ON

THE INVENTION OF STEREOSCOPIC GLASSES FOR SINGLE PICTURES:

WITH PRELIMINARY OBSERVATIONS ON THE STEREOSCOPE, AND ON THE PHYSIOLOGY OF STEREOSCOPIC VISION.

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FOR

SINGLE PICTURES,

&c. &c.

CHAPTER I.

ON THE STEREOSCOPE.

Students of drawing, especially in their early essays, must often be perplexed to find the perspective which they have sketched, while using one eye alone, different from that which presents itself when the object is looked at with the other eye alone, and still more different from that which is seen with both eyes in action. I remember, when a boy learning to draw, that I never could trace any satisfactory outline of an object if I looked at it with both eyes; and that, although I did not experience the same difficulty if I used one eye only, my sketch appeared very inaccurate when I came to compare its outline with the appearance which the object presented either to the other eye alone or to both at the same time. Having thus found that I could not draw any other appearance but that which presents itself when the object is viewed with a single eye, I gave up the attempt to use both in sketching. I did not, however, until long afterwards, become convinced that it is really impossible to represent, on a plain surface, the appearance which objects of three dimensions present when viewed with the two eyes, and learned the reason of the impossibility.

With both eyes, let us look at an object possessed of the three dimensions, length, breadth, and thickness, and situated at no great distance from us, and let us note well its position and the degree of relief it presents. If now, without changing the position of the head, we shut the left eye and look at the object with the right only, we shall see it occupying a situation a little to the left of that which it appeared to occupy before; we shall see it also in different perspective and in much less relief. If, now, we shut the right eye and look at the object with the left only, we shall see it occupying a reverse position—viz., one a little to the right of that which it appeared to occupy when it was viewed with both eyes, and in a perspective the reverse of that in which it was seen by the right eye, in so far, that while more of its right side was seen when viewed by the right eye, more of its left side is now seen when viewed by the left eye. The relief appears to the left eye as much diminished as it appeared to the right eye.

As an object of three dimensions, viewed at a short distance, thus yields to the right eye a perspective appreciably different from that which it yields to the left eye; and as, when viewed with both eyes, its appearance is not like either the perspective seen by the right eye or that seen by the left, but is one in strong relief or intaglio,—such as can never be seen at a glance with a single eye,—it is evident that the impression of a different perspective of the object, both in regard to position and form, on the retina of each eye, constitutes the physiological condition on which the perception by the mind of full relief or intaglio depends.

This view of the matter had, no doubt, often occurred to observant and thoughtful persons; but the inference, though drawn, remained barren of results, until the happy idea was conceived of testing it by the experiment of making drawings on paper of the two dissimilar perspectives of an object of three dimensions,—the one perspective as seen with the right eye, and the other as seen with the left,—and presenting them simultaneously, each to its respective eye, *i. e.*, the drawing of the right perspective to the right eye only, and the drawing of the left perspective to the left eye only. The result was, that the observer perceived an appearance of the object in relief or intaglio as full and complete as if the real object had been actually before him—an appearance incapable of being represented by a single drawing on a plain surface, and unlike either of the perspectives of which the drawings on paper were actually presented to the eyes.

This experiment was devised and the instrument for it—the Stereoscope—constructed by Mr Wheatstone more than twenty years ago. In thus attributing to Mr Wheatstone the invention of the Stereoscope, however, it would be unjust to ignore the claim of Mr Elliot, of Edinburgh, who, according to Sir David Brewster, had, a few years before Mr Wheatstone published on the subject, projected a similar instrument, which, however, he did not publicly exhibit until 1839, a year after Mr Wheatstone had made known his invention. Mr Elliot's dissimilar perspective drawings, a copy of which Sir David Brewster gives in his work on the Stereoscope, prove that he had correctly conceived the principle of stereoscopic vision. Whatever may be the claims of Mr Elliot, however, to the honours of invention, it cannot, I believe, be denied that it was directly from Mr Wheatstone's Stereoscope, subsequently modified and improved by the addition of Sir David Brewster's lenses, and supplied by photography with perspectives for the slides embracing every variety of subject, that Stereoscopy, such as it is now known in all its beauty and perfection, was developed.

