he read an extract from the *Journal of Mental Science*, which he claimed showed the awakening interest manifested by Europeans in "unconscious states." The Doctor then wandering off to the fall of a Swiss mountain and to Astronomy, was called to order, and subsided.

Dr. Spitzka, without desiring to introduce personalities into the discussion, remarked that it was a pity the preceding speaker had not turned back a few pages in the *Journal of Mental Science* and read the extract relating to the collapse of Dr. Beard's demonstration in England, and how Dr. Beard had failed to come forward with a paper he had announced before a scientific body. As to the paper read that evening, he regretted to say that instead of science being behind in its views on the question of alcoholism, it was the paper which was far from being up to the science of the day. He would call the attention of the reader to Magnan's work, in which he would find such of his cases as had the strongest semblance to reality, carefully described under the heads of alcoholic stupor and alcoholic epilepsy. As to the hack-driver's case, that was an evident example of a well-established and well-known form of disease, namely—alcoholic paralytic dementia. He was surprised to find such a common manifestation of alcoholism as tremor reported absent by Dr. Crothers. He was still further surprised to find such ordinary everyday and characteristic symptoms of chronic alcoholism as delusions of marital infidelity, morbid suspicion, inconsistencies of behavior, stupor and amnesia erected into trance-like states. Nowhere in the paper did the author give any evidence that he made that distinction between Dipsomania, Chronic Alcoholism and Acute Alcoholic Delirium, which was the A B C of our knowledge of the subject. The speaker concluded by regretting that the first time in years that so important a matter was brought before the Society, it was brought forward in so imperfect a form, and coupled with a term "trance," which in the past history of the Society had certainly acquired no good odor.

Dr. Girdner endorsed the preceding speaker's remarks, and gave an analysis of the ordinary effects of alcohol on the mind, which he referred to dynamic interferences. He concluded by objecting to the acceptation of such views as Dr. Crothers advanced until they could be better substantiated, as their acceptation would involve some remarkable medico-legal consequences. He did not believe that alcoholism, aside from its effect in producing chronic insanity, should constitute an excuse for crime. He thought that a crime committed in a drunken excess should be punished like any other crime, because the person, by his own agency, put himself in a proper condition to commit such crime.

Mr. Eller, of the New York Bar, stated that the view last announced by the preceding speaker was not a sound one in law; it was certainly not the one entertained by lawyers. He alluded to the great injustice done by police justices in sending persons to the workhouse on the complaint of any two (possibly) conspiring persons, that such person was a "habitual drunkard." He thought that term required definition.

Dr. Crothers, in closing the discussion, among other remarks of a general character, stated that our knowledge of alcoholism was not at all perfect, and that his views were an addition to science, notwithstanding what had been alleged that evening.

M. PICKET has examined seven varieties of steel (chiefly from a Sheffield and a Vienna house) with regard to magnetic power *Arch. des Sciences*, August 15). This power he finds to depend on the presence of carbon in the iron, and the aggregation of these substances. One of the two steels giving the best results had ⅞th per cent of carbon. Samples with 1½ and 1⅛th per cent were inferior.

NEW YORK ACADEMY OF SCIENCES.

October 24, 1881.

SECTION OF PHYSICS.

Vice-president, Dr. B. N. Martin, in the Chair.

Thirty-one persons present.

Mr. W. Le Conte Stevens read a paper, of which the following is an abstract.

WHEATSTONE AND BREWSTER'S THEORY OF BINOCULAR PERSPECTIVE.

For some time after the publication of Sir Charles Wheatstone's essay (1) in 1838, on the Physiology of Vision, this subject was studied with much zeal by Sir David Brewster, whose name is permanently associated with the lenticular stereoscope, an instrument now familiar in every household. Although the theories advanced by these two physicists to account for the illusion of binocular relief have since been shown insufficient, their mode of accounting for the estimate of distance as perceived in the stereoscope has been quite generally accepted. In 1844, Brewster published an essay (2) "On the Knowledge of Distance given by Binocular Vision," in which he elaborated and abundantly illustrated the idea that the apparent distance of an object is determined by the intersection of visual lines. The stereoscope had already been explained as an instrument by which rays of light from two slightly dissimilar pictures were made to enter the eyes, as if coming from a single object into which they are combined in front, and on each point of which the visual lines could be made to meet. Thus, in Fig. 1

