value greater than it has when the stress in the outermost layer only reaches the intensity q', in the ratio of 4 to 3.[1] It is obvious from this consideration that the ultimate strength of a shaft to resist torsion is no more deducible from a knowledge of the ultimate shearing strength of the material than the ultimate strength of a beam to resist bending is deducible from a knowledge of f_t and f_c. It should be noticed also that as regards ultimate strength a solid shaft has an important advantage over a hollow shaft of the same elastic strength, or a hollow shaft so proportioned that the greatest working intensity of stress is the same as in the solid shaft.

69. *Twisting combined with Longitudinal Stress.*—When a rod is twisted and pulled axially, or when a short block is twisted and compressed axially, the greatest intensity of stress (the greater principal stress) is to be found by compounding the longitudinal and shearing stresses as in § 64. In a circular rod of radius r_1, a total longitudinal force P in the direction of the axis gives a longitudinal normal stress whose intensity $p_1 = P/\pi r_1^2$. A twisting couple M applied to the same rod gives a shearing stress whose greatest intensity $q_1 = 2M/\pi r_1^3$. The two together give rise to a pair of principal stresses of intensities $r = P/2\pi r_1^2 \pm \sqrt{(2M/\pi r_1^3)^2 + (P/2\pi r_1^3)^2}$, their inclinations to the axis being defined by the equation $\tan 2\theta = 2M/r_1 P$, and the term under the square root is the greatest intensity of shearing stress.

70. *Twisting combined with Bending.*—This important practical case is realized in a crank-shaft (fig. 41). Let a force P be applied at the crank-pin A at right angles to the plane of the crank. At any section of the shaft C (between the crank and the bearing) there is a twisting moment $M_1 = P \cdot AB$, and a bending moment $M_2 = P \cdot BC$. There is also a direct shearing force P, but this does not require to be taken into account in calculating the stress at points at the top or bottom of the circumference (where the intensity is greatest), since (by § 63) the direct shearing stress is distributed so that its intensity is zero at these points. The stress there is consequently made up of longitudinal normal stress (due to bending), $p_1 = 4M_2/\pi r_1^3$, and shearing stress (due to torsion), $q_1 = 2M_1/\pi r_1^3$. Combining these, as in § 64, we find for the principal stresses $r = 2(M_2 \pm \sqrt{M_1^2 + M_2^2})/\pi r_1^3$, or $r = 2P(BC \pm AC)/\pi r_1^3$. The greatest shearing stress is $2P \cdot AC/\pi r_1^3$, and the axes of principal stress are inclined so that $\tan 2\theta = M_1/M_2 = AB/BC$. The axis of greater principal stress bisects the angle ACB.

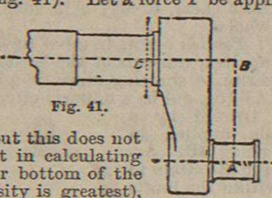

Fig. 41.

71. *Long Columns and Struts—Compression and Bending.*—A long strut or pillar, compressed by forces P applied at the ends in the direction of the axis, becomes unstable as regards flexure when P exceeds a certain value. Under no circumstances can this value of P be exceeded in loading a strut. But it may happen that the intensity of stress produced by smaller loads exceeds the safe compressive strength of the material, in which case a lower limit of load must be chosen. If the applied load is not strictly axial, if the strut is not initially straight, if it is subject to any deflexion by transverse forces, or if the modulus of elasticity is not uniform over each cross-section,—then loads smaller than the limit which causes instability will produce a certain deflexion which increases with increase of load, and will give rise to a uniformly varying stress of the kind illustrated in figs. 26 and 28. We shall first consider the ideal case in which the forces at the ends are strictly axial, the strut perfectly straight and free from transverse loads and perfectly symmetrical as to elasticity. Two conditions have to be distinguished—that in which the ends are left free to bend, and that in which the ends are held fixed. In what follows, the ends are supposed free to bend. The value of the load which causes instability will be found by considering what force P applied to each end would suffice to hold an originally straight strut in a bent state, supposing it to have received a small amount of elastic curvature in any way. Using u as before to denote the deflexion at any part of the length, the bending moment is Pu, and (taking the origin at the middle of the chord) the equation to the elastic curve is

$$\frac{d^2u}{dx^2} = \frac{-Pu}{EI},$$

from which, for a strut of uniform section, $u = u_1 \cos x\sqrt{P/EI}$, u_1 being the deflexion at the centre, Now $u=0$ when $x = \frac{1}{2}L$ (the half length), and therefore $\frac{1}{2}L\sqrt{P/EI} = \frac{1}{2}\pi$ or an integral multiple of $\frac{1}{2}\pi$. The smallest value $(\frac{1}{2}\pi)$ corresponds to the least force P. Thus the force required to maintain the strut in its curved state is $P = \pi^2 EI/L^2$, and is independent of u_1. This means that with this particular value of P (which for brevity we shall write P_1) the strut will be in neutral equilibrium when bent; with a value of P less than P_1 it will be stable; with a greater value it will be unstable. Hence a load exceeding P_1 will certainly cause rupture. The value $\pi^2 EI/L^2$ applies to struts with round ends, or ends free to turn. If the ends are fixed the effective length for bending is reduced by one half, so that P_1 then is $4\pi^2 EI/L^2$. When one end is fixed and the other is free P_1 has an intermediate value, probably about $9\pi^2 EI/4L^2$.

72. The above theory, which is Euler's, assigns P_1 as a limit to the strength of a strut on account of flexural instability; but a stress less than P_1 may cause direct crushing. Let S be the area of section, and f_c the strength of the material to resist crushing. Thus a strut which conforms to the ideal conditions specified above will fail by simple crushing if $f_c S$ is less than P_1, but by bending if $f_c S$ is greater than P_1. Hence with a given material and form of section the ideal strut will fail by direct crushing if the length is less than a certain multiple of the least breadth (easily calculated from the expression for P_1), and in that case its strength will be independent of the length; when the length is greater than this the strut will yield by bending, and its strength diminishes rapidly as the length is increased.

