

IS A SENSE OF SPACE ACQUIRED?

OUR PERCEPTION AND ESTIMATION OF AREAS AND DISTANCES.

BY P. ALTPETER.

THE actions and assertions of persons who were blind at birth and have subsequently acquired the power of vision through surgical operations prove that our perceptions of distance, area, and solidity, and our ability to distinguish between right and left, up and down, before and behind, are not born in us, but are

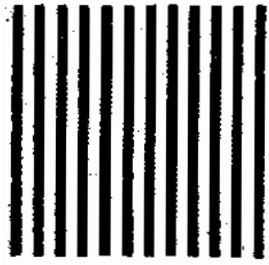


FIG. 1.



FIG. 2.

acquired by long practice and experience. A person blind from birth, who has learned to distinguish triangles, squares, circles, and objects of other forms by feeling, is not able, immediately after the acquisition of sight, to distinguish these familiar objects by sight alone, but is still compelled to rely upon feeling. In the beginning all objects appear to him as shapeless, tremulous spots of various colors situated close to the eye, and only gradually and by exercise does he learn to recognize their true places, forms, and dimensions. Young infants with normal sight evidently experience a similar course of training, as their actions indicate.

The fact that a chick, immediately after its escape from the shell, is able to run about and pick up food might seem to prove that the faculties of orientation and locomotion may, in some animals, be innate and hereditary, but this inference is unwarranted. The

estimations of length or distance enumerated above are based on estimations of time.

In the same way a person blind from birth obtains, by feeling, a notion of the height of a chair, the length and breadth of a table, the length and thickness of a pencil, etc. Here, evidently, the organs employed are the skin, the muscles, and the sensory nerves.

In estimating a distance by sight, likewise, the controlling factor is the time occupied by the eye in run-



FIG. 6.

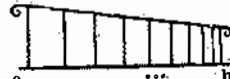


FIG. 7.

ning over the distance, and the muscular sense is again called into play. Thus the breadth of a vertically ruled square (Fig. 1) appears greater than its height, because the eye, in sweeping over it horizontally, is momentarily arrested and consequently delayed by each line, but is not thus delayed in traversing the figure vertically. For the same reason the height of a horizontally ruled square (Fig. 2) appears to exceed its breadth. Hence the apparent height of a woman is increased by a gown having horizontal stripes or flounces and diminished by vertically-striped garments, and ceilings are apparently raised by horizontally, and lowered by vertically-striped wall paper.

Fig. 4 gives another illustration of the same law. The subdivided half of the line appears longer than the undivided half, because the movement of the eye is delayed by the division marks.

Now if an unruled square (Fig. 3) is observed closely its height appears slightly greater than its breadth, although there is nothing to impede the free

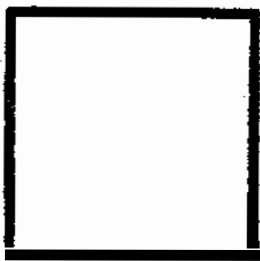


FIG. 3.

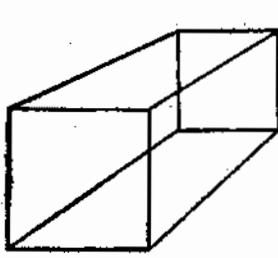


FIG. 8.

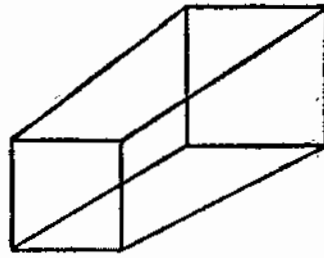


FIG. 9.