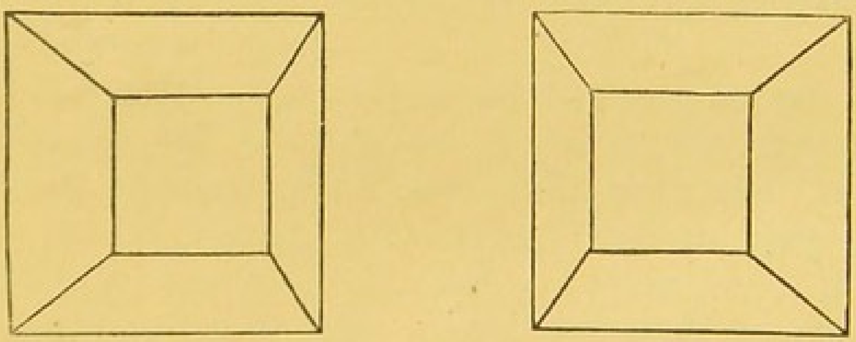
It was not until I saw Mr Wheatstone's Stereoscope, that I learned to understand the true cause of the perplexity which I had experienced in my early attempts to draw from nature, and became convinced that it is a mere delusion to suppose that near objects of three dimensions can be represented by painting on a plain surface in the same full relief or intaglio as that in which they are seen in reality when viewed with two eyes. All that can be really represented by painting on a plain surface, it is now demonstrated, is merely the semblance of relief or intaglio such as is seen when the object is viewed with one eye only. This explains why it is, that in looking at pictures we see them to greater advantage when one eye is closed. When we use both eyes in looking at pictures, the illusion of relief, even such only as is seen with one eye, is in a great measure destroyed; because, as with the two eyes we recognise real relief or intaglio, so with the two eyes we equally recognise the absence of it, and thus detect the flatness of surface.

Seeing that it is impossible to represent by painting on a plain surface objects in as full relief or intaglio as that in which they are seen in reality when viewed with the two eyes, the skill of the artist is best shown by not attempting what cannot be done, but by so planning the perspective of his picture, and grouping the objects represented, that the appearance of relief or intaglio, as perceptible to one eye, may be brought out to the best advantage.

Now that photography has lent its aid in providing slides for the Stereoscope, and this instrument has thereby become a household ornament and toy, there is no one but will admit that paintings do not represent near objects in as full relief or intaglio as that in which they appear in nature when viewed with two eyes. Before, however, photography had supplied slides with beautiful pictures instead of the diagrams at first employed, and while the Stereoscope was, therefore, as yet but little known and appreciated, I remember more than one instance in which an artist stoutly maintained, in opposition to what I said to the contrary, that the objects represented in painting did appear in as full relief or intaglio as that in which they actually appear in nature when viewed with two eyes.

The essentials of a Stereoscope are :—1st. The two perspective pictures of the slide ; the one being such as would be seen by the right eye, and the other such as would be seen by the left, supposing the real object represented by them were viewed at no great distance. 2nd. An arrangement by means of which the right perspective picture may be received by the right eye exclusively, and the left by the left eye, each on those parts of its retina which would have been impressed had the eyes been actually directed to the real object.

The arrangement in question need be of a very simple character. Thus, let the annexed figures be the dissimilar perspectives of a slide ; a board of a



book, or even the flat hand held between the eyes, will serve the purpose, though not without some straining of the sight. By the arrangement in Sir David Brewster's Lenticular Stereoscope there is no such straining, but immediately we look into the instrument the stereoscopic effect is seen, just as if there was the real object in miniature enclosed in the box.

It is to be observed, that in Sir David Brewster's Lenticular Stereoscope we have nothing new in the principle of the instrument; for that was fully developed in the first one made, whether by Mr Wheatstone or Mr Elliot. Sir David's improvement, admirable as it is, belongs merely to the arrangement by means of which the two perspectives of the slide are presented one to each eye separately. It consists in substituting for the ordinary convex glasses the two halves of one, placed with their circumferential edges next each other. These segments of lenses, at the same time that they magnify, act as prisms, displacing the perspective seen by the right eye a little towards the left, and that seen by the left eye a little towards the right; so that the eyes are enabled to view each its own perspective, as if in the same position as that in which they would have seen the dissimilar perspectives of a real object before them, and consequently with equal facility.

CHAPTER II.

ON THE PSYCHICAL ACTION OF THE OPTIC NERVOUS APPARATUS, AND ITS ADAPTATION TO THE PHYSICAL CONSTITUTION OF THE EYE.—OUTNESS OF VISUAL PERCEPTION. — ERECT VISION, THOUGH RETINAL IMPRESSIONS ARE INVERTED.