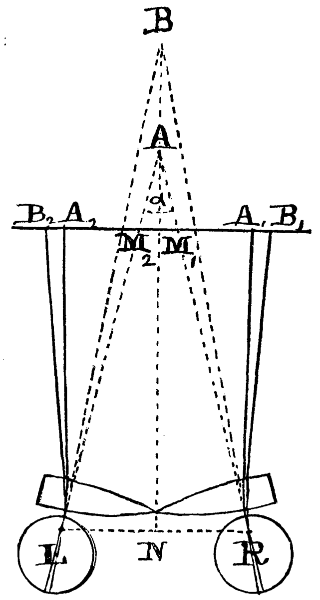

FIG. 1.

if rays from the conjugate foreground points, A_1 and A_2, be deviated by the semi-lenses, they appear to have come from A. In like manner, the background appears at B. If i = interocular distance RL., and a = optic angle, then for the distance of A we have

$$D = \tfrac{1}{2}\, i \cot \tfrac{1}{2}\, a$$

From this formula it is obvious that D ceases to have any positive finite value when the visual lines cease to converge.

If the semi-lenses be taken away, and A_1 and A_2 be

(1) Phil. Transactions, 1838, Part II.
Reprinted in Phil. Magazine, s. 4, vol., III., April, 1852.

(2) Edinburgh Transactions, vol. XV., Part III., p. 360.

removed to M_1 and M_2 respectively, while the convergence of visual lines remains unchanged, the images still appear at A and B. Wheatstone seems to have been the first to show experimentally that the illusion of apparent solidity can be obtained in this manner from a pair of projections representing the same object from slightly different points of view. If the eyes be properly trained, the visual lines may be directed to points whose distance is greater or less than that of the objects regarded at the same moment, and Brewster described many striking illusions thus obtained without the aid of the stereoscope. The principle applied by him, as described in the paper to which reference has been made, may be briefly given, and his results can be easily tested by anyone who is accustomed to analyzing his own visual sensations. Upon a uniform horizontal surface (Fig. 2) let two lines, A C and B C, be drawn, forming a small angle, β, with its vertex toward the observer. Let the eyes, R and L, be placed above this. If they be directed to the point, C, this appears in its true position. If the right eye be directed to B and the left to A, the axes meet at P; this point Brewster calls the binocular centre; and since the retinal images of B and A correspond, the visual effect is that of the union of these two external points at the binocular centre. Sweeping the glance toward C, the two lines appear united in the air, and P C is the apparent position of the combination, intermediate in direction between two monocular images, which may be disregarded or hidden from view with screens. If the convergence of visual lines be now diminished, the binocular image is lost until the right eye becomes directed to A and the left to B. The two points appear united at P′, and the line P′C now appears in the air on the further side of the surface. If the convergence be increased till P is again the binocular centre, and the face be lowered and withdrawn till the eyes are at R″ and L″, then C P″ becomes the position of the variable external image. And if lowered until R″L″ coincides with the surface, C P″ vanishes at the moment of becoming coincident with the prolongation of G C, the median of the triangle A C B.

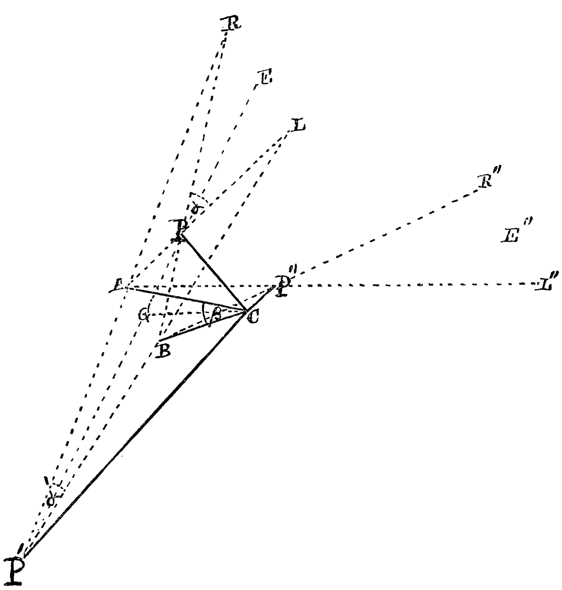

FIG. 2.

Brewster's formula for determining the distance of the binocular centre from G is easily deduced and applied.

Let i = interocular distance, R L.

" a = interval between the corresponding points, A and B.

Let b = distance, G E, between card and observer.