But the conditions which the above theory assumes are never realized in practice. The load is never strictly axial, nor the strut absolutely straight to begin with, nor the elasticity uniform. The result is that the strength is in all cases less than either $f_c S$ or P_1. The effect of deviations from axiality, from straightness, and from uniformity of elasticity may be treated by introducing a term expressing an imaginary initial deflexion, and in this way Euler's theory may be so modified as to agree well with experimental results on the fracture of struts,[2] and may be reconciled with the observed fact that the deflexion of a strut begins gradually and passes through stable values before the stage of instability is reached. In consequence of this stable deflexion the stress of compression on the inside edge becomes greater than P/S, the stress on the outside edge becomes less than P/S, and may even change into tension, and the strut may yield by one or the other of these stresses becoming greater than f_c or f_t respectively. As regards the influence of length and moment of inertia of section on the deflexion of struts, analogy to the case of beams suggests that the greatest deflexion consistent with stability will vary as L^2/b, b being the least breadth, and the greatest and least stress, at opposite edges of the middle section, will consequently be

$$p_1 = \frac{P}{S}\left(1 \pm \frac{aL^2}{b^2}\right),$$

where a is a coefficient depending on the material and the form of the section. This gives, for the breaking load, $P = Sf_c/(1 + aL^2/b^2)$ or $-Sf_t/(1 - aL^2/b^2)$, the smaller of the two being taken.

This formula, which is generally known as Gordon's, can be made to agree fairly with the results of experiments on struts of ordinary proportions, when the values of f as well as a are treated as empirical constants to be determined by trial with struts of the same class as those to which the formula is to be applied. Gordon's formula may also be arrived at in another way. For very short struts we have seen that the breaking load is $f_c S$, and for very long struts it is $\pi^2 EI/L^2$. If we write $P = f_c S/(1 + f_c SL^2/\pi^2 EI)$, we have a formula which gives correct values in these two extreme cases, and intermediate values for struts of medium length. By writing this $P = fS/(1 + cSL^2/I)$, and treating f and c as empirical constants, we have Gordon's formula in a slightly modified shape. Gordon's formula is largely used; it is, however, essentially empirical, and it is only by adjustment of both constants that it can be brought into agreement with experimental results.[3] For values of the constants, see BRIDGES. In the case of fixed ends, c is to be divided by 4.

73. *Bursting Strength of Circular Cylinders and Spheres.*—Space remains for the consideration of only one other mode of stress, of great importance from its occurrence in boilers, pipes, hydraulic and steam cylinders, and guns. The material of a hollow cylinder, subjected to pressure from within, is thrown into a stress of circumferential pull. When the thickness t is small compared with the radius R, we may treat this stress as uniformly distributed over the thickness. Let p be the intensity of fluid pressure within a hollow circular cylinder, and let f be the intensity of circumferential stress. Consider the forces on a small rectangular plate (fig. 42), with its sides parallel and perpendicular to the direction of the axis, of length l and width $R\delta\theta$, $\delta\theta$ being the small angle it subtends at the axis. Whatever forces act on this plate in the direction of the axis are equal and opposite. The remaining forces, which are in equilibrium, are P, the total pressure from within, and a force T at each side due to the circumferential stress. $P = plR\delta\theta$

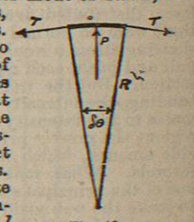

Fig. 42.

[1] See ELASTICITY, §§ 10–20.

[2] See papers by Profs. Ayrton and Perry, *The Engineer*, Dec. 10 and 24, 1886, and by T. C. Fidler, *Min. Proc. Inst. C.E.*, vol. lxxxvi. p. 261.

[3] For experiments on the breaking strength of struts, see papers by Hodgkinson, *Phil. Trans.*, 1840; Berkeley, *Min. Proc. Inst. C.E.*, vol. xxx.; Christie, *Trans. Amer. Soc. Civ. Eng.*, 1884.

and $T = flt$. But by the triangle of forces (fig. 43) $P = T\delta\theta$. Hence $f = pR/t$.

The ends of the cylinder may or may not be held together by longitudinal stress in the cylinder sides; if they are, then, whatever be the form of the ends, a transverse section, the area of which is $2\pi Rt$, has to bear a total force $p\pi R^2$. Hence, if f' be the intensity of longitudinal stress, $f' = pR/2t = \frac{1}{2}f$.

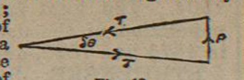

Fig. 43.

74. A thin hollow sphere under internal pressure has equal circumferential pull in all directions. To find its value consider the plate of fig. 42. There are now four equal forces T, on each of the four sides, to equilibrate the radial force P. Hence $P = 2T\delta\theta$ and $f = pR/2t$.

75. When the thickness is not small compared with the radius, the radial pressure is transmitted from layer to layer with reduced intensity, and the circumferential pull diminishes towards the outside. In the case of a thick cylinder with free ends[1] we have to deal at any point with two principal stresses, radial and circumferential, which may be denoted by p and p' respectively. Supposing (as we may properly do in dealing with a cylinder which is not very short) that a transverse section originally plane remains plane, the longitudinal strain is uniform. Since there is no longitudinal stress this strain is due entirely to the lateral action of the stresses p and p', and its amount is $(p+p')/\sigma E$. Hence at all points $p + p' = \text{constant}$.[2] Further, by considering the equilibrium of any thin layer, as we have already considered that of a thin cylinder, we have $\frac{d}{dr}(pr) = p'$.

These two equations give by integration, $p = C + C'/r^2$, and $p' = C - C'/r^2$.

If r_1 be the external and r_2 the internal radius, and p_0 the pressure on the inner surface, the conditions that $p = p_0$ when $r = r_2$ and $p = 0$ when $r = r_1$ give $C = -p_0 r_2^2/(r_1^2 - r_2^2)$ and $C' = -Cr_1^2$. Hence the circumferential stress at any radius r is $p' = -p_0 r_2^2(1 + r_1^2/r^2)/(r_1^2 - r_2^2)$. At the inside, where this is greatest, its value is $-p_0(r_1^2 + r_2^2)/(r_1^2 - r_2^2)$,—a quantity always greater than p_0, however thick the cylinder is.