WHILE the projection on the two retinæ of the dissimilar perspectives of an object or the dissimilar perspectives in the Stereoscope is a *physical* process, our perception of relief or intaglio from the impressions thereby made is a *psychical* or *mental* act, and therefore not at all to be explained by any reference to the physical principles according to which the perspectives come to be projected on the two retinæ. In short, given the impression on each retina of the dissimilar perspective of an object of three dimensions—no matter, let us suppose, how the impressions came to be made, provided they are made on certain parts of the retina—and we perceive the stereoscopic effect.

As physical and psychical questions are thus involved in our subject, we must, in discussing the theory of stereoscopic vision, take care not to confound the two with each other, but to keep them prominently distinct. In order to do this, it will be necessary to premise some observations on the psychical action of the optic nervous apparatus generally, and its adaptation to the physical constitution of the eye.

The *physical* part of vision has ended when, by the optical action of the refractive media of the eye, the rays of light from the object looked at have been brought to foci on the retina. With the perception of the sensation excited by the impression of the light on that nervous expansion, the *psychical* part of vision begins.

In the act of seeing, we refer our perceptions to without, and to some distance from the eye,—to the place where the object is, whence the rays of light making the impression emanated. In this respect, sight differs from touch; for we refer our tactile sensations to the part of the skin impressed. In this peculiarity of sight we may perceive an adaptation to the means by which the retina is impressed —viz., not directly by the object, as the skin is in touch, but only through the medium of the rays of light proceeding from the object. In thus referring our visual perceptions to without, and to some distance from the eye, we take no cognizance of the fact that the impression exciting the sensation is actually made on the retina, nor of the nature of the intervention of the impressing agent, light.

This faculty of *outness* of visual perception is owing to an original inborn law of our minds, and not, as has often been maintained, on experience and association acquired through the sense of touch. In support of what is here advanced, the sense of touch itself affords an illustration — viz., the well-known fact that persons who have had the misfortune to lose a limb sometimes feel as if the lost organ were still in connection with the body, and that some part of it, perhaps, is the seat of pain. Thus, to quote from the 'Spectator,' "The poor fellow, who lost his arm last siege, will tell you he feels the fingers that were buried in Flanders ache every cold morning at Chelsea." This is an example of a tactile sensation referred by the mind, under abnormal conditions, not to any part of the existing body, but to without and to some distance therefrom, just as a visual sensation is, under normal conditions, referred.

The direction outwards in which the mind refers its visual perceptions is that of the axis rays of the cones of light which make the impression. The mind, therefore, in referring its visual perceptions outwards, does so to the side opposite that on which the impression is made on the retina. Thus, if the impression is made on the lower part of the retina, the sensation resulting therefrom is referred to a point outwards and upwards—to that part of the object, in fact, whence the rays making the impression come. If the impression is made on the upper part of the retina, the sensation resulting therefrom is referred to a point outwards and downwards. And so on—if on the right side of the retina, to a point outwards and to the left; if on the left side, outwards and to the right. Though it is thus outwards in the direction of the axis rays of the cones of light, making the impression, that the mind refers the sensation, it is proper to observe that this in no way depends on the direction of the rays of light; for if the axis rays be prevented from entering the eye, the same effect nevertheless follows the impression of any of the circumferential rays alone, the direction of which is different. Besides, a luminous spectrum excited by an impression on the retina independently of light—by direct pressure, for example—appears to us, in like manner, projected outwards, and to the side opposite that where the pressure is applied.

It is on this law, which has been named the *law of visible direction*, that our seeing objects upright as they are depends, notwithstanding that, in conformity with the laws of light, the pictures of external objects projected on the retina by the dioptric apparatus in front of it are necessarily inverted—in other words, erect vision, notwithstanding that the impressions on the retina are inverted. In this law, we have an additional example of the adaptation of the psychical endowments of the retina to the optical conditions under which external objects make their impressions on that nervous expansion.

CHAPTER III.

ON SINGLE VISION WITH TWO EYES.—CORRESPONDING OR IDENTICAL PARTS OF THE TWO RETINÆ.

SINGLE vision with two eyes is also dependent, in part at least, on the law of visible direction.

As the rays of light emanating or reflected from the different points of a visible object proceed in all directions, and in straight lines, those from the same points must, necessarily, some of them, enter the one eye and some the other, and so impress both retinæ in the same manner and at the same time. From these two impressions, it is to be observed, we have not a double perception of the object, but only a single one, provided the two eyes be naturally directed, —that is, provided their optic axes intersect at some point of the object, provided their centres of revolution coincide, and provided their horizontal and vertical diameters are respectively parallel. When the two eyes are thus naturally directed, the parts of the two retinæ which receive similar and simultaneous impressions from the rays of light entering them from given points of the object are the various parts of the right half of the one retina, and the various parts of the left half of the other retina, equally situated in relation to their vertices or central points. These parts of the two retinæ, as similar and simultaneous impressions on them yield but a single visual perception, are named *corresponding* or *identical parts.* If the two eyes are not directed in the natural manner above described, the rays of light from a given point of the object will not then fall on corresponding parts of the two retinæ, and the consequence will be that the two impressions will be perceived by the mind separately, and the object will appear double,—that is to say, two images of the object will be seen, each being referred by the mind to a different place in the field of view.

