he was at any rate the first to show what conjecture could do towards restoring a hopelessly corrupt passage. The work, however, on which his fame as a scholar is most surely based is the *Thesaurus Græcæ Linguæ*. After making due allowance for the fact that considerable materials for the work had been already collected by his father, and that he received considerable assistance from the German scholar Sylburg, he is still entitled to the very highest praise as the producer of a work which was of the greatest service to scholarship and which in those early days of Greek learning could have been produced by no one but a giant. Two editions of the *Thesaurus* have been published in this century—at London by Valpy (1815–25) and at Paris by Didot (1831–63). It was one of Henri Estienne's great merits that, unlike nearly all the French scholars who preceded him, he did not neglect his own language. While Budé wrote French with difficulty and considered it hardly a fit language for a scholar to use, Henri Estienne was loud in its praises and gave practical proof of its capabilities. Of his French writings three were devoted to this theme:—(1) *Conformité du Langage François avec le Grec* (published in 1575, but without date; ed. L. Feugère, 1850), in which French is shown to have, among modern languages, the most affinity with Greek, the first of all languages; (2) *Deux Dialogues du nouveau François Italianizé* (Geneva, 1578; reprinted, 2 vols., 1883), directed against the fashion prevailing in the court of Catherine de' Medici of using Italian words and forms; (3) *Project du Livre Intitulé de la Precellence du Langage François* (Paris, 1579; ed. Feugère, 1853), which treats of the superiority of French to Italian. An interesting feature of this tract is the account of French proverbs, and, Henry III. having expressed some doubts as to the genuineness of some of them, Henri Estienne published, in 1594, (4) *Les Premices ou le I. Livre des Proverbes Epigrammatizez* (never reprinted and very rare). Finally, there remains (5) the *Apologie pour Hérodote*, the work by virtue of which Henri Estienne belongs to literature. The ostensible object of the book is to show that the strange stories in Herodotus may be paralleled by equally strange ones of modern times. Virtually it is a bitter satire on the writer's age, especially on the Roman Church. Put together without any method, its extreme desultoriness makes it difficult to read continuously, but the numerous stories, collected partly from various literary sources, notably from the preachers Menot and Maillard, partly from the writer's own multifarious experience, with which it is packed, make it an interesting commentary on the manners and fashions of the time. But satire, to be effective, should be either humorous or righteously indignant, and, while such humour as there is in the *Apologie* is decidedly heavy, the writer's indignation is generally forgotten in his evident relish for scandal. The style is, after all, its chief merit. Though it bears evident traces of hurry, it is, like that of all Henri Estienne's French writings, clear, easy, and vigorous, uniting the directness and sensuousness of the older writers with a suppleness and logical precision which at this time were almost new elements in French prose. An edition of the *Apologie* has recently been published by Liseux (ed. Ristelhuber, 2 vols., 1879), after one of the only two copies of the original uncancelled edition that are known to exist. The very remarkable political pamphlet entitled *Discours Merveilleux de la Vie et des Déportements de Catherine de Médicis*, which appeared in 1574, has been ascribed to Henri Estienne, but the evidence both internal and external is conclusive against his being the author of it. Of his Latin writings the most worthy of notice are the *De Latinitate falso suspecta* (1576), the *Pseudo-Cicero* (1577), and the *Nizoliodidascalus* (1578), all three written against the Ciceronians, and the *Francofordiense Emporium* (1574), a panegyric on the Frankfort fair (reprinted with a French translation by Liseux, 1875). He also wrote a large quantity of indifferent Latin verses, including a long poem entitled *Musa Monitrix Principum* (Basel, 1590).

The primary authorities for an account of the Estiennes are their own works. In the garrulous and egotistical prefaces which Henri was in the habit of prefixing to his editions will be found many scattered biographical details. Twenty-seven letters from Henri to John of Crafftheim (Crato) (ed. F. Passow, 1830) have been printed, and there is one of Robert's in Herminjard's *Correspondance des Réformateurs dans les Pays de Langue Française* (7 vols. published), while a few other contemporary references to him will be found in the same work. The secondary authorities are Janssen van Almeloveen, *De Vitis Stephanorum* (Amst., 1683); Maittaire, *Stephanorum Historia* (Lond., 1709); A. A. Rénouard, *Annales de l'Imprimerie des Estienne* (2d ed., Paris, 1843); the article on Estienne by A. F. Didot in the *Nouv. Biog. Gén.*; and an article by Mark Pattison in the *Quart. Rev.* for April 1865. There is a good account of Henri's *Thesaurus* in the *Quart. Rev.* for January 1820, written by Bishop Blomfield. (A. A. T.)

STEPHENS, Alexander Hamilton (1812–1883), American statesman, was born in Georgia, February 11, 1812. In spite of many difficulties imposed by poverty and ill-health, he became a lawyer and politician of great reputation and popularity. He was one of the Whig leaders of his State until about 1850, and then drifted into the Democratic party through the rising discussions of slavery, serving in Congress from 1843 until 1859. In 1860 he opposed secession warmly; but when his State had seceded he "followed his State," and was elected vice-president of the Confederate States. Whatever there was of opposition to the despotic tendencies of Jefferson Davis gathered around Stephens as a centre; and the vice-president was never an influential member of the Confederate administration. His popularity in Georgia was unbounded, and he was elected representative in Congress in 1877–82, and governor, 1882–83, dying in office. In person he was small and extremely emaciated, seldom weighing more than 90 pounds, and always in delicate health; but his powers as an orator were remarkable.