" x = distance G P, or G P′, which is positive when measured toward the observer, negative in the direction opposite. Then, observing the usual rule of signs, we have, by Geometry,

$$x = \pm \frac{a\,b}{i \pm a}$$

Applying this formula, Brewster constructed a table of distances for the binocular centre. For negative values it is seen that x becomes infinite when the visual lines become parallel; and, if they be slightly divergent, the binocular centre is far in the rear of the observer. Either of these conditions would make binocular vision impossible if the theory be correct. In testing the experiment with trained eyes, it is found quite possible to secure binocular fusion of the images of A and B when the interval between these points equals or slightly exceeds the interocular distance. It is also found that fusion of the images of the whole line at any given instant is impossible, especially when the angle β is large, or the lines are viewed very obliquely, as from R″ and L″. If the images of A and B fall on corresponding retinal points, the resulting sensation is binocular fusion, whether the visual lines be convergent, parallel or divergent; and the images of any two points nearer or farther apart cannot fall on corresponding retinal points at the same moment with those of A and B, though small differences are easily neglected. Whatever may be the importance therefore of optic convergence, as a factor ordinarily in determining the binocular judgment of distance, it has no such exclusive and measurable value as that attributed in Brewster's experiments; and the apparent distance of objects viewed through the stereoscope is obviously not determined by intersection of visual lines, if conditions are such as to render these parallel or divergent. The visual effects of optic divergence can be more conveniently studied by using stereographs than by the method already described, and a modification of Wheatstone's reflecting stereoscope affords the best means of measuring variations of the optic angle. As the lenticular stereoscope, however, is now almost universally employed, it is important that this instrument, as found in the market, be examined first.

By diminishing the natural convergence of visual lines, the stereoscopic effect of binocular relief can be quite easily obtained, while gazing upon a stereograph, without any instrument, when the interval between corresponding points of the two pictures does not exceed that between the observer's optic centres. This distance does not often differ very much from 64 mm., which may be taken as an average value. In Fig. 3 the distance between the two central dots is 50 mm. If the reader will fix his gaze upon a point ten feet off, just visible below the edge of the page, and then suddenly raise the visual lines to the figure without changing their convergence, he will see three circles instead of two; the central one moreover will appear as the base of a cone whose vertex is pointed toward him, but capped with a small circle. A little attention then will reveal the fact that when the dots are seen distinctly and singly, the small circle is double and slightly indistinct, and *vice versa*.

On stereographs, however, the interval between corresponding points is always greater than 50 mm. As the result of measurement made upon the foreground intervals of 166 cards, European and American, taken at random, the mean value I have found to be 72.9 mm., the maximum being 95 mm. If binocular combination is secured without the stereoscope, therefore, optic divergence is nearly always necessary. To ascertain the extent to which this is counteracted by the semi-lenses of our best stereoscopes, 30 pairs of these were kindly loaned me by Mr. H. T. Anthony, of New York. With very slight variation, their focal length was found to be 18.3 cm., and their deviating power not sufficient to prevent the necessity of optic divergence, when the pictures are binocularly regarded through them, if the stereographic interval exceed 80 mm. As this limit is not unfrequently exceeded, optic divergence is often practiced unconsciously in using the stereoscope. Every oculist is familiar with the mode of using prisms to test the power of the muscles of the eyeballs, for both convergence and divergence of visual lines, and knows that 4° or 5° of divergence is not uncommon. Helmholtz (3) refers to the use of stereographs for the same purpose.

