy. The title again suffered forfeiture on Henry's execution, but in 1553 it was recreated for his son Edward (1526-1556). At the latter's death it became dormant in the Courtenay family, till in 1831 a claim by a collateral branch was allowed by the House of Lords, and the earldom of Devon was restored to the peerage, still being held by the head of the Courtenays. The earlier earls of Devon were referred to occasionally as earls of Devonshire, but the former variant has prevailed, and the latter is now solely used for the earldom and dukedom held by the Cavendishes (see Devonshire, Earls and Dukes of, and also the article Courtenay).

DEVONIAN SYSTEM, in geology, the name applied to series of stratified fossiliferous and igneous rocks that were formed during the Devonian period, that is, in the interval of time between the close of the Silurian period and the beginning of the Carboniferous; it includes the marine Devonian and an estuarine Old Red Sandstone series of strata. The name "Devonian" was introduced in 1829 by Sir R. Murchison and A. Sedgwick to describe the older rocks of Cornwall and Devon which W. Lonsdale had shown, from an examination of the fossils, to be intermediate between the Silurian and Carboniferous. The same two workers also carried on further researches upon the same rocks of the European continent, where already several others, F. Roemer, H. E. Beyrich, &c., were endeavouring to elucidate the succession of strata in this portion of the "Transition Series." The labours of these earlier workers, including in addition to those already mentioned, the brothers F. and G. von Sandberger, A. Dumont, J. Gosselet, E. J. A. d'Archiac, E. P. de Verneuil and H. von Dechen, although somewhat modified by later students, formed the foundation upon which the modern classification of the Devonian rocks is based.



Stratigraphy of the Devonian Facies.

Notwithstanding the fact that it was in Devonshire and Cornwall that the Devonian rocks were first distinguished, it is in central Europe that the succession of strata is most clearly made out, and here, too, their geological position was first indicated by the founders of the system, Sedgwick and Murchison.

Continental Europe.—Devonian rocks occupy a large area in the centre of Europe, extending from the Ardennes through the south of Belgium across Rhenish Prussia to Darmstadt. They are best known from the picturesque gorges which have been cut through them by the Rhine below Bingen and by the Moselle below Treves. They reappear from under younger formations in Brittany, in the Harz and Thuringia, and are exposed in Franconia, Saxony, Silesia, North Moravia and eastern Galicia. The principal subdivisions of the system in the more typical areas are indicated in Table I.

This threefold subdivision, with a central mass of calcareous strata, is traceable westwards through Belgium (where the Calcaire de Givet represents the *Stringocephalus* limestone of the Eifel) and eastwards into the Harz. The rocks reappear with local petrographical modifications, but with a remarkable persistence of general palaeontological characters, in Eastern Thuringia, Franconia, Saxony, Silesia, the north of Moravia and East Galicia. Devonian rocks have been detected among the crumpled rocks of the Styrian Alps by means of the evidence of abundant corals, cephalopods, gasteropods, lamellibranchs and other organic remains. Perhaps in other tracts of the Alps, as well as in the Carpathian range, similar shales, limestones and dolomites, though as yet unfossiliferous, but containing ores of silver, lead, mercury, zinc, cobalt and other metals, may be referable to the Devonian system.

In the centre of Europe, therefore, the Devonian rocks consist of a vast thickness of dark-grey sandy and shaly rocks, with occasional seams of limestone, and in particular with one thick central calcareous zone. These rocks are characterized in the lower zones by numerous broad-winged spirifers and by peculiar trilobites (*Phacops*, *Homalonotus*, &c.) which, though generically like those of the Silurian system, are specifically distinct. The central calcareous zone abounds in corals and crinoids as well as in numerous brachiopods. In the highest bands a profusion of coiled cephalopods (*Clymenia*) occurs in some of the limestones, while the shales are crowded with a small but characteristic ostracod crustacean (*Cypridina*). Here and there traces of fishes have been found, more especially in the Eifel, but seldom in such a state of preservation as to warrant their being assigned to any definite place in the zoological scale. Subsequently, however, E. Beyrich has described from Gerolstein in the Eifel an undoubted species of *Pterichthys*, which, as it cannot be certainly identified with any known form, he names *P. Rhenanus*. A *Coccosteus* has been described by F. A. Roemer from the Harz, and still later one has been cited from Bicken near Herborn by V. Koenen; but, as Beyrich points out, there may be some doubt as to whether the latter is not a *Pterichthys*. A *Ctenacanthus*, seemingly undistinguishable from the *C. Bohemicus* of Barrande's Étage G, has also been obtained from the Lower Devonian "Nereitenschichten" of Thuringia. The characteristic *Holoptychius nobilissimus* has been detected in the Psammite de Condroz, which in Belgium forms a characteristic sandy portion of the Upper Devonian rocks. These are interesting facts, as helping to link the Devonian and Old Red Sandstone types together. But they are as yet too few and unsupported to warrant any large deduction as to the correlations between these types.

It is in the north-east of Europe that the Devonian and Old Red Sandstone appear to be united into one system, where the limestones and marine organisms of the one are interstratified with the fish-bearing sandstones and shales of the other. In Russia, as was shown in the great work *Russia and the Ural Mountains* by Murchison, De Verneuil and Keyserling, rocks intermediate between the Upper Silurian and Carboniferous Limestone formations cover an extent of surface larger than the British Islands. This wide development arises not from the thickness but from the undisturbed horizontal character of the strata. Like the Silurian formations described elsewhere, they remain to this day nearly as flat and unaltered as they were originally laid down. Judged by mere vertical depth, they present but a meagre representative of the massive Devonian greywacke and limestone of Germany, or of the Old Red Sandstone of Britain. Yet vast though the area is over which they form the surface rock, it is probably only a small portion of their total extent; for they are found turned up from under the newer formations along the flank of the Ural chain. It would thus seem that they spread continuously across the whole breadth of Russia in Europe. Though almost everywhere undisturbed, they afford evidence of some terrestrial oscillation between the time of their formation and that of the Silurian rocks on which they rest, for they are found gradually to overlap Upper and Lower Silurian formations.

TABLE I.

	Stages.	Ardennes.	Rhineland.	Brittany and Normandy.	
UPPER DEVONIAN.	Famennienc (*Clymenia* beds).	Limestone of Etrœungt. Psammites of Condroz (sandy series). Slates of Famenne (shaly series).	*Cypridina* slates. Pön sandstone (Sauerland). Crumbly limestone (Kramenzelkalk) with *Clymenia*. Neheim slates in Sauerland, and diabases, tuffs, &c., in Dillmulde, &c.	Slates of Rostellec.	
	Frasnien (*Intumescens* beds).	Slates of Matagne. Limestones, marls and shale of Frasne, and red marble of Flanders.	Adorf limestone of Waldeck and shales with *Goniatites* (Eifel and Aix) = Budesheimer shales. Marls, limestone and dolomite with *Rhynchonella cuboides* (Flinz in part). Iberg limestone of Dillmulde.	Limestone of Cop-Choux and green slates of Travuliors.	
MIDDLE DEVONIAN.	Givérien (*Stringocephalus* beds).	Limestone of Givet.	*Stringocephalus* limestone, ironstone of Brilon and Lahnmulde. Upper Lenne shales, crinoidal limestone of Eifel, red sandstones of Aix. Tuffs and diabases of Brilon and Lahnmulde. Red conglomerate of Aix.	Limestones of Chalonnes, Montjean and l'Ecochère.	H c s H

	Eifélien (*Calceola* beds).	Calceola slates and limestones of Couvin. Greywacke with *Spirifer cultrijugatus*.	*Calceola* beds, Wissenbach slates, Lower Lenne beds, Güntroder limestone and clay slate of Lahnmulde, Dillmulde, Wildungen, Griefenstein limestone, Ballersbach limestone.	Slates of Porsguen, greywacke of Fret.	C l C l C a I l
Lower Devonian.	Coblentzien	Greywacke of Hierges. Shales and conglomerate of Burnot with quartzite, of Bierlé and red slates of Vireux, greywacke of Vireux, greywacke of Montigny, sandstone of Anor.	Upper Coblentz slates. Red sandstone of Eifel, Coblentz quartzite, lower Coblentz slates. Hunsrück and Siegener greywacke and slates. Taunus quartzite and greywacke.	Limestones of Erbray, Brulon, Viré and Néhou, greywacke of Faou, sandstone of Gahard.	F V l l
	Gédinnien	Slates of St Hubert and and Fooz, slates of Mondrepuits, arkose of Weismes, conglomerate of Fèpin.	Slates of Gédinne.	Slates and quartzites of Plougastel.	

The chief interest of the Russian rocks of this age lies in the fact, first signalized by Murchison and his associates, that they unite within themselves the characters of the Devonian and the Old Red Sandstone types. In some districts they consist largely of limestones, in others of red sandstones and marls. In the former they present molluscs and other marine organisms of known Devonian species; in the latter they afford remains of fishes, some of which are specifically identical with those of the Old Red Sandstone of Scotland. The distribution of these two palaeontological types in Russia is traced by Murchison to the lithological characters of the rocks, and consequent original diversities of physical conditions, rather than to differences of age. Indeed cases occur where in the same band of rock Devonian shells and Old Red Sandstone fishes lie commingled. In the belt of the formation which extends southwards from Archangel and the White Sea, the strata consist of sands and marls, and contain only fish remains. Traced through the Baltic provinces, they are found to pass into red and green marls, clays, thin limestones and sandstones, with beds of gypsum. In some of the calcareous bands such fossils occur as *Orthis striatula*, *Spiriferina prisca*, *Leptaena productoides*, *Spirifer calcaratus*, *Spirorbis omphaloides* and *Orthoceras subfusiforme*. In the higher beds *Holoptychius* and other well-known fishes of the Old Red Sandstone occur. Followed still farther to the south, as far as the watershed between Orel and Voronezh, the Devonian rocks lose their red colour and sandy character, and become thin-bedded yellow limestones, and dolomites with soft green and blue marls. Traces of salt deposits are indicated by occasional saline springs. It is evident that the geographical conditions of the Russian area during the Devonian period must have closely resembled those of the Rhine basin and central England during the Triassic period. The Russian Devonian rocks have been classified in Table II. There is an unquestionable passage of the uppermost Devonian rocks of Russia into the base of the Carboniferous system.

Table II.

	North-West Russia.		Central Russia.	Petchoraland.	Ural R
Upper.	Red sandstone (Old Red).	Limestones with *Spirifer Verneuili* and *Sp. Archiaci*.	Limestones with *Arca oreliana* Limestones with *Sp.*	Domanik slates and limestones with *Sp. Verneuili*.	*Cypridina* slat *Clymenia* lim (Famennien). Limestones w

			Verneuili and *Sp. Archiaci*.		*Gephyoceras* and *Rhynchon* (Frasnien).
Middle.	Dolomites and limestones with *Spirifer Anossofi*.		Marl with *Spirifer Anossofi* and corals.		Limestones an with Sp. Anos (Givétien). Limestones an Pentamerus b (Eifélien).
	Lower sandstone (Old Red).				
Lower.	Absent.				Limestones an Yuresan and U slate and quart marble of Byc of Bogoslovsk schists and qu

The Lower Devonian of the Harz contains a fauna which is very different from that of the Rhenish region; to this facies the name "Hercynian" has been applied, and the correlation of the strata has been a source of prolonged discussion among continental geologists. A similar fauna appears in Lower Devonian of Bohemia, in Brittany (limestone of Erbray) and in the Urals. The Upper Devonian of the Harz passes up into the Culm.

In the eastern Thuringian Fichtelgebirge the upper division is represented by *Clymenia* limestone and *Cypridina* slates with Adorf limestone, diabase and Planschwitzer tuff in the lower part. The middle division has diabases and tuffs at the top with Tentaculite and Nereite shales and limestones below. The upper part of the Lower Devonian, the sandy shale of Steinach, rests unconformably upon Silurian rocks. In the Carnic Alps are coral reef limestones, the equivalents of the Iberg limestone, which attain an enormous thickness; these are underlain by coral limestones with fossils similar to those of the Konjeprus limestone of Bohemia; below these are shales and nodular limestones with goniatites. The Devonian rocks of Poland are sandy in the lower, and more calcareous in the upper parts. They are of interest because while the upper portions agree closely with the Rhenish facies, from the top of the Coblentzien upwards, in the sandy beds near the base Old Red Sandstone fishes (*Coccosteus*, &c.) are found. In France Devonian rocks are found well developed in Brittany, as indicated in the table, also in Normandy and Maine; in the Boulonnais district only the middle and upper divisions are known. In south France in the neighbourhood of Cabrières, about Montpellier and in the Montagne Noire, all three divisions are found in a highly calcareous condition. Devonian rocks are recognized, though frequently much metamorphosed, on both the northern and southern flanks of the Pyrenees; while on the Spanish peninsula they are extensively developed. In Asturias they are no less than 3280 ft. thick, all three divisions and most of the central European subdivisions are present. In general, the Lower Devonian fossils of Spain bear a marked resemblance to those of Brittany.

Asia.—From the Ural Mountains eastward, Devonian rocks have been traced from point to point right across Asia. In the Altai Mountains they are represented by limestones of Coblentzien age with a fauna possessing Hercynian features. The same features are observed in the Devonian of the Kougnetsk basin, and in Turkestan. Well-developed quartzites with slates and diabases are found south of Yarkand and Khotan. Middle and Upper Devonian strata are widespread in China. Upper Devonian rocks are recorded from Persia, and from the Hindu Kush on the right bank of the Chitral river.

England.—In England the original Devonian rocks are developed in Devon and Cornwall and west Somerset. In north Devonshire these rocks consist of sandstones, grits and slates, while in south Devon there are, in addition, thick beds of massive limestone, and intercalations of lavas and tuffs. The interpretation of the stratigraphy in this region is a difficult matter, partly on account of the absence of good exposures with fossils, and partly through the disturbed condition of the rocks. The system has been subdivided as shown in Table III.

Table III.

	North Devon and West Somerset.	South Devon.
Upper.	Pilton group. Grits, slates and thin limestones. Baggy group. Sandstones and slates. Pickwell Down group. Dark slates and grits. Morte slates (?).	Ashburton slates. Livaton slates. Red and green *Entomis* slates (Famennien). Red and grey slates with tuffs. Chudleigh goniatite limestone Petherwyn beds (Frasnien).
Middle.	Ilfracombe slates with lenticles of limestone. Combe Martin grits and slates.	Torquay and Plymouth limestones and Ashprington volcanic series. (Givétien and Eifélien.) Slates and limestones of Hope's Nose.
Lower.	Hangman grits and slates. Lynton group, grits and calcareous slates. Foreland grits and slates.	Looe beds (Cornwall). Meadfoot, Cockington and Warberry series of slates and greywackes. (Coblentzien and Gédinnien.)

The fossil evidence clearly shows the close agreement of the Rhenish and south Devonshire areas. In north Devonshire the Devonian rocks pass upward without break into the Culm.

North America.—In North America the Devonian rocks are extensively developed; they have been studied most closely in the New York region, where they are classified according to Table IV.

The classification below is not capable of application over the states generally and further details are required from many of the regions where Devonian rocks have been recognized, but everywhere the broad threefold division seems to obtain. In Maryland the following arrangement has been adopted—(1) Helderberg = Coeymans; (2) Oriskany; (3) Romney = Erian; (4) Jennings = Genesee and Portage; (5) Hampshire = Catskill in part. In the interior the Helderbergian is missing and the system commences with (1) Oriskany, (2) Onondaga, (3) Hamilton, (4) Portage (and Genesee), (5) Chemung.

The Helderbergian series is mainly confined to the eastern part of the continent; there is a northern development in Maine, and in Canada (Gaspé, New Brunswick, Nova Scotia and Montreal); an Appalachian belt, and a lower Mississippian region. The series as a whole is mainly calcareous (2000 ft. in Gaspé), and thins out towards the west. The fauna has Hercynian affinities. The Oriskany formation consists largely of coarse sandstones; it is thin in New York, but in Maryland and Virginia it is several hundred feet thick. It is more widespread than the underlying Helderbergian. The Lower Devonian appears to be thick in northern Maine and in Gaspé, New Brunswick and Nova Scotia, but neither the palaeontology nor the stratigraphy has been completely worked out.

In the Middle Devonian the thin clastic deposits at the base, Esopus and Schoharie grits, have not been differentiated west of the Appalachian region; but the Onondaga limestones are much more extensive. The Erian series is often described as the Hamilton series outside the New York district, where the *Marcellus* shales are grouped together with the Hamilton shales, and numerous local subdivisions are included, as in Ohio, Kentucky and Tennessee. The rocks are mostly shales or slates, but limestones predominate in the western development. In Pennsylvania the Hamilton series is from 1500 ft. to 5000 ft. thick, but in the more calcareous western extension it is much thinner. The *Marcellus* shales are bituminous in places.

The Senecan series is composed of shallow-water deposits; the Tully limestone, a local bed in New York, thins out in places into a layer of pyrites which contains a remarkable dwarfed fauna. The bituminous Genesee shales are thickest in Pennsylvania (300 ft.); 25 ft. on Lake Erie. The shales and sandstones of the Portage formation reach 1000 ft. to 1400 ft. in western New York. In the Chautauquan series the Chemung formation is not always clearly separable from the Portage beds, it is a sandstone and conglomerate formation which reaches its maximum thickness (8000 ft.) in Pennsylvania, but thins rapidly towards the west. In the Catskill region the Upper Devonian has an Old Red facies—red shales and sandstones with a freshwater and brackish fauna.

Table IV.

	Groups.	Formations.	Probable European Equivalent.
Upper.	Chautauquan.	Chemung beds with Catskill as a local facies.	Famennien.
	Senecan.	Portage beds (Naples, Ithaca and Oneonta shales as local facies). Genesee shales. Tully limestone.	Frasnien.
Middle.	Erian.	Hamilton shale. Marcellus shale.	Givétien.
	Ulsterian.	Onondaga (Corniferous) limestone. Schoharie grit. Esopus grit (Caudagalli grit).	Eifélien.
Lower.	Oriskanian.	Oriskany sandstone.	Coblentzien.
	Helderbergian.	Kingston beds. Becraft limestone. New Scotland beds. Coeymans limestone.	Gédinnien.

Although the correlation of the strata has only advanced a short distance, there is no doubt as to the presence of undifferentiated Devonian rocks in many parts of the continent. In the Great Plains this system appears to be absent, but it is represented in Colorado, Utah, Nevada, Wyoming, Montana, California and Arizona; Devonian rocks occur between the Sierras and the Rocky Mountains, in the Arbuckle Mountains of Oklahoma and in Texas. In the western interior limestones predominate; 6000 ft. of limestone are found at Eureka, Nevada, beneath 2000 ft. of shale. On the Pacific coast metamorphism of the rocks is common, and lava-flows and tuffs occur in them.

In Canada, besides the occurrences previously mentioned in the eastern region, Devonian strata are found in considerable force along the course of the Mackenzie river and the Canadian Rockies, whence they stretch out into Alaska. It is probable, however, that much that is now classed as Devonian in Canada will prove on fossil evidence to be Carboniferous.

South America, Africa, Australia, &c.—In South America the Devonian is well developed; in Argentina, Bolivia, Brazil, Peru and the Falkland Islands, the palaeontological horizon is about the junction of the Lower and Middle divisions, and the fauna has affinities with the Hamilton shales of North America. Nearly allied to the South American Devonian is that of South Africa, where they are represented by the Bokkeveld beds in the Cape system. In Australia we find Lower Devonian consisting of coarse littoral deposits with volcanic rocks; and a Middle division with coral limestones in Victoria, New South Wales and Queensland; an Upper division has also been observed. In New Zealand the Devonian is well exposed in the Reefton mining field; and it has been suggested that much of the highly metamorphosed rock may belong to this system.

Stratigraphy of the Old Red Sandstone Facies.

The Old Red Sandstone of Britain, according to Sir Archibald Geikie, "consists of two subdivisions, the lower of which passes down conformably into the Upper Silurian deposits, the upper shading off in the same manner into the base of the Carboniferous system, while they are separated from each other by an unconformability." The Old Red strata appear to have been deposited in a number of elongated lakes or lagoons, approximately parallel to one another, with a general alignment in a N.E.-S.W. direction. To these areas of deposit Sir A. Geikie has assigned convenient distinctive names.

In Scotland the two divisions of the system are sharply separated by a pronounced unconformability which is probably indicative of a prolonged interval of erosion. In the central valley between the base of the Highlands and the southern uplands lay "Lake Caledonia." Here the lower division is made up of some 20,000 ft. of shallow-water deposits, reddish-brown, yellow and grey sandstones and conglomerates, with occasional "cornstones," and thin limestones. The grey flagstones with shales are almost confined to Forfarshire, and are known as the "Arbroath flags." Interbedded volcanic rocks, andesites, dacites, diabases, with agglomerates and tuffs constitute an important feature, and attain a thickness of 6000 ft. in the Pentland and Ochil hills. A line of old volcanic vents may be traced in a direction roughly parallel to the trend of the great central valley. On the northern side of the Highlands was "Lake Orcadie," presumably much larger than the foregoing lake, though its boundaries are not determinable. It lay over Moray Firth and the east of Ross and Sutherland, and extended from Caithness to the Orkney Islands and S. Shetlands. It may even have stretched across to Norway, where similar rocks are found in Sognefjord and Dalsfjord, and may have had communications with some parts of northern Russia. Very characteristic of this area are the Caithness flags, dark grey and bituminous, which, with the red sandstones and conglomerates at their base, probably attain a thickness of 16,000 ft. The somewhat peculiar fauna of this series led Murchison to class the flags as Middle Devonian. In the Shetland Islands contemporaneous volcanic rocks have been observed. Over the west of Argyllshire lay "Lake Lorne"; here the volcanic rocks predominate, they are intercalated with shallow-water deposits. A similar set of rocks occupy the Cheviot district.

The upper division of the Old Red Sandstone is represented in Shropshire and South Wales by a great series of red rocks, shales, sandstones and marls, some 10,000 ft. thick. They contain few fossils, and no break has yet been found in the series. In Scotland this series was deposited in basins which correspond only partially with those of the earlier period. They are well developed in central Scotland over the lowlands bordering the Moray Firth. Interbedded lavas and tuffs are found in the island of Hoy. An interesting feature of this series is the occurrence of great crowds of fossil fishes in some localities, notably at Dura Den in Fife. In the north of England this series rests unconformably upon the Lower Old Red and the Silurian.

Flanking the Silurian high ground of Cumberland and Westmorland, and also in the Lammermuir hills and in Flint and Anglesey, a brecciated conglomerate, presenting many of the characters of a glacial deposit in places, has often been classed with the Old Red Sandstone, but in parts, at least, it is more likely to belong to the base of the Carboniferous system. In Ireland the lower division appears to be represented by the Dingle beds and Glengariff grits, while the Kerry rocks and the Kiltorcan beds of Cork are the equivalents of the upper division. Rocks of Old Red type, both lower and upper, are found in Spitzbergen and in Bear Island. In New Brunswick and Nova Scotia the Old Red facies is extensively developed. The Gaspé sandstones have been estimated at 7036 ft. thick. In parts of western Russia Old Red Sandstone fossils are found in beds intercalated with others containing marine fauna of the Devonian facies.

Devonian and Old Red Sandstone Faunas.

The two types of sediment formed during this period—the *marine* Devonian and the *lagoonal* Old Red Sandstone—representing as they do two different but essentially contemporaneous phases of physical condition, are occupied by two strikingly dissimilar faunas. Doubtless at all times there were regions of the earth that were marked off no less clearly from the normal marine conditions of which we have records; but this period is the earliest in which these variations of environment are made obvious. In some respects the faunal break between the older Silurian below and the younger Carboniferous above is not strongly marked; and in certain areas a very close relationship can be shown to exist between the older Devonian and the former, and the younger Devonian and the latter. Nevertheless, taken as a whole, the life of this period bears a distinct stamp of individuality.

The two most prominent features of the Devonian seas are presented by corals and brachiopods. The corals were abundant individually and varied in form; and they are so distinctive of the period that no Devonian species has yet been found either in the Silurian or in the Carboniferous. They built reefs, as in the present day, and contributed to the formation of limestone masses in Devonshire, on the continent of Europe and in North America. Rugose and tabulate forms prevailed; among the former the cyathophyllids (*Cyathophyllum*) were important, *Phillipsastraea*, *Zaphrentis*, *Acervularia* and the curious *Calceola* (*sandalina*), an operculate genus which has given palaeontologists much trouble in its diagnosis, for it has been regarded as a pelecypod (hippurite) and a brachiopod. The tabulate corals were represented by *Favosites*, *Michelinia*, *Pleurodictyum*, *Fistulipora*, *Pachypora* and others. *Heliolites* and *Plasmopora* represent the alcyonarians. Stromatoporoids were important reef builders. A well-known fossil is *Receptaculites*, a genus to which it has been difficult to assign a definite place; it has been thought to be a sponge, it may be a calcareous alga, or a curious representative of the foraminifera.

In the Devonian period the brachiopods reached the climax of their development: they compose three-quarters of the known fauna, and more than 1100 species have been described. Changes were taking place from the beginning of the period in the relative importance of genera; several Silurian forms dropped out, and new types were coming in. A noticeable feature was the development of broad-winged shells in the genus *Spirifer*, other spiriferids were *Ambocoelia*, *Uncites*, *Verneuilia*. Orthids and pentamerids were waning in importance, while the productids (*Productella*, *Chonetes*, *Strophalosia*) were increasing. The strophomenids were still flourishing, represented by the genera *Leptaena*, *Stropheodonta*, *Kayserella*, and others. The ancient *Lingula*, along with *Crania* and *Orbiculoidea*, occur among the inarticulate forms. Another long-lived and wide-ranging species is *Atrypa reticularis*. The athyrids were very numerous (*Athyris*, *Retzia*, *Merista*, *Meristella*, *Kayserina*, &c.); and the rhynchonellids were well represented by *Pugnax*, *Hypothyris*, and several other genera. The important group of terebratulids appears in this system; amongst them *Stringocephalus* is an eminently characteristic Devonian brachiopod; others are *Dielasma*, *Cryptonella*, *Rensselaeria* and *Oriskania*.

The pelecypod molluscs were represented by *Pterinea*, abundant in the lower members along with other large-winged forms, and by *Cucullella*, *Buchiola* and *Curtonotus* in the upper members of the system. Other genera are *Actinodesma*, *Cardiola*, *Nucula*, *Megalodon*, *Aviculopecten*, &c. Gasteropods were becoming more important, but the simple capulid forms prevailed: *Platyceras* (*Capulus*), *Straparollus*, *Pleurotomaria*, *Murchisonia*, *Macrocheilina*, *Euomphalus*. Among the pteropods, *Tentaculites* was very abundant in some quarters; others were *Conularia* and *Styliolina*. In the Devonian period the cephalopods began to make a distinct advance in numbers, and in development. The goniatites appear with the genera *Anarcestes*, *Agoniatites*, *Tornoceras*, *Bactrites* and others; and in the upper strata the clymenoids, forerunners of the later ammonoids, began to take definite shape. While several new nautiloids (*Homaloceras*, *Ryticeras*, &c.) made their appearance several of the older genera still lived on (*Orthoceras*, *Poterioceras*, *Actinoceras*).

Crinoids were very abundant in some parts of the Devonian sea, though they were relatively scarce in others; they include the genera *Melocrinus*, *Haplocrinus*, *Cupressocrinus*, *Calceocrinus* and *Eleuthrocrinus*. The cystideans were falling off (*Proteocystis*, *Tiaracrinus*), but blastoids were in the ascendant (*Nucleocrinus*, *Codaster*, &c.). Both brittle-stars, *Ophiura*, *Palaeophiura*, *Eugaster*, and true starfishes, *Palaeaster*, *Aspidosoma*, were present, as well as urchins (*Lepidocentrus*).

When we turn to the crustaceans we have to deal with two distinct assemblages, one purely marine, trilobitic, the other mainly lacustrine or lagoonal with a eurypteridian facies. The trilobites had already begun to decline in importance, and as happens not infrequently with degenerating races of beasts and men, they began to develop strange eccentricities of ornamentation in some of their genera. A number of Silurian genera lived on into the Devonian period, and some gradually developed into new and distinctive forms; such were *Proëtus*, *Harpes*, *Cheirurus*, *Bronteus* and others. Distinct species of *Phacops* mark the Lower and Upper Devonian respectively, while the genus *Dalmania* (*Odontochile*) was represented by species with an almost world-wide range. The Ostracod *Entomis* (*Cypridina*) was extremely abundant in places—*Cypridinen-Schiefer*—while the true *Cypridina* was also present along with *Beyrichia*, *Leperditia*, &c. The Phyllocarids, *Echinocaris*, *Eleuthrocaris*, *Tropidocaris*, are common in the United States. It is in the Old Red Sandstone that the eurypterids are best preserved; foremost among these was *Pterygotus*; *P. anglicus* has been found in Scotland with a length of nearly 6 ft.; *Eurypterus*, *Slimonia*, *Stylonurus* were other genera.

Insects appear well developed, including both orthopterous and neuropterous forms, in the New Brunswick rocks. Mr Scudder believed he had obtained a specimen of Orthoptera in which a stridulating organ was present. A species of *Ephemera*, allied to the modern may-fly, had a spread of wing extending to 5 in. In the Scottish Old Red Sandstone myriapods, *Kampecaris* and *Archidesmus*, have been described; they are somewhat simpler than more recent forms, each segment being separate, and supplied with only one pair of walking legs. Spiders and scorpions also lived upon the land.

The great number of fish remains in the Devonian and Old Red strata, coupled with the truly remarkable characters possessed by some of the forms, has caused the period to be described as the "age of fishes." As in the case of the crustaceans, referred to above, we find one assemblage more or less peculiar to the freshwater or brackish conditions of the Old Red, and another characteristic of the marine Devonian; on the whole the former is the richer in variety, but there seems little doubt that quite a number of genera were capable of living in either environment, whatever may have been the real condition of the Old Red waters. Foremost in interest are the curious ostracoderms, a remarkable group of creatures possessing many of the characteristics of fishes, but more probably belonging to a distinct class of organisms, which appears to link the vertebrates with the arthropods. They had come into existence late in Silurian times; but it is in the Old Red strata that their remains are most fully preserved. They were abundant in the fresh or brackish waters of Scotland, England, Wales, Russia and Canada, and are represented by such forms as *Pteraspis*, *Cephalaspis*, *Cyathaspis*, *Tremataspis*, *Bothriolepis* and *Pterichthys*.

In the lower members of the Old Red series *Dipterus*, and in the upper members *Phaneropleuron*, represented the dipnoid lung-fishes; and it is of extreme interest to note that a few of these curious forms still survive in the African *Protopterus*, the Australian *Ceratodus* and the South American *Lepidosiren*,—all freshwater fishes. Distantly related to the lung-fishes were the singular arthrodirans, a group possessing the unusual faculty of moving the head in a vertical plane. These comprise the wide-ranging *Coccosteus* with *Homosteus* and *Dinichthys*, the largest fish of the period. The latter probably reached 20 ft. in length; it was armed with exceedingly powerful jaws provided with turtle-like beaks. Sharks were fairly prominent denizens of the sea; some were armed with cutting teeth, others with crushing dental plates; and although they were on the whole marine fishes, they were evidently able to live in fresher waters, like some of their modern representatives, for their remains, mostly teeth and large dermal spines, are found both in the Devonian and Old Red rocks. *Mesacanthus*, *Diplacanthus*, *Climatius*, *Cheiracanthus* are characteristic genera. The crossopterygians, ganoids with a scaly lobe in the centre of the fins, were represented by *Holoptychius* and *Glyptopomus* in the Upper Old Red, and by such genera as *Diplopterus*, *Osteolepis*, *Gyroptychius* in the lower division. The *Polypterus* of the Nile and *Calamoichthys* of South Africa are the modern exemplars of this group. *Cheirolepis*, found in the Old Red of Scotland and Canada, is the only Devonian representative of the actinopterygian fishes. The cyclostome fishes have, so far, been discovered only in Scotland, in the tiny *Palaeospondylus*. Amphibian remains have been found in the Devonian of Belgium; and footprints supposed to belong to a creature of the same class (*Thinopus antiquus*) have been described by Professor Marsh from the Chemung formation of Pennsylvania.

Plant Life.—In the lacustrine deposits of the Old Red Sandstone we find the earliest well-defined assemblage of terrestrial plants. In some regions so abundant are the vegetable remains that in places they form thin seams of veritable coal. These plants evidently flourished around the shores of the lakes and lagoons in which their remains were buried along with the other forms of life. Lycopods and ferns were the predominant types; and it is important to notice that both groups were already highly developed. The ferns include the genera *Sphenopteris*, *Megalopteris*, *Archaeopteris*, *Neuropteris*. Among the Lycopods are *Lycopodites*, *Psilophyton*, *Lepidodendron*. Modern horsetails are represented by *Calamocladus*, *Asterocalamites*, *Annularia*. Of great interest are the genera *Cordaites*, *Araucarioxylon*, &c., which were synthetic types, uniting in some degree the Coniferae and the Cycadofilicales. With the exception of obscure markings, aquatic plants are not so well represented as might have been expected; *Parka*, a common fossil, has been regarded as a water plant with a creeping stem and two kinds of sporangia in sessile sporocarps.

Physical Conditions, &c.—Perhaps the most striking fact that is brought out by a study of the Devonian rocks and their fossils is the gradual transgression of the sea over the land, which took place quietly in every quarter of the globe shortly after the beginning of the period. While in most places the Lower Devonian sediments succeed the Silurian formations in a perfectly conformable manner, the Middle and Upper divisions, on account of this encroachment of the sea, rest unconformably upon the older rocks, the Lower division being unrepresented. This is true over the greater part of South America, so far as our limited knowledge goes, in much of the western side of North America, in western Russia, in Thuringia and other parts of central Europe. Of the distribution of land and sea and the position of the coast lines in Devonian times we can state nothing with precision. The known deposits all point to shallow waters of epicontinental seas; no abyssal formations have been recognized. E. Kayser has pointed out the probability of a Eurasian sea province extending through Europe towards the east, across north and central Asia towards Manitoba in Canada, and an American sea province embracing the United States, South America and South Africa. At the same time there existed a great North Atlantic land area caused partly by the uplift of the Caledonian range just before the beginning of the period, which stretched across north Europe to eastern Canada; on the fringe of this land the Old Red Sandstone was formed.

In the European area C. Barrois has indicated the existence of three zones of deposition: (1) A northern, Old Red, region, including Great Britain, Scandinavia, European Russia and Spitzbergen; here the land was close at hand; great brackish lagoons prevailed, which communicated more or less directly with the open sea. In European Russia, during its general advance, the sea occasionally gained access to wide areas, only to be driven off again, during pauses in the relative subsidence of the land, when the continued terrigenous sedimentation once more established the lagoonal conditions. These alternating phases were frequently repeated. (2) A middle region, covering Devonshire and Cornwall, the Ardennes, the northern part of the lower Rhenish mountains, and the upper Harz to the Polish Mittelgebirge; here we find evidence of a shallow sea, clastic deposits and a sublittoral fauna. (3) A southern region reaching from Brittany to the south of the Rhenish mountains, lower Harz, Thuringia and Bohemia; here was a deeper sea with a more pelagic fauna. It must be borne in mind that the above-mentioned regions are intended to refer to the time when the extension of the Devonian sea was near its maximum. In the case of North America it has been shown that in early and middle Devonian time more or less distinct faunas invaded the continent from five different centres, viz. the Helderberg, the Oriskany, the Onondaga, the southern Hamilton and the north-western Hamilton; these reached the interior approximately in the order given.