Cleveland's *A. H. Stephens in Public and Private* and Johnston and Browne's *Life of A. H. Stephens* are the main authorities for Stephens's life. His political opinions are fully given in his work, *The War between the States.*

STEPHENS, John Lloyd (1805–1852), traveller, was born 28th November 1805, at Shrewsbury, N.J., United States. Having been admitted to the bar, he practised his profession for about eight years in New York city. In 1834, the state of his health rendering it advisable that he should travel, he visited Europe, and for two years made a tour through many countries of that continent, extending his travels to Egypt and Syria. On his return to New York he published (under the name of "George" Stephens) in 1837 *Incidents of Travel in Egypt, Arabia Petræa, and the Holy Land.* This work was followed next year by the publication, also in two volumes, of *Incidents of Travel in Greece, Turkey, Russia, and Poland.* In 1839 Stephens arranged with Frederick Catherwood of London, who had accompanied him on some of his travels, and illustrated the above-mentioned publications, that they should make an exploration together in Central America, with a view to discovering and examining ancient art said to exist in the dense forests of that tropical region. Stephens, meantime, was appointed United States minister to Central America. The joint travels of Stephens and F. Catherwood occupied some eight months in 1839 and 1840. As the result of these researches Stephens published in 1841 *Incidents of Travels in Central America, Chiapas, and Yucatan.* In the autumn of 1841 the two travellers made a second exploration of Yucatan, the fruits of which were gathered up in a work published by Stephens in 1843,—*Incidents of Travel in Yucatan.* This work describes the most extensive travels executed till that date by a stranger in the peninsula, and, as the author claims, "contains account of visits to forty-four ruined cities or places in which remains or vestiges of ancient populations were found." It fixed the sites of many prehistoric cities and supplied correct delineations of their existing monuments. This publication enjoyed a wide popularity, and made such an impression on Prescott the historian that he urged Stephens to prosecute his researches of American antiquities in Peru. Stephens was, however, disinclined to so distant an expedition. He became a director of the newly-formed American Ocean Steam Navigation Company, which established the first American line of trans-Atlantic steamships. He visited Panama to reconnoitre the ground with a view to the construction of a railway across the isthmus, and, first as vice-president and then as president of the Panama Railway Company, spent the greater part of two years in superintending the project. His health was, however, entirely undermined by his long and incautious exposure to the deadly climate of Central America, and he died at New York on the 10th October 1852.

Stephens made no pretensions to the title of a scientific traveller. He had, however, a natural curiosity after all kinds of human knowledge, shrewd and accurate powers of observation, and a more than common measure of perseverance, tact, and resource.

STEPHENSON, George (1781–1848), perfecter of the locomotive, was the son of Robert Stephenson, fireman of a colliery engine at Wylam, near Newcastle, where he was born 9th June 1781. In boyhood he was employed as a cowherd, and occupied his leisure in erecting clay engines and similar mechanical amusements. Afterwards he drove the ginhorse at a colliery, and in his fourteenth year became assistant to his father in firing the engine at a shilling a day. He set himself diligently to qualify himself for higher duties, and in his seventeenth year was appointed engineman or plugman. As yet he was unable to read, but, stimulated by the desire to obtain fuller information regarding the wonderful inventions of Boulton and Watt, he began in his eighteenth year to attend a night school, and soon made remarkably rapid progress. In 1801 he obtained the situation of brakesman, and in 1812 was appointed engine-wright at Killingworth high pit at a salary of £100 a year. Meantime he had been employing his leisure in watch and clock cleaning, in studying mechanics, and in various experiments with a view of solving the difficulties connected with the construction of a satisfactory locomotive. Having obtained permission from Lord Ravensworth, the principal partner of the Killingworth colliery to incur the outlay for constructing a "travelling engine" for the tramroads between the colliery and the shipping port nine miles distant, he made a successful trial with the engine, which he named "My Lord," 25th July 1814. Setting himself diligently to improve his invention, he thoroughly satisfied himself that for the proper success of the locomotive a railway as nearly as possible level was an essential condition. In 1822 he succeeded in impressing with the importance of his invention the projectors of the Stockton and Darlington Railway, who had contemplated using horses for their waggons, and was appointed engineer of the railway, with liberty to carry out his own plans, the result being the opening, 27th September 1825, of the first railway over which passengers and goods were carried by a locomotive. The success of the Stockton and Darlington Railway led to the employment of Stephenson in the construction of the Liverpool and Manchester Railway, which, notwithstanding prognostications of failure by the most eminent engineers of the day, he carried successfully through Chat Moss. He also succeeded in persuading the directors to give the locomotive a trial, and, as his improved invention, the "Rocket," during her trial trip made 29 miles an hour, his suggestion met with complete approval; with the opening of the line, 15th September 1830, the modern era of railways may be said to have been definitely inaugurated. While his experiments in connexion with locomotives were in progress, the construction of a safety lamp for use in mines occupied much of his attention. There can be no doubt regarding the justice of his claims to be considered the first inventor of the tube safety lamp, notwithstanding that the name of Sir Humphry Davy has been chiefly associated with the discovery. In recognition of the "valuable service he had thus rendered to mankind," subscriptions were in 1815 collected in behalf of Stephenson which amounted to £1000, a sum which he found of great convenience in connexion with his locomotive experiments. Stephenson was closely connected with the more important of the railway projects which the success of the Liverpool and Manchester line called into existence, but he strongly disapproved of the railway mania which ensued, and predicted that only ruin could result from the prevalent disposition towards railway speculation. He was frequently consulted in regard to the construction of foreign railways, and in this connexion visited Belgium and Spain in 1845. Towards the close of his life he retired from active duties, and at his residence at Tupton House, Chesterfield, interested himself chiefly in farming and horticultural pursuits. He died 12th August 1848.