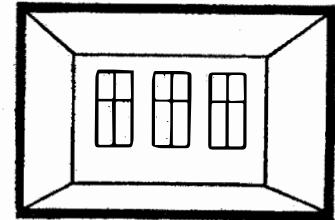


FIG. 12.

and is therefore smaller than that angle. So, for the other posts, the angle traversed diminishes as the distance increases. Hence as the eye does less work and occupies less time in moving through a small than a large angle, the more distant posts appear smaller in the proportion of their distance. This is neither an optical illusion nor a false judgment, but the natural consequence of the genesis of perceptions of length by unconscious deduction from the muscular efforts of the eye.

Our first notion of depth, in a picture or an actual landscape, is derived from the apparent sizes of objects. Of two essentially similar objects, the one which appears to be the smaller also appears to be the more distant. Thus Fig. 6 represents a railing perpendicular to the line of sight, and Fig. 7 represents a railing oblique to the line of sight and receding toward the right.

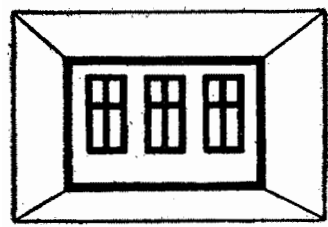


FIG. 13.

newly-hatched chick, if observed very carefully, is seen to move in an uncertain manner, to run against obstacles and often to miss the grain at which it aims. Even the chick, therefore, acquires its spatial perceptions by practice, although it acquires them much more rapidly than human beings acquire theirs.

Let us now examine the method and the organs which are employed in this process.

If the eyes are closed, it is still easy to determine which of two sticks or strings is the longer by drawing the objects between the fingers successively and with about the same velocity. The comparative lengths of the objects are inferred from the times required for the fingers to pass from one end to the other, in each case. Similarly, all distances appear longer in proportion to the times occupied in traversing them. This law may lead to erroneous judgments,

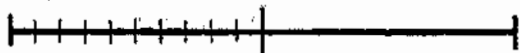


FIG. 4.

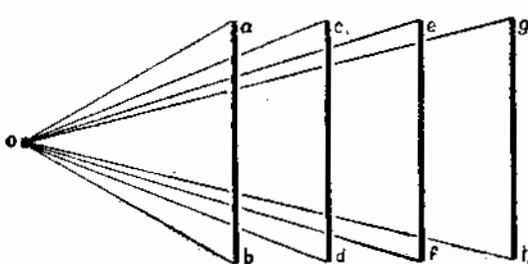


FIG. 5.

sweep of the eye over it in any direction. The explanation is that the eye, like the arm, moves more easily and rapidly in a horizontal than in a vertical direction. For this reason the apparent excess of height over breadth, in Fig. 2, is greater than the apparent excess of breadth over height, in Fig. 1.

These examples show that the visual estimate of a distance is based on the time and labor involved in glancing over the distance, as perceived and transmitted to the brain by the sensory nerves of the ocular muscles. Stone cutters, cabinet makers and many other artisans acquire, by long practice, remarkable certainty and precision in this unconscious operation, so that they can gage moderate lengths to 1/10 or 1/25 inch.

Pupils in drawing acquire such precision very slowly. Hence it is preposterous to set beginners to copying geometrical and symmetrical figures which they cannot draw with any approach to accuracy without the use of rulers or other unlawful aids.

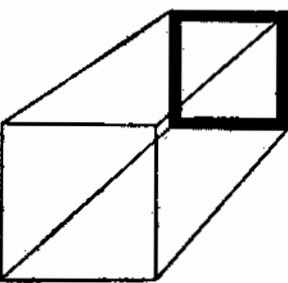


FIG. 10.

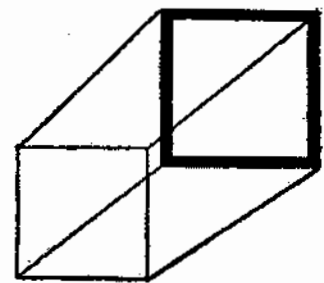


FIG. 11.