Towards the close of the period, when the various local faunas had mingled one with another and a more generalized life assemblage had been evolved, we find many forms with a very wide range, indicating great uniformity of conditions. Thus we find identical species of brachiopods inhabiting the Devonian seas of England, France, Belgium, Germany, Russia, southern Asia and China; such are, *Hypothyris* (*Rhynchonella*) *cuboides*, *Spirifer disjunctus* and others. The fauna of the *Calceola* shales can be traced from western Europe to Armenia and Siberia; the *Stringocephalus* limestones are represented in Belgium, England, the Urals and Canada; and the (*Gephyroceras*) *intumescens* shales are found in western Europe and in Manitoba.

The Devonian period was one of comparative quietude; no violent crustal movements seem to have taken place, and while some changes of level occurred towards its close in Great Britain, Bohemia and Russia, generally the passage from Devonian to Carboniferous conditions was quite gradual. In later periods these rocks have suffered considerable movement and metamorphism, as in the Harz, Devonshire and Cornwall, and in the Belgian coalfields, where they have frequently been thrust over the younger Carboniferous rocks. Volcanic activity was fairly widespread, particularly during the middle portion of the period. In the Old Red rocks of Scotland there is a great thickness (6000 ft.) of igneous rocks, including diabases and andesitic lavas with agglomerates and tuffs. In Devonshire diabases and tuffs are found in the middle division. In west central Europe volcanic rocks are found at many horizons, the most common rocks are diabases and diabase tuffs, *schalstein*. Felsitic lavas and tuffs occur in the Middle Devonian of Australia. Contemporaneous igneous rocks are generally absent in the American Devonian, but in Nova Scotia and New Brunswick there appear to be some.

There is little evidence as to the climate of this period, but it is interesting to observe that local glacial conditions *may* have existed in places, as is suggested by the coarse conglomerate with striated boulders in the upper Old Red of Scotland. On the other hand, the prevalence of reef-building corals points to moderately warm temperatures in the Middle Devonian seas.

The economic products of Devonian rocks are of some importance: in many of the metamorphosed regions veins of tin, lead, copper, iron are exploited, as in Cornwall, Devon, the Harz; in New Zealand, gold veins occur. Anthracite of Devonian age is found in China and a little coal in Germany, while the Upper Devonian is the chief source of oil and gas of western Pennsylvania and south-western New York. In Ontario the middle division is oil-bearing. Black phosphates are worked in central Tennessee, and in England the marls of the "Old Red" are employed for brick-making.

References.—The literature of the Devonian rocks and fossils is very extensive; important papers have been contributed by the following geologists: J. Barrande, C. Barrois, F. Béclard, E. W. Benecke, L. Beushausen, A. Champernowne, J. M. Clarke, Sir J. W. Dawson, A. Denckmann, J. S. Diller, E. Dupont, F. Frech, J. Fournet, Sir A. Geikie, G. Gürich, R. Hoernes, E. Kayser, C. and M. Koch, A. von Koenen, Hugh Miller, D. P. Oehlert, C. S. Prosser, P. de Rouville, C. Schuchert, T. Tschernyschew, E. O. Ulrich, W. A. E. Ussher, P. N. Wenjukoff, G. F. Whidborne, J. F. Whiteaves and H. S. Williams. Sedgwick and Murchison's original description appeared in the *Trans. Geol. Soc.* (2nd series, vol. v., 1839). Good general accounts will be found in Sir A. Geikie's *Text-Book of Geology* (vol. ii., 4th ed., 1903), in E. Kayser's *Lehrbuch der Geologie* (vol. ii., 2nd ed., 1902), and, for North America, in Chamberlin and Salisbury's *Geology* (vol. ii., 1906). See the *Index to the Geological Magazine* (1864-1903), and in subsequent annual volumes; *Geological Literature added to the Geological Society's Library* (London), annually since 1893; and the *Neues Jahrbuch für Min., Geologie und Paläontologie* (Stuttgart, 2 annual volumes). The U.S. Geological Survey publishes at intervals a *Bibliography and Index of North American Geology, &c.*, and this (e.g. Bulletin 301,—the *Bibliog. and Index* for 1901-1905) contains numerous references for the Devonian system in North America.

(J. A. H.)

DEVONPORT, a municipal, county and parliamentary borough of Devonshire, England, contiguous to East Stonehouse and Plymouth, the seat of one of the royal dockyards, and an important naval and military station. Pop. (1901) 70,437. It is situated immediately above the N.W. angle of Plymouth Sound, occupying a triangular peninsula formed by Stonehouse Pool on the E. and the Hamoaze on the W. It is served by the Great Western and the London & South Western railways. The town proper was formerly enclosed by a line of ramparts and a ditch excavated out of the limestone, but these are in great part demolished. Adjoining Devonport are East Stonehouse (an urban district, pop. 15,111), Stoke and Morice Town, the two last being suburbs of Devonport. The town hall, erected in 1821-1822 partly after the design of the Parthenon, is distinguished by a Doric portico; while near it are the public library, in Egyptian style, and a conspicuous Doric column built of Devonshire granite. This monument, which is 100 ft. high, was raised in commemoration of the naming of the town in 1824. Other institutions are the Naval Engineering College, Keyham (1880); the municipal technical schools, opened in 1899, the majority of the students being connected with the dockyard; the naval barracks, Keyham (1885); the Raglan barracks and the naval and military hospitals. On Mount Wise, which was formerly defended by a battery (now a naval signalling station), stands the military residence, or Government House, occupied by the commander of the Plymouth Coast Defences; and near at hand is the principal naval residence, the naval commander-in-chief's house. The prospect from Mount Wise over the Hamoaze to Mount Edgecumbe on the opposite shore is one of the finest in the south of England. The most noteworthy feature of Devonport, however, is the royal dockyard, originally established by William III. in 1689 and until 1824 known as Plymouth Dock. It is situated within the old town boundary and contains four docks. To this in 1853 was added Keyham steamyard, situated higher up the Hamoaze beyond the old boundary and connected with the Devonport yard by a tunnel. In 1896 further extensions were begun at the Keyham yard, which became known as Devonport North yard. Before these were begun the yard comprised two basins, the northern one being 9 acres and the southern 7 acres in area, and three docks, having floor-lengths of

295, 347 and 413 ft., together with iron and brass foundries, machinery shops, engineer students' shop, &c. The new extensions, opened by the Prince of Wales on the 21st of February 1907, cover a total area of 118 acres lying to the northward in front of the Naval Barracks, and involved the reclamation of 77 acres of mudflats lying below high-water mark. The scheme presented three leading features—a tidal basin, a group of three graving docks with entrance lock, and a large enclosed basin with a coaling depôt at the north end. The tidal basin, close to the old Keyham north basin, is 740 ft. long with a mean width of 590 ft., and has an area of 10 acres, the depth being 32 ft. at low water of spring tides. It affords access to two graving docks, one with a floor-length of 745 ft. and 20½ ft. of water over the sill, and the other with a length of 741 ft. and 32 ft. of water over the sill. Each of these can be subdivided by means of an intermediate caisson, and (when unoccupied) may serve as an entrance to the closed basin. The lock which leads from the tidal to the closed basin is 730 ft. long, and if necessary can be used as a dock. The closed basin, out of which opens a third graving dock, 660 ft. long, measures 1550 ft. by 1000 ft. and has an area of 35½ acres, with a depth of 32 ft. at low-water springs; it has a direct entrance from the Hamoaze, closed by a caisson. The foundations of the walls are carried down to the rock, which in some places lies covered with mud 100 ft. or more below coping level. Compressed air is used to work the sliding caissons which close the entrances of the docks and closed basin. A ropery at Devonport produces half the hempen ropes used in the navy.

By the Reform Act of 1832 Devonport was erected into a parliamentary borough including East Stonehouse and returning two members. The ground on which it stands is for the most part the property of the St Aubyn family (Barons St Levan), whose steward holds a court leet and a court baron annually. The town is governed by a mayor, sixteen aldermen and forty-eight councillors. Area, 3044 acres.

DEVONPORT, EAST and **WEST**, a town of Devon county, Tasmania, situated on both sides of the mouth of the river Mersey, 193 m. by rail N.W. of Hobart. Pop. (1901), East Devonport, 673, West Devonport, 2101. There is regular communication from this port to Melbourne and Sydney, and it ranks as the third port in Tasmania. A celebrated regatta is held on the Mersey annually on New Year's day.

DEVONSHIRE, EARLS AND DUKES OF. The Devonshire title, now in the Cavendish family, had previously been held by Charles Blount (1563-1606), 8th Lord Mountjoy, great-grandson of the 4th Lord Mountjoy (d. 1534), the pupil of Erasmus; he was created earl of Devonshire in 1603 for his services in Ireland, where he became famous in subduing the rebellion between 1600 and 1603; but the title became extinct at his death. In the Cavendish line the 1st earl of Devonshire was William (d. 1626), second son of Sir William Cavendish (q.v.), and of Elizabeth Hardwick, who afterwards married the 6th earl of Shrewsbury. He was created earl of Devonshire in 1618 by James I., and was succeeded by William, 2nd earl (1591-1628), and the latter by his son William (1617-1684), a prominent royalist, and one of the original members of the Royal Society, who married a daughter of the 2nd earl of Salisbury.

William Cavendish, 1st duke of Devonshire (1640-1707), English statesman, eldest son of the earl of Devonshire last mentioned, was born on the 25th of January 1640. After completing his education he made the tour of Europe according to the custom of young men of his rank, being accompanied on his travels by Dr Killigrew. On his return he obtained, in 1661, a seat in parliament for Derbyshire, and soon became conspicuous as one of the most determined and daring opponents of the general policy of the court. In 1678 he was one of the committee appointed to draw up articles of impeachment against the lord treasurer Danby. In 1679 he was re-elected for Derby, and made a privy councillor by Charles II.; but he soon withdrew from the board with his friend Lord Russell, when he found that the Roman Catholic interest uniformly prevailed. He carried up to the House of Lords the articles of impeachment against Lord Chief-Justice Scroggs, for his arbitrary and illegal proceedings in the court of King's bench; and when the king declared his resolution not to sign the bill for excluding the duke of York, afterwards James II., he moved in the House of Commons that a bill might be brought in for the association of all his majesty's Protestant subjects. He also openly denounced the king's counsellors, and voted for an address to remove them. He appeared in defence of Lord Russell at his trial, at a time when it was scarcely more criminal to be an accomplice than a witness. After the condemnation he gave the utmost possible proof of his attachment by offering to exchange clothes with Lord Russell in the prison, remain in his place, and so allow him to effect his escape. In November 1684 he succeeded to the earldom on the death of his father. He opposed arbitrary government under James II. with the same consistency and high spirit as during the previous reign. He was withdrawn from public life for a time, however, in consequence of a hasty and imprudent act of which his enemies knew how to avail themselves. Fancying that he had received an insulting look in the presence chamber from Colonel Colepepper, a swaggerer whose attendance at court the king encouraged, he immediately avenged the affront by challenging the colonel, and, on the challenge being refused, striking him with his cane. This offence was punished by a fine of £30,000, which was an enormous sum even to one of the earl's princely fortune. Not being able to pay he was imprisoned in the king's bench, from which he was released only on signing a bond for the whole amount. This was afterwards cancelled by King William. After his discharge the earl went for a time to Chatsworth, where he occupied himself with the erection of a new mansion, designed by William Talman, with decorations by Verrio, Thornhill and Grinling Gibbons. The Revolution again brought him into prominence. He was one of the seven who signed the original paper inviting the prince of Orange from Holland, and was the first nobleman who appeared in arms to receive him at his landing. He received the order of the Garter on the occasion of the coronation, and was made lord high steward of the new court. In 1690 he accompanied King William on his visit to Holland. He was created marquis of Hartington and duke of Devonshire in 1694 by William and Mary, on the same day on which the head of the house of Russell was created duke of Bedford. Thus, to quote Macaulay, "the two great houses of Russell and Cavendish, which had long been closely connected by friendship and by marriage, by common opinions, common sufferings and common triumphs, received on the same day the highest honour which it is in the power of the crown to confer." His last public service was assisting to conclude the union with Scotland, for negotiating which he and his eldest son, the marquis of Hartington, had been appointed among the commissioners by Queen Anne. He died on the 18th of August 1707, and ordered the following inscription to be put on his monument:—

Willielmus Dux Devon,
Bonorum Principum Fidelis Subditus,
Inimicus et Invisus Tyrannis.

He had married in 1661 the daughter of James, duke of Ormonde, and he was succeeded by his eldest son William as 2nd duke, and by the latter's son William as 3rd duke (viceroy of Ireland, 1737-1744). The latter's son William (1720-1764) succeeded in 1755 as 4th duke; he married the daughter and heiress of Richard Boyle, earl of Burlington and Cork, who brought Lismore Castle and the Irish estates into the family; and from November 1756 to May 1757 he was prime minister, mainly in order that Pitt, who would not then serve under the duke of Newcastle, should be in power. His son William (1748-1811), 5th duke, is memorable as the husband of the beautiful Georgiana Spencer, duchess of Devonshire (1757-1806), and of the intellectual Elizabeth Foster, duchess of Devonshire (1758-1824), both of whom Gainsborough painted. His son William, 6th duke (1790-1858), who died unmarried, was sent on a special mission to the coronation of the tsar Nicholas at Moscow in 1826, and became famous for his expenditure on that occasion; and it was he who employed Sir Joseph Paxton at Chatsworth. The title passed in 1858 to his cousin William (1808-1891), 2nd earl of Burlington, as 7th duke, a man who, without playing a prominent part in public affairs, exercised great influence, not only by his position but by his distinguished abilities. At Cambridge in 1829 he was second wrangler, first Smith's prizeman, and eighth classic, and subsequently he became chancellor of the university.

Spencer Compton Cavendish, 8th duke (1833-1908), born on the 23rd of July 1833, was the son of the 7th duke (then earl of Burlington) and his wife Lady Blanche Howard (sister of the earl of Carlisle). In 1854 Lord Cavendish, as he then was, took his degree at Trinity College, Cambridge; in 1856 he was attached to the special mission to Russia for the new tsar's accession; and in 1857 he was returned to parliament as Liberal member for North Lancashire. At the opening of the new parliament of 1859 the marquis of Hartington (as he had now become) moved the amendment to the address which overthrew the government of Lord Derby. In 1863 he became first a lord of the admiralty, and then under-secretary for war, and on the formation of the Russell-Gladstone administration at the death of Lord Palmerston he entered it as war secretary. He retired with his colleagues in July 1866; but upon Mr Gladstone's return to power in 1868 he became postmaster-general, an office which he exchanged in 1871 for that of secretary for Ireland. When Mr Gladstone, after his defeat and resignation in 1874, temporarily withdrew from the leadership of the Liberal party in January 1875, Lord Hartington was chosen Liberal leader in the House of Commons, Lord Granville being leader in the Lords. Mr W. E. Forster, who had taken a much more prominent part in public life, was the only other possible nominee, but he declined to stand. Lord Hartington's rank no doubt told in his favour, and Mr Forster's education bill had offended the Nonconformist members, who would probably have withheld their support. Lord Hartington's prudent management in difficult circumstances laid his followers under great obligations, since not only was the opposite party in the ascendant, but his own former chief was indulging in the freedom of independence. After the complete defeat of the Conservatives in the general election of 1880, a large proportion of the party would have rejoiced if Lord Hartington could have taken the Premiership instead of Mr Gladstone, and the queen, in strict conformity with constitutional usage (though Gladstone himself thought Lord Granville should have had the preference), sent for him as leader of the Opposition. Mr Gladstone, however, was clearly master of the situation: no cabinet could be formed without him, nor could he reasonably be expected to accept a subordinate post. Lord Hartington, therefore, gracefully abdicated the leadership, and became secretary of state for India, from which office, in December 1882, he passed to the war office. His administration was memorable for the expeditions of General Gordon and Lord Wolseley to Khartum, and a considerable number of the Conservative party long held him chiefly responsible for the "betrayal of Gordon." His lethargic manner, apart from his position as war minister, helped to associate him in their minds with a disaster which emphasized the fact that the government acted "too late"; but Gladstone and Lord Granville were no less responsible than he. In June 1885 he resigned along with his colleagues, and in December was elected for the Rossendale Division of Lancashire, created by the new reform bill. Immediately afterwards the great political opportunity of Lord Hartington's life came to him in Mr Gladstone's conversion to home rule for Ireland. Lord Hartington's refusal to follow his leader in this course inevitably made him the chief of the new Liberal Unionist party, composed of a large and influential section of the old Liberals. In this capacity he moved the first resolution at the famous public meeting at the opera house, and also, in the House of Commons, moved the rejection of Mr Gladstone's Bill on the second reading. During the memorable electoral contest which followed, no election excited more interest than Lord Hartington's for the Rossendale division, where he was returned by a majority of nearly 1500 votes. In the new parliament he held a position much resembling that which Sir Robert Peel had occupied after his fall from power, the leader of a small, compact party, the standing and ability of whose members were out of all proportion to their numbers, generally esteemed and trusted beyond any other man in the country, yet in his own opinion forbidden to think of office. Lord Salisbury's offers to serve under him as prime minister (both after the general election, and again when Lord Randolph Churchill resigned) were declined, and Lord Hartington continued to discharge the delicate duties of the leader of a middle party with no less judgment than he had shown when leading the Liberals during the interregnum of 1875-1880. It was not until 1895, when the differences between Conservatives and Liberal Unionists had become almost obliterated by changed circumstances, and the habit of acting together, that the duke of Devonshire, as he had become by the death of his father in 1891, consented to enter Lord Salisbury's third ministry as president of the council. The duke thus was the nominal representative of education in the cabinet at a time when educational questions were rapidly becoming of great importance; and his own technical knowledge of this difficult and intricate question being admittedly superficial, a good deal of criticism from time to time resulted. He had however by this time an established position in public life, and a reputation for weight of character, which procured for him universal respect and confidence, and exempted him from bitter attack, even from his most determined political opponents. Wealth and rank combined with character to place him in a measure above party; and his succession to his father as chancellor of the university of Cambridge in 1892 indicated his eminence in the life of the country. In the same year he had married the widow of the 7th duke of Manchester.

He continued to hold the office of lord president of the council till the 3rd of October 1903, when he resigned on account of differences with Mr Balfour (q.v.) over the latter's attitude towards free trade. As Mr Chamberlain had retired from the cabinet, and the duke had not thought it necessary to join Lord George Hamilton and Mr Ritchie in resigning a fortnight earlier, the defection was unanticipated and was sharply criticized by Mr Balfour, who, in the rearrangement of his ministry, had only just appointed the duke's nephew and heir, Mr Victor Cavendish, to be secretary to the treasury. But the duke had come to the conclusion that while he himself was substantially a free-trader,[1] Mr Balfour did not mean the same thing by the term. He necessarily became the leader of the Free Trade Unionists who were neither Balfourites nor Chamberlainites, and his weight was thrown into the scale against any association of Unionism with the constructive policy of tariff reform, which he identified with sheer Protection. A struggle at once began within the Liberal Unionist organization between those who followed the duke and those who followed Mr Chamberlain (q.v.); but the latter were in the majority and a reorganization in the Liberal Unionist Association took place, the Unionist free-traders seceding and becoming a separate body. The duke then became president of the new organizations, the Unionist Free Food League and the Unionist Free Trade Club. In the subsequent developments the duke played a dignified but somewhat silent part, and the Unionist rout in 1906 was not unaffected by his open hostility to any taint of compromise with the tariff reform movement. But in the autumn of 1907 his health gave way, and grave symptoms of cardiac weakness necessitated his abstaining from public effort and spending the winter abroad. He died, rather suddenly, at Cannes on the 24th of March 1908.

The head of an old and powerful family, a wealthy territorial magnate, and an Englishman with thoroughly national tastes for sport, his weighty and disinterested character made him a statesman of the first rank in his time, in spite of the absence of showy or brilliant qualities. He had no self-seeking ambitions, and on three occasions preferred not to become prime minister. Though his speeches were direct and forcible, he was not an orator, nor "clever"; and he lacked all subtlety of intellect; but he was conspicuous for solidity of mind and straightforwardness of action, and for conscientious application as an administrator, whether in his public or private life. The fact that he once yawned in the middle of a speech of his own was commonly quoted as characteristic; but he combined a great fund of common sense and knowledge of the average opinion with a patriotic sense of duty towards the state. Throughout his career he remained an old-fashioned Liberal, or rather Whig, of a type which in his later years was becoming gradually more and more rare.

There was no issue of his marriage, and he was succeeded as 9th duke by his nephew Victor Christian Cavendish (b. 1868), who had been Liberal Unionist member for West Derbyshire since 1891, and was treasurer of the household (1900 to 1903) and financial secretary to the treasury (1903 to 1905); in 1892 he married a daughter of the marquess of Lansdowne, by whom he had two sons.

(H. Ch.)

[1] His own words to Mr Balfour at the time were: "I believe that our present system of free imports is on the whole the most advantageous to the country, though I do not contend that the principles on which it rests possess any such authority or sanctity as to forbid any departure from it, for sufficient reasons."

DEVONSHIRE (Devon), a south-western county of England, bounded N.W. and N. by the Bristol Channel, N.E. by Somerset and Dorset, S.E. and S. by the English Channel, and W. by Cornwall. The area, 2604.9 sq. m., is exceeded only by those of Yorkshire and Lincolnshire among the English counties. Nearly the whole of the surface is uneven and hilly. The county contains the highest land in England south of Derbyshire (excepting points on the south Welsh border); and the scenery, much varied, is in most parts striking and picturesque. The heather-clad uplands of Exmoor, though chiefly within the borders of Somerset, extend into North Devon, and are still the haunt of red deer, and of the small hardy ponies called after the district. Here, as on Dartmoor, the streams are rich in trout. Dartmoor, the principal physical feature of the county, is a broad and lofty expanse of moorland which rises in the southern part. Its highest point, 2039 ft., is found in the north-western portion. Its rough wastes contrast finely with the wild but wooded region which immediately surrounds the granite of which it is composed, and with the rich cultivated country lying beyond. Especially noteworthy in this fertile tract are the South Hams, a fruitful district of apple orchards, lying between the Erme and the Dart; the rich meadow-land around Crediton, in the vale of Exeter; and the red rocks near Sidmouth. Two features which lend a characteristic charm to the Devonshire landscape are the number of picturesque old cottages roofed with thatch; and the deep lanes, sunk below the common level of the ground, bordered by tall hedges, and overshadowed by an arch of boughs. The north and south coasts of the county differ much in character, but both have grand cliff and rock scenery, not surpassed by any in England or Wales, resembling the Mediterranean seaboard in its range of colour. As a rule the long combes or glens down which the rivers flow seaward are densely wooded, and the country immediately inland is of great beauty. Apart from the Tamar, which constitutes the boundary between Devon and Cornwall, and flows into the English Channel, after forming in its estuary the harbours of Devonport and Plymouth, the principal rivers rise on Dartmoor. These include the Teign, Dart, Plym and Tavy, falling into the English Channel, and the Taw flowing north towards Bideford Bay. The river Torridge, also discharging northward, receives part of its waters from Dartmoor through the Okement, but itself rises in the angle of high land near Hartland point on the north coast, and makes a wide sweep southward. The lesser Dartmoor streams are the Avon, the Erme and the Vealm, all running south. The Exe rises on Exmoor in Somersetshire; but the main part of its course is through Devonshire (where it gives name to Exeter), and it is joined on its way to the English Channel by the lesser streams of the Culm, the Creedy and the Clyst. The Otter, rising on the Blackdown Hills, also runs south, and the Axe, for part of its course, divides the counties of Devon and Dorset. These eastern streams are comparatively slow; while the rivers of Dartmoor have a shorter and more rapid course.

Geology.—The greatest area occupied by any one group of rocks in Devonshire is that covered by the Culm, a series of slates, grits and greywackes, with some impure limestones and occasional radiolarian cherts as at Codden Hill; beds of "culm," an impure variety of coal, are found at Bideford and elsewhere. This series of rocks occurs at Bampton, Exeter and Chudleigh and extends thence to the western boundary. North and south of the Culm an older series of slates, grits and limestones appears; it was considered so characteristic of the county that it was called the Devonian system (q.v.), the marine equivalent of the Old Red Sandstone of Hereford and Scotland. It lies in the form of a trough with its axis running east and west. In the central hollow the Culm reposes, while the northern and southern rims rise to the surface respectively north of the latitude of Barnstaple and South Molton and south of the latitude of Tavistock. These Devonian rocks have been subdivided into upper, middle and lower divisions, but the stratigraphy is difficult to follow as the beds have suffered much crumpling; fine examples of contorted strata may be seen almost anywhere on the north coast, and in the south, at Bolt Head and Start Point they have undergone severe metamorphism. Limestones are only poorly developed in the north, but in the south important masses occur, in the middle and at the base of the upper subdivisions, about Plymouth, Torquay, Brixham and between Newton

Abbot and Totnes. Fossil corals abound in these limestones, which are largely quarried and when polished are known as Devonshire marbles.

On the eastern side of the county is found an entirely different set of rocks which cover the older series and dip away from them gently towards the east. The lower and most westerly situated members of the younger rocks is a series of breccias, conglomerates, sandstones and marls which are probably of lower Bunter age, but by some geologists have been classed as Permian. These red rocks are beautifully exposed on the coast by Dawlish and Teignmouth, and they extend inland, producing a red soil, past Exeter and Tiverton. A long narrow strip of the same formation reaches out westward on the top of the Culm as far as Jacobstow. Farther east, the Bunter pebble beds are represented by the well-known pebble deposit of Budleigh Salterton, whence they are traceable inland towards Rockbeare. These are succeeded by the Keuper marls and sandstones, well exposed at Sidmouth, where the upper Greensand plateau is clearly seen to overlie them. The Greensand covers all the high ground northward from Sidmouth as far as the Blackdown Hills. At Beer Head and Axmouth the Chalk is seen, and at the latter place is a famous landslip on the coast, caused by the springs which issue from the Greensand below the Chalk. The Lower Chalk at Beer has been mined for building stone and was formerly in considerable demand. At the extreme east of the county, Rhaetic and Lias beds make their appearance, the former with a "bone" bed bearing the remains of saurians and fish.

Dartmoor is a mass of granite that was intruded into the Culm and Devonian strata in post-Carboniferous times and subsequently exposed by denudation. Evidences of Devonian volcanic activity are abundant in the masses of diabase, dolerite, &c., at Bradford and Trusham, south of Exeter, around Plymouth and at Ashprington. Perhaps the most interesting is the Carboniferous volcano of Brent Tor near Tavistock. An Eocene deposit, the product of the denudation of the Dartmoor Hills, lies in a small basin at Bovey Tracey (see Bovey Beds); it yields beds of lignite and valuable clays.

Raised beaches occur at Hope's Nose and the Thatcher Stone near Torquay and at other points, and a submerged forest lies in the bay south of the same place. The caves and fissures in the Devonian limestone at Kent's Hole near Torquay, Brixham and Oreston are famous for the remains of extinct mammals; bones of the elephant, rhinoceros, bear and hyaena have been found as well as flint implements of early man.

Minerals.—Silver-lead was formerly worked at Combe Martin near the north coast, and elsewhere. Tin has been worked on Dartmoor (in stream works) from an unknown period. Copper was not much worked before the end of the 18th century. Tin occurs in the granite of Dartmoor, and along its borders, but rather where the Devonian than where the Carboniferous rocks border the granite. It is found most plentifully in the district which surrounds Tavistock, which, for tin and other ores, is in effect the great mining district of the county. Here, about 4 m. from Tavistock, are the Devon Great Consols mines, which from 1843 to 1871 were among the richest copper mines in the world, and by far the largest and most profitable in the kingdom. The divided profits during this period amounted to £1,192,960. But the mining interests of Devonshire are affected by the same causes, and in the same way, as those of Cornwall. The quantity of ore has greatly diminished, and the cost of raising it from the deep mines prevents competition with foreign markets. In many mines tin underlies the general depth of the copper, and is worked when the latter has been exhausted. The mineral products of the Tavistock district are various, and besides tin and copper, ores of zinc and iron are largely distributed. Great quantities of refined arsenic have been produced at the Devon Great Consols mine, by elimination from the iron pyrites contained in the various lodes. Manganese occurs in the neighbourhood of Exeter, in the valley of the Teign and in N. Devon; but the most profitable mines, which are shallow, are, like those of tin and copper, in the Tavistock district.

The other mineral productions of the county consist of marbles, building stones, slates and potters' clay. Among building stones, the granite of Dartmoor holds the foremost place. It is much quarried near Princetown, near Moreton Hampstead on the N.E. of Dartmoor and elsewhere. The annual export is considerable. Hard traps, which occur in many places, are also much used, as are the limestones of Buckfastleigh and of Plymouth. The Roborough stone, used from an early period in Devonshire churches, is found near Tavistock, and is a hard, porphyritic elvan, taking a fine polish. Excellent roofing slates occur in the Devonian series round the southern part of Dartmoor. The chief quarries are near Ashburton and Plymouth (Cann quarry). Potters' clay is worked at King's Teignton, whence it is largely exported; at Bovey Tracey; and at Watcombe near Torquay. The Watcombe clay is of the finest quality.

China clay or kaolin is found on the southern side of Dartmoor, at Lee Moor, and near Trowlesworthy. There is a large deposit of umber close to Ashburton.

Climate and Agriculture.—The climate varies greatly in different parts of the county, but everywhere it is more humid than that of the eastern or south-eastern parts of England. The mean annual temperature somewhat exceeds that of the midlands, but the average summer heat is rather less than that of the southern counties to the east. The air of the Dartmoor highlands is sharp and bracing. Mists are frequent, and snow often lies long. On the south coast frost is little known, and many half hardy plants, such as hydrangeas, myrtles, geraniums and heliotropes, live through the winter without protection. The climate of Sidmouth, Teignmouth, Torquay and other watering places on this coast is very equable, the mean temperature in January being 43.6° at Plymouth. The north coast, exposed to the storms and swell of the Atlantic, is more bracing; although there also, in the more sheltered nooks (as at Combe Martin), myrtles of great size and age flower freely, and produce their annual crop of berries.

Rather less than three-quarters of the total area of the county is under cultivation; the cultivated area falling a little below the average of the English counties. There are, however, about 160,000 acres of hill pasture in addition to the area in permanent pasture, which is more than one-half that of the cultivated area. The Devon breed of cattle is well adapted both for fattening and for dairy purposes; while sheep are kept in great numbers on the hill pastures. Devonshire is one of the chief cattle-farming and sheep-farming counties. It is specially famous for two products of the dairy—the clotted cream to which it gives its name, and junket. Of the area under grain crops, oats occupy about three times the acreage under wheat or barley. The bulk of the acreage under green crops is occupied by turnips, swedes and mangold. Orchards occupy a large acreage, and consist chiefly of apple-trees, nearly every farm maintaining one for the manufacture of cider.

Fisheries.—Though the fisheries of Devon are less valuable than those of Cornwall, large quantities of the pilchard and herrings caught in Cornish waters are landed at Plymouth. Much of the fishing is carried on within the three-mile limit; and it may be asserted that trawling is the main feature of the Devonshire industry, whereas seining and driving characterize that of Cornwall. Pilchard, cod, sprats, brill, plaice, soles, turbot, shrimps, lobsters, oysters and mussels are met with, besides herring and mackerel, which are fairly plentiful. After Plymouth, the principal fishing station is at Brixham, but there are lesser stations in every bay and estuary.

Other Industries.—The principal industrial works in the county are the various Government establishments at Plymouth and Devonport. Among other industries may be noted the lace-works at Tiverton; the manufacture of pillow-lace for which Honiton and its neighbourhood has long been famous; and the potteries and terra-cotta works of Bovey Tracey and Watcombe. Woollen goods and serges are made at Buckfastleigh and Ashburton, and boots and shoes at Crediton. Convict labour is employed in the direction of agriculture, quarrying, &c., in the great prison of Dartmoor.

Communications.—The main line of the Great Western railway, entering the county in the east from Taunton, runs to Exeter, skirts the coast as far as Teignmouth, and continues a short distance inland by Newton Abbot to Plymouth, after which it crosses the estuary of the Tamar by a great bridge to Saltash in Cornwall. Branches serve Torquay and other seaside resorts of the south coast; and among other branches are those from Taunton to Barnstaple and from Plymouth northward to Tavistock and Launceston. The main line of the London & South-Western railway between Exeter and Plymouth skirts the north and west of Dartmoor by Okehampton and Tavistock. A branch from Yeoford serves Barnstaple, Ilfracombe, Bideford and Torrington, while the Lynton & Barnstaple and the Bideford, Westward Ho & Appledore lines serve the districts indicated by their names. The branch line to Princetown from the Plymouth-Tavistock line of the Great Western company in part follows the line of a very early railway—that constructed to connect Plymouth with the Dartmoor prison in 1819-1825, which was worked with horse cars. The only waterways of any importance are the Tamar, which is navigable up to

Gunnislake (3 m. S.W. of Tavistock), and the Exeter ship canal, noteworthy as one of the oldest in England, for it was originally cut in the reign of Elizabeth.

Population and Administration.—The area of the ancient county is 1,667,154 acres, with a population in 1891 of 631,808, and 1901 of 661,314. The area of the administrative county is 1,671,168 acres. The county contains 33 hundreds. The municipal boroughs are Barnstaple (pop. 14,137), Bideford (8754), Dartmouth (6579), Devonport, a county borough (70,437), Exeter, a city and county borough (47,185), Torrington, officially Great Torrington (3241), Honiton (3271), Okehampton (2569), Plymouth, a county borough (107,636), South Molton (2848), Tiverton (10,382), Torquay (33,625), Totnes (4035). The other urban districts are Ashburton (2628), Bampton (1657), Brixham (8092), Buckfastleigh (2520), Budleigh Salterton (1883), Crediton (3974), Dawlish (4003), East Stonehouse (15,111), Exmouth (10,485), Heavitree (7529), Holsworthy (1371), Ilfracombe (8557), Ivybridge (1575), Kingsbridge (3025), Lynton (1641), Newton Abbot (12,517), Northam (5355), Ottery St Mary (3495), Paignton (8385), Salcombe (1710), Seaton (1325), Sidmouth (4201), Tavistock (4728), Teignmouth (8636). The county is in the western circuit, and assizes are held at Exeter. It has one court of quarter sessions, and is divided into twenty-four petty sessional divisions. The boroughs of Barnstaple, Bideford, Devonport, Exeter, Plymouth, South Molton, and Tiverton have separate commissions of the peace and courts of quarter sessions, and those of Dartmouth, Great Torrington, Torquay and Totnes have commissions of the peace only. There are 461 civil parishes. Devonshire is in the diocese of Exeter, with the exception of small parts in those of Salisbury and Truro; and there are 516 ecclesiastical parishes or districts wholly or in part within the county. The parliamentary divisions are the Eastern or Honiton, North-eastern or Tiverton, Northern or South Molton, North-western or Barnstaple, Western or Tavistock, Southern or Totnes, Torquay, and Mid or Ashburton, each returning one member; and the county also contains the parliamentary boroughs of Devonport and Plymouth, each returning two members, and that of Exeter, returning one member.