Amidst the various movements of the eyeballs, the correspondence in direction necessary for single vision is maintained by the concurrent action of their muscles.

In accordance with the law of visible direction, the mind, in referring a sensation excited by an impression on the retina to without and to some distance from the eye, does so in a direction depending on the part of the retina impressed. Now, when similar impressions are simultaneously made on corresponding parts of the two retinæ, the two similar sensations resulting from the impressions are referred by the mind outwards to one and the same place. The image seen by the one eye, thus coinciding with that seen by the other, the object appears single. This, so far as regards distant objects, is true; but there are other considerations to be taken into account in explanation of single vision with two eyes. The images of a near object, viewed by each eye separately, are not referred by the mind to exactly one and the same place;—that is, as has been already shown, the right eye, when the left is shut, sees the object a little to the left of the place where it appeared to the two eyes to be; and the left eye, when the right eye is shut, sees the object a little to the opposite side. As soon, however, as the two eyes are in simultaneous action, the two images come to be referred to the same place. When the two images are thus referred to one and the same place, and consequently appear run together into one, it cannot exactly be said that they are superposed merely; for we have seen that the two dissimilar perspective images of an object of three dimensions, or the two figures of a stereoscopic slide, are seen as one, though that one is like neither of the perspective images. In this case there must be a mental combination of the two into one.

A superposition of two images does, indeed, appear to take place, if they are quite different from each other, either in respect to colour or shape. Thus, when impressions different in colour, though of the same shape, are made on corresponding parts of the two retinæ,—which may be done by means of a Stereoscope and a blank slide on which a blue wafer has been stuck on the one division, and a yellow wafer on the other,—the images of the two wafers run together, and one round spot is seen, but an admixture of the two colours does not take place. The spot appears either blue alone or yellow alone, at the same instant of time, as if the image of the one wafer was merely superposed over that of the other. Sometimes, however, the blue is seen in part, and the yellow in part, as if portions of the superposed wafer had vanished, allowing of portions of the subjacent one to be seen through. If the colour of the one wafer be much more brilliant than that of the other, so that the impression on the one retina is more striking than that on the other, the more brilliant colour prevails or excludes the other altogether from the mind's perception. When the impressions are entirely different in shape, though of the same colour, the images are perceived to alternate in a similar manner, unless the one be much more striking than the other, in which case it also, like the brightest colour, predominates, and the other is not perceived.

As the dissimilar perspectives of an object of three dimensions or the two figures of a stereoscopic slide cannot all fall on exclusively corresponding points of the two retinæ, it follows that it is not an indispensable condition for single vision that every part of the impression on the two retinæ be made on exactly corresponding *points*. Still, if the non-correspondence of the points of the two retinæ impressed be beyond certain limits, there is double vision.

In elucidation of the question of corresponding points, it is to be observed that the retina is endowed with the greatest sensibility in the region of its vertex, or central part. Thence, towards its circumference, the sensibility diminishes. In consequence of this, we see very distinctly only that part of an object to which the axes of the eyes are at the moment turned. The difference in the degree of sensibility of the central and circumferential parts of the retina may be illustrated by a reference to the different degrees of sensibility manifested by the skin at different places—the skin of the lips, for example, and the skin of the cheeks. If the two points of a pair of compasses, when the legs are separated a very short distance from each other, be applied to the skin of the lips, we distinguish the two impressions ; but when the points are applied to the skin of the cheek, there is no distinct perception of two points, but a sensation is experienced as if one impression only were made, and that not a very well defined one.

Thus it is, to return to the consideration of the combined sensations of the two retinæ, that though the mind perceives separately impressions on neighbouring non-corresponding points of the two retinæ in the region of the vertex or most sensible part, at the same instant of time, it does not perceive separately impressions on neighbouring non-corresponding points at the circumferential and less sensitive parts of the retinæ. It perceives merely a sensation as if one impression were made, and that not a very well defined one—a sort of mean of the two.