FIG. 14.

for the apparent length of a railway journey depends on the speed of the train, and distances about town are miraculously shortened by the installation of a trolley line. The depth of a well or a pit may be estimated from the time occupied by a stone in falling from the top to the bottom and the distance of a thunder cloud from the interval elapsed between the flash of lightning and the peal of thunder. All of the

The estimation of volume, which includes that of distance in the line of sight, requires a closer analysis. The drawing master teaches that both the vertical posts of a fence and the horizontal intervals between them appear, and therefore should be drawn, smaller in proportion to their distance from the eye. The intimate connection of this and other laws of perspective with the facts described above becomes

but both of these boxes will apparently be seen, in an unnatural manner, from below.

The second most convincing evidence of depth or distance is distinctness of near and the indistinctness of remote objects. Hence if one end of each of the boxes is drawn in heavy outlines, as in Figs. 10 and 11, that end will appear to be nearer than the other. This effect is exhibited still more strikingly by Figs.

12 and 13. Even if all the lines were equally heavy, Fig. 12 would naturally be taken to represent the interior of a room, and the heavy outlines of the open side only strengthen this impression, but in Fig. 13 the heavy lines of the windows and the wall pierced by them completely reverse the perspective and bring the small side forward, to form an architectural monstrosity.

A third cause of the impressions of depth and solidity is found in the distribution and the varying intensity of light and shade. Light appears brighter and shade deeper in the foreground than in the background. Seen from a great distance, a white house or a blossoming cherry tree appears grayish, and black objects lose something of their blackness.

Hence in painting, vivid contrasts of color are introduced in the foreground, while the background is painted in neutral or grayish tints, shading into each other without sharp outlines. The shadows cast by objects also heighten the effect of solidity. In Fig. 14 the indication of a shadow causes the heavy black line to stand out from the paper and suggest an upright stake in bright sunlight.

The perception of depth or distance is aided by the accommodation or change of focus of the eye in viewing objects at different distances. The crystalline lens becomes more convex when a very near object is regarded, and flattens for distant vision. These changes are required to throw the image, in each case, on the retina, and not before or behind it. The

accommodation is effected by unconscious muscular effort. A still greater muscular effort is required in order to converge both eyes upon the same point, especially a near point. Stereoscopic or binocular perspective results from the variation of this convergence of the eyes for various distances and from the slight differences between the images formed on the two retinas.

Except for near objects, however, the perspective effects of both monocular and binocular accommodation are very small in comparison with the effects of relative size, light, shade and color, as is proved by the realistic impression produced by good photographs, paintings, panoramas, and especially by large projected pictures, moving or motionless.—Kosmos.

THE INVENTION OF THE PANTOGRAPH.

CHRISTOPH SCHEINER'S WONDERFUL DEVICE.

EVERY draftsman is familiar with the ingenious instrument known as the pantograph, with the aid of which any design can be copied with accuracy, in the dimensions of the original or on a larger or smaller scale. The pantograph consists essentially of four flat rods jointed to form a parallelogram (ABCD, Fig. 1), two adjacent sides of which are prolonged. Any straight line such as PM, which intersects all four rods is divided by their median lines into segments which preserve the same ratios to each other in all positions of the instrument. Hence if a pivot is placed at P, a tracing point at N and a pencil at M, and the pivot is

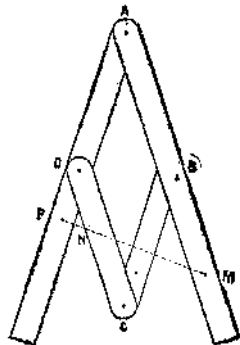


FIG. 1.—THE PANTOGRAPH IN ITS PRESENT FORM.

fixed by being pressed firmly on the drawing board while the tracing point is caused to follow the lines of a drawing, an enlarged copy will be drawn by the pencil.