History.—The Saxon conquest of Devonshire must have begun some time before the 8th century, for in 700 there existed at Exeter a famous Saxon school. By this time, however, the Saxons had become Christians, and established their supremacy, not by destructive inroads, but by a gradual process of colonization, settling among the native Welsh and allowing them to hold lands under equal laws. The final incorporation of the district which is now Devonshire with the kingdom of Wessex must have taken place about 766, but the county, and even Exeter, remained partly Welsh until the time of Æthelstan. At the beginning of the 9th century Wessex was divided into definite *pagi*, probably corresponding to the later shires, and the Saxon Chronicle mentions Devonshire by name in 823, when a battle was fought between the Welsh in Cornwall and the people of Devonshire at Camelford. During the Danish invasions of the 9th century aldermen of Devon are frequently mentioned. In 851 the invaders were defeated by the fyrd and aldermen of Devon, and in 878, when the Danes under Hubba were harrying the coast with a squadron of twenty-three ships, they were again defeated with great slaughter by the fyrd. The modern hundreds of Devonshire correspond in position very nearly with those given in the Domesday Survey, though the names have in many cases been changed, owing generally to alterations in their places of meeting. The hundred of Bampton formerly included estates west of the Exe, now transferred to the hundred of Witheridge. Ten of the modern hundreds have been formed by the union of two or more Domesday hundreds, while the Domesday hundred of Liston has had the new hundred of Tavistock severed from it since 1114. Many of the hundreds were separated by tracts of waste and forest land, of which Devonshire contained a vast extent, until in 1204 the inhabitants paid 5000 marks to have the county disafforested, with the exception only of Dartmoor and Exmoor.

Devonshire in the 7th century formed part of the vast bishopric of Dorchester-on-Thames. In 705 it was attached to the newly created diocese of Sherborne, and in 910 Archbishop Plegmund constituted Devonshire a separate diocese, and placed the see at Crediton. About 1030 the dioceses of Devonshire and Cornwall were united, and in 1049 the see was fixed at Exeter. The archdeaconries of Exeter, Barnstaple and Totnes are all mentioned in the

12th century and formerly comprised twenty-four deaneries. The deaneries of Three Towns, Collumpton and Ottery have been created since the 16th century, while those of Tamerton, Dunkeswell, Dunsford and Plymptre have been abolished, bringing the present number to twenty-three.

At the time of the Norman invasion Devonshire showed an active hostility to Harold, and the easy submission which it rendered to the Conqueror accounts for the exceptionally large number of Englishmen who are found retaining lands after the Conquest. The many vast fiefs held by Norman barons were known as honours, chief among them being Plympton, Okehampton, Barnstaple, Harberton and Totnes. The honour of Plympton was bestowed in the 12th century on the Redvers family, together with the earldom of Devon; in the 13th century it passed to the Courtenay family, who had already become possessed of the honour of Okehampton, and who in 1335 obtained the earldom. The dukedom of Exeter was bestowed in the 14th century on the Holland family, which became extinct in the reign of Edward IV. The ancestors of Sir Walter Raleigh, who was born at Budleigh, had long held considerable estates in the county.

Devonshire had an independent sheriff, the appointment being at first hereditary, but afterwards held for one year only. In 1320 complaint was made that all the hundreds of Devonshire were in the hands of the great lords, who did not appoint a sufficiency of bailiffs for their proper government. The miners of Devon had independent courts, known as stannary courts, for the regulation of mining affairs, the four stannary towns being Tavistock, Ashburton, Chagford, and Plympton. The ancient miners' parliament was held in the open air at Crockern's Tor.

The castles of Exeter and Plympton were held against Stephen by Baldwin de Redvers, and in the 14th and 15th centuries the French made frequent attacks on the Devonshire coast, being repulsed in 1404 by the people of Dartmouth. In the Wars of the Roses the county was much divided, and frequent skirmishes took place between the earl of Devon and Lord Bonville, the respective champions of the Lancastrian and Yorkist parties. Great disturbances in the county followed the Reformation of the 16th century and in 1549 a priest was compelled to say mass at Sampford Courtney. On the outbreak of the Civil War the county as a whole favoured the parliament, but the prevailing desire was for peace, and in 1643 a treaty for the cessation of hostilities in Devonshire and Cornwall was agreed upon. Skirmishes, however, continued until the capture of Dartmouth and Exeter in 1646 put an end to the struggle. In 1688 the prince of Orange landed at Torbay and was entertained for several days at Ford and at Exeter.

The tin mines of Devon have been worked from time immemorial, and in the 14th century mines of tin, copper, lead, gold and silver are mentioned. Agriculturally the county was always poor, and before the disafforestation rendered especially so through the ravages committed by the herds of wild deer. At the time of the Domesday Survey the salt industry was important, and there were ninety-nine mills in the county and thirteen fisheries. From an early period the chief manufacture was that of woollen cloth, and a statute 4 Ed. IV. permitted the manufacture of cloths of a distinct make in certain parts of Devonshire. About 1505 Anthony Bonvis, an Italian, introduced an improved method of spinning into the county, and cider-making is mentioned in the 16th century. In 1680 the lace industry was already flourishing at Colyton and Ottery St Mary, and flax, hemp and malt were largely produced in the 17th and 18th centuries.

Devonshire returned two members to parliament in 1290, and in 1295 Barnstaple, Exeter, Plympton, Tavistock, Torrington and Totnes were also represented. In 1831 the county with its boroughs returned a total of twenty-six members, but under the Reform Act of 1832 it returned four members in two divisions, and with ten boroughs was represented by a total of eighteen members. Under the act of 1868 the county returned six members in three divisions, and four of the boroughs were disfranchised, making a total of seventeen members.

Antiquities.—In primeval antiquities Devonshire is not so rich as Cornwall; but Dartmoor abounds in remains of the highest interest, the most peculiar of which are the long parallel alignments of upright stones, which, on a small scale, resemble those of Carnac in Brittany. On Dartmoor the lines are invariably straight, and are found in direct connexion with cairns, and with circles which are probably sepulchral. These stone avenues are very numerous. Of the so-called sacred circles the best examples are the "Longstones" on Scorhill Down, and the "Grey Wethers" under Sittaford Tor. By far the finest cromlech is the "Spinster's Rock" at Drewsteignton, a three-pillared cromlech which may well be compared with those of Cornwall. There are numerous menhirs or single upright stones; a large dolmen or holed stone lies in the bed of the Teign, near the Scorhill circle; and rock basins occur on the summit of nearly every tor on Dartmoor (the largest are on Kestor, and on Heltor, above the Teign). It is, however, tolerably evident that these have been produced by the gradual disintegration of the granite, and that the dolmen in the Teign is due to the action of the river. Clusters of hut foundations, circular, and formed of rude granite blocks, are frequent; the best example of such a primitive village is at Batworthy, near Chagford; the type resembles that of East Cornwall. Walled enclosures, or pounds, occur in many places; Grimspound is the most remarkable. Boundary lines, also called trackways, run across Dartmoor in many directions; and the rude bridges, formed of great slabs of granite, deserve notice. All these remains are on Dartmoor. Scattered over the county are numerous large hill castles and camps,—all earthworks, and all apparently of the British period. Roman relics have been found from time to time at Exeter (*Isca Damnoniorum*), the only large Roman station in the county.

The churches are for the most part of the Perpendicular period, dating from the middle of the 14th to the end of the 15th century. Exeter cathedral is of course an exception, the whole (except the Norman towers) being very beautiful Decorated work. The special features of Devonshire churches, however, are the richly carved pulpits and chancel screens of wood, in which this county exceeded every other in England, with the exception of Norfolk and Suffolk. The designs are rich and varied, and the skill displayed often very great. Granite crosses are frequent, the finest and earliest being that of Coplestone, near Crediton. Monastic remains are scanty; the principal are those at Tor, Buckfast, Tavistock and Buckland Abbeys. Among domestic buildings the houses of Wear Gilford, Bradley and Dartington of the 15th century; Bradfield and Holcombe Rogus (Elizabethan), and Forde (Jacobean), deserve notice. The ruined castles of Okehampton (Edward I.), Exeter, with its vast British earthworks, Berry Pomeroy (Henry III., with ruins of a large Tudor mansion), Totnes (Henry III.) and Compton (early 15th century), are all interesting and picturesque.

Authorities.—T. Westcote, *Survey of Devon*, written about 1630, and first printed in 1845; J. Prince, *Worthies of Devon* (Exeter, 1701); Sir W. Pole, *Collections towards a History of the County of Devon* (London, 1791); R. Polwhele, *History of Devonshire* (3 vols. Exeter, 1797, 1798-1800); T. Moore, *History of Devon from the Earliest Period to the Present Time* (vols, i., ii., London, 1829-1831); G. Oliver, *Historic Collections relating to the Monasteries in Devon* (Exeter, 1820); D. and S. Lysons, *Magna Britannia* (vol. vi., London, 1822); *Ecclesiastical Antiquities in Devon* (Exeter, 1844); Mrs Bray, *Traditions of Devonshire*, in a series of letters to Robert Southey (London, 1838); G. C. Boase, *Devonshire Bibliography* (London, 1883); Sir W. R. Drake, *Devonshire Notes and Notelets* (London, 1888); S. Hewett, *Peasant Speech of Devon* (London, 1892); R. N. Worth, *History of Devonshire* (London, 1886, new edition, 1895); C. Worthy, *Devonshire Parishes* (Exeter, 1887); *Devonshire Wills* (London, 1896); *Victoria County History, Devonshire*.

DEVRIENT, the name of a family of German actors.

Ludwig Devrient (1784-1832), born in Berlin on the 15th of December 1784, was the son of a silk merchant. He was apprenticed to an upholsterer, but, suddenly leaving his employment, joined a travelling theatrical company, and made his first appearance on the stage at Gera in 1804 as the messenger in Schiller's *Braut von Messina*. By the interest of Count Brühl, he appeared at Rudolstadt as Franz Moor in Schiller's *Räuber*, so successfully that he obtained a permanent engagement at the ducal theatre in Dessau, where he played until 1809. He then received a call to Breslau, where he remained for six years. So brilliant was his success in the title-parts of several of Shakespeare's plays, that Iffland began to fear for his own reputation; yet that great artist was generous enough to recommend the young actor as his only possible successor. On Iffland's death Devrient was summoned to Berlin, where he was for fifteen years the popular idol. He died there on the 30th of December 1832. Ludwig Devrient was equally great in comedy and tragedy. Falstaff, Franz Moor, Shylock, King Lear and Richard II. were among his best parts. Karl von Holtei in his *Reminiscences* has given a graphic picture of him and the "demoniac fascination" of his acting.

See Z. Funck, *Aus dem Leben zweier Schauspieler, Ifflands und Devrients* (Leipzig, 1838); H. Smidt in *Devrient-Novellen* (3rd ed., Berlin, 1882); R. Springer in the novel *Devrient und Hoffmann* (Berlin, 1873), and Eduard Devrient's *Geschichte der deutschen Schauspielkunst* (Leipzig, 1861).

Three of the nephews of Ludwig Devrient, sons of his brother, a merchant, were also connected with the stage. KARL AUGUST DEVRIENT (1797-1872) was born at Berlin on the 5th of April 1797. After being for a short time in business, he entered a cavalry regiment as volunteer and fought at Waterloo. He then joined the stage, making his first appearance on the stage in 1819 at Brunswick. In 1821 he received an engagement at the court theatre in Dresden, where, in 1823, he married Wilhelmine Schröder (see SCHRÖDER-DEVRIENT). In 1835 he joined the company at Karlsruhe, and in 1839 that at Hanover. His best parts were Wallenstein and King Lear. He died on the 5th of April 1872. His brother PHILIPP EDUARD DEVRIENT (1801-1877), born at Berlin on the 11th of August 1801, was for a time an opera singer. Turning his attention to theatrical management, he was from 1844 to 1846 director of the court theatre in Dresden. Appointed to Karlsruhe in 1852, he began a thorough reorganization of the theatre, and in the course of seventeen years of assiduous labour, not only raised it to a high position, but enriched its repertory by many noteworthy librettos, among which *Die Gunst des Augenblicks* and *Verirrungen* are the best known. But his chief work is his history of the German stage—*Geschichte der deutschen Schauspielkunst* (Leipzig, 1848-1874). He died on the 4th of October 1877. A complete edition of his works—*Dramatische und dramaturgische Schriften*—was published in ten volumes (Leipzig, 1846-1873).

The youngest and the most famous of the three nephews of Ludwig Devrient was GUSTAV EMIL DEVRIENT (1803-1872), born in Berlin on the 4th of September 1803. He made his first appearance on the stage in 1821, at Brunswick, as Raoul in Schiller's *Jungfrau von Orleans*. After a short engagement in Leipzig, he received in 1829 a call to Hamburg, but after two years accepted a permanent appointment at the court theatre in Dresden, to which he belonged until his retirement in 1868. His chief characters were Hamlet, Uriel Acosta (in Karl Gutzkow's play), Marquis Posa (in Schiller's *Don Carlos*), and Goethe's Torquato Tasso. He acted several times in London, where his Hamlet was considered finer than Kemble's or Edmund Kean's. He died on the 7th of August 1872.

OTTO DEVRIENT (1838-1894), another actor, born in Berlin on the 3rd of October 1838, was the son of Philipp Eduard Devrient. He joined the stage in 1856 at Karlsruhe, and acted successively in Stuttgart, Berlin and Leipzig, until he received a fixed appointment at Karlsruhe, in 1863. In 1873 he became stage manager at Weimar, where he gained great praise for his *mise en scène* of Goethe's *Faust*. After being manager of the theatres in Mannheim and Frankfort he retired to Jena, where in 1883 he was given the honorary degree of doctor of philosophy. In 1884 he was appointed director of the court theatre in Oldenburg, and in 1889 director of dramatic plays in Berlin. He died at Stettin on the 23rd of June 1894.

DEW. The word "dew" (O.E. *deaw*; cf. Ger. *Tau*) is a very ancient one and its meaning must therefore be defined on historical principles. According to the *New English Dictionary*, it means "the moisture deposited in minute drops upon any cool surface by condensation of the vapour of the atmosphere; formed after a hot day, during or towards night and plentiful in the early morning." Huxley in his *Physiography* makes the addition "without production of mist." The formation of mist is not necessary for the formation of dew, nor does it necessarily prevent it. If the deposit of moisture is in the form of ice instead of water it is called hoarfrost. The researches of Aitken suggest that the words "by condensation of the vapour in the atmosphere" might be omitted from the definition. He has given reasons for believing that the large dewdrops on the leaves of plants, the most characteristic of all the phenomena of dew, are to be accounted for, in large measure at least, by the exuding of drops of water from the plant through the pores of the leaves themselves. The formation of dewdrops in such cases is the continuation of the irrigation process of the plant for supplying the leaves with water from the soil. The process is set up in full vigour in the daytime to maintain tolerable thermal conditions at the surface of the leaf in the hot sun, and continued after the sun has gone.

On the other hand, the most typical physical experiment illustrating the formation of dew is the production of a deposit of moisture, in minute drops, upon the exterior surface of a glass or polished metal vessel by the cooling of a liquid contained in the vessel. If the liquid is water, it can be cooled by pieces of ice; if volatile like ether, by bubbling air through it. No deposit is formed by this process until the temperature is reduced to a point which, from that circumstance, has received a special name, although it depends upon the state of the air round the vessel. So generally accepted is the physical analogy between the natural formation of dew and its artificial production in the manner described, that the point below which the temperature of a surface must be reduced in order to obtain the deposit is known as the "dew-point."

In the view of physicists the dew-point is the temperature at which, *by being cooled without change of pressure*, the air becomes saturated with water vapour, not on account of any increase of supply of that compound, but by the diminution of the capacity of the air for holding it in the gaseous condition. Thus, when the dew-point temperature has been determined, the pressure of water vapour in the atmosphere at the time of the deposit is given by reference to a table of saturation pressures of water vapour at different temperatures. As it is a well-established proposition that the pressure of the water vapour in the air does not vary while the air is being cooled without change of its total external pressure, the saturation pressure at the dew-point gives the pressure of water vapour in the air when the cooling commenced. Thus the artificial formation of dew and consequent determination of the dew-point is a recognized method of measuring the pressure, and thence the amount of water vapour in the atmosphere. The dew-point method is indeed in some ways a fundamental method of hygrometry.

The dew-point is a matter of really vital consequence in the question of the oppressiveness of the atmosphere or its reverse. So long as the dew-point is low, high temperature does not matter, but when the dew-point begins to approach the normal temperature of the human body the atmosphere becomes insupportable.

The physical explanation of the formation of dew consists practically in determining the process or processes by which leaves, blades of grass, stones, and other objects in the open air upon which dew may be observed, become cooled "below the dew-point."

Formerly, from the time of Aristotle at least, dew was supposed to "fall." That view of the process was not extinct at the time of Wordsworth and poets might even now use the figure without reproach. To Dr Charles Wells of London belongs the credit of bringing to a focus the ideas which originated with the study of radiation at the beginning of the 19th century, and which are expressed by saying that the cooling necessary to produce dew on exposed surfaces is to be attributed to the radiation from the surfaces to a clear sky. He gave an account of the theory of automatic cooling by radiation, which has found a place in all text-books of physics, in his first *Essay on Dew* published in 1818. The theory is supported in that and in a second essay by a number of well-planned observations, and the essays are indeed models of scientific method. The process of the formation of dew as represented by Wells is a simple one. It starts from the point of view that all bodies are constantly radiating heat, and cool automatically unless they receive a corresponding amount of heat from other bodies by radiation or conduction. Good radiators, which are at the same time bad conductors of heat, such as blades of grass, lose heat rapidly on a clear night by radiation to the sky and become cooled below the dew-point of the atmosphere.

The question was very fully studied by Melloni and others, but little more was added to the explanation given by Wells until 1885, when John Aitken of Falkirk called attention to the question whether the water of dewdrops on plants or stones came from the air or the earth, and described a number of experiments to show that under the conditions of observation in Scotland, it was the earth from which the moisture was probably obtained, either by the operation of the vascular system of plants in the formation of exuded dewdrops, or by evaporation and subsequent condensation in the lowest layer of the atmosphere. Some controversy was excited by the publication of Aitken's views, and it is interesting to revert to it because it illustrates a proposition which is of general application in meteorological questions, namely, that the physical processes operative in the evolution of meteorological phenomena are generally complex. It is not radiation alone that is necessary to produce dew, nor even radiation from a body which does not conduct heat. The body must be surrounded by an atmosphere so fully supplied with moisture that the dew-point can be passed by the cooling due to radiation. Thus the conditions favourable for the formation of dew are (1) a good radiating surface, (2) a still atmosphere, (3) a clear sky, (4) thermal insulation of the radiating surface, (5) warm moist ground or some other provision to produce a supply of moisture in the surface layers of air.

Aitken's contribution to the theory of dew shows that in considering the supply of moisture we must take into consideration the ground as well as the air and concern ourselves with the temperature of both. Of the five conditions mentioned, the first four may be considered necessary, but the fifth is very important for securing a copious deposit. It can hardly be maintained that no dew could form unless there were a supply of water by evaporation from warm ground, but, when such a supply is forthcoming, it is evident that in place of the limited process of condensation which deprives the air of its moisture and is therefore soon terminable, we have the process of distillation which goes on as long as conditions are maintained. This distinction is of some practical importance for it indicates the protecting power of wet soil in favour of young plants as against night frost. If distillation between the ground and the leaves is set up, the temperature of the leaves cannot fall much below the original dew-point because the supply of water for condensation is kept up; but if the compensation for loss of heat by radiation is dependent simply on the condensation of water from the atmosphere, without renewal of the supply, the dew-point will gradually get lower as the moisture is deposited and the process of cooling will go on.

In these questions we have to deal with comparatively large changes taking place within a small range of level. It is with the layer a few inches thick on either side of the surface that we are principally concerned, and for an adequate comprehension of the conditions close consideration is required. To illustrate this point reference may be made to figs. 1 and 2, which represent the condition of affairs at 10.40 P.M. on about the 20th of October 1885, according to observations by Aitken. Vertical distances represent heights in feet, while the temperatures of the air and the dew-point are represented by horizontal distances and their variations with height by the curved lines of the diagram. The line marked 0 is the ground level itself, a rather indefinite quantity when the surface is grass. The whole vertical distance represented is from 4 ft. above ground to 1 ft. below ground, and the special phenomena which we are considering take place in the layer which represents the rapid transition between the temperature of the ground 3 in. below the surface and that of the air a few inches above ground.

The point of interest is to determine where the dew-point curve and dry-bulb curve will cut. If they cut above the surface, mist will result; if they cut at the surface, dew will be formed. Below the surface, it may be assumed that the air is saturated with moisture and any difference in temperature of the dew-point is accompanied by distillation. It may be remarked, by the way, that such distillation between soil layers of different temperatures must be productive of the transference of large quantities of water between different levels in the soil either upward or downward according to the time of year.

These diagrams illustrate the importance of the warmth and moisture of the ground in the phenomena which have been considered. From the surface there is a continual loss of heat going on by radiation and a continual supply of warmth and moisture from below. But while the heat can escape, the moisture cannot. Thus the dry-bulb line is deflected to the left as it approaches the surface, the dew-point line to the right. Thus the effect of the moisture of the ground is to cause the lines to approach. In the case of grass, fig. 2, the deviation of the dry-bulb line to the left to form a sharp minimum of temperature at the surface is well shown. The dew-point line is also shown diverted to the left to the same point as the dry-bulb; but that could only happen if there were so copious a condensation from the atmosphere as actually to make the air drier at the surface than up above. In diagram 1, for soil, the effect on air temperature and moisture is shown; the two lines converge to cut at the surface where a dew deposit will be formed. Along the underground line there must be a gradual creeping of heat and moisture towards the surface by distillation, the more rapid the greater the temperature gradient.

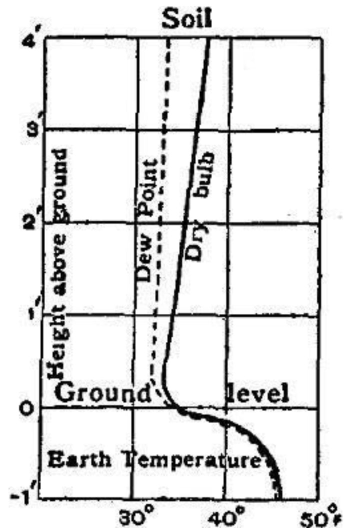


Fig. 1.

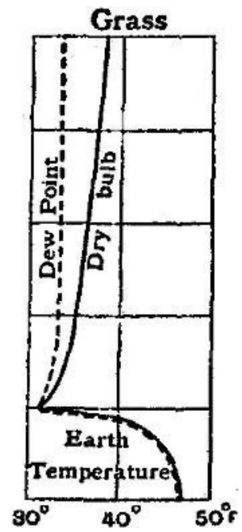


Fig. 2.

The amount of dew deposited is considerable, and, in tropical countries, is sometimes sufficiently heavy to be collected by gutters and spouts, but it is not generally regarded as a large percentage of the total rainfall. Loesche estimates the amount of dew for a single night on the Loango coast at 3 mm., but the estimate seems a high one. Measurements go to show that the depth of water corresponding with the aggregate annual deposit of dew is 1 in. to 1.5 in. near London (G. Dines), 1.2 in. at Munich (Wollny), 0.3 in. at Montpellier (Crova), 1.6 in. at Tenbury, Worcestershire (Badgley).

With the question of the amount of water collected as dew, that of the maintenance of "dew ponds" is intimately associated. The name is given to certain isolated ponds on the upper levels of the chalk downs of the south of England and elsewhere. Some of these ponds are very ancient, as the title of a work on *Neolithic Dewponds* by A. J. and G. Hubbard indicates. Their name seems to imply the hypothesis that they depend upon dew and not entirely upon rain for their maintenance as a source of water supply for cattle, for which they are used. The question has been discussed a good deal, but not settled; the balance of evidence seems to be against the view that dew deposits make any important contribution to the supply of water. The construction of dew ponds is, however, still practised on traditional lines, and it is said that a new dew pond has first to be filled artificially. It does not come into existence by the gradual accumulation of water in an impervious basin.

Authorities.—For *Dew*, see the two essays by Dr Charles Wells (London, 1818), also "An Essay on Dew," edited by Casella (London, 1866), Longmans', with additions by Strachan; Melloni, *Pogg. Ann.* lxxi. pp. 416, 424 and lxxiii. p. 467; Jamin, "Compléments à la théorie de la rosée," *Journal de physique*, viii. p. 41; J. Aitken, on "Dew," *Trans. Roy. Soc. of Edinburgh*, xxxiii., part i. 2, and "Nature," vol. xxxiii. p. 256; C. Tomlinson, "Remarks on a new Theory of Dew," *Phil. Mag.* (1886), 5th series, vol. 21, p. 483 and vol. 22, p. 270; Russell, *Nature*, vol 47, p. 210; also *Met. Zeit.* (1893), p. 390; Homén, *Bodenphysikalische und meteorologische Beobachtungen* (Berlin, 1894), iii.; *Taubildung*, p. 88, &c.; Rubenson, "Die Temperatur-und Feuchtigkeitsverhältnisse in den

unteren Luftschichten bei der Taubildung," *Met. Zeit.* xi. (1876), p. 65; H. E. Hamberg, "Température et humidité de l'air à différentes hauteurs à Upsal," *Soc. R. des sciences d'Upsal* (1876); review in *Met. Zeit.* xii. (1877), p. 105.

For *Dew Ponds*, see Stephen Hales, *Statical Essays*, vol. i., experiment xix., pp. 52-57 (2nd ed., London, 1731); Gilbert White, *Natural History and Antiquities of Selborne*, letter xxix. (London, 1789); Dr C. Wells, *An Essay on Dew* (London, 1818, 1821 and 1866); Rev. J. C. Clutterbuck, "Prize Essay on Water Supply," *Journ. Roy. Agric. Soc.*, 2nd series, vol. i. pp. 271-287 (1865); Field and Symons, "Evaporation from the Surface of Water," *Brit. Assoc. Rep.* (1869), sect., pp. 25, 26; J. Lucas, "Hydrogeology: One of the Developments of Modern Practical Geology," *Trans. Inst. Surveyors*, vol. ix. pp. 153-232 (1877); H. P. Slade, "A Short Practical Treatise on Dew Ponds" (London, 1877); Clement Reid, "The Natural History of Isolated Ponds," *Trans. Norfolk and Norwich Naturalists' Society*, vol. v. pp. 272-286 (1892); Professor G. S. Brady, *On the Nature and Origin of Freshwater Faunas* (1899); Professor L. C. Miall, "Dew Ponds," *Reports of the British Association* (Bradford Meeting, 1900), pp. 579-585; A. J. and G. Hubbard, "Neolithic Dewponds and Cattle-Ways" (London, 1904, 1907).

(W. N. S.)

DEWAN or DIWAN, an Oriental term for finance minister. The word is derived from the Arabian *diwan*, and is commonly used in India to denote a minister of the Mogul government, or in modern days the prime minister of a native state. It was in the former sense that the grant of the *dewanny* to the East India Company in 1765 became the foundation of the British empire in India.

DEWAR, SIR JAMES (1842-   ), British chemist and physicist, was born at Kincardine-on-Forth, Scotland, on the 20th of September 1842. He was educated at Dollar Academy and Edinburgh University, being at the latter first a pupil, and afterwards the assistant, of Lord Playfair, then professor of chemistry; he also studied under Kekulé at Ghent. In 1875 he was elected Jacksonian professor of natural experimental philosophy at Cambridge, becoming a fellow of Peterhouse, and in 1877 he succeeded Dr J. H. Gladstone as Fullerian professor of chemistry in the Royal Institution, London. He was president of the Chemical Society in 1897, and of the British Association in 1902, served on the Balfour Commission on London Water Supply (1893-1894), and as a member of the Committee on Explosives (1888-1891) invented cordite jointly with Sir Frederick Abel. His scientific work covers a wide field. Of his earlier papers, some deal with questions of organic chemistry, others with Graham's hydrogenium and its physical constants, others with high temperatures, e.g. the temperature of the sun and of the electric spark, others again with electro-photometry and the chemistry of the electric arc. With Professor J. G. M'Kendrick, of Glasgow, he investigated the physiological action of light, and examined the changes which take place in the electrical condition of the retina under its influence. With Professor G. D. Liveing, one of his colleagues at Cambridge, he began in 1878 a long series of spectroscopic observations, the later of which were devoted to the spectroscopic examination of various gaseous constituents separated from atmospheric air by the aid of low temperatures; and he was joined by Professor J. A. Fleming, of University College, London, in the investigation of the electrical behaviour of substances cooled to very low temperatures. His name is most widely known in connexion with his work on the liquefaction of the so-called permanent gases and his researches at temperatures approaching the zero of absolute temperature. His interest in this branch of inquiry dates back at least as far as 1874, when he discussed the "Latent Heat of Liquid Gases" before the British Association. In 1878 he devoted a Friday evening lecture at the Royal Institution to the then recent work of L. P. Cailletet and R. P. Pictet, and exhibited for the first time in Great Britain the working of the Cailletet apparatus. Six years later, in the same place, he described the researches of Z. F. Wroblewski and K. S. Olszewski, and illustrated for the first time in public the liquefaction of oxygen and air, by means of apparatus specially designed for optical projection so that the actions taking place might be visible to the audience. Soon afterwards he constructed a machine from which the liquefied gas could be drawn off through a valve for use as a cooling agent, and he showed its employment for this purpose in connexion with some researches on meteorites; about the same time he also obtained oxygen in the solid state. By 1891 he had designed and erected at the Royal Institution an apparatus which yielded liquid oxygen by the pint, and towards the end of that year he showed that both liquid oxygen and liquid ozone are strongly attracted by a magnet. About 1892 the idea occurred to him of using vacuum-jacketed vessels for the storage of liquid gases, and so efficient did this device prove in preventing the influx of external heat that it is found possible not only to preserve the liquids for comparatively long periods, but also to keep them so free from ebullition that examination of their optical properties becomes possible. He next experimented with a high-pressure hydrogen jet by which low temperatures were realized through the Thomson-Joule effect, and the successful results thus obtained led him to build at the Royal Institution the large refrigerating machine by which in 1898 hydrogen was for the first time collected in the liquid state, its solidification following in 1899. Later he investigated the gas-absorbing powers of charcoal when cooled to low temperatures, and applied them to the production of high vacua and to gas analysis (see Liquid Gases). The Royal Society in 1894 bestowed the Rumford medal upon him for his work in the production of low temperatures, and in 1899 he became the first recipient of the Hodgkins gold medal of the Smithsonian Institution, Washington, for his contributions to our knowledge of the nature and properties of atmospheric air. In 1904 he was the first British subject to receive the Lavoisier medal of the French Academy of Sciences, and in 1906 he was the first to be awarded the Matteucci medal of the Italian Society of Sciences. He was knighted in 1904, and in 1908 he was awarded the Albert medal of the Society of Arts.

DEWAS, two native states of India, in the Malwa Political Charge of Central India, founded in the first half of the 18th century by two brothers, Punwar Mahrattas, who came into Malwa with the peshwa, Baji Rao, in 1728. Their descendants are known as the senior and junior branches of the family, and since 1841 each has ruled his own portion as a separate state, though the lands belonging to each are so intimately entangled, that even in Dewas, the capital town, the two sides of the main street are under different administrations and have different arrangements for water supply and lighting. The senior branch has an area of 446 sq. m. and a population of 62,312, while the area of the junior branch is 440 sq. m. and its population 54,904.

DEWBERRY, *Rubus caesius*, a trailing plant, allied to the bramble, of the natural order Rosaceae. It is common in woods, hedges and the borders of fields in England and other countries of Europe. The leaves have three leaflets, are hairy beneath, and of a dusky green; the flowers which appear in June and July are white, or pale rose-coloured. The fruit is large, and closely embraced by the calyx, and consists of a few drupules, which are black, with a glaucous bloom; it has an agreeable acid taste.

DEW-CLAW, the rudimentary toes, two in number, or the "false hoof" of the deer, sometimes also called the "nails." In dogs the dew-claw is the rudimentary toe or hallux (corresponding to the big toe in man) hanging loosely attached to the skin, low down on the hinder part of the leg. The origin of the word is unknown, but it has been fancifully suggested that, while the other toes touch the ground in walking, the dew-claw merely brushes the dew from the grass.

D'EWES, SIR SIMONDS, Bart. (1602-1650), English antiquarian, eldest son of Paul D'Ewes of Milden, Suffolk, and of Cecilia, daughter and heir of Richard Simonds, of Coaxdon or Coxden, Dorsetshire, was born on the 18th of December 1602, and educated at the grammar school of Bury St Edmunds, and at St John's College, Cambridge. He had been admitted to the Middle Temple in 1611, and was called to the bar in 1623, when he immediately began his collections of material and his studies in history and antiquities. In 1626 he married Anne, daughter and heir of Sir William Clopton, of Luton's Hall in Suffolk, through whom he obtained a large addition to his already considerable fortune. On the 6th of December he was knighted. He took an active part as a strong Puritan and member of the moderate party in the opposition to the king's arbitrary government in the Long Parliament of 1640, in which he sat as member for Sudbury. On the 15th of July he was created a baronet by the king, but nevertheless adhered to the parliamentary party when war broke out, and in 1643 took the Covenant. He was one of the members expelled by Pride's Purge in 1648, and died on the 18th of April 1650. He had married secondly Elizabeth, daughter of Sir Henry Willoughby, Bart., of Risley in Derbyshire, by whom he had a son, who succeeded to his estates and title, the latter becoming extinct on the failure of male issue in 1731. D'Ewes appears to have projected a work of very ambitious scope, no less than the whole history of England based on original documents. But though excelling as a collector of materials, and as a laborious, conscientious and accurate transcriber, he had little power of generalization or construction, and died without publishing anything except an uninteresting tract, *The Primitive Practice for Preserving Truth* (1645), and some speeches. His *Journals of all the Parliaments during the Reign of Queen Elizabeth*, however, a valuable work, was published in 1682. His large collections, including transcripts from ancient records, many of the originals of which are now dispersed or destroyed, are in the Harleian collection in the British Museum. His unprinted Diaries from 1621-1624 and from 1643-1647, the latter valuable for the notes of proceedings in parliament, are often the only authority for incidents and speeches during that period, and are amusing from the glimpses the diarist affords of his own character, his good estimation of himself and his little jealousies; some are in a cipher and some in Latin.