See *Story of the Life of George Stephenson*, by Samuel Smiles, 1857, new ed. 1873; and Smiles's *Lives of British Engineers*, vol. iii.

STEPHENSON, Robert (1803–1859), engineer, son of the preceding by his first wife Fanny Henderson, was born at Willington Quay, 16th October 1803. Remembering his own early difficulties owing to deficient instruction, his father bestowed special care on his education, sending him in his twelfth year to attend Mr Bruce's school in Percy Street, Newcastle, where he remained about four years. In 1819 he was apprenticed to a coalviewer at Killingworth to learn the business of the colliery, after which, to perfect his training in technical science, he was sent in 1822 to attend the science classes at the university of Edinburgh. On his return he assisted his father in the survey of various railway lines, but in 1824 he accepted an engagement to take charge of the engineering operations of the Columbian Mining Association of London. On account of the harassing difficulties of the situation he resigned it in 1827, and after his return to England undertook the management of his father's factory in Newcastle, greatly aiding him in the improvement of his locomotives, the result being the construction of the "Rocket," which firmly established the practicability of steam locomotion on railways. Subsequently his services were in great request as a railway engineer, and after the retirement of his father he was regarded as the chief authority on the subject. In this connexion his most remarkable achievements were his railway viaducts on the tubular system, constructed with the aid of the practical knowledge of Sir William Fairbairn, and justly characterized as "the greatest discovery in construction in our day." Among his more notable bridges are the Royal Border bridge at Berwick-on-Tweed, the high-level bridge at Newcastle-on-Tyne, the Britannia tubular bridge over the Menai Straits, the Conway tubular bridge, and the Victoria tubular bridge over the St Lawrence, Canada. In 1847 he entered the House of Commons as member for Whitby. He was frequently consulted in the construction of foreign railways, and was decorated for his services by the king of Belgium, the king of Sweden, and the emperor of the French. In 1855 he was elected president of the Institute of Civil Engineers. He died 12th October 1859, and was buried in Westminster Abbey.

See *The Story of the Life of George Stephenson, including a Memoir of his Son Robert Stephenson*, by Samuel Smiles, 1857, new ed. 1873; Jeaffreson, *Life of Robert Stephenson*, 2 vols., 1864; and Smiles's *Lives of British Engineers*, vol. iii.

STEREOCHROMY. See Silica.

STEREOSCOPE is an optical instrument for representing in apparent relief and solidity all natural objects by uniting into one image two representations of these objects as seen by each eye separately. That the two eyes form different images of any objects which are near enough to have dissimilar perspective projections has been long known, and may be readily tested by any one. Euclid proved it geometrically with reference to a sphere (26th, 27th, and 28th theorems of his *Treatise on Optics*); Galen showed how the demonstration might be made.[1] Porta (*q.v.*), in his work on *Refraction*, also writes on the subject, and Leonardo da Vinci adduced the want of correspondence between the parts of the background intercepted by a near object seen by the two eyes singly "as the reason why no painting can show a *rilievo* equal to that of natural objects seen by both eyes within a moderate distance."[2] In 1613 Aguilonius, a Jesuit, in his work on *Optics*, attributed the union of the two unlike pictures into

[1] *De Usu Partium Corporis Humani*, Lyons, 1550, p. 593.
[2] *Trattato della Pictura, Scultura, ed Architettura*, Milan, 1584

a clear image to a "common sense" which gave its aid equally to each eye,—this common sense being specially exerted when the object is placed much nearer to one eye than to the other, so that the sizes as well as the forms of the two retinal pictures are sensibly different. The subject was merely touched by various other writers after Aguilonius until 1775, when Harris[1] observes: "We have other helps for distinguishing prominences of small parts besides those by which we distinguish distances in general, as to their degrees of light and shade, and the prospect we have round them. Again, by the parallax, on account of the distance betwixt our eyes, we can distinguish, besides the front part, the two sides of a near object not thicker than the said distance, and this gives a visible rilievo to such objects, which helps greatly to raise or detach them from the plane in which they lie. Thus the nose on a face is the more remarkably raised by our seeing both sides of it at once." This was undoubtedly a considerable step towards a sound theory of binocular vision, but it cannot be said to have anticipated the invention of the stereoscope. This instrument owes its origin entirely to the experimental researches of Sir Charles Wheatstone on binocular vision, and the following passage from Mayo's *Outlines of Human Physiology*, p. 288, published in 1833, is the first clear enunciation of the principle on which it is constructed:—"A solid object, being so placed as to be regarded by both eyes, projects a different perspective figure on each retina; now if these two perspectives be actually copied on paper, and presented one to each eye, so as to fall on corresponding parts, the original solid figure will be apparently reproduced in such a manner that no effort of the imagination can make it appear as a representation on a plane surface." Sir Charles Wheatstone's "Contributions to the Physiology of Vision, Part the First" appeared in the *Philosophical Transactions* of 1838, but this paper was the result of investigations extending over a period of years, and there is evidence that reflecting stereoscopes were constructed for Wheatstone by Newman, a well-known philosophical instrument maker, so early as the winter of 1832. Wheatstone no doubt also, as early as 1845, employed photographic pictures for his reflecting stereoscope. The subject was taken up by Sir David Brewster, and was developed more particularly in two papers read to the Royal Society of Edinburgh in January 1843 and April 1844. These researches led Brewster to the invention of the lenticular or refracting stereoscope. The discoveries of Daguerre and Talbot, and the rapid development of the art of photography, enabled photographs to be taken suitable for the stereoscope, thus superseding the geometrical drawings previously employed, and in 1849 Duboscq, a Parisian optician, began the manufacture of lenticular stereoscopes and executed a series of binocular daguerrotypes of living individuals, statues, bouquets of flowers, and objects of natural history. For many years the refracting stereoscope of Brewster was one of the most popular of scientific instruments, and was to be found, along with an appropriate collection of pictures, in every drawing-room, but of late years it has somewhat fallen into the background, and the manufacture by photographers of stereoscopic views now forms but a small portion of their work. Whilst much credit is due to Brewster for his writings on binocular vision, and for the efforts he made to introduce the stereoscope to the public, there is no doubt that Wheatstone was not only the real inventor of the instrument but he also laid down in his paper published in 1838, and in a second contribution which appeared in the *Philosophical Transactions* in 1852, the true principles of binocular vision.[2]