The story of the invention of the pantograph is curious and interesting. The invention is three centuries old and is due to a Jesuit priest, Christoph Scheiner, who attained distinction by researches in physics and astronomy and who discovered sun spots independently of Galileo, if not before him. In 1631 Scheiner, who was then teaching in Rome, published a quarto volume of 100 pages, entitled: "Pantographice sen Ars delineandi res quaslibet per parallelogrammum lineare sen cavum, mechanicum, mobile." (Pantography, or the art of delineating all things with a

plication of the instrument, slightly modified, to the mechanical production of plane drawings of solid objects, statues, and landscapes. To the modified instrument Scheiner gave the name stereograph, and he naturally included both forms under the designation of pantograph, or universal drawing instrument.

It would be interesting to follow the author in his description of various possible forms of the instrument, especially the ingenious stereograph which, for the purpose for which it was designed, has never, to my knowledge, been surpassed, except by photography. But we are now concerned solely with the history of the invention, as Scheiner narrates it in his book.

In 1603, twenty-eight years before the publication of his *Pantographia*, Scheiner, then thirty years of age, was teaching belles-lettres and mathematics in the college of Dillingen. Among his friends was an artist, whom he designates merely by his first name, George. The priest and the painter were so intimate that neither ever kept a secret from the other until one day the painter asserted that he knew a method of reproducing any drawing exactly, on any scale, without looking at the copy, but giving his entire attention to the original. Scheiner begged for an explanation, but the artist replied that the invention was "more divine than human and that he would not divulge it to mortals for any consideration." All the information that Scheiner could obtain, after much urging, was the statement that nothing was required except "a compass and a fixed center." "Seeing that I was speaking to deaf ears," Scheiner continues, "I resolved to adopt another course and to confide in God."

All this occurred in the beginning of the year 1603. Scheiner immediately went to work. His first idea was to use a wire; then he tried successively, in thought or in practice, a wooden rod, two rods, and finally four rods, forming a parallelogram.

During the night of January 19th-20th, the solution of the problem came to him. "It was like a flash of lightning," Scheiner writes. "To-day, after twenty-seven years, my memory of it is as fresh as if it had happened yesterday. On rising in the morning I returned thanks to God, and repeated in my heart Archimedes's shout of 'Eureka!' Then I joined my four rods with pins and made an enlarged copy of a picture of St. Ignatius, very accurately and without the least difficulty."

Scheiner made several other copies and sent them, with his pantograph, to the painter George, who proudly admitted that the instrument was far superior to his own, in which the relative positions of the fixed center, the tracing point and the pencil were invariable. George called Scheiner a benefactor of humanity but, rather inconsistently, warned him not to vulgarize his God-given invention by making it public. Scheiner showed the instrument to very few persons, but it was much talked of and so came to the knowledge of Duke Wilhelm of Bavaria, a talented artist, who summoned Scheiner to Munich and expressed great admiration for the invention. Subsequently Scheiner exhibited his parallelogram, or epipedograph, to his classes in mathematics, but he showed the stereograph only to a fellow priest and to one of his pupils, the Archduke Maximilian of Austria.

Finally, in 1631, Scheiner published the volume describing both instruments. Fig. 2, taken from that volume, represents the epipedograph, which differed in no essential particular from the pantograph of to-day. Few inventions have remained in use in their original forms for so long a time—three centuries.—Cosmos.

Rubber Oil (protection against rust).—According to a German this is prepared as follows: The crude oils, obtained by the dry distillation of brown oil, peat, or other earthy resinous substances, are subjected to a further distillation. Thin, rolled rubber (India rub-

ber) cut into narrow strips is saturated with four times the quantity of this oil and left standing for eight days. The mass thus produced is subjected to the action of vulcan oil, or some similar substance, until a perfectly uniform, clear substance has been produced. This substance, applied in as thin a layer as possible to metal surfaces, forms, after drying slowly, a sort of pellicle, which is perfectly resistant to atmospheric influences.

INTERMITTENT SPRINGS.