Extracts from his *Autobiography and Correspondence* from the MSS. in the British Museum were published by J. O. Halliwell-Phillips in 1845, by Hearne in the appendix to his *Historia vitae et regni Ricardi II.* (1729), and in the *Bibliotheca topographica Britannica*, No. xv. vol. vi. (1783); and from a Diary of later date, *College Life in the Time of James I.* (1851). His Diaries have been extensively drawn upon by Forster, Gardiner, and by Sanford in his *Studies of the Great Rebellion*. Some of his speeches have been reprinted in the Harleian Miscellany and in the Somers Tracts.

DE WET, CHRISTIAN (1854-), Boer general and politician, was born on the 7th of October 1854 at Leeuwkop, Smithfield district (Orange Free State), and later resided at Dewetsdorp. He served in the first Anglo-Boer War of 1880-81 as a field cornet, and from 1881 to 1896 he lived on his farm, becoming in 1897 member of the Volksraad. He took part in the earlier battles of the Boer War of 1899 in Natal as a commandant and later, as a general, he went to serve under Cronje in the west. His first successful action was the surprise of Sanna's Post near Bloemfontein, which was followed by the victory of Reddersburg a little later. Thenceforward he came to be regarded more and more as the most formidable leader of the Boers in their guerrilla warfare. Sometimes severely handled by the British, sometimes escaping only by the narrowest margin of safety from the columns which attempted to surround him, and falling upon and annihilating isolated British posts, De Wet continued to the end of the war his successful career, striking heavily where he could do so and skilfully evading every attempt to bring him to bay. He took an active part in the peace negotiations of 1902, and at the conclusion of the war he visited Europe with the other Boer generals. While in England the generals sought, unavailingly, a modification of the terms of peace concluded at Pretoria. De Wet wrote an account of his campaigns, an English version of which appeared in November 1902 under the title *Three Years' War*. In November, 1907 he was elected a member of the first parliament of the Orange River Colony and was appointed minister of agriculture. In 1908-9 he was a delegate to the Closer Union Convention.

DE WETTE, WILHELM MARTIN LEBERECHT (1780-1849), German theologian, was born on the 12th of January 1780, at Ulla, near Weimar, where his father was pastor. He was sent to the gymnasium at Weimar, then at the height of its literary glory. Here he was much influenced by intercourse with Johann Gottfried Herder, who frequently examined at the school. In 1799 he entered on his theological studies at Jena, his principal teachers being J. J. Griesbach and H. E. G. Paulus, from the latter of whom he derived his tendency to free critical inquiry. Both in methods and in results, however, he occupied an almost solitary position among German theologians. Having taken his doctor's degree, he became *privat-docent* at Jena; in 1807 professor of theology at Heidelberg, where he came under the influence of J. F. Fries (1773-1843); and in 1810 was transferred to a similar chair in the newly founded university of Berlin, where he enjoyed the friendship of Schleiermacher. He was, however, dismissed from Berlin in 1819 on account of his having written a letter of consolation to the mother of Karl Ludwig Sand, the murderer of Kotzebue. A petition in his favour presented by the senate of the university was unsuccessful, and a decree was issued not only depriving him of the chair, but banishing him from the Prussian kingdom. He retired for a time to Weimar, where he occupied his leisure in the preparation of his edition of Luther, and in writing the romance *Theodor oder die Weihe des Zweiflers* (Berlin, 1822), in which he describes the education of an evangelical pastor. During this period he made his first essay in preaching, and proved himself to be possessed of very popular gifts. But in 1822 he accepted the chair of theology in the university of Basel, which had been reorganized four years before. Though his appointment had been strongly opposed by the orthodox party, De Wette soon won for himself great influence both in the university and among the people generally. He was admitted a citizen, and became rector of the university, which owed to him much of its recovered strength, particularly in the theological faculty. He died on the 16th of June 1849.

De Wette has been described by Julius Wellhausen as "the epoch-making opener of the historical criticism of the Pentateuch." He prepared the way for the Supplement-theory. But he also made valuable contributions to other branches of theology. He had, moreover, considerable poetic faculty, and wrote a drama in three acts, entitled *Die Entsagung* (Berlin, 1823). He had an intelligent interest in art, and studied ecclesiastical music and architecture. As a Biblical critic he is sometimes classed with the destructive school, but, as Otto Pfleiderer says (*Development of Theology*, p. 102), he "occupied as free a position as the Rationalists with regard to the literal authority of the creeds of the church, but that he sought to give their due value to the religious feelings, which the Rationalists had not done, and, with a more unfettered mind towards history, to maintain the connexion of the present life of the church with the past." His works are marked by exegetical skill, unusual power of condensation and uniform fairness. Accordingly they possess value which is little affected by the progress of criticism.

The most important of his works are:—*Beiträge zur Einleitung in das Alte Testament* (2 vols., 1806-1807); *Kommentar über die Psalmen* (1811), which has passed through several editions, and is still regarded as of high authority; *Lehrbuch der hebräisch-jüdischen Archäologie* (1814); *Über Religion und Theologie* (1815); a work of great importance as showing its author's general theological position; *Lehrbuch der christlichen Dogmatik* (1813-1816); *Lehrbuch der historisch-kritischen Einleitung in die Bibel* (1817); *Christliche Sittenlehre* (1819-1821); *Einleitung in das Neue Testament* (1826); *Religion, ihr Wesen, ihre Erscheinungsform, und ihr Einfluss auf das Leben* (1827); *Das Wesen des christlichen Glaubens* (1846); and *Kurzgefasstes exegetisches Handbuch zum Neuen Testament* (1836-1848). De Wette also edited Luther's works (5 vols., 1825-1828).

See K. R. Hagenbach in *Herzog's Realencyklopädie*; G. C. F. Lücke's *W. M. L. De Wette, zur freundschaftlicher Erinnerung* (1850); and D. Schenkel's *W. M. L. De Wette und die Bedeutung seiner Theologie für unsere Zeit* (1849). Rudolf Stähelin, *De Wette nach seiner theol. Wirksamkeit und Bedeutung* (1880); F. Lichtenberger, *History of German Theology in the Nineteenth Century* (1889); Otto Pfleiderer, *Development of Theology* (1890), pp. 97 ff.; T. K. Cheyne, *Founders of the Old Testament Criticism*, pp. 31 ff.

DEWEY, DAVIS RICH (1858-   ), American economist and statistician, was born at Burlington, Vermont, U.S.A., on the 7th of April 1858. He was educated at the university of Vermont and at Johns Hopkins University, and afterwards became professor of economics and statistics at the Massachusetts Institute of Technology. He was chairman of the state board on the question of the unemployed (1895), member of the Massachusetts commission on public, charitable and reformatory interests (1897), special expert agent on wages for the 12th census, and member of a state commission (1904) on industrial relations. He wrote an excellent *Syllabus on Political History since 1815* (1887), a *Financial History of the U.S.* (1902), and *National Problems* (1907).

DEWEY, GEORGE (1837-   ), American naval officer, was born at Montpelier, Vermont, on the 26th of December 1837. He studied at Norwich University, then at Norwich, Vermont, and graduated at the United States Naval Academy in 1858. He was commissioned lieutenant in April 1861, and in the Civil War served on the steamsloop "Mississippi" (1861-1863) during Farragut's passage of the forts below New Orleans in April 1862, and at Port Hudson in March 1863; took part in the fighting below Donaldsonville, Louisiana, in July 1863; and in 1864-1865 served on the steam-gunboat "Agawam" with the North Atlantic blockading squadron and took part in the attacks on Fort Fisher in December 1864 and January 1865. In March 1865 he became a lieutenant-commander. He was with the European squadron in 1866-1867; was an instructor in the United States Naval Academy in 1868-1869; was in command of the "Narragansett" in 1870-1871 and 1872-1875, being commissioned commander in 1872; was light-house inspector in 1876-1877; and was secretary of the light-house board in 1877-1882. In 1884 he became a captain; in 1889-1893 was chief of the bureau of equipment and recruiting; in 1893-1895 was a member of the light-house board; and in 1895-1897 was president of the board of inspection and survey, being promoted to the rank of commodore in February 1896. In November 1897 he was assigned, at his own request, to sea service, and sent to Asiatic waters. In April 1898, while with his fleet at Hong Kong, he was notified by cable that war had begun between the United States and Spain, and was ordered to "capture or destroy the Spanish fleet" then in Philippine waters. On the 1st of May he overwhelmingly defeated the Spanish fleet under Admiral Montojo in Manila Bay, a victory won without the loss of a man on the American ships (see Spanish-American War). Congress, in a joint resolution, tendered its thanks to Commodore Dewey, and to the officers and men under his command, and authorized "the secretary of the navy to present a sword of honor to Commodore George Dewey, and cause to be struck bronze medals commemorating the battle of Manila Bay, and to distribute such medals to the officers and men of the ships of the Asiatic squadron of the United States." He was promoted rear-admiral on the 10th of May 1898. On the 18th of August his squadron assisted in the capture of the city of Manila. After remaining in the Philippines under orders from his government to maintain control, Dewey received the rank of admiral (March 3, 1899)—that title, formerly borne only by Farragut and Porter, having been revived by act of Congress (March 2, 1899),—and returned home, arriving in New York City, where, on the 3rd of October 1899, he received a great ovation. He was a member (1899) of the Schurman Philippine Commission, and in 1899 and 1900 was spoken of as a possible Democratic candidate for the presidency. He acted as president of the Schley court of inquiry in 1901, and submitted a minority report on a few details.

DEWEY, MELVIL (1851-   ), American librarian, was born at Adams Center, New York, on the 10th of December 1851. He graduated in 1874 at Amherst College, where he was assistant librarian from 1874 to 1877. In 1877 he removed to Boston, where he founded and became editor of *The Library Journal*, which became an influential factor in the development of libraries in America, and in the reform of their administration. He was also one of the founders of the American Library Association, of which he was secretary from 1876 to 1891, and president in 1891 and 1893. In 1883 he became librarian of Columbia College, and in the following year founded there the School of Library Economy, the first institution for the instruction of librarians ever organized. This school, which was very successful, was removed to Albany in 1890, where it was re-established as the State Library School under his direction; from 1888 to 1906 he was director of the New York State Library and from 1888 to 1900 was secretary of the University of the State of New York, completely reorganizing the state library, which he made one of the most efficient in America, and establishing the system of state travelling libraries and picture collections. His "Decimal System of Classification" for library cataloguing, first proposed in 1876, is extensively used.

DEWING, THOMAS WILMER (1851-), American figure painter, was born in Boston, Massachusetts, on the 4th of May 1851. He was a pupil of Jules Lefebvre in Paris from 1876 to 1879; was elected a full member of the National Academy of Design in 1888; was a member of the society of Ten American Painters, New York; and received medals at the Paris Exhibition (1889), at Chicago (1893), at Buffalo (1901) and at St Louis (1904). His decorative genre pictures are notable for delicacy and finish. Among his portraits are those of Mrs Stanford White and of his own wife. Mrs Dewing (b, 1855), *née* Maria Oakey, a figure and flower painter, was a pupil of John La Farge in New York, and of Couture in Paris.

DE WINT, PETER (1784-1849), English landscape painter, of Dutch extraction, son of an English physician, was born at Stone, Staffordshire, on the 21st of January 1784. He studied art in London, and in 1809 entered the Academy schools. In 1812 he became a member of the Society of Painters in Watercolours, where he exhibited largely for many years, as well as at the Academy. He married in 1810 the sister of William Hilton, R.A. He died in London on the 30th of January 1849. De Wint's life was devoted to art; he painted admirably in oils, and he ranks as one of the chief English water-colourists. A number of his pictures are in the National Gallery and the Victoria and Albert Museum.

DE WINTER, JAN WILLEM (1750-1812), Dutch admiral, was born at Kampen, and in 1761 entered the naval service at the age of twelve years. He distinguished himself by his zeal and courage, and at the revolution of 1787 he had reached the rank of lieutenant. The overthrow of the "patriot" party forced him to fly for his safety to France. Here he threw himself heart and soul into the cause of the Revolution, and took part under Dumouriez and Pichegru in the campaigns of 1792 and 1793, and was soon promoted to the rank of brigadier-general. When Pichegru in 1795 overran Holland, De Winter returned with the French army to his native country. The states-general now utilized the experience he had gained as a naval officer by giving him the post of adjunct-general for the reorganization of the Dutch navy. In 1796 he was appointed vice-admiral and commander-in-chief of the fleet. He spared no efforts to strengthen it and improve its condition, and on the 11th of October 1797 he ventured upon an encounter off Camperdown with the British fleet under Admiral Duncan. After an obstinate struggle the Dutch were defeated, and De Winter himself was taken prisoner. He remained in England until December, when he was liberated by exchange. His conduct in the battle of Camperdown was declared by a court-martial to have nobly maintained the honour of the Dutch flag.

From 1798 to 1802 De Winter filled the post of ambassador to the French republic, and was then once more appointed commander of the fleet. He was sent with a strong squadron to the Mediterranean to repress the Tripoli piracies, and negotiated a treaty of peace with the Tripolitan government. He enjoyed the confidence of Louis Bonaparte, when king of Holland, and, after the incorporation of the Netherlands in the French empire, in an equal degree of the emperor Napoleon. By the former he was created marshal and count of Huessen, and given the command of the armed forces both by sea and land. Napoleon gave him the grand cross of the Legion of Honour and appointed him inspector-general of the northern coasts, and in 1811 he placed him at the head of the fleet he had collected at the Texel. Soon afterwards De Winter was seized with illness and compelled to betake himself to Paris, where he died on the 2nd of June 1812. He had a splendid public funeral and was buried in the Pantheon. His heart was enclosed in an urn and placed in the Nicolaas Kerk at Kampen.

DE WITT, CORNELIUS (1623-1672), brother of John de Witt (q.v.), was born at Dort in 1623. In 1650 he became burgomaster of Dort and member of the states of Holland and West Friesland. He was afterwards appointed to the important post of *ruwaard* or governor of the land of Putten and bailiff of Beierland. He associated himself closely with his greater brother, the grand pensionary, and supported him throughout his career with great ability and vigour. In 1667 he was the deputy chosen by the states of Holland to accompany Admiral de Ruyter in his famous expedition to Chatham. Cornelius de Witt on this occasion distinguished himself greatly by his coolness and intrepidity. He again accompanied De Ruyter in 1672 and took an honourable part in the great naval fight at Sole Bay against the united English and French fleets. Compelled by illness to leave the fleet, he found on his return to Dort that the Orange party were in the ascendant, and he and his brother were the objects of popular suspicion and hatred. An account of his imprisonment, trial and death, is given below.

DE WITT, JOHN (1625-1672), Dutch statesman, was born at Dort, on the 24th of September 1625. He was a member of one of the old burgher-regent families of his native town. His father, Jacob de Witt, was six times burgomaster of Dort, and for many years sat as a representative of the town in the states of Holland. He was a strenuous adherent of the republican or oligarchical states-right party in opposition to the princes of the house of Orange, who represented the federal principle and had the support of the masses of the people. John was educated at Leiden, and early displayed remarkable talents, more especially in mathematics and jurisprudence. In 1645 he and his elder brother Cornelius visited France, Italy, Switzerland and England, and on his return he took up his residence at the Hague, as an advocate. In 1650 he was appointed pensionary of Dort, an office which made him the leader and spokesman of the town's deputation in the state of Holland. In this same year the states of Holland found themselves engaged in a struggle for provincial supremacy, on the question of the disbanding of troops, with the youthful prince of Orange, William II. William, with the support of the states-general and the army, seized five of the leaders of the states-right party and imprisoned them in Loevestein castle; among these was Jacob de Witt. The sudden death of William, at the moment when he had crushed opposition, led to a reaction. He left only a posthumous child, afterwards William III. of Orange, and the principles advocated by Jacob de Witt triumphed, and the authority of the states of Holland became predominant in the republic.

At this time of constitutional crisis such were the eloquence, sagacity and business talents exhibited by the youthful pensionary of Dort that on the 23rd of July 1653 he was appointed to the office of grand pensionary (*Raadpensionaris*) of Holland at the age of twenty-eight. He was re-elected in 1658, 1663 and 1668, and held office until his death in 1672. During this period of nineteen years the general conduct of public affairs and administration, and especially of foreign affairs, such was the confidence inspired by his talents and industry, was largely placed in his hands. He found in 1653 his country brought to the brink of ruin through the war with England, which had been caused by the keen commercial rivalry of the two maritime states. The Dutch were unprepared, and suffered severely through the loss of their carrying trade, and De Witt resolved to bring about peace as soon as possible. The first demands of Cromwell were impossible, for they aimed at the absorption of the two republics into a single state, but at last in the autumn of 1654 peace was concluded, by which the Dutch made large concessions and agreed to the striking of the flag to English ships in the narrow seas. The treaty included a secret article, which the states-general refused to entertain, but which De Witt succeeded in inducing the states of Holland to accept, by which the provinces of Holland pledged themselves not to elect a stadtholder or a captain-general of the union. This Act of Seclusion, as it was called, was aimed at the young prince of Orange, whose close relationship to the Stuarts made him an object of suspicion to the Protector. De Witt was personally favourable to this exclusion of William III. from his ancestral dignities, but there is no truth in the suggestion that he prompted the action of Cromwell in this matter.

The policy of De Witt after the peace of 1654 was eminently successful. He restored the finances of the state, and extended its commercial supremacy in the East Indies. In 1658-59 he sustained Denmark against Sweden, and in 1662 concluded an advantageous peace with Portugal. The accession of Charles II. to the English throne led to the rescinding of the Act of Seclusion; nevertheless De Witt steadily refused to allow the prince of Orange to be appointed stadtholder or captain-general. This led to ill-will between the English and Dutch governments, and to a renewal of the old grievances about maritime and commercial rights, and war broke out in 1665. The zeal, industry and courage displayed by the grand pensionary during the course of this fiercely contested naval struggle could scarcely have been surpassed. He himself on more than one occasion went to sea with the fleet, and inspired all with whom he came in contact by the example he set of calmness in danger, energy in action and inflexible strength of will. It was due to his exertions as an organizer and a diplomatist quite as much as to the brilliant seamanship of Admiral de Ruyter, that the terms of the treaty of peace signed at Breda (July 31, 1667), on the principle of *uti possidetis*, were so honourable to the United Provinces. A still greater triumph of diplomatic skill was the conclusion of the Triple Alliance (January 17, 1668) between the Dutch Republic, England and Sweden, which checked the attempt of Louis XIV. to take possession of the Spanish Netherlands in the name of his wife, the infanta Maria Theresa. The check, however, was but temporary, and the French king only bided his time to take vengeance for the rebuff he had suffered. Meanwhile William III. was growing to manhood, and his numerous adherents throughout the country spared no efforts to undermine the authority of De Witt, and secure for the young prince of Orange the dignities and authority of his ancestors.

In 1672 Louis XIV. suddenly declared war, and invaded the United Provinces at the head of a splendid army. Practically no resistance was possible. The unanimous voice of the people called William III. to the head of affairs, and there were violent demonstrations against John de Witt. His brother Cornelius was (July 24) arrested on a charge of conspiring against the prince. On the 4th of August John de Witt resigned the post of grand pensionary that he had held so long and with such distinction. Cornelius was put to the torture, and on the 19th of August he was sentenced to deprivation of his offices and banishment. He was confined in the Gevangenpoort, and his brother came to visit him in the prison. A vast crowd on hearing this collected outside, and finally burst into the prison, seized the two brothers and literally tore them to pieces. Their mangled remains were hung up by the feet to a lamp-post. Thus perished, by the savage act of an infuriated mob, one of the greatest statesmen of his age.

John de Witt married Wendela Bicker, daughter of an influential burgomaster of Amsterdam, in 1655, by whom he had two sons and three daughters.

Bibliography.—J. Geddes, *History of the Administration of John de Witt*, (vol. i. only, London, 1879); A. Lefèvre-Pontalis, *Jean de Witt, grand pensionnaire de Hollande* (2 vols., Paris, 1884); P. Simons, *Johan de Witt en zijn tijd* (3 vols., Amsterdam, 1832-1842); W. C. Knottenbelt, *Geschiedenis der Staatkunde van J. de Witt* (Amsterdam, 1862); *J. de Witt, Brieven ... gewisselt tusschen den Heer Johan de Witt ... ende de gevolgmaghtigden v. d. staedt d. Vereen. Nederlanden so in Vranckryck, Engelandt, Sweden, Denemarken, Poolen, enz. 1652-69* (6 vols., The Hague, 1723-1725); *Brieven ... 1650-1657 (1658) eerste deel bewerkt den R. Fruin uitgegeven d., C. W. Kernkamp* (Amsterdam, 1906).

DEWLAP (from the O.E. *læppa*, a lappet, or hanging fold; the first syllable is of doubtful origin and the popular explanation that the word means "the fold which brushes the dew" is not borne out, according to the *New English Dictionary*, by the equivalent words such as the Danish *doglaeb*, in Scandinavian languages), the loose fold of skin hanging from the neck of cattle, also applied to similar folds in the necks of other animals and fowls, as the dog, turkey, &c. The American practice of branding cattle by making a cut in the neck is known as a "dewlap brand." The skin of the neck in human beings often becomes pendulous with age, and is sometimes referred to humorously by the same name.

DEWSBURY, a market town and municipal and parliamentary borough in the West Riding of Yorkshire, England, on the river Calder, 8 m. S.S.W. of Leeds, on the Great Northern, London & North-Western, and Lancashire & Yorkshire railways. Pop. (1901) 28,060. The parish church of All Saints was for the most part rebuilt in the latter half of the 18th century; the portions still preserved of the original structure are mainly Early English.

The chief industries are the making of blankets, carpets, druggets and worsted yarn; and there are iron foundries and machinery works. Coal is worked in the neighbourhood. The parliamentary borough includes the adjacent municipal borough of Batley, and returns one member. The municipal borough, incorporated in 1862, is under a mayor, 6 aldermen and 18 councillors. Area, 1471 acres. Paulinus, first archbishop of York, about the year 627 preached in the district of Dewsbury, where Edwin, king of Northumbria, whom he converted to Christianity, had a royal mansion. At Kirklees, in the parish, are remains of a Cistercian convent of the 12th century, in an extensive park, where tradition relates that Robin Hood died and was buried.

DEXIPPUS, PUBLIUS HERENNIUS (c. A.D. 210-273), Greek historian, statesman and general, was an hereditary priest of the Eleusinian family of the Kerykes, and held the offices of archon basileus and eponymus in Athens. When the Heruli overran Greece and captured Athens (269), Dexippus showed great personal courage and revived the spirit of patriotism among his degenerate fellow-countrymen. A statue was set up in his honour, the base of which, with an inscription recording his services, has been preserved (*Corpus Inscrr. Atticarum*, iii. No. 716). It is remarkable that the inscription is silent as to his military achievements. Photius (*cod.* 82) mentions three historical works by Dexippus, of which considerable fragments remain: (1) Τὰ μετ᾽ Ἀλέξανδρον, an epitome of a similarly named work by Arrian; (2) Σκυθικά, a history of the wars of Rome with the Goths (or Scythians) in the 3rd century; (3) Χρονικὴ ἱστορία, a chronological history from the earliest times to the emperor Claudius Gothicus (270), frequently referred to by the writers of the Augustan history. The work was continued by Eunapius of Sardis down to 404. Photius speaks very highly of the style of Dexippus, whom he places on a level with Thucydides, an opinion by no means confirmed by the fragments (C. W. Müller, *F.H.G.* iii. 666-687).

DEXTER, HENRY MARTYN (1821-1890), American clergyman and author, was born in Plympton, Massachusetts, on the 13th of August 1821. He graduated at Yale in 1840 and at the Andover Theological Seminary in 1844; was pastor of a Congregational church in Manchester, New Hampshire, in 1844-1849, and of the Berkeley Street Congregational church, Boston, in 1849-1867; was an editor of the *Congregationalist* in 1851-1866, of the *Congregational Quarterly* in 1859-1866, and of the *Congregationalist*, with which the *Recorder* was merged, from 1867 until his death in New Bedford, Mass., on the 13th of November 1890. He was an authority on the history of Congregationalism and was lecturer on that subject at the Andover Theological Seminary in 1877-1879; he left his fine library on the Puritans in America to Yale University. Among his works are: *Congregationalism, What it is, Whence it is, How it works, Why it is better than any other Form of Church Government, and its consequent Demands* (1865), *The Church Polity of the Puritans the Polity of the New Testament* (1870), *As to Roger Williams and His "Banishment" from the Massachusetts Colony* (1876), *Congregationalism of the Last Three Hundred Years, as seen in its Literature* (1880), his most important work, *A Handbook of Congregationalism* (1880), *The True Story of John Smyth, the "Se-Baptist"* (1881), *Common Sense as to Woman Suffrage* (1885), and many reprints of pamphlets bearing on early church history in New England, especially Baptist controversies. His *The England and Holland of the Pilgrims* was completed by his son, Morton Dexter (b. 1846), and published in 1905.

DEXTER, TIMOTHY (1747-1806), American merchant, remarkable for his eccentricities, was born at Malden, Massachusetts, on the 22nd of February 1747. He acquired considerable wealth by buying up quantities of the depreciated continental currency, which was ultimately redeemed by the Federal government at par. He assumed the title of Lord Dexter and built extraordinary houses at Newburyport, Mass., and Chester, New Hampshire. He maintained a poet laureate and collected inferior pictures, besides erecting in one of his gardens some forty colossal statues carved in wood to represent famous men. A statue of himself was included in the collection, and had for an inscription "I am the first in the East, the first in the West, and the greatest philosopher in the Western World." He wrote a book entitled *Pickle for the Knowing Ones*. It was wholly without punctuation marks, and as this aroused comment, he published a second edition, at the end of which was a page displaying nothing but commas and stops, from which the readers were invited to "peper and solt it as they plese." He beat his wife for not weeping enough at the rehearsal of his funeral, which he himself carried out in a very elaborate manner. He died at Newburyport on the 26th of October 1806.

DEXTRINE (British Gum, Starch Gum, Leiocome), $(C_6H_{10}O_5)_x$, a substance produced from starch by the action of dilute acids, or by roasting it at a temperature between 170° and 240° C. It is manufactured by spraying starch with 2% nitric acid, drying in air, and then heating to about 110°. Different modifications are known, e.g. amylodextrine, erythrodextrine and achroodextrine. Its name has reference to its powerful dextrorotatory action on polarized light. Pure dextrine is an insipid, odourless, white substance; commercial dextrine is sometimes yellowish, and contains burnt or unchanged starch. It dissolves in water and dilute alcohol; by strong alcohol it is precipitated from its solutions as the hydrated compound,

$C_6H_{10}O_5.H_2O$. Diastase converts it eventually into maltose, $C_{12}H_{22}O_{11}$; and by boiling with dilute acids (sulphuric, hydrochloric, acetic) it is transformed into dextrose, or ordinary glucose, $C_6H_{12}O_6$. It does not ferment in contact with yeast, and does not reduce Fehling's solution. If heated with strong nitric acid it gives oxalic, and not mucic acid. Dextrine much resembles gum arabic, for which it is generally substituted. It is employed for sizing paper, for stiffening cotton goods, and for thickening colours in calico printing, also in the making of lozenges, adhesive stamps and labels, and surgical bandages.

See Otto Lueger, *Lexikon der gesamten Technik*.

DEY (an adaptation of the Turk, dāī, a maternal uncle), an honorary title formerly bestowed by the Turks on elderly men, and appropriated by the janissaries as the designation of their commanding officers. In Algeria the deys of the janissaries became in the 17th century rulers of that country (see Algeria: History). From the middle of the 16th century to the end of the 17th century the ruler of Tunisia was also called dey, a title frequently used during the same period by the sovereigns of Tripoli.

DHAMMAPĀLA, the name of one of the early disciples of the Buddha, and therefore constantly chosen as their name in religion by Buddhist novices on their entering the brotherhood. The most famous of the Bhikshus so named was the great commentator who lived in the latter half of the 5th century A.D. at the Badara Tittha Vihdāra, near the east coast of India, just a little south of where Madras now stands. It is to him we owe the commentaries on seven of the shorter canonical books, consisting almost entirely of verses, and also the commentary on the Netti, perhaps the oldest

Pāli work outside the canon. Extracts from the latter work, and the whole of three out of the seven others, have been published by the Pdāli Text Society. These works show great learning, exegetical skill and sound judgment. But as Dhammapāla confines himself rigidly either to questions of the meaning of words, or to discussions of the ethical import of his texts, very little can be gathered from his writings of value for the social history of his time. For the right interpretation of the difficult texts on which he comments, they are indispensable. Though in all probability a Tamil by birth, he declares, in the opening lines of those of his works that have been edited, that he followed the tradition of the Great Minster at Anurdādhapura in Ceylon, and the works themselves confirm this in every respect. Hsüan Tsang, the famous Chinese pilgrim, tells a quaint story of a Dhammapdāla of Kdānchipura (the modern Konjevaram). He was a son of a high official, and betrothed to a daughter of the king, but escaped on the eve of the wedding feast, entered the order, and attained to reverence and distinction. It is most likely that this story, whether legendary or not (and Hsüan Tsang heard the story at Kdānchipura nearly two centuries after the date of Dhammapdāla), referred to this author. But it may also refer, as Hsüan Tsang refers it, to another author of the same name. Other unpublished works, besides those mentioned above, have been ascribed to Dhammapdāla, but it is very doubtful whether they are really by him.

AUTHORITIES.—T. Watters, *On Yuan Chwang* (ed. Rhys Davids and Bushell, London, 1905), ii. 169, 228; Edmund Hardy in *Zeitschrift der deutschen morgenländischen Gesellschaft* (1898), pp. 97 foll.; *Netti* (ed. E. Hardy, London, Pāli Text Society, 1902), especially the Introduction, passim; *Therī Gdāthdā Commentary*, *Peta Vatthu Commentary*, and *Vimdāna Vatthu Commentary*, all three published by the Pāli Text Society.

(T. W. R. D.)

DHANIS, FRANCIS, Baron (1861-1909), Belgian administrator, was born in London in 1861 and passed the first fourteen years of his life at Greenock, where he received his early education. He was the son of a Belgian merchant and of an Irish lady named Maher. The name Dhanis is supposed to be a variation of D'Anvers. Having completed his education at the École Militaire he entered the Belgian army, joining the regiment of grenadiers, in which he rose to the rank of major. As soon as he reached the rank of lieutenant he volunteered for service on the Congo, and in 1887 he went out for a first term. He did so well in founding new stations north of the Congo that, when the government decided to put an end to the Arab domination on the Upper Congo, he was selected to command the chief expedition sent against the slave dealers. The campaign began in April 1892, and it was not brought to a successful conclusion till January 1894. The story of this war has been told in detail by Dr Sydney Hinde, who took part in it, in his book *The Fall of the Congo Arabs*. The principal achievements of the campaign were the captures in succession of the three Arab strongholds at Nyangwe, Kassongo and Kabambari. For his services Dhanis was raised to the rank of baron, and in 1895 was made vice-governor of the Congo State. In 1896 he took command of an expedition to the Upper Nile. His troops, largely composed of the Batetela tribes who had only been recently enlisted, and who had been irritated by the execution of some of their chiefs for indulging their cannibal proclivities, mutinied and murdered many of their white officers. Dhanis found himself confronted with a more formidable adversary than even the Arabs in these well-armed and half-disciplined mercenaries. During two years (1897-1898) he was constantly engaged in a life-and-death struggle with them. Eventually he succeeded in breaking up the several bands formed out of his mutinous soldiers. Although the incidents of the Batetela operations were less striking than those of the Arab war, many students of both think that the Belgian leader displayed the greater ability and fortitude in bringing them to a successful issue. In 1899 Baron Dhanis returned to Belgium with the honorary rank of vice governor-general. He died on the 14th of November 1909.

DHAR, a native state of India, in the Bhopawar agency, Central India. It includes many Rajput and Bhil feudatories, and has an area of 1775 sq. m. The raja is a Punwar Mahratta. The founder of the present ruling family was Anand Rao Punwar, a descendant of the great Paramara clan of Rajputs who from the 9th to the 13th century, when they were driven out by the Mahommedans, had ruled over Malwa from their capital at Dhar. In 1742 Anand Rao received Dhar as a fief from Baji Rao, the peshwa, the victory of the Mahrattas thus restoring the sovereign power to the family which seven centuries before had been expelled from this very city and country. Towards the close of the 18th and in the early part of the 19th century, the state was subject to a series of spoliations by Sindia and Holkar, and was only preserved from destruction by the talents and courage of the adoptive mother of the fifth raja. By a treaty of 1819 Dhar passed under British protection, and bound itself to act in subordinate co-operation. The state was confiscated for rebellion in 1857, but in 1860 was restored to Raja Anand Rao Punwar, then a minor, with the exception of the detached district of Bairusia, which was granted to the begum of Bhopal. Anand Rao, who received the personal title Maharaja and the K.C.S.I. in 1877, died in 1898, and was succeeded by Udaji Rao Punwar. In 1901 the population was 142,115. The state includes the ruins of Mandu, or Mandogarh, the Mahommedan capital of Malwa.

THE TOWN OF DHAR is 33 m. W. of Mhow, 908 ft. above the sea. Pop. (1901) 17,792. It is picturesquely situated among lakes and trees surrounded by barren hills, and possesses, besides its old walls, many interesting buildings, Hindu and Mahommedan, some of them containing records of a great historical importance. The Lat Masjid, or Pillar Mosque, was built by Dilawar Khan in 1405 out of the remains of Jain temples. It derives its name from an iron pillar, supposed to have been originally set up at the beginning of the 13th century in commemoration of a victory, and bearing a later inscription recording the seven days' visit to the town of the emperor Akbar in 1598. The pillar, which was 43 ft. high, is now overthrown and broken. The Kamal Maula is an enclosure containing four tombs, the most notable being that of Shaikh Kamal Maulvi (Kamal-ud-din), a follower of the famous 13th-century Mussulman saint Nizam-ud-din Auliya.[1] The mosque known as Raja Bhoj's school was built out of Hindu remains in the 14th or 15th century: its name is derived from the slabs, covered with inscriptions giving rules of Sanskrit grammar, with which it is paved. On a small hill to the north of the town stands the fort, a conspicuous pile of red sandstone, said to have been built by Mahommed ben Tughlak of Delhi in the 14th century. It contains the palace of the raja. Of modern institutions may be mentioned the high school, public library, hospital, and the chapel, school and hospital of the Canadian Presbyterian mission. There is also a government opium depot for the payment of duty, the town being a considerable centre for the trade in opium as well as in grain.