[1] *Opticks*, vol. ii. pp. 41 and 245.

[2] See *Brewster on the Stereoscope*, 1856; Wheatstone's *Scientific Papers*, published by the Physical Society of London, 1879; and an article by the late Dr William Carpenter in *Edinburgh Review* for 1858.

When we look at an external object with both eyes it is seen generally as a single object, although there must be two retinal pictures, one for each eye. This depends on the fact that the excitation of certain associated spots on the two retinæ is referred to the same point in space, or, in other words, that the luminous impression which originates by the irritation of two associated points appears as one point in the visual field. Such associated points or areas of the retina are said to be corresponding or identical. When an object is seen single by two eyes, the two images must fall on corresponding points of the retina. If one eye be pushed to the side, the image on the retina of that eye is displaced from its appropriate identical point, and a double image is the result. Now the term *horopter* is applied to represent an imaginary surface containing "all those points of the outer world from which rays of light passing to both eyes fall upon identical points of the retina, the eyes being in a certain position." The horopter varies with the different positions of the eyes (see EYE, vol. viii. p. 826). But it is a familiar experience that we not only see a single object with two eyes, but the object, say a cube or a book lying on the table, is seen in relief, that is, we take cognizance of the third dimension occupied by the body in space, although the two retinal pictures are on a plane. It is clear that the two images of the object which do not coincide with the horopter cannot be completely united so as to furnish one single visual impression. Further, it can readily be demonstrated that the two retinal pictures are dissimilar, and yet the two images are fused into one and give the impression of a single object occupying three dimensions. To explain these phenomena, Wheatstone put forward the theory that the mind completely fused the dissimilar pictures into one, and that whenever there occurs such complete mental fusion of images really dissimilar, and incapable of mathematical coincidence, the result is a perception of depth of space, or solidity, or relief. The objection to this theory as stated by Wheatstone is that complete fusion does not take place. It is always possible by close analysis of visual perceptions to distinguish between the two retinal pictures. Further, if the fusion is mental, as stated by Wheatstone, it is an example of unconscious cerebration. Another explanation has been suggested by Brücke.[3] When we look at objects near at hand the optic axes are converged strongly, and they become less and less converged as we gaze at objects farther and farther away. There is thus a series of axial adjustments, the necessary muscular movements giving rise to definite sensations, by which we estimate the relative distance of objects in the field of view. A man with one eye cannot judge by this method. We habitually depend upon binocular vision for the guidance of all such movements as require an exact estimate of the respective proximity of two or more objects. "A very good test experiment is to suspend a curtain ring in such a manner as to present its edge at the distance of four or five feet from the eye, and then to try to push sideways through its hoop the curved handle of a walking stick held by the lower end; in this feat, which can be readily accomplished under the guidance of binocular vision, large odds may be laid that success will not be attained when one eye is closed, until a succession of trials shall have enabled the experimenter to measure the distance of the ring by the muscular movements of his arm."[1] According to Brücke, the two eyes are continually in a state of motion, and their position of convergence, now greater now less, passes from one side to the other, so that the observer combines successively the different parts of the two pictures, thus giving rise to sensations of depth of space and of subjects standing out in relief. Brücke's theory, in short, is that our perception of depth depends on the fusion of muscular sensations, or rather of nervous impressions arising from the muscles of the eyeballs. It was, however, pointed out by Dove that the sensation of relief, solidity, or perspective is perfect even when natural objects or stereoscopic pictures are seen momentarily by an electric flash lasting only $\frac{1}{24,000}$ of a second, during which time it is inconceivable that there can be any change in the degree of convergence of the optic axes. This experiment is fatal to Brücke's theory, and Wheatstone was right in asserting that the sensation of relief is instantaneous. A third theory is that of Joseph Le Conte, advanced in 1871, and thus stated by himself:—"All objects or points of objects either beyond or nearer than the point of sight are doubled, but differently,—the former homonymously, the latter heteronymously. The double images in the former case are united by less convergence, in the latter case by greater convergence, of the optic axes. Now, the observer knows instinctively and without trial, in any case of double images, whether they will be united by greater or less optic convergence, and therefore never makes a mistake, or attempts to unite by making a wrong movement of the optic axes. In other words, the eye (or the mind) instinctively distinguishes homonymous from heteronymous images, referring the former to objects beyond, and the latter to objects this side of, the point of sight."[2] Thus, according to Le Conte, the mind perceives relief *instantly* but not *immediately*, and it does so by means of double images. This theory does not possess the merit of simplicity, and, whilst it may explain the phenomenon of relief as experienced by those who have been specially trained to the analysis of visual perceptions, it does not satisfactorily account for the experience of everyday life. We are therefore obliged to fall back on the theory of Wheatstone, somewhat modified, namely, that there are, behind the phenomena referred to the retina, psychical operations, unconsciously performed, which fuse together the results of the retinal impressions. In the language of Hermann, "corresponding points are therefore such points as furnish images, which, as experience teaches, are habitually combined or fused. But, as it appears necessary to effect these combinations in order to obtain correct impressions of objects, we get into the habit of fusing also the images of the two not perfectly corresponding points which, under ordinary circumstances, we should perceive as double. It can easily be demonstrated that simultaneous images which fall upon corresponding points are not united, although it is true that they do not form second images. When the mind must unite images which do not fall upon corresponding points, the process must be associated with the conception that the corresponding points in the object occupy the situation for which the eye would have to be arranged, in order that the image should coincide."[3]

