INTERESTING OPTICAL ILLUSIONS.

BY GEO. M. HOPKINS.

One is five. Two are ten. Straight is crooked. Motion is quiet. These are strange and apparently contradictory statements; but if we are to rely entirely upon the evidence of our visual organs, they are true. Human visual apparatus has certain qualities which cannot be classed among defects, although under certain conditions they prevent seeing things as they really are. To persistence of vision, or the property of the retinal nerves by which an image is retained after the object by which it was formed has disappeared, are due the phenomena here described and illustrated.

A short time since the writer, in search of new optical illusions wherewith to amuse if not to instruct a little company of scientific persons, found in the store of the well known optician, Mr. T. H. McAllister, of this city, an instrument known as the anorthoscope, which was imported by him about thirty years ago. Although it was a novelty then, and probably well known to many, it is now rare. In fact, perhaps not one in the two or three hundred who have seen it had ever even heard of it.

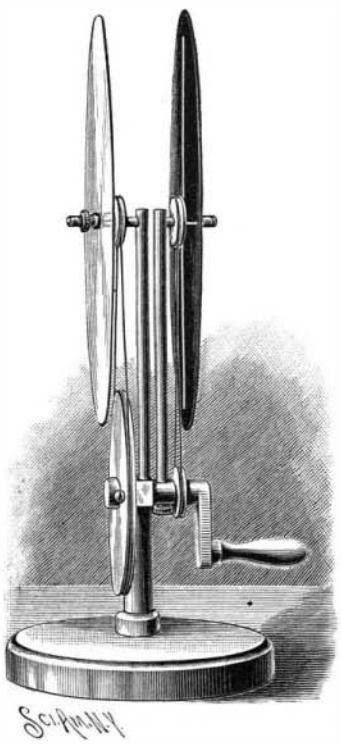


Fig. 1.—THE ANORTHOSCOPE.

The anorthoscope shown in Fig. 1 is a modified form of the instrument above referred to, and is adapted to experiments other than those belonging to the original apparatus. This instrument has a standard provided with a sleeve upon which is pivoted a movable arm. In the upper end of the standard and free end of the movable arm are inserted studs upon which are placed sleeves, each furnished with a pair of collars for clamping the paper disks—presently to be described—also a grooved pulley.

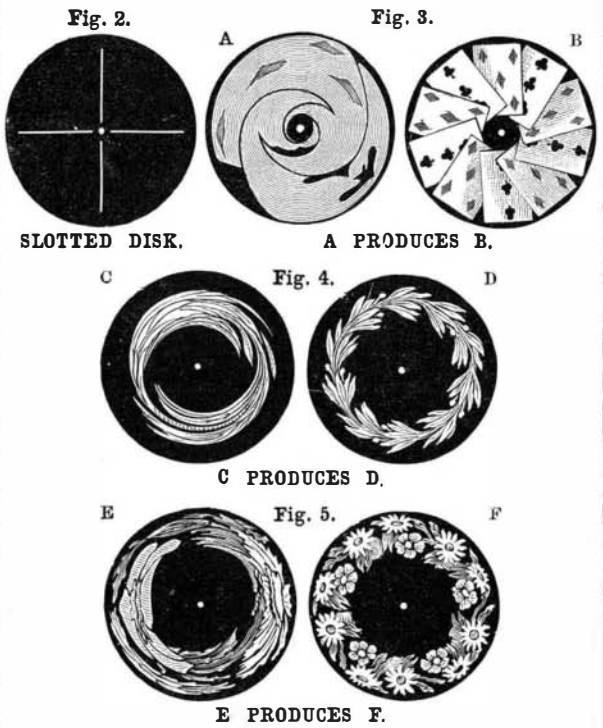
In the sleeve in the standard is journaled a shaft having at one end a crank, and a pulley of the same sizeas that above it at the upper end of the standard, and upon the other end a grooved wheel four times the diameter of the grooved pulley at the upper end of the movable arm. The small pulley below is connected with the small pulley above by a crossed belt, and the large grooved pulley is connected with the small pulley above it by a "straight" belt.

Between the collars upon the sleeve driven by the crossed belt is placed a black disk having four equidistant radial slots, and upon the other sleeve is secured a translucent disk bearing an anamorphosed design which, viewed separately from the instrument, bears little resemblance to the object it is intended to represent, but when revolved in the anorthoscope and viewed through the slots of the black disk, the enormous distortion is corrected and five correct images are seen. This number of images is accounted for by the four revolutions in one direction of the disk carrying the design and the single revolution of the disk with radial slots in opposite direction, giving five views of the same object for every revolution of the radially slotted disk. The designs are distorted only in the direction of their rotation, the proportions in the direction of the radii of the disk being normal. A face view of the radially slotted disk is given in Fig. 2.