The town, the name of which is usually derived from Dhara Nagari (the city of sword blades), is of great antiquity, and was made the capital of the Paramara chiefs of Malwa by Vairisinha II., who transferred his headquarters hither from Ujjain at the close of the 9th century. During the rule of the Paramara dynasty Dhar was famous throughout India as a centre of culture and learning; but, after suffering various vicissitudes, it was finally conquered by the Mussulmans at the beginning of the 14th century. At the close of the century Dilawar Khan, the builder of the Lat Masjid, who had been appointed governor in 1399, practically established his independence, his son Hoshang Shah being the first Mahommedan king of Malwa. Under this dynasty Dhar was second in importance to the capital Mandu. Subsequently, in the time of Akbar, Dhar fell under the dominion of the Moguls, in whose hands it remained till 1730, when it was conquered by the Mahrattas.

See *Imperial Gazetteer of India* (Oxford, 1908).

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[1] Nizam-ud-din, whose beautiful marble tomb is at Indarpat near Delhi, was, according to some authorities, an assassin of the secret society of Khorasan. By some modern authorities he is supposed to have been the founder of Thuggism, the Thugs having a special reverence for his memory.

DHARAMPUR, a native state of India, in the Surat political agency division of Bombay, with an area of 704 sq. m. The population in 1901 was 100,430, being a decrease of 17% during the decade; the estimated gross revenue is £25,412; and the tribute £600. Its chief is a Sesodia Rajput. The state has been surveyed for land revenue on the Bombay system. It contains one town, Dharampur (pop. in 1901, 63,449), and 272 villages. Only a small part of the state, the climate of which is very unhealthy, is capable of cultivation; the rest is covered with rocky hills, forest and brushwood.

DHARMSALA, a hill-station and sanatorium of the Punjab, India, situated on a spur of the Dhaola Dhar, 16 m. N.E. of Kangra town, at an elevation of some 6000 ft. Pop. (1901) 6971. The scenery of Dharmsala is of peculiar grandeur. The spur on which it stands is thickly wooded with oak and other trees; behind it the pine-clad slopes of the mountain tower towards the jagged peaks of the higher range, snow-clad for half the year; while below stretches the luxuriant cultivation of the Kangra valley. In 1855 Dharmsala was made the headquarters of the Kangra district of the Punjab in place of Kangra, and became the centre of a European settlement and cantonment, largely occupied by Gurkha regiments. The station was destroyed by the earthquake of April 1905, in which 1625 persons, including 25 Europeans and 112 of the Gurkha garrison, perished (*Imperial Gazetteer of India*, 1908).

DHARWAR, a town and district of British India, in the southern division of Bombay. The town has a station on the Southern Mahratta railway. The population in 1901 was 31,279. It has several ginning factories and a cotton-mill; two high schools, one maintained by the Government and the other by the Basel German Mission.

The District of Dharwar has an area of 4602 sq. m. In the north and north-east are great plains of black soil, favourable to cotton-growing; in the south and west are successive ranges of low hills, with flat fertile valleys between them. The whole district lies high and has no large rivers.

In 1901 the population was 1,113,298, showing an increase of 6% in the decade. The most influential classes of the community are Brahmans and Lingayats. The Lingayats number 436,968, or 46% of the Hindu population; they worship the symbol of Siva, and males and females both carry this emblem about their person in a silver case. The principal crops are millets, pulse and cotton. The centres of the cotton trade are Hubli and Gadag, junctions on the Southern Mahratta railway, which traverses the district in several directions.

The early history of the territory comprised within the district of Dharwar has been to a certain extent reconstructed from the inscription slabs and memorial stones which abound there. From these it is clear that the country fell in turn under the sway of the various dynasties that ruled in the Deccan, memorials of the Chalukyan dynasty, whether temples or inscriptions, being especially abundant. In the 14th century the district was first overrun by the Mahommedans, after which it was annexed to the newly established Hindu kingdom of Vijayanagar, an official of which named Dhar Rao, according to local tradition, built the fort at Dharwar town in 1403. After the defeat of the king of Vijayanagar at Talikot (1565), Dharwar was for a few years practically independent under its Hindu governor; but in 1573 the fort was captured by the sultan of Bijapur, and Dharwar was annexed to his dominions. In 1685 the fort was taken by the emperor Aurangzeb, and Dharwar, on the break-up of the Mogul empire, fell under the sway of the peshwa of Poona. In 1764 the province was overrun by Hyder Ali of Mysore, who in 1778 captured the fort of Dharwar. This was retaken in 1791 by the Mahrattas. On the final overthrow of the peshwa in 1817, Dharwar was incorporated with the territory of the East India Company.

DHOLPUR, a native state of India, in the Rajputana agency, with an area of 1155 sq. m. It is a crop-producing country, without any special manufactures. All along the bank of the river Chambal the country is deeply intersected by ravines; low ranges of hills in the western portion of the state supply inexhaustible quarries of fine-grained and easily-worked red sandstone. In 1901 the population of Dholpur was 270,973, showing a decrease of 3% in the decade. The estimated revenue is £83,000. The state is crossed by the Indian Midland railway from Jhansi to Agra. In recent years it has suffered severely from drought. In 1896-1897 the expenditure on famine relief amounted to £8190.

The town of Dholpur is 34 m. S. of Agra by rail. Pop. (1901) 19,310. The present town, which dates from the 16th century, stands somewhat to the north of the site of the older Hindu town built, it is supposed, in the 11th century by the Tonwar Rajput Raja Dholan (or Dhawal) Deo, and named after him Dholdera or Dhawalpuri. Among the objects of interest in the town may be mentioned the fortified *sarai* built in the reign of Akbar, within which is the fine tomb of Sadik Mahommed Khan (d. 1595), one of his generals. The town, from its position on the railway, is growing in importance as a centre of trade.

Little is known of the early history of the country forming the state of Dholpur. Local tradition affirms that it was ruled by the Tonwar Rajputs, who had their seat at Delhi from the 8th to the 12th century. In 1450 it had a raja of its own; but in 1501 the fort of Dholpur was taken by the Mahommedans under Sikandar Lodi and in 1504 was transferred to a Mussulman governor. In 1527, after a strenuous resistance, the fort was captured by Baber and with the surrounding country passed under the sway of the Moguls, being included by Akbar in the province of Agra. During the dissensions which followed the death of Aurangzeb in 1707, Raja Kalyan Singh Bhadauria obtained possession of Dholpur, and his family retained it till 1761, after which it was taken successively by the Jat raja, Suraj Mal of Bharatpur, by Mirza Najaf Khan in 1775, by Sindhia in 1782, and in 1803 by the British. It was restored to Sindhia by the treaty of Sarji Anjangaon, but in consequence of new arrangements was again occupied by the British. Finally, in 1806, the territories of Dholpur, Bari and Rajakhera were handed over to the maharaj rana Kirat Singh, ancestor of the present chiefs of Dholpur, in exchange for his state of Gohad, which was ceded to Sindhia.

The maharaj rana of Dholpur belongs to the clan of Bamraolia Jats, who are believed to have formed a portion of the Indo-Scythian wave of invasion which swept over northern India about A.D. 100. An ancestor of the family appears to have held certain territories at Bamraoli near Agra c. 1195. His descendant in 1505, Singhan Deo, having distinguished himself in an expedition against the freebooters of the Deccan, was rewarded by the sovereignty of the small territory of Gohad, with the title of *rana*. In 1779 the rana of Gohad joined the British forces against Sindhia, under a treaty which stipulated that, at the conclusion of peace between the English and Mahrattas, all the territories then in his possession should be guaranteed to him, and protected from invasion by Sindhia. This protection was subsequently withdrawn, the rana having been guilty of treachery, and in 1783 Sindhia succeeded in recapturing the fortress of Gwalior, and crushed his Jat opponent by seizing the whole of Gohad. In 1804, however, the family were restored to Gohad by the British government; but, owing to the opposition of Sindhia, the rana agreed in 1805 to exchange Gohad for his present territory of Dholpur, which was taken under British protection, the chief binding himself to act in subordinate co-operation with the paramount power, and to refer all disputes with neighbouring princes to the British government. Kirat Singh, the first maharaj rana of Dholpur, was succeeded in 1836 by his son Bhagwant Singh, who showed great loyalty during the Mutiny of 1857, was created a K.C.S.I., and G.C.S.I. in 1869. He was succeeded in 1873 by his grandson Nihal Singh, who received the C.B. and frontier medal for services in the Tirah campaign. He died in 1901, and was succeeded by his eldest son Ram Singh (b. 1883).

See *Imperial Gazetteer of India* (Oxford, 1908) and authorities there given.

DHOW, the name given to a type of vessel used throughout the Arabian Sea. The language to which the word belongs is unknown. According to the *New English Dictionary* the place of origin may be the Persian Gulf, assuming that the word is identical with the tava mentioned by Athanasius Nikitin (*India in the 15th Century*, Hakluyt Society, 1858). Though the word is used generally of any craft along the East African coast, it is usually applied to the vessel of about 150 to 200 tons burden with a stem rising with a long slope from the water; dhows generally have one mast with a lateen sail, the yard being of enormous length. Much of the coasting trade of the Red Sea and Persian Gulf is carried on by these vessels. They were the regular vessels employed in the slave trade from the east coast of Africa.

DHRANGADRA, a native state of India, in the Gujarat division of Bombay, situated in the north of the peninsula of Kathiawar. Its area is 1156 sq. m. Pop. (1901) 70,880. The estimated gross revenue is £38,000 and the tribute £3000. A state railway on the metre gauge from Wadhwan to the town of Dhrangadra, a distance of 21 m., was opened for traffic in 1898. Some cotton is grown, although the soil is as a whole poor; the manufactures include salt, metal vessels and stone hand-mills. The chief town, Dhrangadra, has a population (1901) of 14,770.

The chief of Dhrangadra, who bears the title of Raj Sahib, with the predicate of His Highness, is head of the ancient clan of Jhala Rajputs, who are said to have entered Kathiawar from Sind in the 8th century. Raj Sahib Sir Mansinghji Ranmalsinghji (b. 1837), who succeeded his father in 1869, was distinguished for the enlightened character of his administration, especially in the matter of establishing schools and internal communications. He was created a K.C.S.I in 1877. He died in 1900, and was succeeded by his grandson Ajitsinghji Jaswatsinghji (b. 1872).

DHULEEP SINGH (1837-1893), maharaja of Lahore, was born in February 1837, and was proclaimed maharaja on the 18th of September 1843, under the regency of his mother the rani Jindan, a woman of great capacity and strong will, but extremely inimical to the British. He was acknowledged by Ranjit Singh and recognized by the British government. After six years of peace the Sikhs invaded British territory in 1845, but were defeated in four battles, and terms were imposed upon them at Lahore, the capital of the Punjab. Dhuleep Singh retained his territory, but it was administered to a great extent by the British government in his name. This arrangement increased the regent's dislike of the British, and a fresh outbreak occurred in 1848-49. In spite of the valour of the Sikhs, they were utterly routed at Gujarat, and in March 1849 Dhuleep Singh was deposed, a pension of £40,000 a year being granted to him and his dependants. He became a Christian and elected to live in England. On coming of age he made an arrangement with the British government by which his income was reduced to £25,000 in consideration of advances for the purchase of an estate, and he finally settled at Elvedon in Suffolk. While passing through Alexandria in 1864 he met Miss Bamba Müller, the daughter of a German merchant who had married an Abyssinian. The maharaja had been interested in mission work by Sir John Login, and he met Miss Müller at one of the missionary schools where she was teaching. She became his wife on the 7th of June 1864, and six children were the issue of the marriage. In the year after her death in 1890 the maharaja married at Paris, as his second wife, an English lady, Miss Ada Douglas Wetherill, who survived him. The maharaja was passionately fond of sport, and his shooting parties were celebrated, while he himself became a *persona grata* in English society. The result, however, was financial difficulty, and in 1882 he appealed to the government for assistance, making various claims based upon the alleged possession of private estates in the Punjab, and upon the surrender of the Koh-i-nor diamond to the British Crown. His demand was rejected, whereupon he started for India, after drawing up a proclamation to his former subjects. But as it was deemed inadvisable to allow him to visit the Punjab, he remained for some time as a guest at the residency at Aden, and was allowed to receive some of his relatives to witness his abjuration of Christianity, which actually took place within the residency itself. As the climate began to affect his health, the maharaja at length left Aden and returned to Europe. He stayed for some time in Russia, hoping that his claim against England would be taken up by the Russians; but when that expectation proved futile he proceeded to Paris, where he lived for the rest of his life on the pension allowed him by the Indian government. His death from an attack of apoplexy took place at Paris on the 22nd of October 1893. The maharaja's eldest son, Prince Victor Albert Jay Dhuleep Singh (b. 1866), was educated at Trinity and Downing Colleges, Cambridge. In 1888 he obtained a commission in the 1st Royal Dragoon Guards. In 1898 he married Lady Anne Coventry, youngest daughter of the earl of Coventry.

(G. F. B.)

DHULIA, a town of British India, administrative headquarters of West Khandesh district in Bombay, on the right bank of the Panjhra river. Pop. (1901) 24,726. Considerable trade is done in cotton and oil-seeds, and weaving of cotton. A railway connects Dhulia with Chalisgaon, on the main line of the Great Indian Peninsula railway.

DIABASE, in petrology, a rock which is a weathered form of dolerite. It was long widely accepted that the pre-Tertiary rocks of this group differed from their Tertiary and Recent representatives in certain essential respects, but this is now admitted to be untenable, and the differences are known to be merely the result of the longer exposure to decomposition, pressure and shearing, which the older rocks have experienced. Their olivine tends to become serpentinized; their augite changes to chlorite and uralite; their felspars are clouded by formation of zeolites, calcite, sericite and epidote. The rocks acquire a green colour (from the development of chlorite, uralite and epidote); hence the older name of "greenstones," which is now little used. Many of them become somewhat schistose from pressure ("greenstone-schists," meta-diabase, &c.). Although the original definition of the group can no longer be justified, the name is so well established in current usage that it can hardly be discarded. The terms diabase and dolerite are employed really to designate distinct facies of the same set of rocks.

The minerals of diabase are the same as those of dolerite, viz. olivine, augite, and plagioclase felspar, with subordinate quantities of hornblende, biotite, iron oxides and apatite.

There are olivine-diabases and diabases without olivine; quartz-diabases, analcite-diabases (or teschenites) and hornblende diabases (or proterobases). Hypersthene (or bronzite) is characteristic of another group. Many of them are ophitic, especially those which contain olivine, but others are intersertal, like the intersertal dolerites. The last include most quartz-diabases, hypersthene-diabases and the rocks which have been described as tholeites. Porphyritic structure appears in the diabase-porphyrites, some of which are highly vesicular and contain remains of an abundant fine-grained or partly glassy ground-mass (*diabas-mandelstein*, amygdaloidal diabase). The somewhat ill-defined spilites are regarded by many as modifications of diabase-porphyrite. In the intersertal and porphyrite diabases, fresh or devitrified glassy base is not infrequent. It is especially conspicuous in some tholeites (hyalo-tholeites) and in weisselbergites. These rocks consist of augite and plagioclase, with little or no olivine, on a brown, vitreous, interstitial matrix. Devitrified forms of tachylyte (sordawilite, &c.) occur at the rapidly chilled margins of dolerite sills and dikes, and fine-grained spotted rocks with large spherulites of grey or greenish felspar, and branching growths of brownish-green augite (variolites).

To nearly every variety in composition and structure presented by the diabases, a counterpart can be found among the Tertiary dolerites. In the older rocks, however, certain minerals are more common than in the newer. Hornblende, mostly of pale green colours and somewhat fibrous habit, is very frequent in diabase; it is in most cases secondary after pyroxene, and is then known as uralite; often it forms pseudomorphs which retain the shape of the original augite. Where diabases have been crushed or sheared, hornblende readily develops at the expense of pyroxene, sometimes replacing it completely. In the later stages of alteration the amphibole becomes compact and well crystallized; the rocks consist of green hornblende and plagioclase felspar, and are then generally known as epidiorites or amphibolites. At the same time a schistose structure is produced. But transition forms are very common, having more or less of the augite remaining, surrounded by newly formed hornblende which at first is rather fibrous and tends to spread outwards through the surrounding felspar. Chlorite also is abundant both in sheared and unsheared diabases, and with it calcite may make its appearance, or the lime set free from the augite may combine with the titanium of the iron oxide and with silica to form incrustations or borders of sphene around the original crystals of ilmenite. Epidote is another secondary lime-bearing mineral which results from the decomposition of the soda lime felspars and the pyroxenes. Many diabases, especially those of the teschenite sub-group, are filled with zeolites.

Diabases are exceedingly abundant among the older rocks of all parts of the globe. Popular names for them are "whinstone," "greenstone," "toadstone" and "trap." They form excellent road-mending stones and are much quarried for this purpose, being tough, durable and resistant to wear, so long as they are not extremely decomposed. Many of them are to be preferred to the fresher dolerites as being less brittle. The quality of the Cornish greenstones appears to have been distinctly improved by a smaller amount of recrystallization where they have been heated by contact with intrusive masses of granite.

(J. S. F.)

DIABETES (from Gr. διά, through, and βαίνειν, to pass), a constitutional disease characterized by a habitually excessive discharge of urine. Two forms of this complaint are described, viz. Diabetes Mellitus, or Glycosuria, where the urine is not only increased in quantity, but persistently contains a greater or less amount of sugar, and Diabetes Insipidus, or Polyuria, where the urine is simply increased in quantity, and contains no abnormal ingredient. This latter, however, must be distinguished from the polyuria due to chronic granular kidney, lardaceous disease of the kidney, and also occurring in certain cases of hysteria.

Diabetes mellitus is the disease to which the term is most commonly applied, and is by far the more serious and important ailment. It is one of the diseases due to altered metabolism (see Metabolic Diseases). It is markedly hereditary, much more prevalent in towns and especially modern city life than in more primitive rustic communities, and most common among the Jews. The excessive use of sugar as a food is usually considered one cause of the disease, and obesity is supposed to favour its occurrence, but many observers consider that the obesity so often met with among diabetics is due to the same cause as the disease itself. No age is exempt, but it occurs most commonly in the fifth decade of life. It attacks males twice as frequently as females, and fair more frequently than dark people.

The symptoms are usually gradual in their onset, and the patient may suffer for a length of time before he thinks it necessary to apply for medical aid. The first symptoms which attract attention are failure of strength, and emaciation, along with great thirst and an increased amount and frequent passage of urine. From the normal quantity of from 2 to 3 pints in the 24 hours it may be increased to 10, 20 or 30 pints, or even more. It is usually of pale colour, and of thicker consistence than normal urine, possesses a decidedly sweet taste, and is of high specific gravity (1030 to 1050). It frequently gives rise to considerable irritation of the urinary passages.

By simple evaporation crystals of sugar may be obtained from diabetic urine, which also yields the characteristic chemical tests of sugar, while the amount of this substance can be accurately estimated by certain analytical processes. The quantity of sugar passed may vary from a few ounces to two or more pounds per diem, and it is found to be markedly increased after saccharine or starchy food has been taken. Sugar may also be found in the blood, saliva, tears, and in almost all the excretions of persons suffering from this disease. One of the most distressing symptoms is intense thirst, which the patient is constantly seeking to allay, the quantity of liquid consumed being in general enormous, and there is usually, but not invariably, a voracious appetite. The mouth is always parched, and a faint, sweetish odour may be evolved from the breath. The effect of the disease upon the general health is very marked, and the patient becomes more and more emaciated. He suffers from increasing muscular weakness, the temperature of his body is lowered, and the skin is dry and harsh. There is often a peculiar flush on the face, not limited to the malar eminences, but extending up to the roots of the hair. The teeth are loosened or decay, there is a tendency to bleeding from the gums, while dyspeptic symptoms, constipation and loss of sexual power are common accompaniments. There is in general great mental depression or irritability.

Diabetes as a rule advances comparatively slowly except in the case of young persons, in whom its progress is apt to be rapid. The complications of the disease are many and serious. It may cause impaired vision by weakening the muscles of accommodation, or by lessening the sensitiveness of the retina to light. Also cataract is very common. Skin affections of all kinds may occur and prove very intractable. Boils, carbuncles, cellulitis and gangrene are all apt to occur as life advances, though gangrene is much more frequent in men than in women. Diabetics are especially liable to phthisis and pneumonia, and gangrene of the lungs may set in if the patient survives the crisis in the latter disease. Digestive troubles of all kinds, kidney diseases and heart failure due to fatty heart are all of common occurrence. Also patients seem curiously susceptible to the poison of enteric fever, though the attack usually runs a mild course. The sugar temporarily disappears during the fever. But the most serious complication of all is known as diabetic coma, which is very commonly the final cause of death. The onset is often insidious, but may be indicated by loss of appetite, a rapid fall in the quantity of both urine and sugar, and by either constipation or diarrhoea. More rarely there is most acute abdominal pain. At first the condition is rather that of collapse than true coma, though later the patient is absolutely comatose. The patient suffers from a peculiar kind of dyspnoea, and the breath and skin have a sweet ethereal odour. The condition may last from twenty-four hours to three days, but is almost invariably the precursor of death.

Diabetes is a very fatal form of disease, recovery being exceedingly rare. Over 50% die of coma, another 25% of phthisis or pneumonia, and the remainder of Bright's disease, cerebral haemorrhage, gangrene, &c. The most favourable cases are those in which the patient is advanced in years, those in which it is associated with obesity or gout, and where the social conditions are favourable. A few cures have been recorded in which the disease supervened after some acute illness. The unfavourable cases are those in which there is a family history of the disease and in which the patient is young. Nevertheless much may be done by appropriate treatment to mitigate the severity of the symptoms and to prolong life.

There are two distinct lines of treatment, that of diet and that of drugs, but each must be modified and determined entirely by the idiosyncrasy of the patient, which varies in this condition between very wide limits. That of diet is of primary importance inasmuch as it has been proved beyond question that certain kinds of food have a powerful influence in aggravating the disease, more particularly those consisting largely of saccharine and starchy matter; and it may be stated generally that the various methods of treatment proposed aim at the elimination as far as possible of these constituents from the diet. Hence it is recommended that such articles as bread, potatoes and all farinaceous foods, turnips, carrots, parsnips and most fruits should be avoided; while animal food and soups, green vegetables, cream, cheese, eggs, butter, and tea and coffee without sugar, may be taken with advantage. As a substitute for ordinary bread, which most persons find it difficult to do without for any length of time, bran bread, gluten bread and almond biscuits. A patient must never pass suddenly from an ordinary to a carbohydrate-free diet. Any such sudden transition is extremely liable to bring on diabetic coma, and the change must be made quite gradually, one form of carbohydrate after another being taken out of the diet, whilst the effect on the quantity of sugar passed is being carefully noted meanwhile. The treatment may be begun by excluding potatoes, sugar and fruit, and only after several days is the bread to be replaced by some diabetic substitute. When the sugar excretion has been reduced to its lowest point, and maintained there for some time, a certain amount of carbohydrate may be cautiously allowed, the consequent effect on the glycosuria being estimated. The best diet can only be worked out experimentally for each individual patient. But in every case, if drowsiness or any symptom suggesting coma supervene, all restrictions must be withdrawn, and carbohydrate freely allowed. The question of alcohol is one which must be largely determined by the previous history of the patient, but a small quantity will help to make up the deficiencies of a diet poor in carbohydrate. Scotch and Irish whisky, and Hollands gin, are usually free from sugar, and some of the light Bordeaux wines contain very little. Fat is beneficial, and can be given as cream, fat of meat and cod-liver oil. Green vegetables are harmless, but the white stalks of cabbages and lettuces and also celery and endive yield sugar. Laevulose can be assimilated up to 1½ ozs. daily without increasing the glycosuria, and hence apples, cooked or raw, are allowable, as the sugar they contain is in this form. The question of milk is somewhat disputed; but it is usual to exclude it from the rigid diet, allowing a certain quantity when the diet is being extended. Thirst is relieved by anything that relieves the polyuria. But hypodermic injections of pilocarpine stimulate the flow of saliva, and thus relieve the dryness of the mouth. Constipation appears to increase the thirst, and must always be carefully guarded against. The best remedies are the aperient mineral waters.

Numerous medicinal substances have been employed in diabetes, but few of them are worthy of mention as possessed of any efficacy. Opium is often found of great service, its administration being followed by marked amelioration in all the symptoms. Morphia and codeia have a similar action. In the severest cases, however, these drugs appear to be of little or no use, and they certainly increase the constipation. Heroin hydrochloride has been tried in their place, but this seems to have more power over slight than over severe cases. Salicylate of sodium and aspirin are both very beneficial, causing a diminution in the sugar excretion without counterbalancing bad effects.

In *diabetes insipidus* there is constant thirst and an excessive flow of urine, which, however, is not found to contain any abnormal constituent. Its effects upon the system are often similar to those of diabetes mellitus, except that they are much less marked, the disease being in general very slow in its progress. In some cases the health appears to suffer very slightly. It is rarely a direct cause of death, but from its debilitating effects may predispose to serious and fatal complications. It is best treated by tonics and generous diet. Valerian has been found beneficial, the powdered root being given in 5-grain doses.

DIABOLO, a game played with a sort of top in the shape of two cones joined at their apices, which is spun, thrown, and caught by means of a cord strung to two sticks. The idea of the game appears originally to have come from China, where a top (*Kouengen*), made of two hollow pierced cylinders of metal or wood, joined by a rod—and often of immense size,—was made by rotation to hum with a loud noise, and was used by pedlars to attract customers. From China it was introduced by missionaries to Europe; and a form of the game, known as "the devil on two sticks," appears to have been known in England towards the end of the 18th century, and Lord Macartney is credited with improvements in it. But its principal vogue was in France in 1812, where the top was called "le diable." Amusing old prints exist (see *Fry's Magazine*, March and December 1907), depicting examples of the popular craze in France at the time. The *diable* of those days resembled a globular wooden dumb-bell with a short waist, and the sonorous hum when spinning—the *bruit du diable*—was a pronounced feature. At intervals during the century occasional attempts to revive the game of spinning a top of this sort on a string were made, but it was not till 1906 that the sensation of 1812 began to be repeated. A French engineer, Gustave Phillipart, discovering some old implements of the game, had experimented for some time with new forms of top with a view to bringing it again into popularity; and having devised the double-cone shape, and added a miniature bicycle tire of rubber round the rims of the two ends of the double-cone, with other improvements, he named it "diabolo." The use of celluloid in preference to metal or wood as its material appears to have been due to a suggestion of Mr C. B. Fry, who was consulted by the inventor on the subject. The game of spinning, throwing and catching the diabolo was rapidly elaborated in various directions, both as an exercise of skill in doing tricks, and in "diabolo tennis" and other ways as an athletic pastime. From Paris, Ostend and the chief French seaside resorts, where it became popular in 1906, its vogue spread in 1907 so that in France and England it became the fashionable "rage" among both children and adults.

The mechanics of the diabolo were worked out by Professor C. V. Boys in the *Proc. Phys. Soc.* (London), Nov. 1907.

DIACONICON, in the Greek Church, the name given to a chamber on the south side of the central apse, where the sacred utensils, vessels, &c., of the church were kept. In the reign of Justin II. (565-574), owing to a change in the liturgy, the diaconicon and protheses were located in apses at the east end of the aisles. Before that time there was only one apse. In the churches in central Syria of slightly earlier date, the diaconicon is rectangular, the side apses at Kalat-Seman having been added at a later date.

DIADOCHI (Gr. διαδἐχεσθαι, to receive from another), i.e. "Successors," the name given to the Macedonian generals who fought for the empire of Alexander after his death in 323 B.C. The name includes Antigonus and his son Demetrius Poliorcetes, Antipater and his son Cassander, Seleucus, Ptolemy, Eumenes and Lysimachus. The kingdoms into which the Macedonian empire was divided under these rulers are known as Hellenistic. The chief were Asia Minor and Syria under the Seleucid Dynasty (q.v.), Egypt under the Ptolemies (q.v.), Macedonia under the successors of Antigonus Gonatas, Pergamum (q.v.) under the Attalid dynasty. Gradually these kingdoms were merged in the Roman empire. (See Macedonian Empire.)

DIAGONAL (Gr. ;δία, through, γωνία, a corner), in geometry, a line joining the intersections of two pairs of sides of a rectilinear figure.

DIAGORAS, of Melos, surnamed the Atheist, poet and sophist, flourished in the second half of the 5th century B.C. Religious in his youth and a writer of hymns and dithyrambs, he became an atheist because a great wrong done to him was left unpunished by the gods. In consequence of his blasphemous speeches, and especially his criticism of the Mysteries, he was condemned to death at Athens, and a price set upon his head (Aristoph. *Clouds*, 830; *Birds*, 1073 and Schol.). He fled to Corinth, where he is said to have died. His work on the Mysteries was called Φρύγιοι λόγοι or Ἀποπυργίζοντες, in which he probably attacked the Phrygian divinities.

DIAGRAM (Gr. διάγραμμα, from διαγράφειν, to mark out by lines), a figure drawn in such a manner that the geometrical relations between the parts of the figure illustrate relations between other objects. They may be classed according to the manner in which they are intended to be used, and also according to the kind of analogy which we recognize between the diagram and the thing represented. The diagrams in mathematical treatises are intended to help the reader to follow the mathematical reasoning. The construction of the figure is defined in words so that even if no figure were drawn the reader could draw one for himself. The diagram is a good one if those features which form the subject of the proposition are clearly represented.

Diagrams are also employed in an entirely different way—namely, for purposes of measurement. The plans and designs drawn by architects and engineers are used to determine the value of certain real magnitudes by measuring certain distances on the diagram. For such purposes it is essential that the drawing be as accurate as possible. We therefore class diagrams as diagrams of illustration, which merely suggest certain relations to the mind of the spectator, and diagrams drawn to scale, from which measurements are intended to be made. There are some diagrams or schemes, however, in which the form of the parts is of no importance, provided their connexions are properly shown. Of this kind are the diagrams of electrical connexions, and those belonging to that department of geometry which treats of the degrees of cyclosis, periphraxy, linkedness and knottedness.

Diagrams purely Graphic and mixed Symbolic and Graphic.—Diagrams may also be classed either as purely graphical diagrams, in which no symbols are employed except letters or other marks to distinguish particular points of the diagrams, and mixed diagrams, in which certain magnitudes are represented, not by the magnitudes of parts of the diagram, but by symbols, such as numbers written on the diagram. Thus in a map the height of places above the level of the sea is often indicated by marking the number of feet above the sea at the corresponding places on the map. There is another method in which a line called a contour line is drawn through all the places in the map whose height above the sea is a certain number of feet, and the number of feet is written at some point or points of this line. By the use of a series of contour lines, the height of a great number of places can be indicated on a map by means of a small number of written symbols. Still this method is not a purely graphical method, but a partly symbolical method of expressing the third dimension of objects on a diagram in two dimensions.

In order to express completely by a purely graphical method the relations of magnitudes involving more than two variables, we must use more than one diagram. Thus in the arts of construction we use plans and elevations and sections through different planes, to specify the form of objects having three dimensions. In such systems of diagrams we have to indicate that a point in one diagram corresponds to a point in another diagram. This is generally done by marking the corresponding points in the different diagrams with the same letter. If the diagrams are drawn on the same piece of paper we may indicate corresponding points by drawing a line from one to the other, taking care that this line of correspondence is so drawn that it cannot be mistaken for a real line in either diagram. (See Geometry: *Descriptive*.)

In the stereoscope the two diagrams, by the combined use of which the form of bodies in three dimensions is recognized, are projections of the bodies taken from two points so near each other that, by viewing the two diagrams simultaneously, one with each eye, we identify the corresponding points intuitively. The method in which we simultaneously contemplate two figures, and recognize a correspondence between certain points in the one figure and certain points in the other, is one of the most powerful and fertile methods hitherto known in science. Thus in pure geometry the theories of similar, reciprocal and inverse figures have led to many extensions of the science. It is sometimes spoken of as the method or principle of Duality. Geometry *Projective*.)

Diagrams in Mechanics.

The study of the motion of a material system is much assisted by the use of a series of diagrams representing the configuration, displacement and acceleration of the parts of the system.

Diagram of Configuration.—In considering a material system it is often convenient to suppose that we have a record of its position at any given instant in the form of a diagram of configuration. The position of any particle of the system is defined by drawing a straight line or vector from the origin, or point of reference, to the given particle. The position of the particle with respect to the origin is determined by the magnitude and direction of this vector. If in the diagram we draw from the origin (which need not be the same point of space as the origin for the material system) a vector equal and parallel to the vector which determines the position of the particle, the end of this vector will indicate the position of the particle in the diagram of configuration. If this is done for all the particles we shall have a system of points in the diagram of configuration, each of which corresponds to a particle of the material system, and the relative positions of any pair of these points will be the same as the relative positions of the material particles which correspond to them.

We have hitherto spoken of two origins or points from which the vectors are supposed to be drawn—one for the material system, the other for the diagram. These points, however, and the vectors drawn from them, may now be omitted, so that we have on the one hand the material system and on the other a set of points, each point corresponding to a particle of the system, and the whole representing the configuration of the system at a given instant.

This is called a diagram of configuration.

Diagram of Displacement.—Let us next consider two diagrams of configuration of the same system, corresponding to two different instants. We call the first the initial configuration and the second the final configuration, and the passage from the one configuration to the other we call the displacement of the system. We do not at present consider the length of time during which the displacement was effected, nor the intermediate stages through which it passed, but only the final result—a change of configuration. To study this change we construct a diagram of displacement.

Let A, B, C be the points in the initial diagram of configuration, and A′, B′, C′ be the corresponding points in the final diagram of configuration. From o, the origin of the diagram of displacement, draw a vector oa equal and parallel to AA′, ob equal and parallel to BB′, oc to CC′, and so on. The points a, b, c, &c., will be such that the vector ab indicates the displacement of B relative to A, and so on. The diagram containing the points a, b, c, &c., is therefore called the diagram of displacement.

In constructing the diagram of displacement we have hitherto assumed that we know the absolute displacements of the points of the system. For we are required to draw a line equal and parallel to AA′, which we cannot do unless we know the absolute final position of A, with respect to its initial position. In this diagram of displacement there is therefore, besides the points a, b, c, &c., an *origin*, o, which represents a point absolutely fixed in space. This is necessary because the two configurations do not exist at the same time; and therefore to express their relative position we require to know a point which remains the same at the beginning and end of the time.

But we may construct the diagram in another way which does not assume a knowledge of absolute displacement or of a point fixed in space. Assuming any point and calling it a, draw ak parallel and equal to BA in the initial configuration, and from k draw kb parallel and equal to A′B′ in the final configuration. It is easy to see that the position of the point b relative to a will be the same by this construction as by the former construction, only we must observe that in this second construction we use only vectors such as AB, A′B′, which represent the relative position of points both of which exist simultaneously, instead of vectors such as AA′, BB′, which express the position of a point at one instant relative to its position at a former instant, and which therefore cannot be determined by observation, because the two ends of the vector do not exist simultaneously.

It appears therefore that the diagram of displacements, when drawn by the first construction, includes an origin o, which indicates that we have assumed a knowledge of absolute displacements. But no such point occurs in the second construction, because we use such vectors only as we can actually observe. Hence the diagram of displacements *without an origin* represents neither more nor less than all we can ever know about the displacement of the material system.