To apply what has just been said of the difference in the degree of sensibility which the retina presents from its centre to its circumference, to the question of single vision with two eyes :—In viewing an object of three dimensions with the optic axes convergent, it is that part of it at which the optic axes intersect, the image of which is projected on the central part of each retina. Now, of the perspectives of the object which are projected on the two retinæ, this is the only part which is similar for the two eyes. The impression of the image of this part of the object, therefore, is confined to corresponding points, which is the condition necessary for a single visual perception from an affection of the central parts of the two retinæ. It is, on the contrary, those parts of the object lying out of the *horopter*—an imaginary spheroidal surface, the circumference of which cuts the point of intersection of the optic axes, on the one hand, and the points of intersection of the lines of visible direction within the two eyeballs, on the other—the image of which, necessarily dissimilar for the two eyes, is projected on the circumferential parts of the retinæ ; the very parts, affections of accurately corresponding points in which are not, as above seen, a necessary condition for a single visual perception.

CHAPTER IV.

ON STEREOSCOPIC VISION, OR THE VISUAL PERCEPTION OF THE THREE DIMENSIONS OF SPACE—LENGTH, BREADTH, AND THICKNESS.

THE preceding disquisition on single vision with two eyes has prepared us to enter upon the examination of the nature of stereoscopic vision, or the visual perception of the three dimensions of space—length, breadth, and thickness—or solidity and depth.

All that can be perceived of solidity or depth by means of one eye may be represented by painting on a plain surface; but we have shown that it is not so in regard to what can be seen of them by means of the two eyes whilst their axes are in a state of convergence. In the former case, a *semblance* of solidity or depth is seen; and this is all, as before pointed out, that a picture can represent: in the latter case, solidity or depth is perceived as really as it may be by the touch of two fingers; and this, as also before pointed out, is what a single picture cannot represent. The perception of solidity or depth is owing to the position of the two eyes in the head at some distance apart, whereby each is fitted to receive on its retina a different perspective of the object, whilst the mind, in conformity with an original inborn law of the economy, does not perceive two superposed dissimilar images, but only a single one, and that, unlike either of the two perspectives, in full relief or intaglio, as the case may be.

When the object looked at is so very distant that the axes of the eyes are little or not at all convergent, not more of solidity or depth is seen with the two eyes than can be seen with one only; for in this case the perspectives received by the two eyes are not dissimilar. The appearance of the object, as thus seen, might, therefore, be represented on a plain surface.

When the object is not so very distant but that the axes of the eyes require to be converged towards it somewhat, and yet not so very near as to require any great degree of convergence, we have a proportionate degree of stereoscopic vision.

Our faculty of perceiving the three dimensions of space—length, breadth, and thickness—used to be attributed by philosophers solely to the touch; the perception of solidity or depth by the eyes being, they supposed, a faculty acquired merely by experience through that sense. It is quite true that, by the active exercise of touch—by moulding the hand around a solid body—we recognise its three dimensions. It is also quite true, that using one eye only in vision — or even two eyes, if the object be very distant—though we may infer that an object presents length, breadth, and thickness, the appearance of solidity or depth is not bold or striking, and is such as can be represented by painting on a plain surface. The judgment as to the three dimensions by vision with one eye—or even with the two eyes, if the object be very distant—cannot, therefore, be depended on. But, on the other hand, it is quite true—and this is to be particularly remarked—that though by moulding the hand around a solid body we can recognise its three dimensions, we cannot by simple touch—that is, by contact of the skin with a solid body—recognise any more than the two dimensions of length and breadth. Again, it is also quite true that though by means of one eye we can recognise truly length and breadth only, we can, if we look with the two eyes at a solid body near us, perceive its three dimensions of length, breadth, and thickness, as certainly and demonstrably as we can by the touch when moulding the hand around the object.

The faculty of perceiving the three dimensions of space with the two eyes implies the faculty of recognising, by the same means, the distance and position of objects looked at with the optic axes in a state of convergence. Whilst, with the two eyes, objects and their several parts are seen fixed, as it were, each in its own position and at its own distance, the same is not the case with one eye. We cannot, for instance, with one eye only so perceive position and distance as to be able accurately to pour wine into a glass, snuff a candle, or perform the like operation. With one eye, indeed, we cannot even, under all circumstances, distinguish between relief and intaglio. Thus, if we look with one eye fixedly on the intaglio of a seal from which the light is shaded, the design will sometimes appear as if in relief; but as soon as we open the other eye, the illusion is dissipated, and the intaglio becomes unmistakeably evident. As in viewing very distant objects with the two eyes the optic axes are not convergent, the perspectives received by the two retinæ are similar; we, therefore, do not perceive more of their three dimensions than we can with a single eye. We cannot, accordingly, even with the two eyes, determine with great exactness the relative position and the projecting or receding of distant objects.