In the construction of guns various devices have been used to equalize the circumferential tension. With cast guns a chilled core has been employed to make the inner layers solidify and cool first, so that they are afterwards compressed by the later contraction of the outer layers. In guns built up of wrought-iron or steel hoops the hoops are bored small by a regulated amount and are shrunk on over the barrel or over the inner hoops. In Mr Longridge's system, now under trial, the gun is made by winding steel wire or ribbon, with suitable initial tension, on a central barrel.

76. The circumferential stress at any point of a thick hollow sphere exposed to internal fluid pressure is found, by a process like that of the last paragraph, to be $-p_0 r_2^3(1 + r_1^3/2r^3)/(r_1^3 - r_2^3)$, which gives, for the greatest tension, the value

$$-p_0(r_1^3 + 2r_2^3)/2(r_1^3 - r_2^3). \qquad \text{(J. A. E.)}$$

STRICKLAND, AGNES (1806–1874), a popular historical writer, was born in 1806, the third daughter of Thomas Strickland, of Roydon Hall, Suffolk. Her first literary efforts were historical romances in verse in the style of Walter Scott,—*Worcester Field* (published without date), *Demetrius and other Poems* (1833). From this she passed to prose histories, written in a simple style for the young. A picturesque sketch of the *Pilgrims of Walsingham* appeared in 1835, two volumes of *Tales and Stories from History* in the following year. Then with the assistance of her sister she projected a more ambitious work, *The Lives of the Queens of England*, from Mathilda of Flanders to Queen Anne. The first volume appeared in 1840, the twelfth and last in 1849. Miss Strickland was a warm partisan on the side of royalty and the church, but she made industrious study of "official records and other public documents," gave copious extracts from them, and drew interesting pictures of manners and customs. While engaged on this work she found time to edit (in 1843) the *Letters of Mary, Queen of Scots*, whose innocence she championed with enthusiasm. In 1850 she followed up her *Queens of England* with the *Lives of the Queens of Scotland*, completing the series in eight volumes in 1859. Unresting in her industry, she turned next to the *Batchelor Kings of England*, about whom she published a volume in 1861. The *Lives of the Seven Bishops* followed in 1866—after a longer interval, part of which was employed in producing an abridged version of her *Queens of England*. Her last work was the *Lives of the Last Four Stuart Princesses*, published in 1872. In 1871 she obtained a civil list pension of £100 in recognition of her merits. She died at Roydon Hall on the 8th of July 1874.

A *Life* by her sister, Jane Margaret Strickland, appeared in 1887.

STRIEGAU, an industrial town of Prussia, in the province of Silesia, is situated on a small tributary of the Weistritz, 30 miles to the south-west of Breslau. In 1880 it contained 11,470 inhabitants, 6928 of whom were Protestants and 4379 Roman Catholics. Their chief occupations are tanning and the manufacture of albums, portfolios, and other articles in leather. Granite is quarried in the neighbourhood, and a trade is carried on in grain. It was near Striegau that Frederick the Great gained the important victory usually named after the village of Hohenfriedberg (June 4, 1745).

STROMBOLI. See LIPARI ISLANDS.

STRONTIUM, a metallic chemical element intermediate in its character between barium and calcium, with which it forms a natural "triad." Though widely diffused as a frequent companion of calcium (including oceanic), it occurs nowhere in abundance. Its most important mineral forms are the sulphate, $SrSO_4$, known as *Cœlestine* (from the sky-blue colour of certain varieties), and the carbonate, $SrCO_3$, called *Strontianite* because it was discovered first at Strontian, in Argyllshire, Scotland. Crawford and (independently of him) Cruickshanks in 1790 were the first to recognize the latter mineral as a thing of its own kind and different from witherite ($BaCO_3$). Hope, in 1793, proved it to be the carbonate of a new earth, which discovery was confirmed by Klaproth.

Regarding metallic strontium, see CHEMISTRY, vol. v. pp. 525–6. For the making of strontium preparations strontianite, of course, is the handier raw material, being readily convertible into (for instance) nitrate by treatment with dilute nitric acid. From the nitrate the oxide, SrO, is obtained by prolonged calcination at ultimately a bright red heat, as a greyish-white absolutely infusible and non-volatile mass, which acts violently on water with formation of the hydrate, $Sr(OH)_2$, which latter readily takes up $8H_2O$ of water to form crystals soluble in fifty parts of cold and far less of boiling water. An impure oxide is obtainable directly from strontianite by strong ignition with charcoal; and from such crude oxide pure crystals of the hydrate are easily produced by obvious operations.

In the working up of cœlestine the first step is to reduce it to sulphide, SrS, by means of charcoal at a red heat. The sulphide when boiled with water is decomposed thus:—

$$2SrS + 2H_2O = \underset{\text{Hydrate.}}{SrOH_2O} + \underset{\text{Sulph-hydrate.}}{SrSH_2S}.$$

Both products dissolve in the hot water; from the solution the S of the SrH_2S_2 is easily eliminated, by treatment with oxide of copper or oxide of zinc, as insoluble metallic sulphide; the filtrate on cooling gives crystals of pure hydrate. From it any strontia salt of course is easily made by means of the respective acid; in many cases the salt wished for can be obtained similarly from the sulphide.

Nitrate of strontia from hot solutions crystallizes in anhydrous octahedra, SrN_2O_6, soluble in about $\frac{1}{2}$ part of boiling and in 5 parts of cold water. From colder solutions hydrated crystals, $SrN_2O_6 + 4H_2O$, separate out. The anhydrous salt is used largely by pyrotechnists for the making of "red fire."

The hydroxide some years ago promised to play an important part in the sugar industry as a precipitant for the cane-sugar known to be present largely in uncrystallizable molasses (see SUGAR), but the process so far has failed to take root in industry.