Diagram of Velocity.—If the relative velocities of the points of the system are constant, then the diagram of displacement corresponding to an interval of a unit of time between the initial and the final configuration is called a diagram of relative velocity. If the relative velocities are not constant, we suppose another system in which the velocities are equal to the velocities of the given system at the given instant and continue constant for a unit of time. The diagram of displacements for this imaginary system is the required diagram of relative velocities of the actual system at the given instant. It is easy to see that the diagram gives the velocity of any one point relative to any other, but cannot give the absolute velocity of any of them.

Diagram of Acceleration.—By the same process by which we formed the diagram of displacements from the two diagrams of initial and final configuration, we may form a diagram of changes of relative velocity from the two diagrams of initial and final velocities. This diagram may be called that of total accelerations in a finite interval of time. And by the same process by which we deduced the diagram of velocities from that of displacements we may deduce the diagram of rates of acceleration from that of total acceleration.

We have mentioned this system of diagrams in elementary kinematics because they are found to be of use especially when we have to deal with material systems containing a great number of parts, as in the kinetic theory of gases. The diagram of configuration then appears as a region of space swarming with points representing molecules, and the only way in which we can investigate it is by considering the number of such points in unit of volume in different parts of that region, and calling this the *density* of the gas.

In like manner the diagram of velocities appears as a region containing points equal in number but distributed in a different manner, and the number of points in any given portion of the region expresses the number of molecules whose velocities lie within given limits. We may speak of this as the velocity-density.

Diagrams of Stress.—Graphical methods are peculiarly applicable to statical questions, because the state of the system is constant, so that we do not need to construct a series of diagrams corresponding to the successive states of the system. The most useful of these applications, collectively termed Graphic Statics, relates to the equilibrium of plane framed structures familiarly represented in bridges and roof-trusses. Two diagrams are used, one called the diagram of the frame and the other called the diagram of stress. The structure itself consists of a number of separable pieces or links jointed together at their extremities. In practice these joints have friction, or may be made purposely stiff, so that the force acting at the extremity of a piece may not pass exactly through the axis of the joint; but as it is unsafe to make the stability of the structure depend in any degree upon the stiffness of joints, we assume in our calculations that all the joints are perfectly smooth, and therefore that the force acting on the end of any link passes through the axis of the joint.

The axes of the joints of the structure are represented by points in the diagram of the frame. The link which connects two joints in the actual structure may be of any shape, but in the diagram of the frame it is represented by a straight line joining the points representing the two joints. If no force acts on the link except the two forces acting through the centres of the joints, these two forces must be equal and opposite, and their direction must coincide with the straight line joining the centres of the joints. If the force acting on either extremity of the link is directed towards the other extremity, the stress on the link is called pressure and the link is called a "strut." If it is directed away from the other extremity, the stress on the link is called tension and the link is called a "tie." In this case, therefore, the only stress acting in a link is a pressure or a tension in the direction of the straight line which represents it in the diagram of the frame, and all that we have to do is to find the magnitude of this stress. In the actual structure gravity acts on every part of the link, but in the diagram we substitute for the actual weight of the different parts of the link two weights which have the same resultant acting at the extremities of the link.

We may now treat the diagram of the frame as composed of links without weight, but loaded at each joint with a weight made up of portions of the weights of all the links which meet in that joint. If any link has more than two joints we may substitute for it in the diagram an imaginary stiff frame, consisting of links, each of which has only two joints. The diagram of the frame is now reduced to a system of points, certain pairs of which are joined by straight lines, and each point is in general acted on by a weight or other force acting between it and some point external to the system. To complete the diagram we may represent these external forces as links, that is to say, straight lines joining the points of the frame to points external to the frame. Thus each weight may be represented by a link joining the point of application of the weight with the centre of the earth.

But we can always construct an imaginary frame having its joints in the lines of action of these external forces, and this frame, together with the real frame and the links representing external forces, which join points in the one frame to points in the other frame, make up together a complete self-strained system in equilibrium, consisting of points connected by links acting by pressure or tension. We may in this way reduce any real structure to the case of a system of points with attractive or repulsive forces acting between certain pairs of these points, and keeping them in equilibrium. The direction of each of these forces is sufficiently indicated by that of the line joining the points, so that we have only to determine its magnitude. We might do this by calculation, and then write down on each link the pressure or the tension which acts in it.

We should in this way obtain a mixed diagram in which the stresses are represented graphically as regards direction and position, but symbolically as regards magnitude. But we know that a force may be represented in a purely graphical manner by a straight line in the direction of the force containing as many units of length as there are units of force in the force. The end of this line is marked with an arrow head to show in which direction the force acts. According to this method each force is drawn in its proper position in the diagram of configuration of the frame. Such a diagram might be useful as a record of the result of calculation of the magnitude of the forces, but it would be of no use in enabling us to test the correctness of the calculation.

But we have a graphical method of testing the equilibrium of any set of forces acting at a point. We draw in series a set of lines parallel and proportional to these forces. If these lines form a closed polygon the forces are in equilibrium. (See MECHANICS.) We might in this way form a series of polygons of forces, one for each joint of the frame. But in so doing we give up the principle of drawing the line representing a force from the point of application of the force, for all the sides of the polygon cannot pass through the same point, as the forces do. We also represent every stress twice over, for it appears as a side of both the polygons corresponding to the two joints between which it acts. But if we can arrange the polygons in such a way that the sides of any two polygons which represent the same stress coincide with each other, we may form a diagram in which every stress is represented in direction and magnitude, though not in position, by a single line which is the common boundary of the two polygons which represent the joints at the extremities of the corresponding piece of the frame.

We have thus obtained a pure diagram of stress in which no attempt is made to represent the configuration of the material system, and in which every force is not only represented in direction and magnitude by a straight line, but the equilibrium of the forces at any joint is manifest by inspection, for we have only to examine whether the corresponding polygon is closed or not.

The relations between the diagram of the frame and the diagram of stress are as follows:—To every link in the frame corresponds a straight line in the diagram of stress which represents in magnitude and direction the stress acting in that link; and to every joint of the frame corresponds a closed polygon in the diagram, and the forces acting at that joint are represented by the sides of the polygon taken in a certain cyclical order, the cyclical order of the sides of the two adjacent polygons being such that their common side is traced in opposite directions in going round the two polygons.

The direction in which any side of a polygon is traced is the direction of the force acting on that joint of the frame which corresponds to the polygon, and due to that link of the frame which corresponds to the side. This determines whether the stress of the link is a pressure or a tension. If we know whether the stress of any one link is a pressure or a tension, this determines the cyclical order of the sides of the two polygons corresponding to the ends of the links, and therefore the cyclical order of all the polygons, and the nature of the stress in every link of the frame.

Reciprocal Diagrams.—When to every point of concourse of the lines in the diagram of stress corresponds a closed polygon in the skeleton of the frame, the two diagrams are said to be reciprocal.

The first extensions of the method of diagrams of forces to other cases than that of the funicular polygon were given by Rankine in his *Applied Mechanics* (1857). The method was independently applied to a large number of cases by W. P. Taylor, a practical draughtsman in the office of J. B. Cochrane, and by Professor Clerk Maxwell in his lectures in King's College, London. In the *Phil. Mag.* for 1864 the latter pointed out the reciprocal properties of the two diagrams, and in a paper on "Reciprocal Figures, Frames and Diagrams of Forces," *Trans. R.S. Edin.* vol. xxvi., 1870, he showed the relation of the method to Airy's function of stress and to other mathematical methods. Professor Fleeming Jenkin has given a number of applications of the method to practice (*Trans. R.S. Edin.* vol. xxv.).

L. Cremona (*Le Figure reciproche nella statica grafica*, 1872) deduced the construction of reciprocal figures from the theory of the two components of a wrench as developed by Möbius. Karl Culmann, in his *Graphische Statik* (1st ed. 1864-1866, 2nd ed. 1875), made great use of diagrams of forces, some of which, however, are not reciprocal. Maurice Levy in his *Statique graphique* (1874) has treated the whole subject in an elementary but copious manner, and R. H. Bow, in his *The Economics of Construction in Relation to Framed Structures* (1873), materially simplified the process of drawing a diagram of stress reciprocal to a given frame acted on by a system of equilibrating external forces.

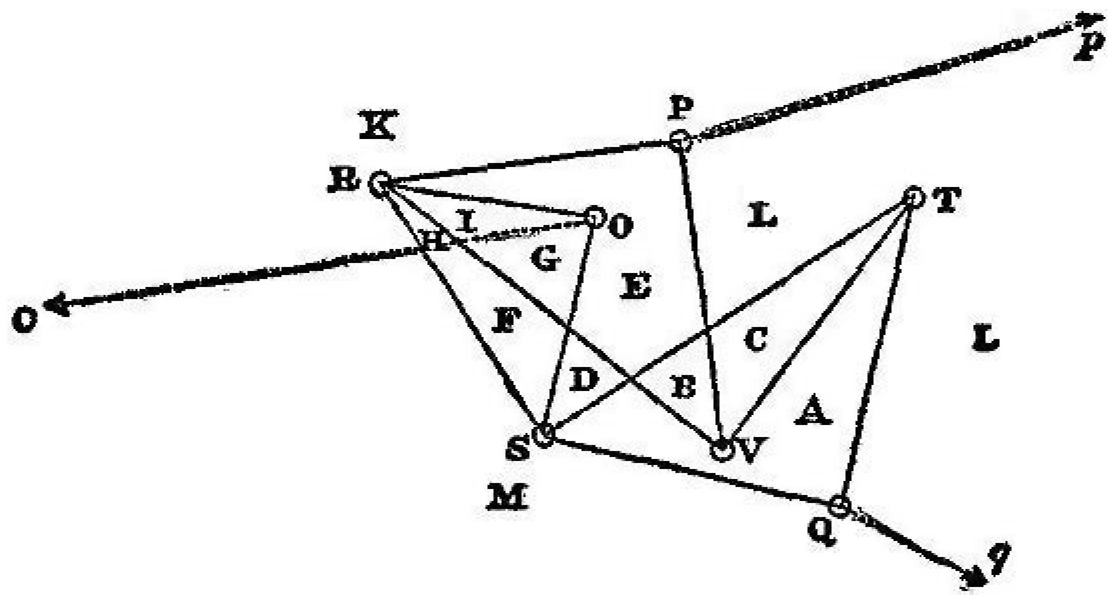

FIG. 1 Diagram of Configuration.

Instead of lettering the joints of the frame, as is usually done, or the links of the frame, as was the custom of Clerk Maxwell, Bow places a letter in each of the polygonal areas enclosed by the links of the frame, and also in each of the divisions of surrounding space as separated by the lines of action of the external forces. When one link of the frame crosses another, the point of apparent intersection of the links is treated as if it were a real joint, and the stresses of each of the intersecting links are represented twice in the diagram of stress, as the opposite sides of the parallelogram which corresponds to the point of intersection.

This method is followed in the lettering of the diagram of configuration (fig. 1), and the diagram of stress (fig. 2) of the linkwork which Professor Sylvester has called a quadruplane.

In fig. 1 the real joints are distinguished from the places where one link appears to cross another by the little circles O, P, Q, R, S, T, V. The four links RSTV form a "contraparallelogram" in which RS = TV and RV = ST. The triangles ROS, RPV, TQS are similar to each other. A fourth triangle (TNV), not drawn in the figure, would complete the quadruplane. The four points O, P, N, Q form a parallelogram whose angle POQ is constant and equal to π - SOR. The product of the distances OP and OQ is constant. The linkwork may be fixed at O. If any figure is traced by P, Q will trace the inverse figure, but turned round O through the constant angle POQ. In the diagram forces Pp, Qq are balanced by the force Co at the fixed point. The forces Pp and Qq are necessarily inversely as OP and OQ, and make equal angles with those lines.

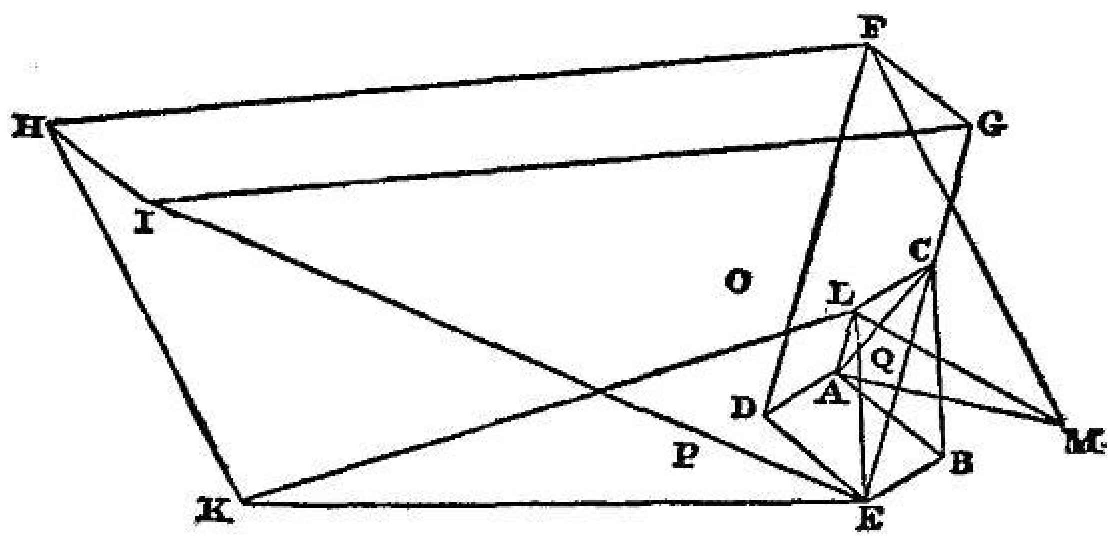

FIG. 2 Diagram of Stress.

Every closed area formed by the links or the external forces in the diagram of configuration is marked by a letter which corresponds to a point of concourse of lines in the diagram of stress. The stress in the link which is the common boundary of two areas is represented in the diagram of stress by the line joining the points corresponding to those areas. When a link is divided into two or more parts by lines crossing it, the stress in each part is represented by a different line for each part, but as the stress is the same throughout the link these lines are all equal and parallel. Thus in the figure the stress in RV is represented by the four equal and parallel lines HI, FG, DE and AB. If two areas have no part of their boundary in common the letters corresponding to them in the diagram of stress are not joined by a straight line. If, however, a straight line were drawn between them, it would represent in direction and magnitude the resultant of all the stresses in the links which are cut by any line, straight or curved, joining the two areas. For instance the areas F and C in fig. 1 have no common boundary, and the points F and C in fig. 2 are not joined by a straight line. But every path from the area F to the area C in fig. 1 passes through a series of other areas, and each passage from one area into a contiguous area corresponds to a line drawn in the diagram of stress. Hence the whole path from F to C in fig. 1 corresponds to a path formed of lines in fig. 2 and extending from F to C, and the resultant of all the stresses in the links cut by the path is represented by FC in fig. 2.

Many examples of stress diagrams are given in the article on bridges (q.v.).

Automatic Description of Diagrams.

There are many other kinds of diagrams in which the two co-ordinates of a point in a plane are employed to indicate the simultaneous values of two related quantities. If a sheet of paper is made to move, say horizontally, with a constant known velocity, while a tracing point is made to move in a vertical straight line, the height varying as the value of any given physical quantity, the point will trace out a curve on the paper from which the value of that quantity at any given time may be determined. This principle is applied to the automatic registration of phenomena of all kinds, from those of meteorology and terrestrial magnetism to the velocity of cannon-shot, the vibrations of sounding bodies, the motions of animals, voluntary and involuntary, and the currents in electric telegraphs.

In Watt's indicator for steam engines the paper does not move with a constant velocity, but its displacement is proportional to that of the piston of the engine, while that of the tracing point is proportional to the pressure of the steam. Hence the co-ordinates of a point of the curve traced on the diagram represent the volume and the pressure of the steam in the cylinder. The indicator-diagram not only supplies a record of the pressure of the steam at each stage of the stroke of the engine, but indicates the work done by the steam in each stroke by the area enclosed by the curve traced on the diagram. (J. C. M.)

DIAL and **DIALLING.** Dialling, sometimes called gnomonics, is a branch of applied mathematics which treats of the construction of sun-dials, that is, of those instruments, either fixed or portable, which determine the divisions of the day (Lat. *dies*) by the motion of the shadow of some object on which the sun's rays fall. It must have been one of the earliest applications of a knowledge of the apparent motion of the sun; though for a long time men would probably be satisfied with the division into morning and afternoon as marked by sun-rise, sun-set and the greatest elevation.

History.—The earliest mention of a sun-dial is found in Isaiah xxxviii. 8: "Behold, I will bring again the shadow of the degrees which is gone down in the *sun-dial* of Ahaz ten degrees backward." The date of this would be about 700 years before the Christian era, but we know nothing of the character or construction of the instrument. The earliest of all sun-dials of which we have any certain knowledge was the hemicycle, or hemisphere, of the Chaldaean astronomer Berossus, who probably lived about 300 B.C. It consisted of a hollow hemisphere placed with its rim perfectly horizontal, and having a bead, or globule, fixed in any way at the centre. So long as the sun remained above the horizon the shadow of the bead would fall on the inside of the hemisphere, and the path of the shadow during the day would be approximately a circular arc. This arc, divided into twelve equal parts, determined twelve equal intervals of time for that day. Now, supposing this were done at the time of the solstices and equinoxes, and on as many intermediate days as might be considered sufficient, and then curve lines drawn through the corresponding points of division of the different arcs, the shadow of the bead falling on one of these curve lines would mark a division of time for that day, and thus we should have a sun-dial which would divide each period of daylight into twelve equal parts. These equal parts were called *temporary hours*; and, since the duration of daylight varies from day to day, the temporary hours of one day would differ from those of another; but this inequality would probably be disregarded at that time, and especially in countries where the variation between the longest summer day and the shortest winter day is much less than in our climates.

The dial of Berossus remained in use for centuries. The Arabians, as appears from the work of Albategnius, still followed the same construction about the year A.D. 900. Four of these dials have in modern times been found in Italy. One, discovered at Tivoli in 1746, is supposed to have belonged to Cicero, who, in one of his letters, says that he had sent a dial of this kind to his villa near Tusculum. The second and third were found in 1751—one at Castel-Nuovo and the other at Rignano; and a fourth was found in 1762 at Pompeii. G. H. Martini in his *Abhandlungen von den Sonnenuhren der Alten* (Leipzig, 1777), says that this dial was made for the latitude of Memphis; it may therefore be the work of Egyptians, perhaps constructed in the school of Alexandria.

Herodotus recorded that the Greeks derived from the Babylonians the use of the gnomon, but the great progress made by the Greeks in geometry enabled them in later times to construct dials of great complexity, some of which remain to us, and are proof not only of extensive knowledge but also of great ingenuity.

Ptolemy's *Almagest* treats of the construction of dials by means of his *analemma*, an instrument which solved a variety of astronomical problems.

The constructions given by him were sufficient for regular dials, that is, horizontal dials, or vertical dials facing east, west, north or south, and these are the only ones he treats of. It is certain, however, that the ancients were able to construct declining dials, as is shown by that most interesting monument of ancient gnomics—the Tower of the Winds at Athens. This is a regular octagon, on the faces of which the eight principal winds are represented, and over them eight different dials—four facing the cardinal points and the other four facing the intermediate directions. The date of the dials is long subsequent to that of the tower; for Vitruvius, who describes the tower in the sixth chapter of his first book, says nothing about the dials, and as he has described all the dials known in his time, we must believe that the dials of the tower did not then exist. The hours are still the temporary hours or, as the Greeks called them, *hectemoria*.

The first sun-dial erected at Rome was in the year 290 B.C., and this Papirius Cursor had taken from the Samnites. A dial which Valerius Messalla had brought from Catania, the latitude of which is five degrees less than that of Rome, was placed in the forum in the year 261 B.C. The first dial actually constructed at Rome was in the year 164 B.C., by order of Q. Marcius Philippus, but as no other Roman has written on gnomonics, this was perhaps the work of a foreign artist. If, too, we remember that the dial found at Pompeii was made for the latitude of Memphis, and consequently less adapted to its position than that of Catania to Rome, we may infer that mathematical knowledge was not cultivated in Italy.

The Arabians were much more successful. They attached great importance to gnomonics, the principles of which they had learned from the Greeks, but they greatly simplified and diversified the Greek constructions. One of their writers, Abu'l Hassan, who lived about the beginning of the 13th century, taught them how to trace dials on cylindrical, conical and other surfaces. He even introduced *equal* or *equinoctial hours*, but the idea was not supported, and the temporary hours alone continued in use.

Where or when the great and important step already conceived by Abu'l Hassan, and perhaps by others, of reckoning by *equal* hours was generally adopted cannot now be determined. The history of gnomonics from the 13th to the beginning of the 16th century is almost a blank, and during that time the change took place. We can see, however, that the change would necessarily follow the introduction of clocks and other mechanical methods of measuring time; for, however imperfect these were, the hours they marked would be of the same length in summer and in winter, and the discrepancy between these equal hours and the temporary hours of the sun-dial would soon be too important to be overlooked. Now, we know that a balance clock was put up in the palace of Charles V. of France about the year 1370, and we may reasonably suppose that the new sun-dials came into general use during the 14th and 15th centuries.

Among the earliest of the modern writers on gnomonics was Sebastian Münster (q.v.), who published his *Horologiographia* at Basel in 1531. He gives a number of correct rules, but without demonstrations. Among his inventions was a moon-dial,[1] but this does not admit of much accuracy.

During the 17th century dialling was discussed at great length by many writers on astronomy. Clavius devotes a quarto volume of 800 pages entirely to the subject. This was published in 1612, and may be considered to contain all that was known at that time.

In the 18th century clocks and watches began to supersede sun-dials, and these have gradually fallen into disuse except as an additional ornament to a garden, or in remote country districts where the old dial on the church tower still serves as an occasional check on the modern clock by its side. The art of constructing dials may now be looked upon as little more than a mathematical recreation.

General Principles.—The diurnal and the annual motions of the earth are the elementary astronomical facts on which dialling is founded. That the earth turns upon its axis uniformly from west to east in twenty-four hours, and that it is carried round the sun in one year at a nearly uniform rate, is the correct way of expressing these facts. But the effect will be precisely the same, and it will suit our purpose better, and make our explanations easier, if we adopt the ideas of the ancients, of which our senses furnish apparent confirmation, and assume the earth to be fixed. Then, the sun and stars revolve round the earth's axis uniformly from east to west once a day—the sun lagging a little behind the stars, making its day some four minutes longer—so that at the end of the year it finds itself again in the same place, having made a complete revolution of the heavens relatively to the stars from west to east.

The fixed axis about which all these bodies revolve daily is a line through the earth's centre; but the radius of the earth is so small, compared with the enormous distance of the sun, that, if we draw a parallel axis through any point of the earth's surface, we may safely look on that as being the axis of the celestial motions. The error in the case of the sun would not, at its maximum, that is, at 6 A.M. and 6 P.M., exceed half a second of time, and at noon would vanish. An axis so drawn is in the plane of the meridian, and points to the pole, its elevation being equal to the latitude of the place.

The diurnal motion of the stars is strictly uniform, and so would that of the sun be if the daily retardation of about four minutes, spoken of above, were always the same. But this is constantly altering, so that the time, as measured by the sun's motion, and also consequently as measured by a sun-dial, does not move on at a strictly uniform pace. This irregularity, which is slight, would be of little consequence in the ordinary affairs of life, but clocks and watches being mechanical measures of time could not, except by extreme complication, be made to follow this irregularity, even if desirable.

The clock is constructed to mark uniform time in such wise that the length of the clock day shall be the average of all the solar days in the year.

Four times a year the clock and the sun-dial agree exactly; but the sun-dial, now going a little slower, now a little faster, will be sometimes behind, sometimes before the clock-the greatest accumulated difference being about sixteen minutes for a few days in November, but on the average much less. The four days on which the two agree are April 15, June 15, September 1 and December 24.

Clock-time is called *mean time*, that marked by the sun-dial is called *apparent time*, and the difference between them is the *equation of time*. It is given in most calendars and almanacs, frequently under the heading "clock slow," "clock fast." When the time by the sun-dial is known, the equation of time will at once enable us to obtain the corresponding clock-time, or vice versa.

Atmospheric refraction introduces another error by altering the apparent position of the sun; but the effect is too small to need consideration in the construction of an instrument which, with the best workmanship, does not after all admit of very great accuracy.

The general principles of dialling will now be readily understood. The problem before us is the following:—A rod, or *style*, as it is called, being firmly fixed in a direction parallel to the earth's axis, we have to find how and where points or lines of reference must be traced on some fixed surface behind the style, so that when the shadow of the style falls on a certain one of these lines, we may know that at that moment it is solar noon,—that is, that the plane through the style and through the sun then coincides with the meridian; again, that when the shadow reaches the next line of reference, it is 1 o'clock by solar time, or, which comes to the same thing, that the above plane through the style and through the sun has just turned through the twenty-fourth part of a complete revolution; and so on for the subsequent hours,—the hours before noon being indicated in a similar manner. The style and the surface on which these lines are traced together constitute the dial.

The position of an intended sun-dial having been selected—whether on church tower, south front of farmstead or garden wall—the surface must be prepared, if necessary, to receive the hour-lines.

The chief, and in fact the only practical difficulty will be the accurate fixing of the style, for on its accuracy the value of the instrument depends. It must be in the meridian plane, and must make an angle with the horizon equal to the latitude of the place. The latter condition will offer no difficulty, but the exact determination of the meridian plane which passes through the point where the style is fixed to the surface is not so simple. At present we shall assume that the style has been fixed in its true position. The style itself will be usually a stout metal wire, and when we speak of the shadow cast by the style it must always be understood that the middle line of the thin band of shade is meant.

The point where the style meets the dial is called the centre of the dial. It is the centre from which all the hour-lines radiate.

The position of the XII o'clock line is the most important to determine accurately, since all the others are usually made to depend on this one. We cannot trace it correctly on the dial until the style has been itself accurately fixed in its proper place. When that is done the XII o'clock line will be found by the intersection of the dial surface with the vertical plane which contains the style; and the most simple way of drawing it on the dial will be by suspending a plummet from some point of the style whence it may hang freely, and waiting until the shadows of both style and plumb-line coincide on the dial. This single shadow will be the XII o'clock line.

In one class of dials, namely, all the vertical ones, the XII o'clock line is simply the vertical line from the centre; it can, therefore, at once be traced on the dial face by using a fine plumb-line.

The XII o'clock line being traced, the easiest and most accurate method of tracing the other hour-lines would, at the present day when good watches are common, be by marking where the shadow of the style falls when 1, 2, 3, &c., hours have elapsed since noon, and the next morning by the same means the forenoon hour-lines could be traced; and in the same manner the hours might be subdivided into halves and quarters, or even into minutes.

But formerly, when watches did not exist, the tracing of the I, II, III, &c., o'clock lines was done by calculating the angle which each of these lines would make with the XII o'clock line. Now, except in the simple cases of a horizontal dial or of a vertical dial facing a cardinal point, this would require long and intricate calculations, or elaborate geometrical constructions, implying considerable mathematical knowledge, but also introducing increased chances of error. The chief source of error would lie in the uncertainty of the data; for the position of the dial-plane would have to be found before the calculations began,—that is, it would be necessary to know exactly by how many degrees it declined from the south towards the east or west, and by how many degrees it inclined from the vertical. The ancients, with the means at their disposal, could obtain these results only very roughly.

Dials received different names according to their position:—

Horizontal dials, when traced on a horizontal plane;

Vertical dials, when on a vertical plane facing one of the cardinal points;

Vertical declining dials, on a vertical plane not facing a cardinal point;

Inclining dials, when traced on planes neither vertical nor horizontal (these were further distinguished as *reclining* when leaning backwards from an observer, *proclining* when leaning forwards);

Equinoctial dials, when the plane is at right angles to the earth's axis, &c. &c.

Dial Construction.—A very correct view of the problem of dial construction may be obtained as follows:—

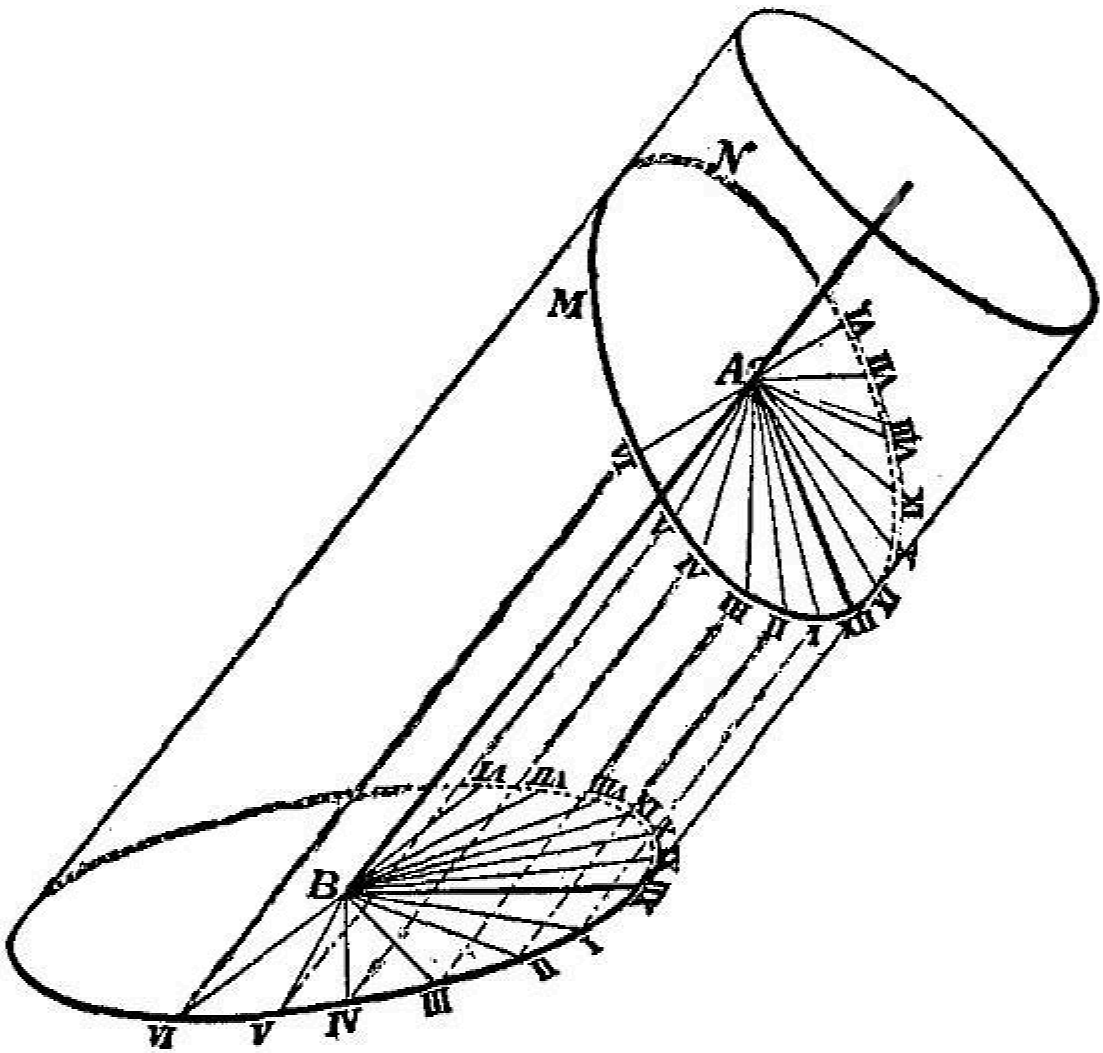

FIG. 1

Conceive a transparent cylinder (fig. 1) having an axis AB parallel to the axis of the earth. On the surface of the cylinder let equidistant generating-lines be traced 15° apart, one of them XII ... XII being in the meridian plane through AB, and the others I ... I, II ... II, &c., following in the order of the sun's motion.

Then the shadow of the line AB will obviously fall on the line XII ... XII at apparent noon, on the line I ... I at one hour after noon, on II ... II at two hours after noon, and so on. If now the cylinder be cut by any plane MN representing the plane on which the dial is to be traced, the shadow of AB will be intercepted by this plane and fall on the lines AXII AI, AII, &c.

The construction of the dial consists in determining the angles made by AI, AII, &c. with AXII; the line AXII itself, being in the vertical plane through AB, may be supposed known.

For the purposes of actual calculation, perhaps a transparent sphere will, with advantage, replace the cylinder, and we shall here apply it to calculate the angles made by the hour-line with the XII o'clock line in the two cases of a horizontal dial and of a vertical south dial.

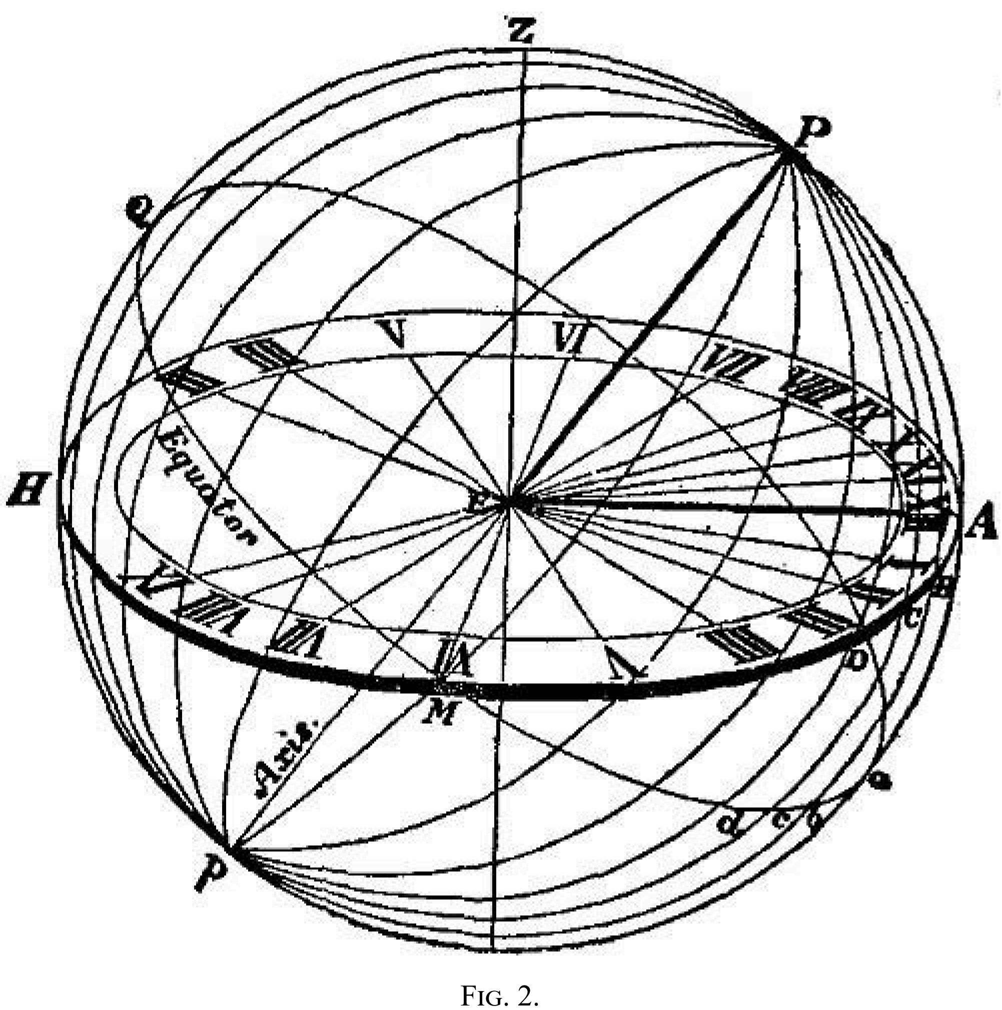

FIG. 2.