[3] This theory is usually attributed to Brücke, but something very similar to it was taught by Brewster. Brewster, however, did not attach importance to muscular sensations as an element in the question, and was content with pointing out that, in looking at the stereoscopic pictures of a bust, for example, "**the eyes will instantly**, by means of their power of convergence, unite the separated points of the eyes, and then the still more separated points of the ears, running over each part of the bust with the rapidity of lightning, and uniting all the corresponding points in succession, precisely as it does in looking at the bust itself." See his article "Stereoscope," in *Encyc. Britan.*, 8th ed., vol. xx. p. 689.

To obtain binocular pictures suitable for the stereoscope, the camera must be placed successively in two points of the circumference of a circle of which the object is the centre, and the points at which the camera is so placed must have the angular distance representing the convergence of the optic axes when the object is to be viewed in the stereoscope. For example, if the pictures are to be seen in the stereoscope at a distance of 8 inches before the eyes, the convergence will be 18°, and the camera must be stationed at two points on the circle at the same angular distance. This *distance* of the camera from the object only affects the *magnitude* of the picture. Usually two cameras are employed, fixed at the proper angular positions. Wheatstone gives the following table of the inclination of the optic axes at different distances, and it also shows "the angular positions of the camera required to obtain binocular pictures which shall appear at a given distance in the stereoscope in their true relief."

Inclination of the optic axes	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°
Distance in inches	71·5	35·7	23·8	17·8	13·2	11·8	10·1	8·8	7·8	7·0	6·4	5·8	5·4	5·0	4·6

"The distance is equal to $\frac{1}{2}\alpha$ cotang $\frac{1}{2}\theta$,—α denoting the distance between the two eyes and θ the inclination of the optic axes" (Wheatstone, *Scientific Papers*, p. 270).

Suppose two stereoscopic pictures thus taken are presented to the two eyes; it is possible by an effort so to converge the eyes as to throw the images on corresponding points, and when this is done the objects are seen in relief (fig. 1). Such an effort, however, soon causes fatigue, and few persons can so control their eyes and keep them in the forced position as to view the pictures in their natural perspective with any comfort. The object of all stereoscopes is to throw the two pictures on corresponding points with the eyes in an ordinary position.

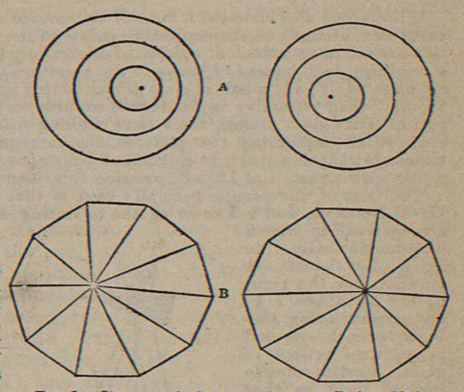

FIG. 1.—Stereoscopic figures. A, cone; B, ten-sided pyramid.

The principle of Wheatstone's reflecting stereoscope is illustrated in fig. 2. It consisted of two plane mirrors, about 4 inches square, fixed in frames and so adjusted that their backs form an angle of 90° with each other. These mirrors are fixed to an upright against the middle line of a vertical board cut away so as to allow the eyes to be placed before the mirrors. On each side there is a panel bearing a groove above and below into which the corresponding pictures can be slid. Mechanical arrangements also exist for the purpose of moving the pictures to or from the mirrors and also for inclining the pictures at any angle (fig. 3). There is one position in which the binocular image will be immediately seen single, of its proper size, and without fatigue, "because in this position only the ordinary relations between the magnitude of the pictures in the retina, the inclination of the optic axes, and the adaptation of the eye to distinct vision at different distances are preserved" (Wheatstone). Although somewhat cumbrous, the reflecting stereoscope is a most useful instrument, and enables one

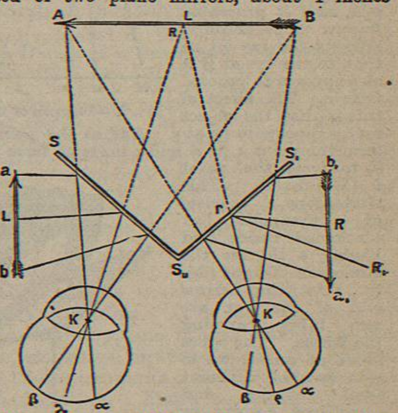

FIG. 2.—Diagram of Wheatstone's Reflecting Stereoscope. K, K, right and left eyes; S, S′, S″, mirrors; L, R, panels for holding pictures; a b, picture on left side; a_1 b_1, picture on right side; α, β, λ and α, β, ρ are corresponding points on retinæ; ALB, object as seen in relief in mirrors; b, seen by left eye in position B, and image on retina at β; L seen at L R, and retinal image at λ; a seen at A, and retinal image at α; a' seen at A, and retinal image at α; R seen at R L, and retinal image at ρ; b' seen at B, and retinal image at β.—Landois and Stirling's *Physiology*.