In Fig. 3 the distorted card design shown at A is seen in the anorthoscope as a hand of cards as shown at B. In Fig. 4 the design, C, produces the wreath, D, in the instrument, and in Fig. 5 the distorted flowers, E, produce the wreath, F. The distorted image is seen only in narrow successive sections, which by the retaining power of the retinal nerves are blended into an image which is shortened in the direction of rotation to one-fifth its real dimensions, while it is multiplied five times.

There are two methods of laying out the designs for this instrument, both based upon the development of the original picture in a subdivided rectangle. It is obvious that if a subdivided square can be produced in the anorthoscope from a distorted representation of it, any figure that can be inscribed in such a square can also be produced in the same way. In Fig. 6 is illustrated a method of laying out a rectangular parallelogram, A, divided into thirty-two equal squares, alternate squares of the upper two rows being shaded.

To lay out the figure, from the center C, strike a circle bounding the periphery of the disk, draw a diametrical line, and at any convenient distance from the peripheral line lay out the rectangular parallelogram, as shown. From the center, C, describe an arc, touching the outer angles of the parallelogram, A; locate a new center, D, below C, on the diametrical line, a distance equal to the versed sine of this arc. From this center describe circles tangent to the horizontal lines of the subdivided rectangular parallelogram. Lay off on the central circle spaces five times greater than and equal in number to the longitudinal divisions of the parallelogram. From a point at the intersection of the diametrical line with the middle circle of the set thus drawn, draw lines intersecting the middle circle at the points set off. These lines radiating from the point, *a*, and the eccentric series of concentric circles bound spaces which appear as squares in the anorthoscope. The lines radiating from the point, *a*, must be increased five times in thickness to secure a line of normal width in the instrument. The spaces in the distorted figure representing the shaded squares are filled up solid with black, the whole forming the figure B, which, viewed in the anorthoscope, appears as at A. Any figure drawn on the subdivided parallelogram and projected on the distorted figure, B, would appear normal in the instrument.



When accuracy is immaterial, the figure may be developed on circular lines, as shown in Fig. 7, the horizontal spaces of the square, A, being developed on the circular lines by radial lines which intersect the middle circular line at equidistant points separated by spaces, each having five times the width of one of the smaller squares. The distorted figure, B, viewed in the anorthoscope, appears very nearly like the outline drawing of the flower in the square, A. In this diagram everything is drawn with reference to the center, C.

Recently the writer has adapted these experiments to the lantern. The distorted pictures, which are drawn on cardboard disks about thirty inches in diameter, are placed on a large rotator about twenty-five feet from the lantern, and in the lantern slide holder is placed the rotary disk shown in Fig. 8. This disk, which is provided with four narrow radial slots, is mounted on a small stud projecting from a plate of glass held by the frame of the apparatus. The slots are extended as nearly as possible to the center of the disk, and the segments of the disk are strengthened by triangular braces.

To avoid using a belt, the disk is driven from its periphery by rubber frictional gearing, as shown. A lantern objective of low power is used and the slots are sharply focused on the large disk. The disks are arranged with their axes in line, and when the revolutions of the smaller and larger disks are as one to four, and in opposite directions, the effects above described are produced on a scale sufficiently extended to be seen by a large number of spectators. In this experiment the axes of the disks must be in line.

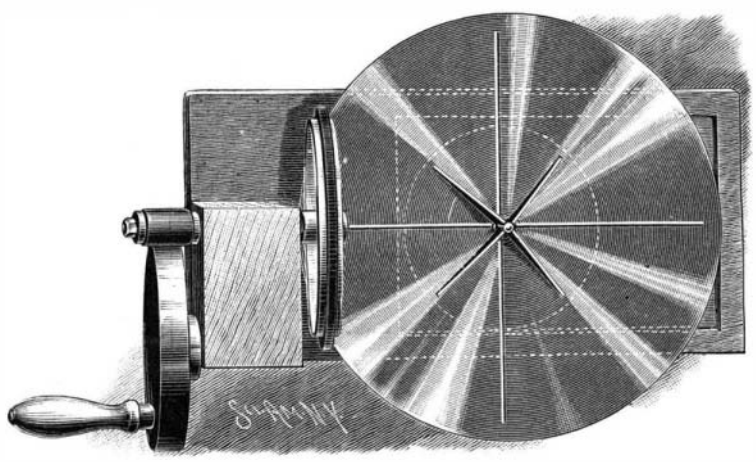


Fig. 8.—ROTARY DISK FOR THE LANTERN.