Horizontal Dial.—Let PEp (fig. 2), the axis of the supposed transparent sphere, be directed towards the north and south poles of the heavens. Draw the two great circles, HMA, QMa, the former

horizontal, the other perpendicular to the axis Pp, and therefore coinciding with the plane of the equator. Let EZ be vertical, then the circle QZP will be the meridian, and by its intersection A with the horizontal circle will determine the XII o'clock line EA. Next divide the equatorial circle QMa into 24 equal parts ab, bc, cd, &c. ... of 15° each, beginning from the meridian Pa, and through the various points of division and the poles draw the great circles Pbp, Pcp, &c. ... These will exactly correspond to the equidistant generating lines on the cylinder in the previous construction, and the shadow of the style will fall on these circles after successive intervals of 1,2, 3, &c., hours from noon. If they meet the horizontal circle in the points B, C, D, &c., then EB, EC, ED, &c. ... will be the I, II, III, &c., hour-lines required; and the problem of the horizontal dial consists in calculating the angles which these lines make with the XII o'clock line EA, whose position is known. The spherical triangles PAB, PAC, &c., enable us to do this readily. They are all right-angled at A, the side PA is the latitude of the place, and the angles APB, APC, &c., are respectively 15°, 30°, &c., then

$$\tan AB = \tan 15^\circ \sin \textit{latitude},$$
$$\tan AC = \tan 30^\circ \sin \textit{latitude},$$
$$\&c. \ \&c.$$

These determine the sides AB, AC, &c., that is, the angles AEB, AEC, &c., required.

The I o'clock hour-line EB must make an angle with the meridian EA of 11° 51' on a London dial, of 12° 31' at Edinburgh, of 11° 23' at Paris, 12° 0' at Berlin, 9° 55' at New York and 9° 19' at San Francisco. In the same way may be found the angles made by the other hour-lines.

The calculations of these angles must extend throughout one quadrant from noon to VI o'clock, but need not be carried further, because all the other hour-lines can at once be deduced from these. In the first place the dial is symmetrically divided by the meridian, and therefore two times equidistant from noon will have their hour-lines equidistant from the meridian; thus the XI o'clock line and the I o'clock line must make the same angles with it, the X o'clock the same as the II o'clock, and so on. And next, the 24 great circles, which were drawn to determine these lines, are in reality only 12; for clearly the great circle which gives I o'clock after midnight, and that which gives I o'clock after noon, are one and the same, and so also for the other hours. Therefore the hour-lines between VI in the evening and VI the next morning are the prolongations of the remaining twelve.

Let us now remove the imaginary sphere with all its circles, and retain only the style EP and the plane HMA with the lines traced on it, and we shall have the horizontal dial.

On the longest day in London the sun rises a little before 4 o'clock, and sets a little after 8 o'clock; there is therefore no necessity for extending a London dial beyond those hours. At Edinburgh the limits will be a little longer, while at Hammerfest, which is within the Arctic circle, the whole circuit will be required.

Instead of a wire style it is often more convenient to use a metal plate from one quarter to half an inch in thickness. This plate, which is sometimes in the form of a right-angled triangle, must have an acute angle equal to the latitude of the place, and, when properly fixed in a vertical position on the dial, its two faces must coincide with the meridian plane, and the sloping edges formed by the thickness of the plate must point to the pole and form two parallel styles. Since there are two styles, there must be two dials, or rather two half dials, because a little consideration will show that, owing to the thickness of the plate, these styles will only one at a time cast a shadow. Thus the eastern edge will give the shadow for all hours before 6 o'clock in the morning. From 6 o'clock until noon the western edge will be used. At noon it will change again to the eastern edge until 6 o'clock in the evening, and finally the western edge for the remaining hours of daylight.

The centres of the two dials will be at the points where the styles meet the dial face; but, in drawing the hour-lines, we must be careful to draw only those lines for which the corresponding style is able to give a shadow as explained above. The dial will thus have the appearance of a single dial plate, and there will be no confusion (see fig. 3).

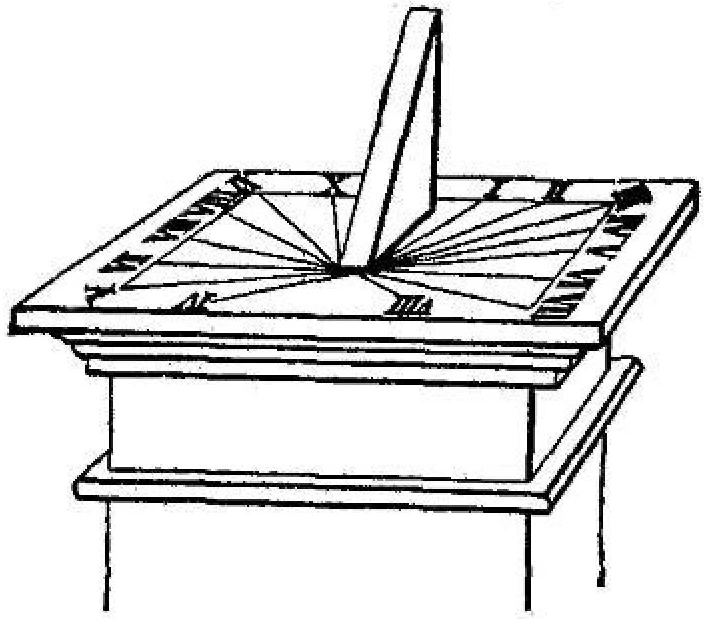

FIG. 3.

The line of demarcation between the shadow and the light will be better defined than when a wire style is used; but the indications by this double dial will always be one minute too fast in the morning and one minute too slow in the afternoon. This is owing to the magnitude of the sun, whose angular breadth is half a degree. The well-defined shadows are given, not by the centre of the sun, as we should require them, but by the forward limb in the morning and by the backward one in the afternoon; and the sun takes just about a minute to advance through a space equal to its half-breadth.

Dials of this description are frequently met with. The dial plate is of metal as well as the vertical piece upon it, and they may be purchased ready for placing on the pedestal,—the dial with all the hour-lines traced on it and the style plate firmly fastened in its proper position, if not even cast in the same piece with the dial plate.

When placing it on the pedestal care must be taken that the dial be perfectly horizontal and accurately oriented. The levelling will be done with a spirit-level, and the orientation will be best effected either in the forenoon or in the afternoon, by turning the dial plate till the time given by the shadow (making the *one* minute correction mentioned above) agrees with a good watch whose error on solar time is known. It is, however, important to bear in mind that a dial, so built up beforehand, will have the angle at the base equal to the latitude of some selected place, such as London, and the hour-lines will be drawn in directions calculated for the same latitude. Such a dial can therefore not be used near Edinburgh or Glasgow, although it would, without appreciable error, be adapted to any place whose latitude did not differ more than 20 or 30 m. from that of London, and it would be safe to employ it in Essex, Kent or Wiltshire.

If a series of such dials were constructed, differing by 30 m. in latitude, then an intending purchaser could select one adapted to a place whose latitude was within 15 m. of his own, and the error of time would never exceed a small fraction of a minute. The following table will enable us to check the accuracy of the hour-lines and of the angle of the style,—all angles on the dial being readily measured with an ordinary protractor. It extends from 50° lat. to 59½° lat., and therefore includes the whole of Great Britain and Ireland:—

LAT.	XI. A.M. I. P.M.	X. A.M. II. P.M.	IX. A.M. III. P.M.	VIII. A.M. IIII. P.M.	VII. A.M. V. P.M.	VI. A.M. VI. P.M.
50° 0′	11° 36′	23° 51′	37° 27′	53° 0′	70° 43′	90° 0′
50 30	11 41	24 1	37 39	53 12	70 51	90 0
51 0	11 46	24 10	37 51	53 23	70 59	90 0
51 30	11 51	24 19	38 3	53 35	71 6	90 0
52 0	11 55	24 28	38 14	53 46	71 13	90 0
52 30	12 0	24 37	38 25	53 57	71 20	90 0
53 0	12 5	24 45	38 37	54 8	71 27	90 0
53 30	12 9	24 54	38 48	54 19	71 34	90 0
54 0	12 14	25 2	38 58	54 29	71 40	90 0
54 30	12 18	25 10	39 9	54 39	71 47	90 0
55 0	12 23	25 19	39 19	54 49	71 53	90 0
55 30	12 27	25 27	39 30	54 59	71 59	90 0
56 0	12 31	25 35	39 40	55 9	72 5	90 0
56 30	12 36	25 43	39 50	55 18	72 11	90 0

57	0	12	40	25	50	39	59	55	27	72	17	90	0
57	30	12	44	25	58	40	9	55	36	72	22	90	0
58	0	12	48	26	5	40	18	55	45	72	28	90	0
58	30	12	52	26	13	40	27	55	54	72	33	90	0
59	0	12	56	26	20	40	36	56	2	72	39	90	0
59	30	13	0	26	27	40	45	56	11	72	44	90	0

Vertical South Dial.—Let us take again our imaginary transparent sphere QZPA (fig. 4), whose axis PEp is parallel to the earth's axis. Let Z be the zenith, and, consequently, the great circle QZP the meridian. Through E, the centre of the sphere, draw a vertical plane facing south. This will cut the sphere in the great circle ZMA, which, being vertical, will pass through the zenith, and, facing south, will be at right angles to the meridian. Let QMa be the equatorial circle, obtained by drawing a plane through E at right angles to the axis PEp. The lower portion Ep of the axis will be the style, the vertical line EA in the meridian plane will be the XII o'clock line, and the line EM, which is obviously horizontal, since M is the intersection of two great circles ZM, QM, each at right angles to the vertical plane QZP, will be the VI o'clock line. Now, as in the previous problem, divide the equatorial circle into 24 equal arcs of 15° each, beginning at a, viz. ab, bc, &c.,—each quadrant aM, MQ, &c., containing 6,—then through each point of division and through the axis Pp draw a plane cutting the sphere in 24 equidistant great circles. As the sun revolves round the axis the shadow of the axis will successively fall on these circles at intervals of one hour, and if these circles cross the vertical circle ZMA in the points A, B, C, &c., the shadow of the lower portion Ep of the axis will fall on the lines EA, EB, EC, &c., which will therefore be the required hour-lines on the vertical dial, Ep being the style.

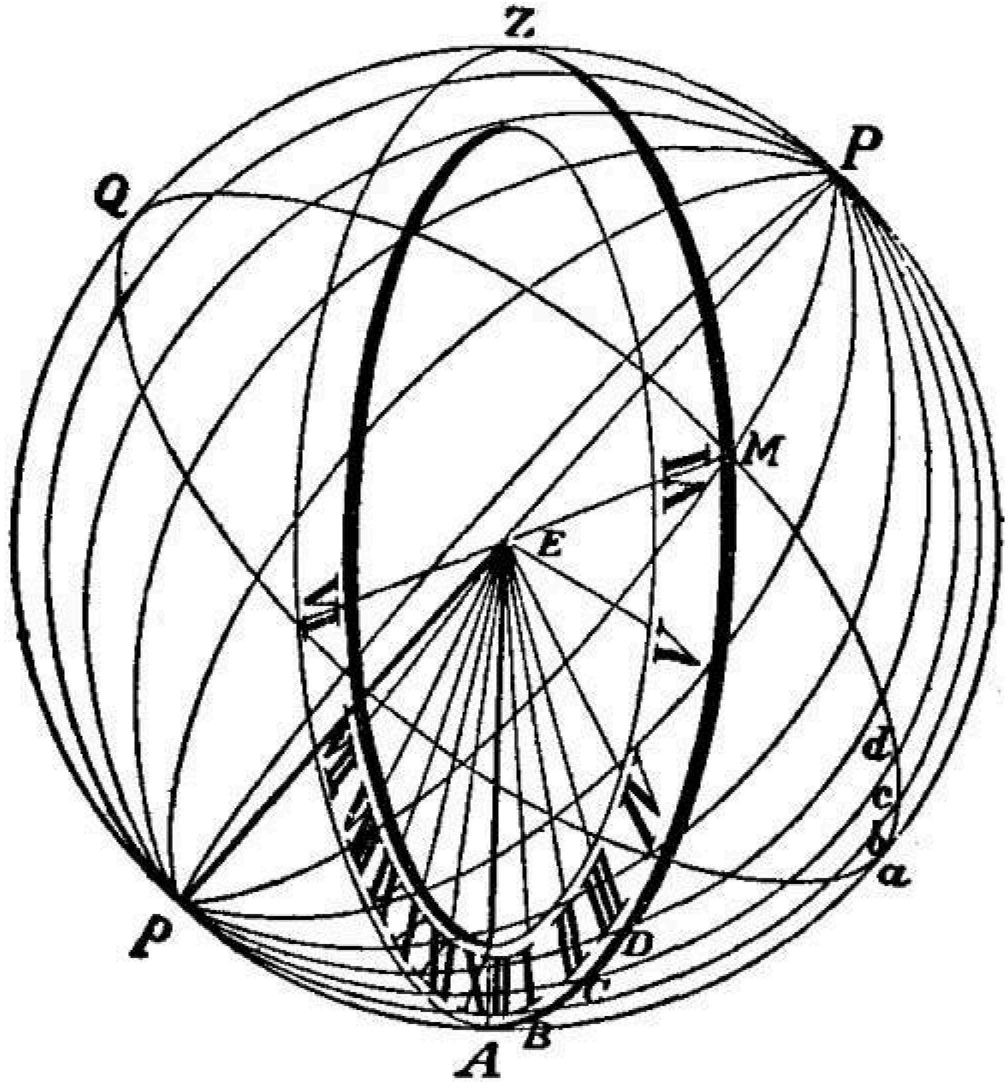

FIG. 4.

There is no necessity for going beyond the VI o'clock hour-line on each side of noon; for, in the winter months the sun sets earlier than 6 o'clock, and in the summer months it passes behind the plane of the dial before that time, and is no longer available.

It remains to show how the angles AEB, AEC, &c., may be calculated.

The spherical triangles pAB, pAC, &c., will give us a simple rule. These triangles are all right-angled at A, the side pA, equal to ZP, is the co-latitude of the place, that is, the difference between the latitude and 90°; and the successive angles ApB, ApC, &c., are 15°, 30°, &c., respectively. Then

$$\tan AB = \tan 15° \sin \textit{co-latitude};$$

or more simply,

$$\tan AB = \tan 15° \cos \textit{latitude},$$
$$\tan AC = \tan 30° \cos \textit{latitude},$$
$$\&c. \&c.$$

and the arcs AB, AC so found are the measure of the angles AEB, AEC, &c., required.

In this ease the angles diminish as the latitudes increase, the opposite result to that of the horizontal dial.

Inclining, Reclining, &c., Dials.—We shall not enter into the calculation of these cases. Our imaginary sphere being, as before supposed, constructed with its centre at the centre of the dial, and all the hour-circles traced upon it, the intersection of these hour-circles with the plane of the dial will determine the hour-lines just as in the previous cases; but the triangles will no longer be right-angled, and the simplicity of the calculation will be lost, the chances of error being greatly increased by the difficulty of drawing the dial plane in its true position on the sphere, since that true position will have to be found from observations which can be only roughly performed.

In all these cases, and in cases where the dial surface is not a plane, and the hour-lines, consequently, are not straight lines, the only safe practical way is to mark rapidly on the dial a few points (one is sufficient when the dial face is plane) of the shadow at the moment when a good watch shows that the hour has arrived, and afterwards connect these points with the centre by a continuous line. Of course the style must have been accurately fixed in its true position before we begin.

Equatorial Dial.—The name equatorial dial is given to one whose plane is at right angles to the style, and therefore parallel to the equator. It is the simplest of all dials. A circle (fig. 5) divided into 24 equal ares is placed at right angles to the style, and hour divisions are marked upon it. Then if care be taken that the style point accurately to the pole, and that the noon division coincide with the meridian plane, the shadow of the style will fall on the other divisions, each at its proper time. The divisions must be marked on both sides of the dial, because the sun will shine on opposite sides in the summer and in the winter months, changing at each equinox.

To find the Meridian Plane.—We have, so far, assumed the meridian plane to be accurately known; we shall proceed to describe some of the methods by which it may be found.

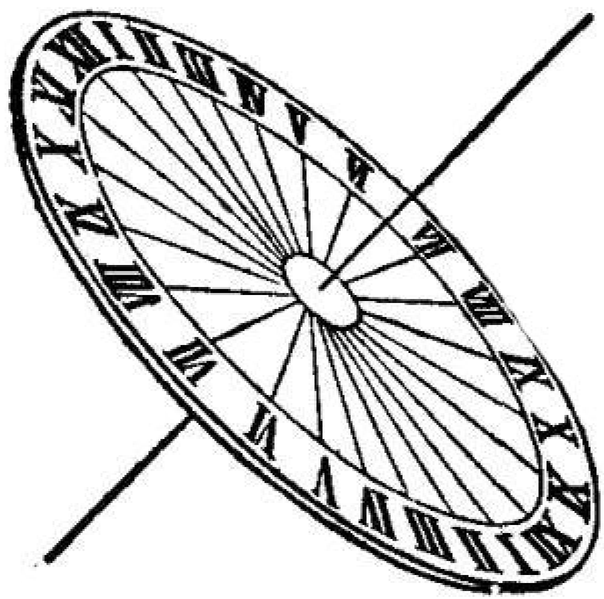

FIG. 5.

The mariner's compass may be employed as a first rough approximation. It is well known that the needle of the compass, when free to move horizontally, oscillates upon its pivot and settles in a direction termed the magnetic meridian. This does not coincide with the true north and south line, but the difference between them is generally known with tolerable accuracy, and is called the variation of the compass. The variation differs widely at different parts of the surface of the earth, and is not stationary at any particular place, though the change is slow; and there is even a small daily oscillation which takes place about the mean position, but too small to need notice here (see MAGNETISM, TERRESTRIAL).

With all these elements of uncertainty, it is obvious that the compass can only give a rough approximation to the position of the meridian, but it will serve to fix the style so that only a small further alteration will be necessary when a more perfect determination has been made.

A very simple practical method is the following:—

Place a table (fig. 6), or other plane surface, in such a position that it may receive the sun's rays both in the morning and in the afternoon. Then carefully level the surface by means of a spirit-level. This must be done very accurately, and the table in that position made perfectly secure, so that there be no danger of its shifting during the day.

Next, suspend a plummet SH from a point S, which must be rigidly fixed. The extremity H, where the plummet just meets the surface, should be somewhere near the middle of one end of the table. With H for centre, describe any number of concentric arcs of circles, AB, CD, EF, &c.

A bead P, kept in its place by friction, is threaded on the plummet line at some convenient height above H.

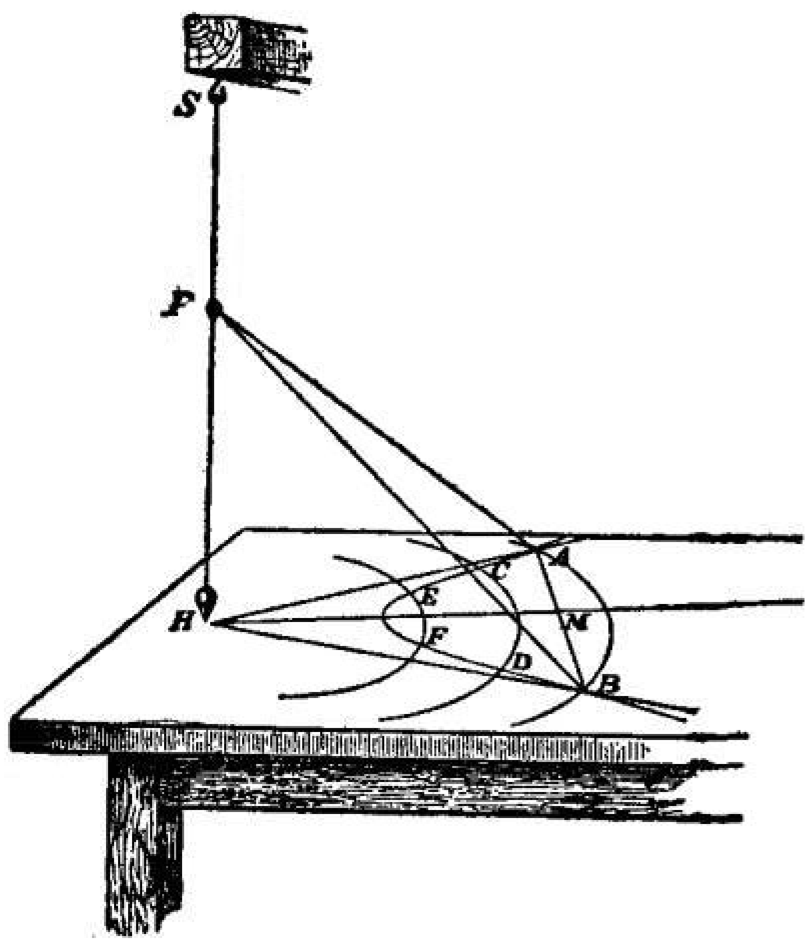

FIG. 6.

Everything being thus prepared, let us follow the shadow of the bead P as it moves along the surface of the table during the day. It will be found to describe a curve ACE ... FDB, approaching the point H as the sun advances towards noon, and receding from it afterwards. (The curve is a conic section—an hyperbola in these regions.) At the moment when it crosses the arc AB, mark the point A;

AP is then the direction of the sun, and, as AH is horizontal, the angle PAH is the altitude of the sun. In the afternoon mark the point B where it crosses the same arc; then the angle PBH is the altitude. But the right-angled triangles PHA, PHB are obviously equal; and the sun has therefore the same altitudes at those two instants, the one before, the other after noon. It follows that, *if the sun has not changed its declination* during the interval, the two positions will be symmetrically placed one on each side of the meridian. Therefore, drawing the chord AB, and bisecting it in M, HM will be the meridian line.

Each of the other concentric arcs, CD, EF, &c., will furnish its meridian line. Of course these should all coincide, but if not, the mean of the positions thus found must be taken.

The proviso mentioned above, that the sun has not changed its declination, is scarcely ever realized; but the change is slight, and may be neglected, except perhaps about the time of the equinoxes, at the end of March and at the end of September. Throughout the remainder of the year the change of declination is so slow that we may safely neglect it. The most favourable times are at the end of June and at the end of December, when the sun's declination is almost stationary. If the line HM be produced both ways to the edges of the table, then the two points on the ground vertically below those on the edges may be found by a plummet, and, if permanent marks be made there, the meridian plane, which is the vertical plane passing through these two points, will have its position perfectly secured.

To place the Style of a Dial in its True Position.—Before giving any other method of finding the meridian plane, we shall complete the construction of the dial, by showing how the style may now be accurately placed in its true position. The angle which the style makes with a hanging plumb-line, being the co-latitude of the place, is known, and the north and south direction is also roughly given by the mariner's compass. The style may therefore be already adjusted approximately—correctly, indeed, as to its inclination—but probably requiring a little horizontal motion east or west. Suspend a fine plumb-line from some point of the style, then the style will be properly adjusted if, at the very instant of noon, its shadow falls exactly on the plumb-line,—or, which is the same thing, if both shadows coincide on the dial.

This instant of noon will be given very simply, by the meridian plane, whose position we have secured by the two permanent marks on the ground. Stretch a cord from the one mark to the other. This will not generally be horizontal, but the cord will be wholly in the meridian plane, and that is the only necessary condition. Next, suspend a plummet over the mark which is nearer to the sun, and, when the shadow of the plumb-line falls on the stretched cord, it is noon. A signal from the observer there to the observer at the dial enables the latter to adjust the style as directed above.

Other Methods of finding the Meridian Plane.—We have dwelt at some length on these practical operations because they are simple and tolerably accurate, and because they want neither watch, nor sextant, nor telescope—nothing more, in fact, than the careful observation of shadow lines.

The Pole star, or *Ursae Minoris*, may also be employed for finding the meridian plane without other apparatus than plumb-lines. This star is now only about 1° 14' from the pole; if therefore a plumb-line be suspended at a few feet from the observer, and if he shift his position till the star is exactly hidden by the line, then the plane through his eye and the plumb-line will never be far from the meridian plane. Twice in the course of the twenty-four hours the planes would be strictly coincident. This would be when the star crosses the meridian above the pole, and again when it crosses it below. If we wished to employ the method of determining the meridian, the times of the stars crossing would have to be calculated from the data in the *Nautical Almanac*, and a watch would be necessary to know when the instant arrived. The watch need not, however, be very accurate, because the motion of the star is so slow that an error of ten minutes in the time would not give an error of one-eighth of a degree in the azimuth.

The following accidental circumstance enables us to dispense with both calculation and watch. The right ascension of the star η *Ursae Majoris*, that star in the tail of the Great Bear which is farthest from the "pointers," happens to differ by a little more than 12 hours from the right ascension of the Pole star. The great circle which joins the two stars passes therefore close to the pole. When the Pole star, at a distance of about 1° 14' from the pole, is crossing the meridian above the pole, the star η *Ursae Majoris*, whose polar distance is about 40°, has not yet reached the meridian below the pole.

When η *Ursae Majoris* reaches the meridian, which will be within half an hour later, the Pole star will have left the meridian; but its slow motion will have carried it only a very little distance away. Now at some instant between these two times—much nearer the latter than the former—the great circle joining the two stars will be exactly vertical; and at this instant, which the observer determines by seeing that the plumb-line hides the two stars simultaneously, neither of the stars is strictly in the meridian; but the deviation from it is so small that it may be neglected, and the plane through the eye and the plumb-line taken for meridian plane.

In all these cases it will be convenient, instead of fixing the plane by means of the eye and one fixed plummet, to have a second plummet at a short distance in front of the eye; this second plummet, being suspended so as to allow of lateral shifting, must be moved so as always to be between the eye and the fixed plummet. The meridian plane will be secured by placing two permanent marks on the ground, one under each plummet.

This method, by means of the two stars, is only available for the upper transit of *Polaris*; for, at the lower transit, the other star η *Ursae Majoris* would pass close to or beyond the zenith, and the observation could not be made. Also the stars will not be visible when the upper transit takes place in the daytime, so that one-half of the year is lost to this method.

Neither could it be employed in lower latitudes than 40° N., for there the star would be below the horizon at its lower transit;—we may even say not lower than 45° N., for the star must be at least 5° above the horizon before it becomes distinctly visible.

There are other pairs of stars which could be similarly employed, but none so convenient as these two, on account of *Polaris* with its very slow motion being one of the pair.

To place the Style in its True Position without previous Determination of the Meridian Plane.—The various methods given above for finding the meridian plane have for ultimate object the determination of the plane, not on its own account, but as an element for fixing the instant of noon, whereby the style may be properly placed.

We shall dispense, therefore, with all this preliminary work if we determine noon by astronomical observation. For this we shall want a good watch, or pocket chronometer, and a sextant or other instrument for taking altitudes. The local time at any moment may be determined in a variety of ways by observation of the celestial bodies. The simplest and most practically useful methods will be found described and investigated in any work on astronomy.

For our present purpose a single altitude of the sun taken in the forenoon will be most suitable. At some time in the morning, when the sun is high enough to be free from the mists and uncertain refractions of the horizon—but to ensure accuracy, while the rate of increase of the altitude is still tolerably rapid, and, therefore, not later than 10 o'clock—take an altitude of the sun, an assistant, at the same moment, marking the time shown by the watch. The altitude so observed being properly corrected for refraction, parallax, &c., will, together with the latitude of the place, and the sun's declination, taken from the *Nautical Almanac*, enable us to calculate the time. This will be the solar or apparent time, that is, the very time we require. Comparing the time so found with the time shown by the watch, we see at once by how much the watch is fast or slow of solar time; we know, therefore, exactly what time the watch must mark when solar noon arrives, and waiting for that instant we can fix the style in its proper position as explained before.

We can dispense with the sextant and with all calculation and observation if, by means of the pocket chronometer, we bring the time from some observatory where the work is done; and, allowing for the change of longitude, and also for the equation of time, if the time we have brought is clock time, we shall have the exact instant of solar noon as in the previous case.

In former times the fancy of dialists seems to have run riot in devising elaborate surfaces on which the dial was to be traced. Sometimes the shadow was received on a cone, sometimes on a cylinder, or on a sphere, or on a combination of these. A universal dial was constructed of a figure in the shape of a cross; another universal dial showed the hours by a globe and by several gnomons. These universal dials required adjusting before use, and for this a mariner's compass and a spirit-level were necessary. But it would be tedious and useless to enumerate the various forms designed, and, as a rule, the more complex the less accurate.

Another class of useless dials consisted of those with variable centres. They were drawn on fixed horizontal planes, and each day the style had to be shifted to a new position. Instead of hour-*lines* they had hour-*points*; and the style, instead of being parallel to the axis of the earth, might make any chosen angle with the horizon. There was no practical advantage in their use, but rather the reverse; and they can only be considered as furnishing material for new mathematical problems.

Portable Dials.—The dials so far described have been fixed dials, for even the fanciful ones to which reference was just now made were to be fixed before using. There were, however, other dials, made generally of a small size, so as to be carried in the pocket; and these, so long as the sun shone, roughly answered the purpose of a watch.

The description of the portable dial has generally been mixed up with that of the fixed dial, as if it had been merely a special case, and the same principle had been the basis of both; whereas there are essential points of difference between them, besides those which are at once apparent.

In the fixed dial the result depends on the *uniform* angular motion of the sun round the fixed style; and a small error in the assumed position of the sun, whether due to the imperfection of the instrument, or to some small neglected correction, has only a trifling effect on the time. This is owing to the angular displacement of the sun being so rapid—a quarter of a degree every minute—that for the ordinary affairs of life greater accuracy is not required, as a displacement of a quarter of a degree, or at any rate of one degree, can be readily seen by nearly every person. But with a portable dial this is no longer the case. The uniform angular motion is not now available, because we have no determined fixed plane to which we may refer it. In the new position, to which the observer has gone, the zenith is the only point of the heavens he can at once practically find; and the basis for the determination of the time is the constantly but *very irregularly* varying zenith distance of the sun.

At sea the observation of the altitude of a celestial body is the only method available for finding local time; but the perfection which has been attained in the construction of the sextant enables the sailor to reckon on an accuracy of seconds. Certain precautions have, however, to be taken. The observations must not be made within a couple of hours of noon, on account of the slow rate of change at that time, nor too near the horizon, on account of the uncertain refractions there; and the same restrictions must be observed in using a portable dial.

To compare roughly the accuracy of the fixed and the portable dials, let us take a mean position in Great Britain, say 54° lat., and a mean declination when the sun is in the equator. It will rise at 6 o'clock, and at noon have an altitude of 36°,—that is, the portable dial will indicate an average change of one-tenth of a degree in each minute, or two and a half times slower than the fixed dial. The vertical motion of the sun increases, however, nearer the horizon, but even there it will be only one-eighth of a degree each minute, or half the rate of the fixed dial, which goes on at nearly the same speed throughout the day.

Portable dials are also much more restricted in the range of latitude for which they are available, and they should not be used more than 4 or 5 m. north or south of the place for which they were constructed.

We shall briefly describe two portable dials which were in actual use.

Dial on a Cylinder.—A hollow cylinder of metal (fig. 7), 4 or 5 in. high, and about an inch in diameter, has a lid which admits of tolerably easy rotation. A hole in the lid receives the style shaped somewhat like a bayonet; and the straight part of the style, which, on account of the two bends, is lower than the lid, projects horizontally out from the cylinder to a

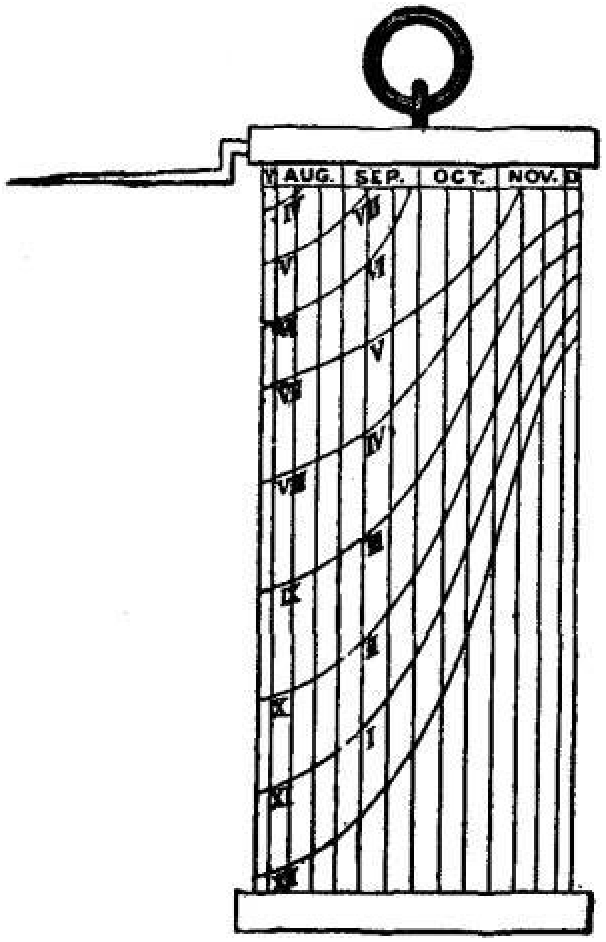

FIG. 7.

distance of 1 or 1½ in. When not in use the style would be taken out and placed inside the cylinder.

A horizontal circle is traced on the cylinder opposite the projecting style, and this circle is divided into 36 approximately equidistant intervals.[2] These intervals represent spaces of time, and to each division is assigned a date, so that each month has three dates marked as follows:- January 10, 20, 31; February 10, 20, 28; March 10, 20, 31; April 10, 20, 30, and so on,—always the 10th, the 20th, and the last day of each month.

Through each point of division a vertical line parallel to the axis of the cylinder is drawn from top to bottom. Now it will be readily understood that if, upon one of these days, the lid be turned, so as to bring the style exactly opposite the date, and if the dial be then placed on a horizontal table so as to receive sunlight, and turned round bodily until the shadow of the style falls exactly on the vertical line below it, the shadow will terminate at some definite point of this line, the position of which point will depend on the length of the style—that is, the distance of its end from the surface of the cylinder—and on the altitude of the sun at that instant. Suppose that the observations are continued all day, the cylinder being very gradually turned so that the style may always face the sun, and suppose that marks are made on the vertical line to show the extremity of the shadow at each exact hour from sunrise to sunset-these times being taken from a good fixed sun-dial,—then it is obvious that the next year, on the *same date*, the sun's declination being about the same, and the observer in about the same latitude, the marks made the previous year will serve to tell the time all that day.