[1] Carpenter, *Edinburgh Review*, 1858.

[2] *American Journal of Science and Arts*, vol. ii., 1871.

[3] Hermann's *Physiology*, translated by Gamgee, p. 430.

to perform a greater variety of experiments on binocular vision than can be carried out easily with the more common form.

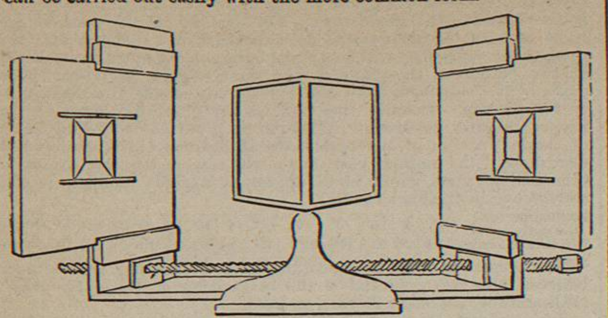

FIG. 3.—Wheatstone's Reflecting Stereoscope.

Wheatstone also invented a form of stereoscope in which the pictures were brought on corresponding points of the retina by refraction instead of by reflexion. This had a form very like the ordinary stereoscope, but, instead of lenses in the apertures to which the eyes are directed, it had "a pair of glass prisms having their faces inclined 15° and their refractive angles turned towards each other. . . . A pair of plate-glass prisms, their faces making with each other an angle of 12°, will bring two pictures, the corresponding points of which are 2¼ inches apart, to coincide at a distance of 12 inches, and a pair with an angle of 15° will occasion coincidence at 8 inches."[1]

The form of stereoscope generally used is that invented by Sir David Brewster, and is known as the refracting stereoscope. The arrangement is shown diagrammatically in fig. 4. Let the left eye be at A and the right at B; let a and b be the corresponding pictures for each eye, and p_1, p_2, two prisms of glass. A prism refracts rays of light so that the object seen through the prism appears to be nearer to the refracting edge; the prism p_1 therefore refracts the ray ap_1 in the direction p_1A, as if it proceeded from c. The prism p_2 refracts the ray bp_2 so that to the eye at B it also appears to proceed from c. The effect of this is that the object really appears to be at c. And as the points a and b combine to form the point c, so d and e unite to form the point f, and g and h to form the point i (Weinhold). This stereoscope consists of a pyramidal box blackened inside and having a lid for the admission of light (fig. 5). At the narrow end of the box are two tubes carrying the lenses. The tubes move up and down to suit eyes of different focal lengths, and sometimes convex or concave lenses are inserted over the prisms to meet the wants of long-sighted or short-sighted persons. Fig. 6 shows the upper end of the stereoscope, with the lenses in position.

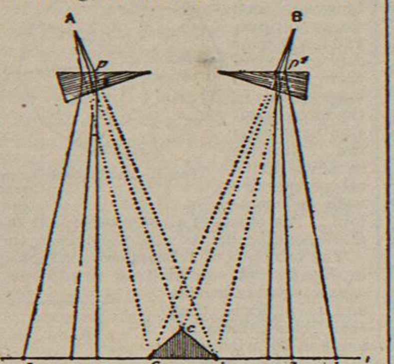

FIG. 4.—Diagram of the Refracting Stereoscope.

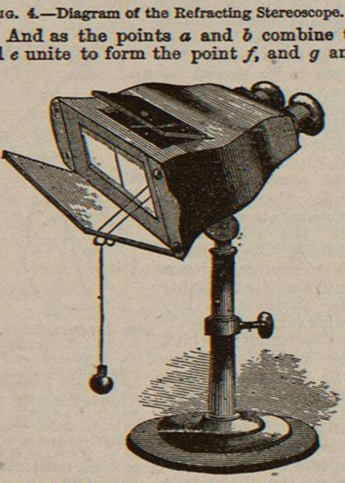

FIG. 5.—Sir David Brewster's Stereoscope.

A. Stroh (without knowing that H. Grubb had described the essentials of the apparatus in 1879) has recently invented a new form of stereoscope based on the well-known effects of the persistence of vision. Two stereoscopic pictures are simultaneously projected by two lanterns on a screen so as to overlap, and disks having suitable slits are rotated in front of the lanterns and also in front of the eyes of the observer, in such a way that only one picture is thrown on the screen at a time, and also that the view of the picture is seen with the right and left eyes alternately. Further, the connexion between the disks is so arranged that the time of obscuring the view of the observer's right eye or left eye coincides with the time when the light is shut off from the right or left lantern, and thus the left eye sees the picture of the left lantern and the right eye that of the right lantern. The two eyes never see at the same time, and each eye views its picture after the other, but the impressions come so fast as to be fused in consciousness, and the result is, the image stands out "in solid relief" (*Proc. Roy. Soc.*, No. 244, vol. xl., April 1, 1886).