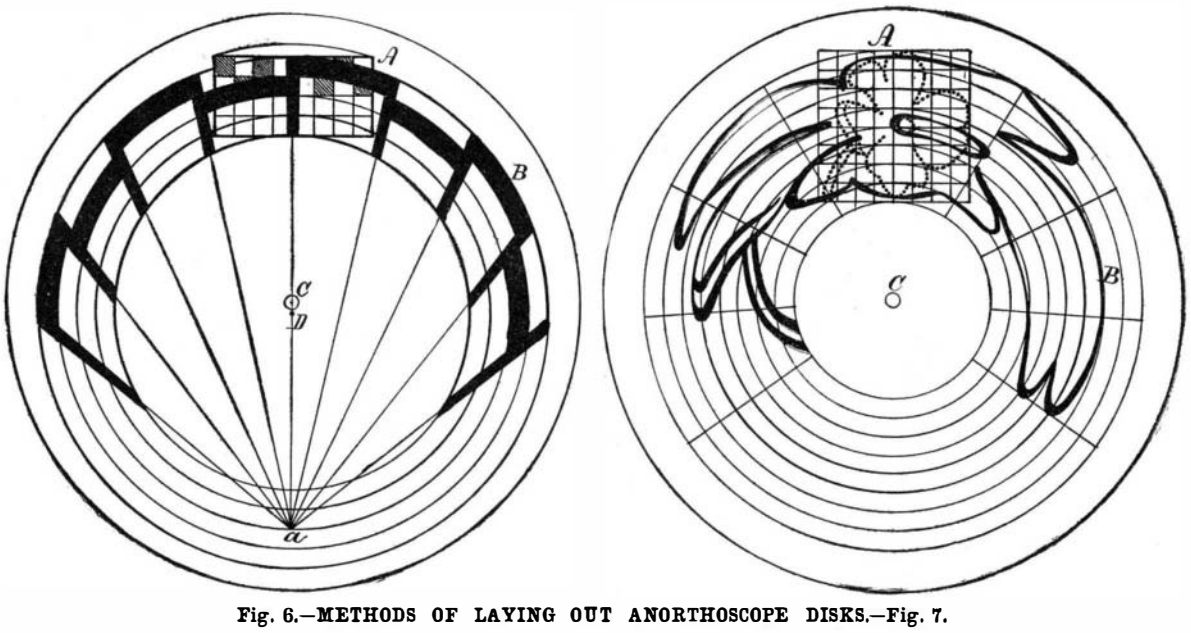
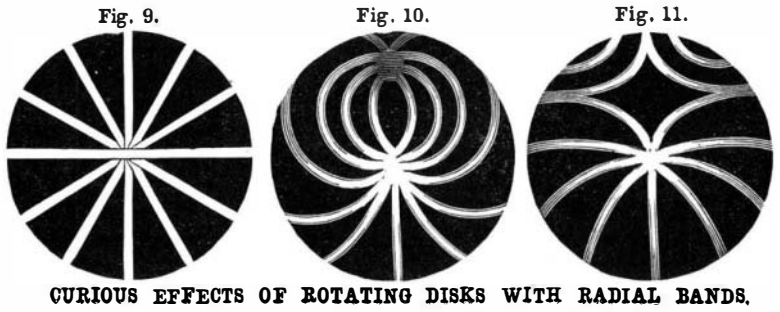


Fig. 6.—METHODS OF LAYING OUT ANORTHOSCOPE DISKS.—Fig. 7.

By substituting the disk shown in Fig. 9 for the anorthoscope disk some very curious effects may be produced. When the axes of the disks are in line, the radial bands will be apparently multiplied or reduced in number according to the relative speeds and the direction of rotation of the disks. When the radially slotted disk in the lantern is arranged eccentrically with reference to the large disk having radial bands, the effect shown in Fig. 10 is produced when both disks are rotated in the same direction, and when they are rotated in opposite directions the effect is as shown in Fig. 11. These forms may be greatly modified by moving the slotted disk in the lantern across the field.

These curious effects are due to the crossing of the white radial bands by the bands of light from the lantern and the retention of the images of these spots of light throughout their entire course, thus giving the appearance of curved bands.

By substituting a disk with radial bands for the anorthoscope disk in the instrument shown in Fig. 1, and swinging the movable arm of the instrument over, so as to arrange the disks eccentrically with reference to each other, the effects last described may be viewed without the use of a lantern.



CURIOUS EFFECTS OF ROTATING DISKS WITH RADIAL BANDS.

A RUBBER layer sandwiched in the sole of the shoe is said to prevent wet feet.