[1] This condition is realized in practice when the fluid causing internal pressure is held in by a piston, and the stress between this piston and the other end of the cylinder is taken by some other part of the structure than the cylinder sides.

[2] The solution which follows in the text is applicable even when there is longitudinal stress, provided that the longitudinal stress is uniformly distributed over each transverse section. If we call this stress p'', the longitudinal strain is $p''/E + (p+p')/\sigma E$. Since the whole strain is uniform, and p'' is uniform, the sum of p and p' is constant at all points, as in the case where the ends are free.

Analysis.—To detect strontium in a salt-solution, we first eliminate the heavy metals by the successive application of sulphuretted hydrogen (and free acid) and of sulphide of ammonium in the presence of ammonia and sal-ammoniac. From the filtrate carbonate of ammonia (in the heat) precipitates only the barium, strontium, and calcium as carbonates, which are filtered off and washed with hot water. The analysis of the precipitate is difficult; but any strontia in it is easily detected by means of the spectroscope (see SPECTROSCOPY).

STROPHANTHUS, a genus of plants of the natural order *Apocyneæ*, deriving its name from the long twisted thread-like segments of the corolla, which in one species attain a length of 12 or 14 inches. The genus at present comprises about 18 species, confined to tropical Africa and Asia, only one species, indigenous to the former continent, being known outside the tropics. Several of the African species furnish the natives of the countries in which they grow with the principal ingredient in their arrow poisons. The inée or onaye poison of the Gaboon, the kombé poison of equatorial North Africa, the arquah poison of the banks of the Niger, and the wanika poison of Zanzibar are all derived from members of this genus. The exact species used in each case cannot be said to be accurately known. There is little doubt, however, that *S. hispidus*, D.C., is the one most frequently employed.

Two of the arrow poisons have been chemically and physiologically examined. The kombé poison was subjected to some preliminary experiments in 1862 by Prof. Sharpey, but was more fully examined a few years subsequently by Prof T. R. Fraser. From the investigations of the latter[1] it appears that the kombé arrow poison, when given in fatal doses, paralyses the action of the heart. In minute doses, however, it possesses a tonic action on that organ. Since the practical value of strophanthus as a medicinal agent has been pointed out by Prof. Fraser, it has been used with considerable success in some forms of heart-disease. The chemical examination showed that its activity is due to a glucoside, which has been named strophanthin. The wanika arrow poison has been examined physiologically by Dr Sydney Ringer and chemically by Mr A. W. Gerrard. Its active principle, a glucoside, was found to resemble strophanthin in its action. Chemically also, as obtained by Mr Gerrard, it seems to be identical with strophanthin.[2] It is soluble in alcohol and water, but insoluble in ether and chloroform; it evolves ammonia when heated with soda-lime, but gives only a slight brown coloration when treated with strong sulphuric acid.

Both *S. hispidus* and *S. Kombe* have hairy seeds with a slender thread-like appendage, terminating in a feathery tuft of long silky hairs, the seeds of the former being coated with short appressed brown hairs, and those of the latter with white hairs; but in the species used at Delagoa Bay and called "umtsuli" the thread-like appendage of the seed is absent. According to information furnished by Messrs T. Christy & Company of London, and obtained from a correspondent on the Zanzibar coast, the natives pound the seeds into an oily mass, which assumes a red colour, portions of this mass being smeared on the arrow immediately behind the barb.

See *Icones Plantarum*, No. 4, 1870; Pelikan, *Arch. Gen. de Médicine*, July 1865, p. 115; Van Hasselt, *Arch. Neerl. des Sc.*, [2], vii., 1872, p. 161; *Arch. de Physiol.*, No. 5, 1872, p. 526; *Rapport sur l'Inaye*, Paris, 1877, 8vo.

STROUD, a market-town of Gloucestershire, is situated on the Swindon and Gloucester branch of the Great Western Railway, on a branch of the Midland Railway, and on the Thames and Severn Junction Canal, 10 miles south of Gloucester and 30 north-east of Bristol. It is picturesquely situated on an eminence environed by higher hills, but is built in a somewhat straggling and irregular fashion. Among the principal buildings are the town-hall, built in the reign of Elizabeth, the Lansdown hall (1879), the Badbrook hall (1869), with reading-room and large room for concerts, the subscription rooms (1834), and the hospital, erected in 1875 at a cost of £8754, to replace the dispensary erected in 1823. The town is the principal seat of the west of England cloth manufacture, and possesses very extensive mills. There are also silk mills, scarlet-dye works, breweries, logwood-crushing mills, and flour-mills. Stroud at the time of the Norman survey was part of Bisley parish, from which it was separated in 1304. The local board was established in 1857. The population of the urban sanitary district (area 999 acres) in 1871 was 7082, and in 1881 it was 7848.

[1] See *Proc. Roy. Soc. Edin.*, 1869-1870, p. 99; reprinted in *Jour. Anat. and Physiol.*, vol. vii. pp. 140-155.

[2] *Pharm. Jour.*, [3], xi. pp. 834, 835.