FIG. 6.—Lenses in Refracting Stereoscope.

During his researches into the physiology of vision, Wheatstone was led to study what he termed conversions of relief. Sometimes when we look at a geometrical figure such as a cube or rhomboid it may be imagined to represent one of two dissimilar figures. In fig. 7 the rhomboid AX is drawn so that the solid angle A should be seen nearest, and solid angle X farthest, and face ABCD foremost, while XDC is behind. Look steadily and the position will change: X will appear nearest, solid angle A farthest; face ACDB will recede behind XDC.[2] The effects are most obvious when seen with one eye, and "no illusion of this kind can take place when an object of three dimensions is seen with both eyes while the optic axes make a sensible angle with each other, because the appearance of two dissimilar figures, one to each eye, prevents the possibility of mistake" (Wheatstone). The conversion of a cameo into an intaglio and of an intaglio into a cameo is a well-known instance of this illusion. Wheatstone observed the conversion of relief exhibited by binocular pictures in the stereoscope when they are transposed, reflected, or inverted, and this led him to the invention of the *Pseudoscope*, an instrument which conveys to the mind false perceptions of all external objects. "Two rectangular prisms of flint glass, the faces of which are 1·2 inch square, are placed in a frame with their hypothenuses parallel and 2·1 inches from each other; each prism has a motion on an axis corresponding with the angle nearest the eyes, that they may be adjusted so that their bases may have any inclination towards each other" (Wheatstone's *Scientific Papers*, p. 275). In fig. 8 there is a diagram of the instrument. If a spherical surface be examined with this instrument, it will appear hollow; whilst a hollow surface will appear convex. It is remarkable, however, that the converting powers of this instrument are greatest where the new forms can be conceived without effort. Thus a cameo and an intaglio, a plaster cast in relief and its mould, or any object similar in its opposite reliefs is at once changed by the pseudoscope into the converse form. As pointed out by Dr Carpenter, by gazing we can reverse the interior of a mask so as to see the countenance stand out in relief; it is more difficult to throw the features of a bust into the shape of a mould; whilst it is impossible to effect any conversion upon the features of the living face. "The optical change is identically the same in its nature in every one of these cases; and there is nothing in the form of the features which refuses to present a converse, this converted shape being presented by the mask; but the mind, which will admit the conception of the converted form when suggested by the inanimate mask or bust, is steeled by its previous experience against the notion that actual flesh and blood can undergo such a metamorphosis" (Carpenter, *Edinburgh Review*, 1858, p. 460).

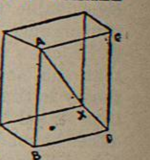

Fig. 7.

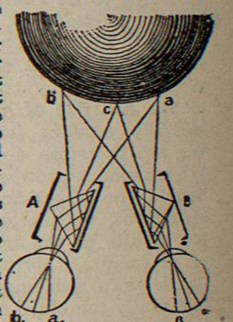

FIG. 8.—Diagram of Wheatstone's Pseudoscope. A, B tubes containing prisms. a_1, b_1, and a, β, corresponding points; a, b, c, position of points in visual field.

A little consideration will show that the pictures of objects placed at a great distance from the eye are practically if not wholly identical. Here there is scarcely any stereoscopic effect, and the landscape may appear to be flat, as in a picture. To obtain a stereoscopic view of a landscape Von Helmholtz invented the *Telestereoscope*, an instrument which places as it were the point of view of both eyes wide apart. It consists of two mirrors L and R, each of which projects its image upon l and r, to which the eyes O and o are directed. The eyes O and o are placed as it were at O_1 and o_1, according to the distance between L and R: consequently two dissimilar pictures are obtained; these are mentally combined, with the result that the landscape is seen like a stereoscopic view.

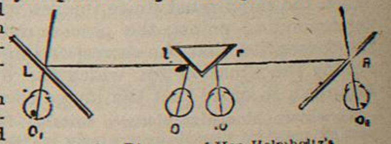

FIG. 9.—Diagram of Von Helmholtz's Telestereoscope.

The principle of the stereoscope was successfully applied by Wenham in 1854 to the construction of the binocular microscope. See MICROSCOPE (vol. xvi. p. 272), and also two papers in the *Jour. Roy. Micr. Soc.*, 1884:—(1) "On the Mode of Vision with Objectives of Wide Aperture," by Prof. E. Abbe, p. 20; and (2) "On the Physiology of Binocular Vision with the Microscope," by Dr Carpenter, p. 486. Prof. Abbe shows, however, that "oblique vision in the microscope is entirely different from that in ordinary vision, inasmuch as there is no perspective, so that we have no longer the dissimilarity which is the basis of the ordinary stereoscopic effect, but an essentially different mode of dissimilarity between the two pictures." In the microscope there is no perspective foreshortening. There is no difference in the outline of an object viewed under the microscope by an axial or by an oblique pencil. There is simply a lateral displacement of the image—an entirely different phenomenon to that which occurs in non-microscopic vision. Thus, whilst the mode of formation of dissimilar pictures in the binocular microscope is different from the production of ordinary stereoscopic pictures, the brain mechanism by which they are so fused as to give rise to sensations of solidity, depth, and perspective is the same. (J. G. M.)

[1] Wheatstone's *Scientific Papers*, p. 267.

[2] Necker, *Phil. Mag.*, 3d series, vol. i. p. 337.