But familiar as is the production of optic divergence by artificial means, little or nothing seems to have been written in regard to the modification which the possibility of it imposes upon the theory of binocular perspective held by both Wheatstone and Brewster, accepted by most writers on vision since their time, and abundantly reproduced in our text books on Physics.* Of these I have not been able to find one that gives any account of the stereoscope except on the hypothesis that the visual lines are made to converge by the use of this instrument. On the uncertainty attached to the judgment of absolute distance from convergence of visual lines alone, Helmholtz (4) has written more fully than any one else. It is unfortunate that no English translation of his masterly work on Physiological Optics has ever been published. Although he gives no analysis of the visual phenomena produced in binocular fusion by optic divergence, his discussion of the judgment of distance would certainly tend to cast some doubt upon the explanation of vision through the stereoscope, as found in our text-books. And yet Helmholtz himself employs Brewster's theory in his mathematical discussion (8) of stereoscopic projection. This discussion, on the data assumed, is a model of elegance; but it contains no provision for divergence of visual lines. It is strictly applicable to the conditions involved in taking photographs with the binocular camera, and to the projection of images viewed in the stereoscope when the convergence of visual lines is identical with that of the camera axes, but not otherwise. Instead of human eyes we may assume a pair of camera lenses, an interocular distance apart, and a pair of sensitized plates behind them. Helmholtz's formulas enable us to determine the stereoscopic displacements in the images projected. If proofs from the negatives thus obtained be inverted and placed in front of a pair of eyes in such manner that the visual lines passing through corresponding photograph points shall bear to each other the exact relation that existed between the secondary camera axes that terminated in them, these two points will appear as one, and nearly at the distance of the real point in space to which the camera axes were converged. The effect is much the same as if the eyes, with normal convergence of visual lines, had been substituted for the cameras. But if the proofs be too near together or too far apart, increase of convergence makes the whole picture seem nearer, while divergence makes it farther. The relation between the different parts having been fixed at the time the picture was taken, increased convergence makes the distance from background to foreground seem less, divergence makes it greater. No one can have failed to notice the gross exaggeration of perspective often seen in the stereoscope, when the pictures are so far apart as to make the visual lines parallel or divergent, while the angle between the camera axes, when they were taken, was relatively large. But in no case do these conditions cause variations of such magnitude as Brewster's theory of binocular perspective would demand. This is easily illustrated with Wheatstone's reflecting stereoscope. (5) Suppose the stereograph to represent a concave surface with the opening toward the observer, and that the arms of the instrument are properly adjusted. If they are pushed back, so as to make the visual lines divergent, the cavity apparently recedes and deepens; if pulled forward, so as to make them strongly convergent, it seems to approach and grow shallow. The apparent diameter of the image enlarges in the first case and diminishes in the second. Wheatstone notices this last variation in the account which he gave of his invention and its applications, in 1852, in the Bakerian lecture before the Royal Society (6); but, strange to say, the variation which is produced in apparent distance and depth under the same conditions seems to have escaped his notice, and the possibility of using his instrument to test the peculiarities of binocular vision with divergence of visual lines, seems not to have occurred to him. For the refracting stereoscope, however, like Brewster, he constructs a table of apparent distances corresponding to various optic angles, and applicable in using the binocular camera for the purpose of taking slightly dissimilar pictures of the same object. He adds, (7) "when the optic axes are parallel, in strictness there should be no difference between the pictures presented to each eye, and in this case there should be no binocular relief; but I find that an excellent effect is produced, when the axes are nearly parallel, by pictures taken at an inclination of 7° or 8°, and even a difference of 16° or 17° has no decidedly bad effect. There is a peculiarity in such images worthy of remark; although the optic axes are parallel, or nearly so, the image does not appear to be referred to the distance we should, from this circumstance, suppose it to be, but it is perceived to be much nearer." This would not have seemed anomalous to Wheatstone, had he supposed binocular vision possible with divergence of visual lines, and entered into an analysis of the resulting visual phenomena. This analysis will be given in a future paper.

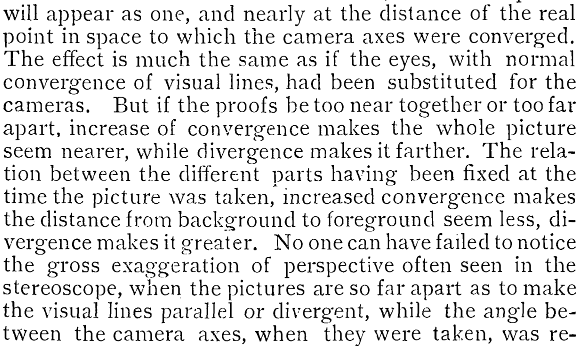

Fig. 3.

THE WATERS OF PARIS.

In one of the previous numbers, *La Nature* gives an account of the work of an English observer, Mr. J. Hogg, on the waters of London. But since 1850, Mr. Hassall[a], at the request of the inhabitants of London, examined the degree of purity of the potable waters of that city, and more recently, Professor Farlow, of Boston, make an analogous work at the request of the citizens of that city.[b] M. A. Gérardin[c], however, has studied this question with a certain authority, by observing the cryptogamic vegetation in small streams of water which receive the waste products from the factories and manufactories on their banks. M. Gérardin observed that such industry favored the development of certain particular species which were

(3) Helmholtz, Optique Physiologique, pp. 616 and 827.

(4) Ditto, pp. 823, 828.

(5) For description see Phil. Mag., s. 4, vol., III., June, 1852, p. 506.

(6) Phil. Mag. s. 4, vol. III., p. 504.

(7) Ditto, p. 514.

(8) Opt. Phys., p. 842.

* Nov. 15th. Since the above was put in type, I have received from Prof. C. F. Himes, of Carlisle, Pa., an article written by him in 1862, in which he mentions his successful attainment of binocular vision by optic divergence, and criticises Brewster's theory of distance in relation to the stereoscope. Though his observation was independent, as my own was also, I find that he was preceded by a German, Burckhardt, in 1860 or 1861. I have already referred to Helmholtz in this connection (*Am. Journal of Science*, Nov. 1881, p. 361) and therefore have claimed no priority in discovering the possibility of this unusual, but still voluntary, employment of the eyes. It is the more remarkable that in our text-books the assumption should be so universal, that convergence of visual lines is a necessity in binocular vision for the determination of the apparent point of sight.