STRUENSEE, JOHANN FRIEDRICH, COUNT (1737-1772), Danish statesman, was of German extraction, and was born August 5, 1737, at Halle, where his father Adam Struensee, of some eminence as a hymn writer, was pastor. He graduated M.D. at Halle in 1756, and obtained the office of physician to the town of Altona through the influence of his father, who had removed thither. On account, however, of a change in his religious views he quarrelled with his father, and for some time he led an unsettled life, until in 1768 he was appointed personal physician to the young king, Christian VII. of Denmark, whom he accompanied on a tour through England, France, Holland, and Germany. The influence he exercised over the almost imbecile king awakened at first the jealousy of the queen, Caroline Matilda, a daughter of George II., but, having had occasion to attend her for a severe malady, he won her complete confidence also, and became equally the favourite of both. When therefore in 1770 he was appointed master of requests, he virtually took the government of the kingdom into his own hands, and on the 20th September the council of state was superseded. Though acting as an absolutist, his sympathies were democratic, and he used his position to promote the general benefit of the people and to curb the influence of the nobility. The extent of his reforms, and the suddenness with which they were introduced, had all the practical effect of a revolution. They included the enfranchisement of the peasants, complete religious toleration, the abolition of commercial restrictions, the reorganization of the army, and the introduction of examinations for public offices. His reforms were received with consternation, and a conspiracy was entered into to effect his overthrow. The queen dowager persuaded Christian VII. that Struensee was carrying on an intrigue with the queen, and had entered into a plot to assassinate him, in order that he might rule as regent. He and his friend Count Brandt were consequently arrested on 20th February 1772. The attempt to prove that he had been unfaithful in his duty as minister to the king failed, but he did not deny the *liaison* with the queen, and he and Count Brandt were both beheaded and quartered on the 28th April (see DENMARK, vol. vii. p. 87).[3]

See *Leben und Begebenheiten der Grafen Struensee und Brandt*, 1772; *Memoirs of an Unfortunate Queen*, London, 1776; Höst, *Struensee og hans Ministerium*, Copenhagen, 1824; Jenssen-Tusch, *Die Verschwörung gegen die Königin Karoline Mathilde und die Gräfen Struensee und Brandt, nach bisher ungedrückten Originalacten*, Leipsic, 1864; Wraxall, *Life and Times of Queen Caroline*, 1864; K. Wittich, *Struensee*, Leipsic, 1879.

STRUVE, FRIEDRICH GEORG WILHELM (1793-1864), astronomer, was born at Altona on April 15, 1793. In 1808 he entered the university of Dorpat, where he first studied philology, but soon turned his attention to astronomy. In 1813 he was appointed observer in the new university observatory and a few years later professor of astronomy. He remained in Dorpat, occupied with researches on double stars and in geodetic work, till 1839, when he removed to Pulkova, near St Petersburg, as director of the new Central Observatory. Here he continued his activity until he was obliged to retire (in 1861) owing to failing health. He died at St Petersburg on November 23, 1864.

[3] Carl Gustav Struensee von Carlsbach, elder brother of Johann Friedrich, born at Halle 18th August 1735, attained high eminence in the service of Prussia. He was ennobled in 1789, became minister of finance and president of the excise department in 1791, and died at Berlin 17th October 1804.

Struve's name is best known by his observations of double stars, which he carried on for many years. These bodies had first been regularly measured by W. Herschel, who discovered that many of them formed systems of two stars revolving round their common centre of gravity. After him J. Herschel (and for some time South) had observed them, but their labours were eclipsed by the systematic and more extensive ones of Struve. With the 9½-inch refractor at Dorpat he discovered a great number of double stars, and published in 1827 a list of all the known objects of this kind (*Catalogus Novus Stellarum Duplicium*). His micrometric measurements of 2714 double stars were made from 1824 to 1837, and are contained in his principal work *Stellarum Duplicium et Multiplicium Mensuræ Micrometricæ* (St Petersburg, 1837, fol.; a convenient summary of the results is given in vol. i. of the *Dunecht Observatory Publications*, 1876). The places of the objects were at the same time determined with the Dorpat meridian circle (*Stellarum Fixarum Imprimis Duplicium et Multiplicium Positiones Mediæ*, St Petersburg, 1852, fol.). At Pulkova he determined anew the constant of aberration, but was chiefly occupied in working out the results of former years' work and in the completion of the geodetic operations in which he had been engaged during the greater part of his life. He had commenced them with a survey of Livonia (1816-19), which was followed by the measurement of an arc of meridian of more than 3½° in the Baltic provinces of Russia (*Beschreibung der Breitengradmessung in den Ostseeprovinzen Russlands*, 2 vols. 4to, Dorpat, 1831). This work was afterwards extended by Struve and General Tenner into a measurement of a meridional arc from the north coast of Norway to Ismail on the Danube (*Arc du Méridien de 25° 20' entre le Danube et la Mer Glaciale*, 2 vols. and 1 vol. plates, St Petersburg, 1857-60, 4to).

STRY, or STRYJ, a town of Galicia, Austria, is pleasantly situated on a tributary of the Dniester, about 40 miles to the south of Lemberg. In 1880 it contained 12,625 inhabitants, chiefly engaged in tanning and the manufacture of matches. In 1886, however, the town was almost wholly destroyed by fire, and its population was greatly reduced by the wholesale migration and deaths from privation consequent upon this calamity.

STRYCHNINE. See POISONS, vol. xix. p. 279, and NUX VOMICA, vol. xvii. p 687.

STRYPE, JOHN (1643-1737), historian and biographer, was the son of John Strype or Van Stryp, a native of Brabant, who to escape religious persecution went to England, and settled near London, in a locality afterwards known as Strype's Yard, formerly in the parish of Stepney, but subsequently annexed to that of Christ Church, Spitalfields. Here he carried on the business of a merchant and silk throwster. The son was born 1st November 1643. He was educated at St Paul's School, and on 5th July 1662 entered Jesus College, Cambridge. Thence he proceeded to Catherine Hall, where he graduated B.A. in 1665 and M.A. in 1669. On the 14th July of the latter year he was preferred to the curacy of Theydon-Bois, Essex, and a few months afterwards was chosen curate and lecturer of Low Leyton in the same county. On account of the smallness of the salary, the patron allowed the people to choose their own minister, the vacancy in the vicarage remaining unfilled during the life of Strype. He was never instituted or inducted, but in 1674 he was licensed by the bishop of London to preach and expound the word of God, and to perform the full office of priest and curate during the vacancy of the vicarage. In his later years he obtained from Archbishop Tenison the sinecure of Tarring, Sussex, and he discharged the duties of lecturer at Hackney till 1724. When he became infirm he took up his residence with Mr Harris, an apothecary at Hackney, who had married his daughter, and died there 11th December 1737 at the advanced age of ninety-four.