THE conditions which give rise to the phenomenon of "intermittent springs" can be very neatly illus-

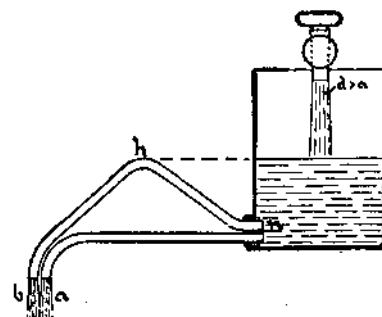


FIG. 1.

trated by means of the model shown in the accompanying diagram (Fig. 1). This model is readily constructed from very simple materials. Take a vessel having an opening at or near the bottom, and insert into this opening a stopper provided with two perforations. Into the lower of these fit a tube shaped as indicated (a), serving as direct outlet. Into the upper perforation fit another tube, to which a knee-shaped bend has been given, so that it can discharge, under suitable conditions, by siphon action. Its highest point h should be below the top of the vessel. Now feed a steady stream of water into the vessel, at such rate that the tube a alone is unable to discharge the water as fast as it is fed in. The level in the vessel will consequently rise, until it reaches the height h of the bend in the siphon tube. As soon as this occurs, the second tube also begins to discharge, and if the feed is properly regulated (greater than the discharge from a, but less than the joint stream from a and b), then the level in the vessel will gradually sink, until it falls below the opening of tube b. At this instant the discharge from b will cease, the level of the water

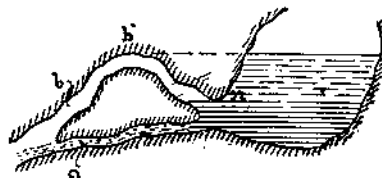


FIG. 2.

will steadily rise once more, and the entire series of events just described will be repeated time after time.

Fig. 2, which represents diagrammatically the structure of an intermittent spring in nature, will now explain itself. It may be added, that in case the lower channel a is entirely absent, the spring will not only show periods of abundance and of comparative subsidence, but will alternately discharge and entirely cease to flow.—Kosmos.

Discoveries of copper, gold, and silver are reported to have been made on the Fiji Islands, and Western Australian mining men are at Suva, Viti Levu, awaiting the publication by the local government of regulations under which mining may be carried on, after which the new discoveries will be thoroughly exploited. No mining on a commercial scale has ever been done on these islands.

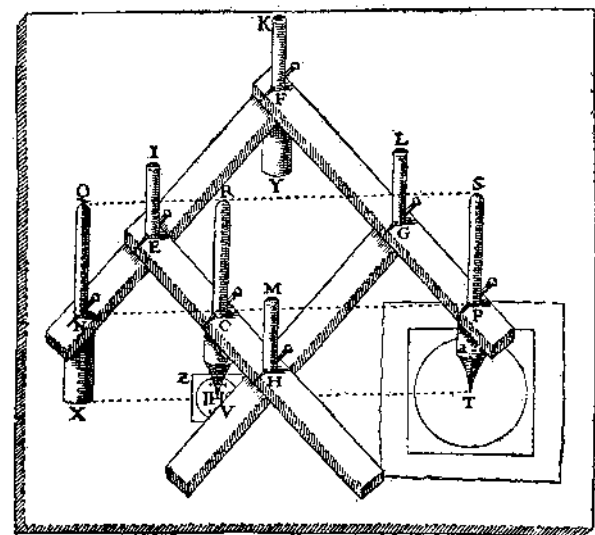


FIG. 2.—SCHEINER'S ILLUSTRATION (PUBLISHED IN 1631) OF HIS PANTOGRAPH (INVENTED IN 1603).

movable, mechanical parallelogram, straight or curved.)

This volume contains the whole theory and practice of the pantograph. The first part, comprising three-fourths of the volume, is devoted to the instrument for copying drawings which has been described above and to which Scheiner gives the name epipedograph.

In the second part of the volume the author explains a very ingenious and now almost forgotten ap-