STEREOTYPE. See TYPOGRAPHY.

STERLING, a city of the United States, in Whiteside county, Illinois, on Rock River (a tributary of the Mississippi), 110 miles west of Chicago. Mainly on account of the abundant water-power produced by the natural rapids of the river and a dam 1100 feet long, it has become the seat of the most varied manufacturing industry. An artesian well 1000 feet deep, discharging 18,000 gallons per hour, contributes to the water-supply of the town. The population was 5312 in 1870 and 5087 in 1880. Sterling was laid out in 1836 and incorporated in 1857.

STERLING, JOHN (1806–1844), author, was descended from a family of Scottish origin which had settled in Ireland about the Cromwellian period. His father, Edward Sterling, born at Waterford 27th February 1773, had been called to the Irish bar, but, having fought as a militia captain at Vinegar Hill, afterwards volunteered with his company into the line. On the breaking up of his regiment he went to Scotland, and took to farming at Kames Castle in Bute, where John, the second son, was born 20th July 1806. In 1810 the family removed to Llanblethian, Glamorganshire, and during his residence there Edward Sterling, under the signature of "Vetus," contributed a number of letters to the *Times*, which were reprinted in 1812, and a second series in 1814. In the latter year he removed to Paris, but, the escape of Napoleon from Elba in 1815 compelling him to return to England, he took up his permanent residence in London, obtaining a connexion with the *Times* newspaper, and ultimately being promoted editor. Carlyle, who allows him the dubious credit of being one of the best of newspaper editors, represents him as manifesting "a thoroughly Irish form of character, fire and fervour, vitality of all kinds in genial abundance, but in a much more loquacious, ostentatious, much *louder* style than is freely patronized on this side of the Channel." His fiery, emphatic, and oracular mode of writing conferred those characteristics on the *Times* which were recognized in the sobriquet of the "Thunderer." The frequent changes of the family residence during the early years of young Sterling rendered his education somewhat desultory, but on the settlement in London it became more systematic. After studying for one year at the university of Glasgow, he in 1824 entered Trinity College, Cambridge, where he had for tutor Julius Charles Hare. At Cambridge he did not distinguish himself except in the debates of the union, where, "none," it was related, "ever came near him except the late Charles Buller." He removed to Trinity Hall with the intention of graduating in law, but left the university without taking a degree. During the next four years he resided chiefly in London, employing himself actively in literature. Along with Frederick Maurice he purchased the *Athenæum* from J. Silk Buckingham, but the enterprise was not a pecuniary success. Through Maurice he became an "assiduous pilgrim" to the shrine of Coleridge at Hampstead. He also formed an intimacy with the Spanish revolutionist General Torrijos, in whose unfortunate expedition he took an active interest. Shortly after his marriage in 1830, symptoms of pulmonary disease induced him to take up his residence in the island of St Vincent, where he had inherited some property, but after fifteen months he returned to England. After spending some time on the Continent he found his health so much re-established that in June 1834 he accepted a curacy at Hurstmonceaux, where his old tutor Julius Hare was vicar. Acting on the advice of his physician he resigned his clerical duties in the following February, but according to Carlyle ill-health was only the external occasion of his resignation, the primary cause being a partly unconscious divergence from the opinions of the church. Be this as it may, the threatening progress of the insidious disease under which he laboured soon rendered "public life in any professional form" quite impossible. There remained to him the "resource of the pen," but, having to "live all the rest of his days as in continual flight for his very existence," his literary achievements were necessarily fragmentary, and cannot be regarded as a criterion of his capabilities. He published in 1833 *Arthur Coningsby*, a novel, which attracted little attention, and his *Poems* (1839), the *Election, a Poem* (1841), and *Strafford*, a tragedy, were not more successful. He had, however, established a connexion with *Blackwood's Magazine*, to which he contributed a variety of papers and several tales, which gave promise that under more favourable conditions he might have "achieved greatness." He died at Ventnor 18th September 1844. His father survived him till 1847.

Sterling's papers were entrusted to the joint care of Thomas Carlyle and Archdeacon Hare, and it was agreed that the selection of his writings for publication and the preparation of a memoir should be undertaken by the latter. *Essays and Tales*, by John Sterling, collected and edited, with a memoir of his life, by Julius Charles Hare, appeared therefore in 1848 in two volumes. So dissatisfied was Carlyle with the memoir, chiefly because it unduly magnified the ecclesiastical side of Sterling's life, that he resolved to give his own "testimony" about his friend, and "record clearly" what his "knowledge of him was." His vivid portraiture of Sterling in the *Life* which appeared in 1851 has perpetuated the memory of Sterling after his writings have ceased to be of interest on their own account.

STERNBERG, a manufacturing town in Moravia, Austria, is situated 9 miles to the north of Olmütz and 47 miles to the north-east of Brünn. It is the chief seat of the Moravian cotton industry, and it also carries on the manufacture of linen, stockings, liqueurs, sugar, and bricks. Its six suburbs and the surrounding districts are also engaged in the textile industry. Fruit, especially cherries, and tobacco are grown in the neighbourhood. The population in 1880 was 14,243. Sternberg is said to have grown up under the shelter of a castle founded by Yaroslaff of Sternberg on the site of his victory over the Mongols in 1241.

STERNE, LAURENCE (1713–1768), one of the greatest of English humorists, was the son of an English officer, and great-grandson of an archbishop of York. Nearly all our information about the first forty-six years of his life before he became famous as the author of *Tristram Shandy* is derived from a short memoir jotted down by