At an early period of his life Strype obtained access to the papers of Sir Michael Hicks, secretary to Lord Burghley, from which he made extensive transcripts; he also carried on an extensive correspondence with Archbishop Wake and Bishops Burnet, Atterbury, and Nicholson. The materials thus obtained formed the basis of his historical and biographical works, which relate chiefly to the period of the Reformation. The greater portion of his original materials have been preserved, and are included in the Lansdowne manuscripts in the British Museum. His works can scarcely be entitled original compositions, his labour having consisted chiefly in the arrangement of his materials, but on this very account they are of considerable value as convenient books of reference, easier of access and almost as trustworthy as the original documents. Besides a number of single sermons published at various periods, he was the author of an edition of Lightfoot's *Works*, vol. ii., 1684; *Memorials of Archbishop Cranmer*, 1694; *Life of Sir Thomas Smith*, 1698; *Life and Actions of John Aylmer, Bishop of London*, 1701; *Life of Sir John Cheke, with his Treatise on Superstition*, 1705; *Annals of the Reformation in England*, 4 vols., vol. i. 1709 (reprinted 1725), vol. ii. 1725, vol. iii. 1728, vol. iv. 1731; 2d ed. 1735, 4 vols.; 3d ed. 1736-38, 4 vols.; *Life and Actions of Edmund Grindal, Archbishop of Canterbury*, 1710, *of Matthew Parker, Archbishop of Canterbury*, 1711, and *of John Whitgift, Archbishop of Canterbury*, 1818; *An Accurate Edition of Stow's Survey of London*, 1720, 2 vols. fol., the standard edition of Stow and of great value, although its interference with the original text is a method of editing which can scarcely be reckoned fair to the original author; and *Ecclesiastical Memorials*, 1721, 3 vols.; 1733, 3 vols.; new ed. 1816. His *Historical and Biographical Works* were published in 10 vols., with a general index, 1820-40.

STUART, STEWART, or STEUART, the surname of a family who became heirs to the Scottish and ultimately to the English crown. Their descent is traced to a Norman baron Alan, whose eldest son William became progenitor of the earls of Arundel, and whose two younger sons Walter and Simon came to Scotland, Walter being appointed high steward of David I., who conferred on him various lands in Renfrewshire, including Paisley, where he founded the abbey in 1160. Walter, his grandson, third steward, was appointed by Alexander II. justiciary of Scotland, and, dying in 1246, left four sons and three daughters. The third son Walter obtained by marriage the earldom of Menteith, which ultimately came by marriage to Robert, duke of Albany, third son of Robert II. Alexander, fourth steward, the eldest son of Walter, third steward, inherited by his marriage with Jean, granddaughter of Somerled, the islands of Bute and Arran, and on 2d October 1263 defeated Haco at Largs. He had two sons, James and John. The latter, who commanded the men of Bute at the battle of Falkirk in 1298, had seven sons:—(1) Sir Alexander, whose grandson became in 1389 earl of Angus, the title afterwards passing in the female line to the Douglases, and in 1761 to the duke of Hamilton; (2) Sir Alan of Dreghorn, ancestor of the earls and dukes of Lennox, from whom Lord Darnley, husband of Queen Mary, and also Arabella Stuart, were descended; (3) Sir Walter, who obtained the barony of Garlies, Wigtownshire, from his uncle John Randolph, earl of Moray, and was the ancestor of the earls of Galloway, younger branches of the family being the Stewarts of Tonderghie, Wigtownshire, and also those of Physgill and Glenturk in the same county; (4) Sir James, who fell at Dupplin in 1332, ancestor of the lords of Lorn, on whose descendants were conferred at different periods the earldoms of Athole, Buchan, and Traquair, and who were also the progenitors of the Stewarts of Appin, Argyllshire, and of Grandtully, Perthshire; (5) Sir John, killed at Halidon Hill in 1333; (6) Sir Hugh, who fought under Edward Bruce in Ireland; and (7) Sir Robert of Daldowie, ancestor of the Stewarts of Allanton and of Coltness. James Stewart, the eldest son of Alexander, fourth steward, succeeded his father in 1283, and, after distinguishing himself in the wars of Wallace and of Bruce, died in 1309. His son Walter, sixth steward, who had joint command with Douglas of the left wing at the battle of Bannockburn, married Marjory, daughter of Robert the Bruce, and during the latter's absence in Ireland was entrusted with the government of the kingdom. He died in 1326, leaving an only son, who as Robert II. ascended the throne of Scotland in 1370 (see vol. xxi. p. 490). Sir Alexander Stewart, earl of Buchan, fourth son of