CHAPTER V.

ON THE RELIEF OR INTAGLIO OF OBJECTS, AS OBSERVABLE IN NATURE WITH THE TWO EYES, COMPARED WITH THAT IN WHICH THEIR REPRESENTATIONS ARE COMMONLY MADE TO APPEAR IN THE STEREOSCOPE.

THE nearer the distance at which we view real objects, the more fully do they appear in relief, both as a whole and in their several parts. They appear more fully in relief as a whole, because the two eyes receive more dissimilar perspectives of them, as regards position, in the field of view. They appear more fully in relief in their several parts, because we see more of them with the one eye on one side, and with the other eye on the other side; the two eyes thus receiving more dissimilar perspectives of the objects in respect to form.

The further the distance at which we view the objects, the less fully do they appear in relief, both as a whole and in their several parts. This is because the optic axes being less convergent, the two eyes receive less dissimilar perspectives of the objects, both in regard to position and form.

When the objects are so very far off, that in looking at them the optic axes are parallel, the perspectives received by the two retinæ are similar. The resulting appearance to the mind, therefore, presents no more relief than if one eye only were used.

To apply what has now been recapitulated to the appearances observed in viewing the natural landscape:—In viewing the natural landscape with both eyes, we perceive it in the distance *receding horizontally* away towards the horizon, into the depth of the space before us. Such is the general effect, irrespective of the objects that intervene. As to them, they are seen to stand out in different degrees of relief, both in respect to their relative position and to their component parts, according to their distance; —objects in the foreground, boldly, like pillars, as it were; objects in the background, rather flat, like pilasters.

With one eye, we do not perceive this *horizontal recession* of the landscape towards the horizon. The background appears rather to *rise vertically* in the field of view to meet the sky at the horizon; whilst the various objects present no greater relief in the foreground than they do in the background, except such apparent relief as depends on nearness, size, &c.,—no greater appearance of relief than may be represented by painting on a plain surface, which is merely a semblance of relief.

As, in viewing the natural landscape, even the objects in the foreground are at some considerable distance from us, they do not appear to the two eyes in very strong relief. The most striking effect usually taken cognisance of by the two eyes is that of the *horizontal recession* of the landscape towards the horizon.

In the Stereoscope, the relief or intaglio of the subject almost always appears much greater than is seen in nature. This is owing to the dissimilarity of the two perspectives of the slide being made very much greater than that which the perspectives received by the two retinæ from the real object could by possibility present, with the eyes placed as they are in the head at so short a distance apart. The great dissimilarity of the two perspectives on stereoscopic slides is intentionally produced by placing the two cameræ, by which they are respectively taken, at a considerable distance from each other. By this contrivance, such different perspectives are obtained as could only be actually seen by the eyes, placed as they are, if the subject were a small model viewed at a short distance. The appearance seen from such a slide in the Stereoscope is, therefore, such only as could be presented by a small but exquisite model. It is an appearance impossible in nature, though in so many respects natural-looking. If the eyes were placed in the head more widely apart (an arrangement, however, for which a much greater breadth of head would be a necessary condition), we should, indeed, be able to see distant objects in greater relief than we do—more nearly like what the pictures in the Stereoscope appear; for in that case we should receive on the retinæ more dissimilar perspectives of them.

Exquisitely beautiful as the views in the Stereoscope are, they are thus not such as can be seen in nature, if the objects represented be at any distance, as they must be in order to be all seen when large. Stereoscopic views from less dissimilar perspectives than are commonly taken—from perspectives more nearly like what could be naturally projected on the retinæ from real objects—though less striking for their relief or intaglio, would be much more natural, and in the end, perhaps, more pleasing. Even real objects of small dimensions, viewed near, are not seen in such strong relief or intaglio as that in which the objects in the Stereoscope are commonly made to appear.

CHAPTER VI.

ON THE STEREOSCOPIC GLASSES FOR SINGLE PICTURES, —THEIR FORM AND OPTICAL ACTION, AND THE STEREOSCOPIC EFFECT OBSERVABLE WITH THEM.

A GOOD picture appears to one eye exactly like what the reality would have appeared to one eye; but to both eyes the picture is not only not like what the reality would have appeared to both eyes, but is less natural-looking than it is to one eye. The interference of the second eye mars the illusion of relief as seen with one eye, by betraying to us the flatness of surface. For, to repeat the remark before made, as with the two eyes we recognise full relief or intaglio, so, on the other hand, with two eyes we detect the absence of it.