What we have said above was merely to make the principle of the instrument clear, for it is evident that this mode of marking, which would require a whole year's sunshine and hourly observation, cannot be the method employed.

The positions of the marks are, in fact, obtained by calculation. Corresponding to a given date, the declination of the sun is taken from the almanac, and this, together with the latitude of the place and the length of the style, will constitute the necessary data for computing the length of the shadow, that is, the distance of the mark below the style for each successive hour.

We have assumed above that the declination of the sun is the same at the same date in different years. This is not quite correct, but, if the dates be taken for the second year after leap year, the results will be sufficiently approximate.

When all the hour-marks have been placed opposite to their respective dates, then a continuous curve, joining the corresponding hour-points, will serve to find the time for a day intermediate to those set down, the lid being turned till the style occupy a proper position between the two divisions. The horizontality of the surface on which the instrument rests is a very necessary condition, especially in summer, when, the shadow of the style being long, the extreme end will shift rapidly for a small deviation from the vertical, and render the reading uncertain. The dial can also be used by holding it up by a small ring in the top of the lid, and probably the vertically is better ensured in that way.

Portable Dial on a Card.—This neat and very ingenious dial is attributed by Ozanam to a Jesuit Father, De Saint Rigaud, and probably dates from the early part of the 17th century. Ozanam says that it was sometimes called the *capuchin*, from some fancied resemblance to a cowl thrown back.

Construction.—Draw a straight line ACB parallel to the top of the card (fig. 8) and another DCE at right angles to it; with C as centre, and any convenient radius CA, describe the semicircle AEB below the horizontal. Divide the whole arc AEB into 12 equal parts at the points r, s, t, &c., and through these points draw perpendiculars to the diameter ACB; these lines will be the hour-lines, viz. the line through r will be the XI ... I line, the line through s the X ... II line, and so on; the hour-line of noon will be the point A itself; by subdivision of the small arcs Ar, rs, st, &c., we may draw the hour-lines corresponding to halves and quarters, but this only where it can be done without confusion.

Draw ASD making with AC an angle equal to the latitude of the place, and let it meet EC in D, through which point draw FDG at right angles to AD.

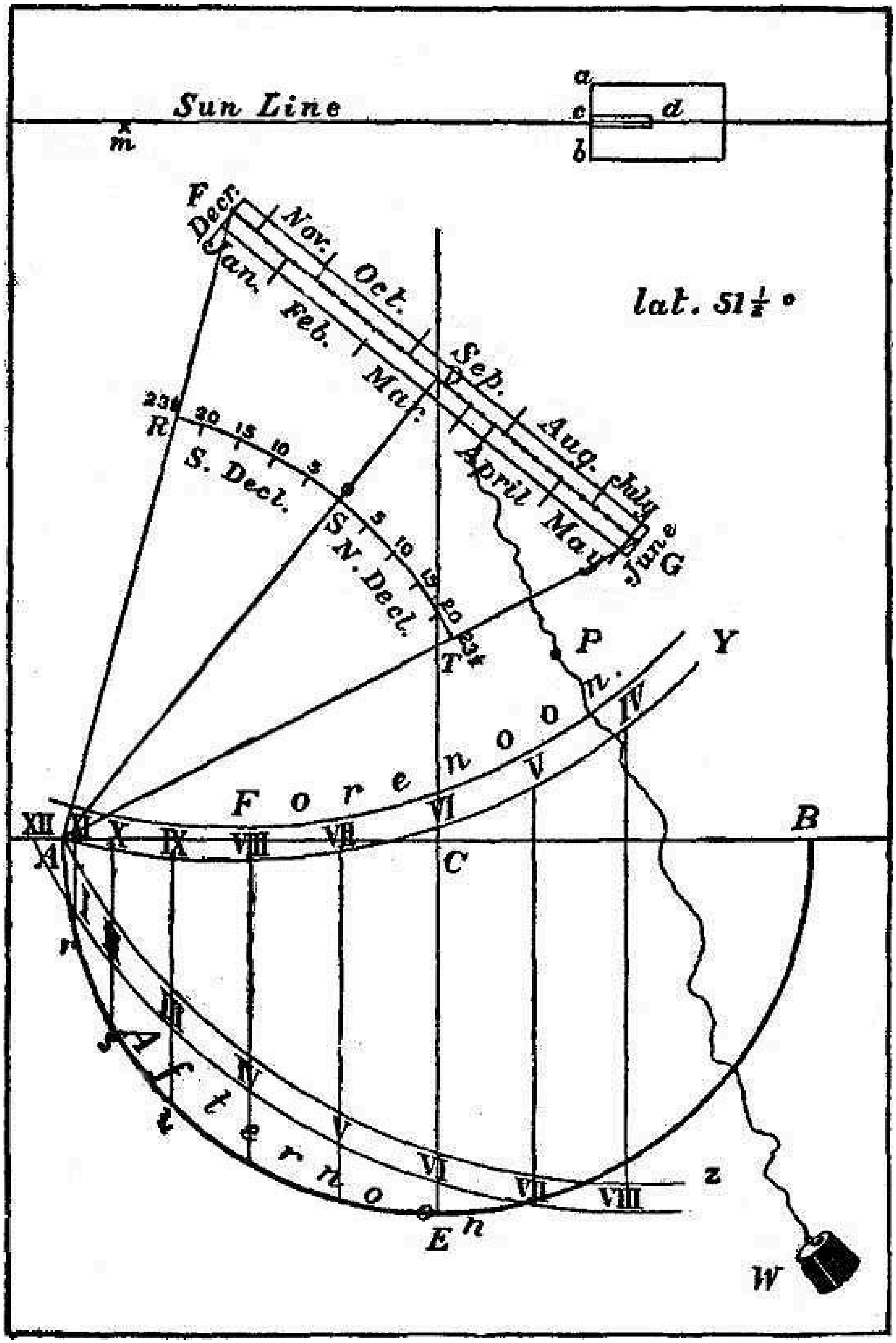
Sun Line
m
a
c
d
b
lat. 51½°
F
Decr.
Nov.
Oct.
Sep.
Aug.
July
June
G
Jan.
Feb.
Mar.
April
May
D
R
S. Decl.
S
N. Decl.
T
P
Y
Forenoon.
Afternoon
XII
XI
X
IX
VIII
VII
VI
V
IV
A
C
B
I
II
III
z
E
h
W

FIG. 8.

With centre A, and any convenient radius AS, describe an arc of circle RST, and graduate this arc by marking degree divisions on it, extending from 0° at S to 23½° on each side at R and T. Next determine the points on the straight line FDG where radii drawn from A to the degree divisions on the arc would cross it, and carefully mark these crossings.

The divisions of RST are to correspond to the sun's declination, south declinations on RS and north declinations on ST. In the other hemisphere of the earth this would be reversed; the north declinations would be on the upper half.

Now, taking a second year after leap year (because the declinations of that year are about the mean of each set of four years), find the days of the month when the sun has these different declinations, and place these dates, or so many of them as can be shown without confusion, opposite the corresponding marks on FDG. Draw the *sun-line* at the top of the card parallel to the line ACB; and, near the extremity, to the right, draw any small figure intended to form, as it were, a door of which a b shall be the hinge. Care must be taken that this hinge is exactly at right angles to the *sun-line*. Make a fine open slit c d right through the card and extending from the hinge to a short distance on the door,—the centre line of this slit coinciding accurately with the *sun-line*. Now, cut the door completely through the card; except, of course, along the hinge, which, when the card is thick, should be partly cut through at the back, to facilitate the opening. Cut the card right through along the line FDG, and pass a thread carrying a little plummet W and a *very* small bead P; the bead having sufficient friction with the thread to retain any position when acted on only by its own weight, but sliding easily along the thread when moved by the hand. At the back of the card the thread terminates in a knot to hinder it from being drawn through; or better, because giving more friction and a better hold, it passes through the centre of a small disk of card—a fraction of an inch in diameter—and, by a knot, is made fast at the back of the disk.

To complete the construction,—with the centres F and G, and radii FA and GA, draw the two arcs AY and AZ which will limit the hour-lines; for in an observation the bead will always be found between them. The forenoon and afternoon hours may then be marked as indicated in the figure. The dial does not of itself discriminate between forenoon and afternoon; but extraneous circumstances, as, for instance, whether the sun is rising or falling, will settle that point, except when close to noon, where it will always be uncertain.

To *rectify* the dial (using the old expression, which means to prepare the dial for an observation),—open the small door, by turning it about its hinge, till it stands well out in front. Next, set the thread in the line FG opposite the day of the month, and stretching it over the point A, slide the bead P along till it exactly coincides with A.

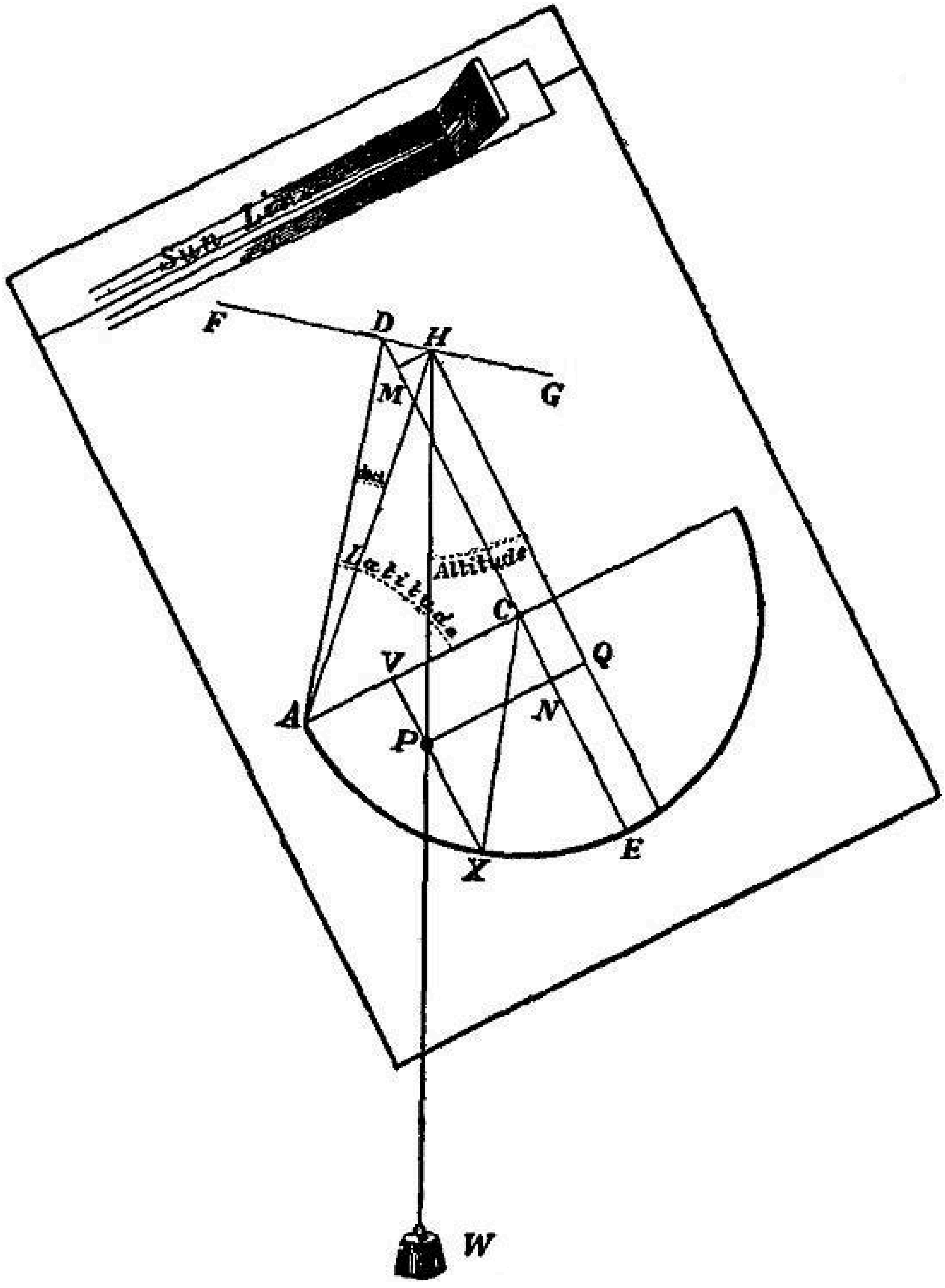

Fig. 9.

To find the hour of the day,—hold the dial in a vertical position in such a way that its plane may pass through the sun. The verticality is ensured by seeing that the bead rests against the card without pressing. Now gradually tilt the dial (without altering its vertical plane), until the central line of sunshine, passing through the open slit of the door, just falls along the sun-line. The hour-line against which the bead P then rests indicates the time.

The *sun-line* drawn above has always, so far as we know, been used as a *shadow-line*. The upper edge of the rectangular door was the prolongation of the line, and, the door being opened, the dial was gradually tilted until the shadow cast by the upper edge exactly coincided with it. But this shadow tilts the card one-quarter of a degree more than the sun-line, because it is given by that portion of the sun which just appears above the edge, that is, by the upper limb of the sun, which is one-quarter of a degree higher than the centre. Now, even at some distance from noon, the sun will sometimes take a considerable time to rise one-quarter of a degree, and by so much time will the indication of the dial be in error.

The central line of light which comes through the open slit will be free from this error, because it is given by light from the centre of the sun.

The card-dial deserves to be looked upon as something more than a mere toy. Its ingenuity and scientific accuracy give it an educational value which is not to be measured by the roughness of the results obtained.

The theory of this instrument is as follows:—Let H (fig. 9) be the point of suspension of the plummet at the time of observation, so that the angle DAH is the north declination of the sun,—P, the bead, resting against the hour-line VX. Join CX, then the angle ACX is the hour-angle from noon given by the bead, and we have to prove that this hour-angle is the correct one corresponding to a north latitude DAC, a north declination DAH and an altitude equal to the angle which the *sun-line*, or its parallel AC, makes with the horizontal. The angle PHQ will be equal to the altitude, if HQ be drawn parallel to DC, for the pair of lines HQ, HP will be respectively at right angles to the sun-line and the horizontal.

Draw PQ and HM parallel to AC, and let them meet DCE in M and N respectively.

Let HP and its equal HA be represented by a. Then the following values will be readily deduced from the figure:—

AD = a cos *decl.* DH = a sin *decl.* PQ = a sin *alt.*

CX = AC = AD cos *lat.* = a cos *decl.* cos *lat.*
PN = CV = CX cos ACX = a cos *decl.* cos *lat.* cos ACX.
NQ = MH = DH sin MDH = sin *decl.* sin *lat.*
(∴ the angle MDH = DAC = latitude.)

And since PQ = NQ + PN,

we have, by simple substitution,

a sin *alt.* = a sin *decl.* sin *lat.* + a cos *del.* cos *lat.* cos ACX; or, dividing by a throughout,

sin *alt.* = sin *decl.* sin *lat.* + cos *decl.* cos *lat.* cos ACX ... (1)

which equation determines the hour-angle ACX shown by the bead.

To determine the hour-angle of the sun at the same moment, let fig. 10 represent the celestial sphere, HR the horizon, P the pole, Z the zenith and S the sun.

From the spherical triangle PZS, we have

cos ZS = cos PS cos ZP + sin PS sin ZP cos ZPS
but ZS = zenith distance = 90° - altitude
ZP = 90° - PR = 90°- latitude
PS = polar distance = 90° - declination,

therefore, by substitution

sin *alt.* = sin *decl.* sin *lat.* + cos *decl.* cos *lat.* cos ZPS ... (2)

and ZPS is the hour-angle of the sun.

A comparison of the two formulae (1) and (2) shows that the hour-angle given by the bead will be the same as that given by the sun, and proves the theoretical accuracy of the card-dial. Just at sun-rise or at sun-set the amount of refraction slightly exceeds half a degree. If, then, a little cross m (see fig. 8) be made just below the sun-line, at a distance from it which would subtend half a degree at c, the time of sun-set would be found corrected for refraction, if the central line of light were made to fall on cm.

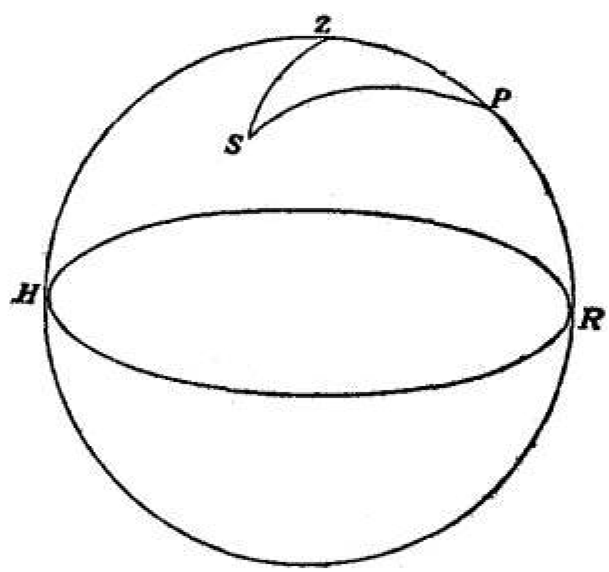

FIG. 10.

LITERATURE.—The following list includes the principal writers on dialling whose works have come down, to us, and to these we must refer for descriptions of the various constructions, some simple and direct, others fanciful and intricate, which have been at different times employed: Ptolemy, *Analemma*, restored by Commandine; Vitruvius, *Architecture*; Sebastian Münster, *Horologiographia*; Orontius Fineus, *De horologiis solaribus*; Mutio Oddi da Urbino, *Horologi solari*; Dryander, *De horologiorum compositione*; Conrad Gesner, *Pandectae*; Andreas Schöner, *Gnomonicae*; F. Commandine, *Horologiorum descriptio*; Joan. Bapt. Benedictus, *De gnomonum usu*; Georgius Schomberg, *Exegesis fundamentorum gnomonicorum*; Joan. Solomon de Caus, *Horologes solaires*; Joan. Bapt. Trolta, *Praxis horologiorum*; Desargues, *Manière universelle pour poser l'essieu*, &c.; Ath. Kircher, *Ars magna lucis et Umbrae*; Hallum, *Explicatio horologii in horto regio Londini*; Joan. Mark, *Tractatus horologiorum*; Clavius, *Gnomonices de horologiis*. Also among more modern writers, Deschales, Ozanam, Schottus, Wolfius, Picard, Lahire, Walper; in German, Paterson, Michael, Müller; in English, Foster, Wells, Collins, Leadbetter, Jones, Leybourn, Emerson and Ferguson. See also Hans Löschner, *Über Sonnenuhren* (2nd ed., Graz, 1906).

(H. G.)

[1] In one of the courts of Queens' College, Cambridge, there is an elaborate sun-dial dating from the end of the 17th or beginning of the 18th century, and around it a series of numbers which make it available as a moon-dial when the moon's age is known.

[2] Strict equality is not necessary, as the observations made are on the vertical line through each division-point, without reference to the others. It is not even requisite that the divisions should go completely and exactly round the cylinder, although they were always so drawn, and both these conditions were insisted upon in the directions for the construction.

DIALECT (from Gr. διάλεκτος, conversation, manner of speaking, διαλέγεϱθαι, to converse), a particular or characteristic manner of speech, and hence any variety of a language. In its widest sense languages which are branches of a common or parent language may be said to be "dialects" of that language; thus Attic, Ionic, Aeolic and Doric are dialects of Greek, though there may never have at any time been a separate language of which they were variations; so the various Romance languages, Italian, French, Spanish, &c., were dialects of Latin. Again, where there have existed side by side, as in England, various branches of a language, such as the languages of the Angles, the Jutes or the Saxons, and the descendant of one particular language, from many causes, has obtained the predominance, the traces of the other languages remain in the "dialects" of the districts where once the original language prevailed. Thus it may be incorrect, from the historical point of view, to say that "dialect" varieties of a language represent degradations of the standard language. A "literary" accepted language, such as modern English, represents the original language spoken in the Midlands, with accretions of Norman, French, and later literary and scientific additions from classical and other sources, while the present-day "dialects" preserve, in inflections, pronunciation and particular words, traces of the original variety of the language not incorporated in the standard language of the country. See the various articles on languages (English, French, &c).

DIALECTIC, or DIALECTICS (from Gr. διάλεκτος, discourse, debate; ἡ διαλεκτική, sc. τέχνη, the art of debate), a logical term, generally used in common parlance in a contemptuous sense for verbal or purely abstract disputation devoid of practical value. According to Aristotle, Zeno of Elea "invented" dialectic, the art of disputation by question and answer, while Plato developed it metaphysically in connexion with his doctrine of "Ideas" as the art of analysing ideas in themselves and in relation to the ultimate idea of the Good (*Repub.* vii.). The special function of the so-called "Socratic dialectic" was to show the inadequacy of popular beliefs. Aristotle himself used "dialectic," as opposed to "science," for that department of mental activity which examines the presuppositions lying at the back of all the particular sciences. Each particular science has its own subject matter and special principles (ἴδιαι ἀρχαί) on which the superstructure of its special discoveries is based. The Aristotelian dialectic, however, deals with the universal laws (κοιναὶ ἀρχαί) of reasoning, which can be applied to the particular arguments of all the sciences. The sciences, for example, all seek to define their own species; dialectic, on the other hand, sets forth the conditions which all definitions must satisfy whatever their subject matter. Again, the sciences all seek to educe general laws; dialectic investigates the nature of such laws, and the kind and degree of necessity to which they can attain. To this general subject matter Aristotle gives the name "Topics" (τόποι, loci, communes loci). "Dialectic" in this sense is the equivalent of "logic." Aristotle also uses the term for the science of probable reasoning as opposed to demonstrative reasoning (ἀποδεικτική). The Stoics divided λογική (logic) into rhetoric and dialectic, and from their time till the end of the middle ages dialectic was either synonymous with, or a part of, logic.

In modern philosophy the word has received certain special meanings. In Kantian terminology *Dialektik* is the name of that portion of the *Kritik d. reinen Vernunft* in which Kant discusses the impossibility of applying to "things-in-themselves" the principles which are found to govern phenomena. In the system of Hegel the word resumes its original Socratic sense, as the name of that intellectual process whereby the inadequacy of popular conceptions is exposed. Throughout its history, therefore, "dialectic" has been connected with that which is remote from, or alien to, unsystematic thought, with the a priori, or transcendental, rather than with the facts of common experience and material things.

DIALLAGE, an important mineral of the pyroxene group, distinguished by its thin foliated structure and bronzy lustre. The chemical composition is the same as diopside, Ca Mg $(SiO_3)_2$, but it sometimes contains the molecules (Mg, Fe") $(Al, Fe''')_2$ SiO_6 and Na Fe''' $(SiO_3)_2$, in addition, when it approaches to augite in composition. Diallage is in fact an altered form of these varieties of pyroxene; the particular kind of alteration which they have undergone being known as "schillerization." This, as described by Prof. J. W. Judd, consists in the development of a fine lamellar structure or parting due to secondary twinning and the separation of secondary products along these and other planes of chemical weakness ("solution planes") in the crystal. The secondary products consist of mixtures of various hydrated oxides—opal, göthite, limonite, &c—and appear as microscopic inclusions filling or partly filling cavities, which have definite outlines with respect to the enclosing crystal and are known as negative crystals. It is to the reflection and interference of light from these minute inclusions that the peculiar bronzy sheen or "schiller" of the mineral is due. The most pronounced lamination is that parallel to the orthopinacoid; another, less distinct, is parallel to the basal plane, and a third parallel to the plane of symmetry; these planes of secondary parting are in addition to the ordinary prismatic cleavage of all pyroxenes. Frequently the material is interlaminated with a rhombic pyroxene (bronzite) or with an amphibole (smaragdite or uralite), the latter being an alteration product of the diallage.

Diallage is usually greyish-green or dark green, sometimes brown, in colour, and has a pearly to metallic lustre or schiller on the laminated surfaces. The hardness is 4, and the specific gravity 3.2 to 3.35. It does not occur in distinct crystals with definite outlines, but only as lamellar masses in deep-seated igneous rocks, principally gabbro, of which it is an essential constituent. It occurs also in some peridotites and serpentines, and rarely in volcanic rocks (basalt) and crystalline schists. Masses of considerable size are found in the coarse-grained gabbros of the Island of Skye, Le Prese near Bornio in Valtellina, Lombardy, Prato near Florence, and many other localities.

The name diallage, from diallage, "difference," in allusion to the dissimilar cleavages and planes of fracture, as originally applied by R. J. Haüy in 1801, included other minerals (the orthorhombic pyroxenes hypersthene, bronzite and bastite, and the smaragdite variety of hornblende) which exhibit the same peculiarities of schiller structure; it is now limited to the monoclinic pyroxenes with this structure. Like the minerals of similar appearance just mentioned, it is sometimes cut and polished for ornamental purposes.

(L. J. S.)

DIALOGUE, properly the conversation between two or more persons, reported in writing, a form of literature invented by the Greeks for purposes of rhetorical entertainment and instruction, and scarcely modified since the days of its invention. A dialogue is in reality a little drama without a theatre, and with scarcely any change of scene. It should be illuminated with those qualities which La Fontaine applauded in the dialogue of Plato, namely vivacity, fidelity of tone, and accuracy in the opposition of opinions. It has always been a favourite with those writers who have something to censure or to impart, but who love to stand outside the pulpit, and to encourage others to pursue a train of thought which the author does not seem to do more than indicate. The dialogue is so spontaneous a mode of expressing and noting down the undulations of human thought that it almost escapes analysis. All that is recorded, in any literature, of what pretend to be the actual words spoken by living or imaginary people is of the nature of dialogue. One branch of letters, the drama, is entirely founded upon it. But in its technical sense the word is used to describe what the Greek philosophers invented, and what the noblest of them lifted to the extreme refinement of an art.

The systematic use of dialogue as an independent literary form is commonly supposed to have been introduced by Plato, whose earliest experiment in it is believed to survive in the *Laches*. The Platonic dialogue, however, was founded on the mime, which had been cultivated half a century earlier by the Sicilian poets, Sophron and Epicharmus. The works of these writers, which Plato admired and imitated, are lost, but it is believed that they were little plays, usually with only two performers. The recently discovered mimes of Herodas (Herondas) give us some idea of their scope. Plato further simplified the form, and reduced it to pure argumentative conversation, while leaving intact the amusing element of character-drawing. He must have begun this about the year 405, and by 399 he had brought the dialogue to its highest perfection, especially in the cycle directly inspired by the death of Socrates. All his philosophical writings, except the *Apology*, are cast in this form. As the greatest of all masters of Greek prose style, Plato lifted his favourite instrument, the dialogue, to its highest splendour, and to this day he remains by far its most distinguished proficient. In the 2nd century a.d. Lucian of Samosata achieved a brilliant success with his ironic dialogues "Of the Gods," "Of the Dead," "Of Love" and "Of the Courtesans." In some of them he attacks superstition and philosophical error with the sharpness of his wit; in others he merely paints scenes of modern life. The title of Lucian's most famous collection was borrowed in the 17th century by two French writers of eminence, each of whom prepared *Dialogues des morts*. These were Fontenelle (1683) and Fénelon (1712). In English non-dramatic literature the dialogue had not been extensively employed until Berkeley used it, in 1713, for his Platonic treatise, *Hylas and Philonous*. Landor's *Imaginary Conversations* (1821-1828) is the most famous example of it in the 19th century, although the dialogues of Sir Arthur Helps claim attention. In Germany, Wieland adopted this form for several important satirical works published between 1780 and 1799. In Spanish literature, the Dialogues of Valdés (1528) and those on Painting (1633) by Vincenzo Carducci, are celebrated. In Italian, collections of dialogues, on the model of Plato, have been composed by Torquato Tasso (1586), by Galileo (1632), by Galiani (1770), by Leopardi (1825), and by a host of lesser writers. In our own day, the French have returned to the original application of dialogue, and the inventions of "Gyp," of Henri Lavedan and of others, in which a mundane anecdote is wittily and maliciously told in conversation, would probably present a close analogy to the lost mimes of the early Sicilian poets, if we could meet with them. This kind of dialogue has been employed in English, and with conspicuous cleverness by Mr Anstey Guthrie, but it does not seem so easily appreciated by English as by French readers.

(E. G.)

DIALYSIS (from the Gr. διά, through, λύειν, to loosen), in chemistry, a process invented by Thomas Graham for separating colloidal and crystalline substances. He found that solutions could be divided into two classes according to their action upon a porous diaphragm such as parchment. If a solution, say of salt, be placed in a drum provided with a parchment bottom, termed a "dialyser," and the drum and its contents placed in a larger vessel of water, the salt will pass through the membrane. If the salt solution be replaced by one of glue, gelatin or gum, it will be found that the membrane is impermeable to these solutes. To the first class Graham gave the name "crystalloids," and to the second "colloids." This method is particularly effective in the preparation of silicic acid. By adding hydrochloric acid to a dilute solution of an alkaline silicate, no precipitate will fall and the solution will contain hydrochloric acid, an alkaline chloride, and silicic acid. If the solution be transferred to a dialyser, the hydrochloric acid and alkaline chloride will pass through the parchment, while the silicic acid will be retained.

DIAMAGNETISM. Substances which, like iron, are attracted by the pole of an ordinary magnet are commonly spoken of as magnetic, all others being regarded as non-magnetic. It was noticed by A. C. Becquerel in 1827 that a number of so-called non-magnetic bodies, such as wood and gum lac, were influenced by a very powerful magnet, and he appears to have formed the opinion that the influence was of the same nature as that exerted upon iron, though much feebler, and that all matter was more or less magnetic. Faraday showed in 1845 (*Experimental Researches*, vol. iii.) that while practically all natural substances are indeed acted upon by a sufficiently strong magnetic pole, it is only a comparatively small number that are attracted like iron, the great majority being repelled. Bodies of the latter class were termed by Faraday *diamagnetics*. The strongest diamagnetic substance known is bismuth, its susceptibility being—0.000014, and its permeability 0.9998. The diamagnetic quality of this metal can be detected by means of a good permanent magnet, and its repulsion by a magnetic pole had been more than once recognized before the date of Faraday's experiments. The metals gold, silver, copper, lead, zinc, antimony and mercury are all diamagnetic; tin, aluminium and platinum are attracted by a very strong pole. (See MAGNETISM.)

DIAMANTE, FRA, Italian fresco painter, was born at Prato about 1400. He was a Carmelite friar, a member of the Florentine community of that order, and was the friend and assistant of Filippo Lippi. The Carmelite convent of Prato which he adorned with many works in fresco has been suppressed, and the buildings have been altered to a degree involving the destruction of the paintings. He was the principal assistant of Fra Filippo in the grand frescoes which may still be seen at the east end of the cathedral of Prato. In the midst of the work he was recalled to Florence by his conventual superior, and a minute of proceedings of the commune of Prato is still extant, in which it is determined to petition the metropolitan of Florence to obtain his return to Prato,—a proof that his share in the work was so important that his recall involved the suspension of it. Subsequently he assisted Fra Filippo in the execution of the frescoes still to be seen in the cathedral of Spoleto, which Fra Diamante completed in 1470 after his master's death in 1469. Fra Filippo left a son ten years old to the care of Diamante, who, having received 200 ducats from the commune of Spoleto, as the balance due for the work done in the cathedral, returned with the child to Florence, and, as Vasari says, bought land for himself with the money, giving but a small portion to the child. The accusation of wrong-doing, however, would depend upon the share of the work executed by Fra

Diamante, and the terms of his agreement with Fra Filippo. Fra Diamante must have been nearly seventy when he completed the frescoes at Spoleto, but the exact year of his death is not known.

DIAMANTE, JUAN BAUTISTA (1640?-1684?), Spanish dramatist, was born at Castillo about 1640, entered the army, and began writing for the stage in 1657. He became a knight of Santiago in 1660; the date of his death is unknown, but no reference to him as a living author occurs after 1684. Like many other Spanish dramatists of his time, Diamante is deficient in originality, and his style is riddled with affectations; *La Desgraciada Raquel*, which was long considered to be his best play, is really Mira de Amescua's *Judía de Toledo* under another title; and the earliest of Diamante's surviving pieces, *El Honrador de su padre* (1658), is little more than a free translation of Corneille's Cid. Diamante is historically interesting as the introducer of French dramatic methods into Spain.

DIAMANTINA (formerly called *Tejuco*), a mining town of the state of Minas Geraes, Brazil, in the N.E. part of the state, 3710 ft. above sea-level. Pop. (1890) 17,980. Diamantina is built partly on a steep hillside overlooking a small tributary of the Rio Jequitinhonha (where diamond-washing was once carried on), and partly on the level plain above. The town is roughly but substantially built, with broad streets and large squares. It is the seat of a bishopric, with an episcopal seminary, and has many churches. Its public buildings are inconspicuous; they include a theatre, military barracks, hospitals, a lunatic asylum and a secondary school. There are several small manufactures, including cotton-weaving, and diamond-cutting is carried on. The surrounding region, lying on the eastern slopes of one of the lateral ranges of the Serra do Espinhaço, is rough and barren, but rich in minerals, principally gold and diamonds. Diamantina is the commercial centre of an extensive region, and has long been noted for its wealth. The date of the discovery of diamonds, upon which its wealth and importance chiefly depend, is uncertain, but the official announcement was made in 1729, and in the following year the mines were declared crown property, with a crown reservation, known as the "forbidden district," 42 leagues in circumference and 8 to 16 leagues in diameter. Gold-mining was forbidden within its limits and diamond-washing was placed under severe restrictions. There are no trustworthy returns of the value of the output, but in 1849 the total was estimated up to that date at 300,000,000 francs (see Diamond). The present name of the town was assumed (instead of Tejuco) in 1838, when it was made a *cidade*.

DIAMANTINO, a small town of the state of Matto Grosso, Brazil, near the Diamantino river, about 6 m. above its junction with the Paraguay, in 14° 24′ 33″ S., 56° 8′ 30″ W. Pop. (1890) of the municipality 2147, mostly Indians. It stands in a broken sterile region 1837 ft. above sea-level and at the foot of the great Matto Grosso plateau. The first mining settlement dates from 1730, when gold was found in the vicinity. On the discovery of diamonds in 1746 the settlement drew a large population and for a time was very prosperous. The mines failed to meet expectations, however, and the population has steadily declined. Ipecacuanha and vanilla beans are now the principal articles of export.

DIAMETER (from the Gr. διά, through, μέτρον, measure), in geometry, a line passing through the centre of a circle or conic section and terminated by the curve; the "principal diameters" of the ellipse and hyperbola coincide with the "axes" and are at ...

(*Continued in volume 8, slice 4, page 158.*)

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