Robert II., who earned by his ferocity the title of the "Wolf of Badenoch," inherited by his wife the earldom of Ross, but died without legitimate issue, although from his illegitimate offspring were descended the Stewarts of Belladrum, of Athole, of Garth, of Urrard, and of St Fort. On the death of the "Wolf of Badenoch" the earldom of Buchan passed to his brother Robert, duke of Albany, also earl of Fife and earl of Menteith, but these earldoms were forfeited on the execution of his son Murdoch in 1425, the earldom of Buchan again, however, coming to the house of Stewart in the person of James, second son of Sir James Stewart, the black knight of Lorn, by Johanna, widow of King James I. From Murdoch, duke of Albany, were descended the Stewarts of Ardvoirlich and other families of the name in Perthshire, and also the Stuarts of Inchbreck and Laithers, Aberdeenshire. From a natural son of Robert II. were descended the Steuarts of Dalguise, Perthshire, and from a natural son of Robert III. the Shaw Stewarts of Blackhall and Greenock. The direct male line of the royal family terminated with the death of James V. in 1542, whose daughter Mary was the first to adopt the spelling "Stuart." Mary was succeeded in her lifetime in 1567 by her only son James VI., who through his father Lord Darnley was also head of the second branch, there being no surviving male issue of the family from progenitors later than Robert II. In James V., son of James IV. by Margaret, daughter of Henry VII., the claims of the English junior branch became merged in the Scottish line, and on the death of Queen Elizabeth of England, last surviving offshoot of Henry VIII., James VI. of Scotland, lineally the nearest heir, was proclaimed king of England, in accordance with a declaration of Elizabeth that no minor person should ascend the throne, but her cousin the king of Scots. The accession of James was, however, contrary to the will of Henry VIII., which favoured the Suffolk branch, whose succession would probably have marvellously altered the complexion of both Scottish and English history. As it was, the only result of that will was a tragedy initiated by Elizabeth, but consummated by James, so as to clothe his memory with deep disgrace. In the Scottish line the nearest heir after James VI., both to the Scottish and English crowns, was Arabella Stuart, only child of Charles, earl of Lennox, younger brother of Lord Darnley,—Lady Margaret Douglas, the mother of Darnley and his brother, having been the daughter of Archibald, sixth earl of Angus by Margaret, queen dowager of James IV. James VI. (I. of England) was thus nearest heir of the junior English branch by a double descent, Arabella Stuart being next heir by a single descent. On account of the descent from Henry VII., the jealousy of Elizabeth had already caused her to imprison Arabella's mother (Elizabeth, daughter of Sir William Cavendish) on learning that she had presumed to marry Lennox. The daughter's marriage she was determined by every possible means to prevent. She objected when King James proposed to marry her to Lord Esme Stuart, whom he had created duke of Lennox, but when the appalling news reached her that Arabella had actually found a lover in William Seymour, grandson of Catherine Grey, heiress of the Suffolk branch, she was so deeply alarmed and indignant that she immediately ordered her imprisonment. This happened immediately before Elizabeth's death, after which she obtained her release. Soon after the accession of James a conspiracy, of which she was altogether ignorant, was entered into to advance her to the throne, but this caused no alteration in her treatment by James, who allowed her a maintenance of £800 a year. In February 1610 it was discovered that she was engaged to Seymour, and, although she then promised never to marry him without the king's consent, the marriage took place secretly in July following. In consequence of this her husband was sent to the Tower, and she was placed in private confinement. Though separated, both succeeded in escaping simultaneously on 3d June 1611; but, less fortunate than her husband, who got safe to the Continent, she was captured at the Straits of Dover, and shut up in the Tower. Her hopeless captivity deprived her of her reason before her sorrows were ended by death, 27th September 1615.

By the usurpation of Cromwell the Stuarts were excluded from the throne from the defeat of Charles I. at Naseby in 1645 until the restoration of his son Charles II. in 1661. Carlyle refers to the opinion of genealogists that Cromwell "was indubitably either the ninth or the tenth or some other fractional part of half a cousin of Charles Stuart," but this has been completely exploded by Walter Rye, in the *Genealogist* ("The Steward Genealogy and Cromwell's Royal Descent," new ser., vol. ii. pp. 34–42). On the death of Charles II. without issue in 1685, his brother James, duke of York, ascended the throne as James II., but he so alienated the sympathies of the nation by his unconstitutional efforts to further the Catholic religion that an invitation was sent to the prince of Orange to come "to the rescue of the laws and religion of England." Next to the son of James II., still an infant under his father's control, Mary, princess of Orange, eldest daughter of James II., had the strongest claim to the crown; but neither were the claims of the prince, even apart from his marriage, very remote, since he was the son of Mary, eldest daughter of Charles I. The marriage had strengthened the claims of both, and they were proclaimed joint sovereigns of England on 12th February 1689, Scotland following the example of England on the 11th April. They had no issue, and the Act of Settlement passed in 1701, excluding Catholics from the throne, secured the succession to Anne, second daughter of James II., and on her death without issue to the Protestant House of Hanover, descended from the princess Elizabeth, daughter of James I., wife of Frederick, count palatine of the Rhine. On the death of Anne in 1714, George, elector of Hanover, eldest son of Sophia, electress of Hanover (only surviving child of the princess Elizabeth), and Ernest, youngest son of George, duke of Brunswick, consequently became sovereign of Great Britain and Ireland, and, notwithstanding somewhat formidable attempts in behalf of the elder Stuart line in 1715 and 1745, the Hanoverian succession has remained uninterrupted, and has ultimately won universal assent. The female line of James II. ended with the death of his daughter, Queen Anne. James, called James III. by the Jacobites and the Old Pretender by the Hanoverians, had two sons,—Charles Edward, the Young Pretender, who died without legitimate issue in 1780, and Henry, titular duke of York, commonly called Cardinal York, at whose death in 1807 the male line of James II. came to an end. He was also the last lineal male representative of any of the crowned heads of the race, so far as either England or Scotland was concerned, and excepting of course the Hanoverian line. In the female Stuart line there are, however, still nearer heirs to the throne than those of the Hanoverian line, viz., the descendants of Henrietta, duchess of Orleans, daughter of Charles I., represented now only in Maria Theresa, married to Prince Louis Leopold of Bavaria, and their nine children. The male representation of the family, being extinct in the royal lines, is claimed by the earls of Galloway and also by the Stewarts of Castlemilk, but the claims of both are more than doubtful.

See Sir George Mackenzie's *Defence of the Royal Line of Scotland*, 1685, and *Antiquity of the Royal Line of Scotland*, 1686; Crawfurd's *Genealogical History of the Royal and Illustrious Family of the Stuarts*, 1710; Duncan Stewart's *Genealogical Account of the Surname of Stewart*, 1739; Andrew Stuart's *Genealogical History of the Stuarts*, 1798; Stothert's *House of Stuart*, privately printed, 1855; *An Abstract of the Evidence to prove that Sir William Stewart of Jedworth, the Paternal Ancestor of the Present Earl of Galloway, was the Second Son of Sir Alexander Stewart of Darnley*, 1801; Townend's *Descendants of the Stuarts*, 1858; Bailey, *The Succession to the English Crown*, 1879. (T. F. H.)