After viewing a picture in the Stereoscope, the best painting, it must be confessed, appears flat and tame in comparison. Considering this, the question has frequently presented itself to my mind, Would it be possible to form lenses through which, when presented before both eyes, any single painting or picture might be seen with something of a real stereoscopic effect ?

The conditions for stereoscopic vision being the projection of a dissimilar perspective on each retina, I saw that lenses by which something of a stereoscopic effect in a single picture might be produced, should be of such a form as to be capable of making the picture looked at appear narrower or broader, on one side to the one eye, and on the opposite side to the other eye.

On applying to an optician to get glasses of such a form made, I did not receive much encouragement.

Grinding lenses with a surface of the desired curve, I was told, would be, if not impossible, at least a matter of much difficulty and expense. I therefore gave up the project; but, after a time, the idea recurred to my mind, and, as I could not get lenses, I resolved to test the question catoptrically. To effect this, I constructed a Reflecting Stereoscope, using for the mirrors silvered metallic plates, which I bent into a concavity with a cycloidoidal curve in the horizontal direction. These mirrors I fixed with their most concave sides away from each other, that is, the one on the right and the other on the left, and presented a *fac-simile* picture to each. The one picture was thus reflected to the right eye somewhat broadened on one side; and the other picture to the left eye, broadened on the opposite side. In short, a slightly different perspective of the picture in a rude way was presented to each eye, and the result perceived was, as I anticipated, a slightly stereoscopic effect in the picture, manifested especially in the appearance of a horizontal recession of the landscape towards the horizon.

The success of this experiment induced me to try again to get lenses to test the question dioptrically. I accordingly procured two pieces of transparent amber, and ground them into lenses myself of the shape required, which, in consequence of the softness of the material, I had not much difficulty in doing. Encouraged by the result obtained from these amber lenses, I next, with the assistance of a lapidary, had glasses ground which still better answered my expectation. Continuing my experiments, I had glasses ground, though still imperfectly enough, into the various forms by which the effect I contemplated might be produced, until I obtained an approach to the form which I have adopted as most convenient for the purpose.

Having succeeded so far, the next step was to get the glasses ground with mathematical precision. This has now been accomplished by the ingenuity of Mr Slater, of 136 Euston Road, at whose establishment the lenses are made with as much perfection nearly as ordinary spherically-curved lenses.

Description of the Glasses.—The glasses of what I call the fundamental form are plain on one side and concave on the other. In the curvature of the concave side lies the peculiarity in the form of the glasses. In a horizontal section, the curve of the concave side may, for the sake of convenience, be described as a circular curve running into a tangent; though, properly speaking, it is something of a cycloidoidal curve. In a vertical section the curve is parabolical or circular, and of a radius somewhat longer than that of the deep part of the curve of the horizontal section. By means of this proportion between the horizontal and vertical curves, the difference in the power of most people's eyes to bring horizontal and vertical rays to a focus is corrected, and definition of the sight thereby improved. Glasses of two different powers in this respect have been made. Some persons find the one power, others the other power, give them the best definition. These two powers suit most eyes, but glasses of any other required power could be made without involving any difference in their stereoscopic performance.

The rays of light which diverge vertically from an object, in passing through a glass of the form just described, are made more divergent in an equal degree vertically above and below. The rays which diverge horizontally from an object are, on the contrary, rendered greatly more divergent only in passing through that portion of the glass which presents the deep concavity. If, therefore, holding such a glass before one eye, the portion of it presenting the deep concavity being next the nose, we view a picture through it, the picture will appear slightly narrowed on the side next the nose—the side, namely, the rays of light diverging horizontally from which pass on their way to the eye through that portion of the glass which, in the horizontal section, presents the deep concavity. If, now, we view a picture with a glass before each eye simultaneously, held in the manner just mentioned (viz., the portion of each glass presenting the deep concavity next the nose), a slightly dissimilar perspective of the picture will be thrown on each retina, and the result is in accordance with the conditions for stereoscopic vision, the perception by the observer of a corresponding stereoscopic effect or appearance of relief in the picture. In consequence of the general prismatic form of the glasses, the picture appears to the right eye displaced towards the right, and to the left eye displaced towards the left. By this displacement, the picture is seen as it would be if the eyes were less convergent. It, therefore, appears as if viewed at a greater distance. Hence the amount of stereoscopic effect, though limited, accords with the greater apparent distance.

The glasses of the fundamental form, as now described, may be mounted either in ordinary spectacle frames or in double eyeglass frames, and may be used by a person who is somewhat short-sighted; but for a far-sighted or a nearer-sighted person, the superaddition of ordinary convex or concave glasses is necessary. In suiting different sights, the commodious plan, however, is to make the glasses in one piece, having the before-described concavity on one side, and the required spherical convexity or concavity on the other.*

Mounted in the eyepieces of a binocular opera or field glass, a little in front of the concave eyeglass, the lenses produce the stereoscopic effect most

* Other forms of glasses, besides that above described, may be made to produce the desired effect along with a convergent or divergent power.

strikingly, whilst the opera-glass or field-glass is, at the same time, improved as an opera-glass or field-glass. Glasses having the superaddition to the fundamental form of a spherical convexity on the opposite side, the radius of which equals that of the concave curve presented by the vertical section of the fundamental form, and thus so far neutralized in their divergent power, may be fitted into any opera-glass or field-glass without interfering with the optical relation between its object-glass and eye-glass.*

In viewing a good picture with an opera-glass fitted with the stereoscopic glasses—say a landscape—the objects represented are all taken in by the two eyes at one glance, and appear to stand out in their relative position and distances, whilst the horizontal recession of the distance towards the horizon is very evident. The amount of stereoscopic effect thus given is sufficient to impart to the picture much of the appearance of reality which the real scene, viewed with the two eyes, would have presented; for in pictures the objects are commonly represented as seen at some distance, and could not therefore have appeared in nature to the two eyes in much stronger relief.

The stereoscopic effect produced by the stereoscopic glasses is very slight, when compared with that usually presented in the stereoscope. It is, however, to be remembered that the effect of relief or intaglio observed in the stereoscope is usually much exaggerated—is not such as the landscape or other subject represented could by any possibility present in nature. The effect in the stereoscope,

* Any binocular opera or field glass can be fitted with the stereoscopic glasses. The very convenient small patent opera and field glasses of Mr Dixey, Optician, 3 New Bond Street, which he has fitted with stereoscopic glasses, I have had most experience of, and have found to perform particularly well.

indeed, we have shown, is such only as could be seen by viewing at a short distance from the eyes a small but perfect model of the subject.

The purpose of the stereoscopic glasses for single pictures is obviously quite distinct from that of the Stereoscope. The sole pretension of the stereoscopic glasses is to add to the beauty of single pictures by giving them something of a real stereoscopic effect when viewed with both eyes, instead of the mere *semblance* of such an effect which single pictures present even when viewed otherwise to the best advantage, as they are with one eye alone.

In the description above given of the stereoscopic effect of the stereoscopic glasses, it is to be understood that I speak principally from what I myself can perceive. The majority of persons who have tried the glasses have described the effect perceived by them in a manner so as to indicate that they perceive it the same as I do. Some persons, on looking through the glasses without being previously aware of their nature, have instantly declared that they perceived a stereoscopic effect; but on reflecting that it was but a single picture they were looking at, they were ready to doubt the correctness of their first impression. One gentleman exclaimed, "But should there not be two pictures?" Other persons, unable at first to realise the effect, have, after a little observation, perceived it, and declared that "the picture looked more natural." Other persons again, however, taking their idea of stereoscopic effect literally from the exaggerated appearances in the Stereoscope, have declared that they could perceive no such effect at all.

On the same principle that the glasses give a stereoscopic effect to single pictures viewed through them with both eyes, they bring out with increased prominence real objects at some distance, such as the actors on the stage, and, besides increasing the effect of *horizontal recession*, enable us, in viewing the natural landscape, to determine with greater exactness the relative position and the projecting or receding of distant objects.

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Mr Dixey's small patent Opera and Field Glasses may be had fitted with Professor Wharton Jones' Stereoscopic Glasses for Single Pictures.

The price of the pair of Glasses, including the setting, is 1*l.* in addition to the cost of the Opera or Field Glass.

3 New Bond Street, W., London.

Mr Slater, 136 Euston Road, N.W., London, supplies Professor Wharton Jones' Patent Stereoscopic Glasses for Single Pictures direct or through an Optician.

The price of the pair of Glasses, including the setting, is 1*l.* in addition to the cost of the Opera or Field Glass, or Spectacle or Eyeglass, Frame in which they may be mounted.

Any Binocular Opera or Field Glass can be fitted with the Stereoscopic Glasses.

Opticians supplied, along with the Glasses, with printed Directions for setting them.