STUART, Gilbert (1755–1828), a distinguished American portrait-painter, was born in Narragansett, Rhode Island, U.S., December 3, 1755. His father, a native of Perth, Scotland, and the son of a Presbyterian minister, had set up a snuff-mill in Narragansett, in company with another Scotsman, Dr Thomas Moffatt, and was known as "the snuff-grinder." The father removed early to Newport, where his son had the advantage of good instruction. He began to draw early, but none of his sketches have been preserved. His first known pictures are of two Spanish dogs, and two portraits, the latter painted when he was thirteen years old, and now in the Redwood Library, Newport. In 1770–71 he received some instruction from a Scottish artist named Cosmo Alexander, who took him to Scotland with him; but, this patron dying soon after his arrival, Stuart, after struggling for a while at the university of Glasgow, had to work his way home in a collier. In the spring of 1775 he sailed again for England, and became the pupil and assistant of Benjamin West, with whom he painted until 1785, when he set up a studio of his own. One of his best pictures of this period is a full-length portrait of W. Grant of Congalton skating in St James's Park, now at Moor Court, Stroud, in the possession of Lord Charles Pelham Clinton. Two fine half-lengths by Stuart are in the National Gallery—his preceptor Benjamin West and the engraver Woolett. Stuart married in London and remained there, with the exception of a short visit to Dublin in 1788, until 1792, when he returned to America. Early in 1795 Stuart painted his first head of Washington. This portrait exhibits the right side of the face, and, although the least familiar, is undoubtedly the truest of the three portraits of Washington from his hand. The second was a full-length for the marquis of Lansdowne, and the third a vignette head now belonging to the Athenæum in Boston, U.S. These last two show the left side of the face, and, although they are the readily recognized "Stuart's Washington," are unsatisfactory as portraits and inferior as works of art. There are sixty-one replicas of these three pictures, and they have been engraved more than two hundred times. In the catalogue of Stuart's works are recorded seven hundred and fifty-four portraits. Stuart remained in Philadelphia, where he painted many of the prominent men of the country, until 1803, when he removed to Washington; two years later he went to Boston, where he died July 27, 1828.

Stuart's pictures have been little injured by time, which is doubtless owing to his use of pure colours and to his manner of employing them. His practice was to lay all the tints in their places separately and distinctly alongside of each other before any blending was used, and then they were united by means of a large soft brush and without corrupting their freshness. It is this method that gives the firmness and solidity to his flesh work. A marked feature of Stuart's work is the total absence of all lines, his work being painted in with the brush from the beginning. It is this process that gives to his modelling its strength and rotundity. Stuart was pre-eminent as a colourist, and his place, judged by the highest canons in art, is unquestionably among the few recognized masters of portraiture.

STUART, John M'Douall (1818–1866), a South-Australian explorer, was born in England in 1818 and arrived in the colony about 1839. He accompanied Captain Sturt's 1844–45 expedition as draughtsman, and between 1858 and 1862 he made six expeditions into the interior, the last of which brought him on July 24 to the shores of the Indian Ocean at Port Darwin, the first to have crossed the island continent from south to north. It was this transcontinental expedition which led to the territorial rights, and, in defiance of geographical position, the name of South Australia being extended over so much of central and north Australia. Stuart was rewarded with £3000 and a grant of 1000 square miles of grazing country in the interior rent free for seven years. His name is perpetuated by Central Mount Stuart. He died in England June 5, 1866.

STUHLWEISSENBURG (Hung. *Székes-Fehérvár*; Lat. *Alba Regia*), the capital of the county of Fehér, and in former times also of Hungary, is situated in 47° 11′ N. lat. and 18° 25′ E. long., in a fertile plain. It is the see of one of the oldest bishoprics in the country, and has a number of religious charities, convents, and nunneries, a seminary, a gymnasium, and a real school. It was the coronation and burial place of the Hungarian kings from the 10th to the 16th century, but has sunk into comparative insignificance. A few years ago some very remarkable excavations were made here. The town is now chiefly agricultural; its fairs, especially for horses, are famous. The population (1885) numbers 27,000.

STURGEON. Sturgeons (*Acipenser*) are a small group of fishes, of which some twenty different species are known, from European, Asiatic, and North American rivers. The distinguishing characters of this group, as well as its position in the system, have been sufficiently indicated in the article Ichthyology (vol. xii. p. 687). They pass a great part of the year in the sea, but periodically ascend large rivers, some in spring to deposit their spawn, others later in the season for some purpose unknown; only a few of the species are exclusively confined to fresh water. None occur in the tropics or in the southern hemisphere.

Sturgeons are found in the greatest abundance in the rivers of southern Russia, more than ten thousand fish being sometimes caught at a single fishing-station in the fortnight during which the up-stream migration lasts. They occur in less abundance in the fresh waters of North America, where their capture is not confined to the rivers, the majority being caught in shallow portions of the shores of the great lakes. In Russia the fisheries are of immense value; yet but little is known of the sturgeon's habits, life, and early stages of development or growth. Early in summer the fish migrate into the rivers or towards the shores of freshwater lakes in large shoals for breeding purposes. The ova are very small, and so numerous that one female has been calculated to produce about three millions in one season. The ova of some species have been observed to hatch within a very few days after exclusion. Probably the growth of the young is very rapid, but we have no knowledge as to the length of time for which the fry remain in fresh water before their first migration to the sea. After they have attained maturity their growth appears to be much slower, although continuing for many years. Frederick the Great attempted to introduce the sterlet into Prussia, and placed a number of this fish in the Görland Lake in Pomerania about 1780; some of these were found to be still alive in 1866, and therefore had reached an age of nearly ninety years. Prof. Von Baer also states, as the result of direct observations made in Russia, that the hausen (*Acipenser huso*) attains to an age of from 200 to 300 years. Sturgeons ranging from 8 to 11 feet in length are by no means scarce, and some species grow to a much larger size.

Sturgeons are ground-feeders. With their projecting wedge-shaped snout they stir up the soft bottom, and by means of their sensitive barbels detect shells, crustaceans, and small fishes, on which they feed. Destitute of teeth, they are unable to seize larger prey.

In countries like England, where few sturgeons are