Some Curious Optical Illusions.

By George Lindsay Johnson, M.A., M.D.

OF the five senses which enable us to become acquainted with the world around us, sight is not only the one which contributes the largest store of information, but is the one in which we believe most implicitly. So confident are we that what we see must be true, that the phrase "seeing is believing" has passed into a proverb. And yet it is quite easy to show that we are continually making mistakes with regard to the colour, size, and position of objects. The eye has often been compared to a photographic camera, the delicate nervous layer at the back, known as the retina, taking the place of the sensitive plate. But here the resemblance ceases. In the case of the camera the intensity of the image increases with each moment of the exposure, whereas in the eye the reverse is the case—in other words, the retina becomes fatigued if an object be gazed at for any considerable length of time, and the brighter the object the sooner the fatigue will be noticed, more especially if it be placed side by side with a dark object. The whole range of phenomena known as colour contrasts is due to this fact. If, for example, we look at a number of black squares separated by broad white lines, as in Fig. 1, the parts of the retina covered by the white lines will be more rapidly fatigued than those covered by the black squares, and, as the eye unconsciously travels from one square to another, the after image which remains whenever a bright object is observed, will cause the parts where the white bands intersect to become for the moment darker than the rest of the bands; while, at the same time, the interiors of the dark squares become somewhat lighter, and the rest of the white bands abnormally white.

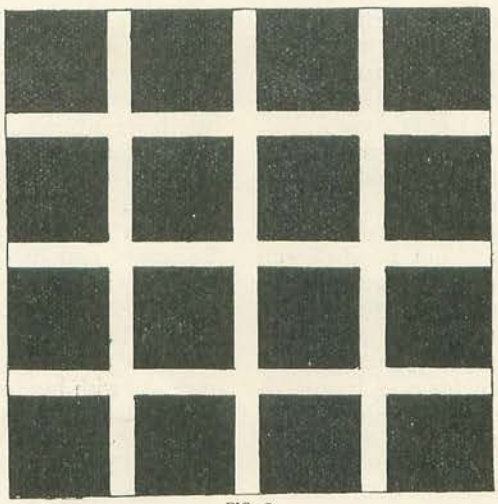

FIG. 1.

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This latter fact has long been known to painters, and advantage taken of it to intensify effects. Thus, if you notice Sir Joshua Reynolds's portraits, or Turner or Claude's landscapes, you will see that the chief point of interest in the picture is generally the brightest, and it is usually placed next to the darkest shade. Hence, by sharp contrast a white horse looks still whiter and more prominent if placed next to a black horse, and a face attracts more notice and looks fairer if partly surrounded by dark shadow.

The influence of adjacent colours is still more striking. If you place a small piece of black or grey paper on a green or yellow ground, and cover the whole with a sheet of tissue paper, the dull green or yellow will cause the grey paper to have its complementary tint, viz., a pink or a bluish shade.

One of the most curious illusions is the error of judgment in estimating the relative heights of lines. If a vertical line be placed at right angles to another of exactly the same length, the upright line will always appear the longer. Thus the line A B in Fig. 2 appears much longer than the horizontal line C D, whereas they are exactly the same length.

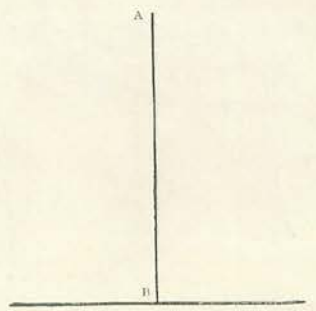

FIG. 2.

It is a common amusement to ask anyone to show on the wall the height at which the crown of a silk hat would reach when the hat is placed on the floor. You naturally imagine that the height of the hat must be at least equal to its breadth, and you invariably over-estimate the height in consequence.

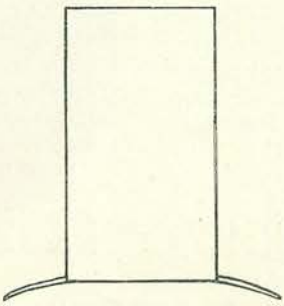

FIG. 3.

Fig. 3 represents a rough outline of a hat in which the height from where it joins the brim is made exactly equal to the breadth. Direct measurement will convince you that it is so. The reason of this deception is, that our range of vision from the horizon upwards is less than half that from side to side, and, moreover, it requires much more muscular effort to raise the eyes upwards than to sweep the horizon. Hence, in an upward direction we take in less at a time, and with greater effort, and that influences our judgment.

Another very common source of visual

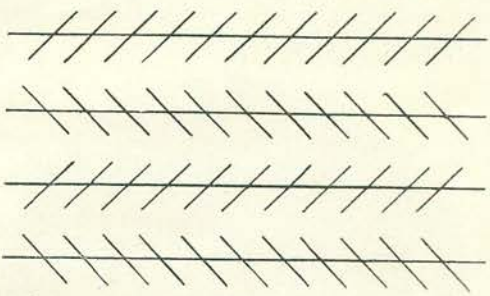

FIG. 4.

deception was discovered by Zöllner, who found that if parallel lines are crossed by another short row of lines inclined at an angle to the first series, the latter will appear to slant in the direction in which the lines are falling. See Fig. 4. If you tilt the lower edge of the book up the illusion is still better.

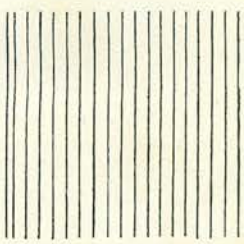

FIG. 5.

A square divided up by horizontal lines looks higher than one made up of vertical ones. See Fig. 5. Hence, if a short man wishes to appear tall he should wear horizontally striped clothes.

Again, if a line is bounded by two shorter parallel lines, it will appear shorter than if bounded by longer ones (Fig. 6). The next

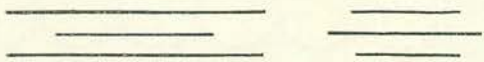

FIG. 6.

figure shows the same thing in a still more striking degree. The line A B is actually longer than C D, but appears to be shorter (Fig. 7).

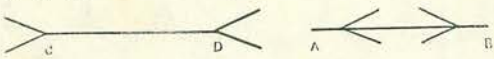

FIG. 7.

An important group of deceptions is due to irradiation. A brightly illuminated object always appears larger, and the margin less distinct, than one less bright. Thus, in Fig. 8

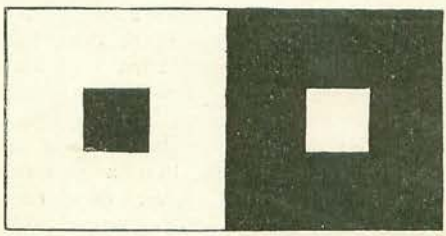

FIG. 8.

the white disc appears larger than the black one. This is due to irradiation, which produces on the retina a kind of halation on the neighbouring sensitive areas similar to the halation of flare-spot produced on the sensitive plate in the camera, when very bright objects are photographed. A similar effect, but caused in a totally different way, is produced when the object looked at is out of focus, as is the case when a distant object is seen by a short-sighted person. When the two phenomena occur together the result is fatal to good vision and produces most curious results. Thus, if Fig. 9 be looked at from a distance of some feet the circles appear to swell out and touch one another, forming rows of

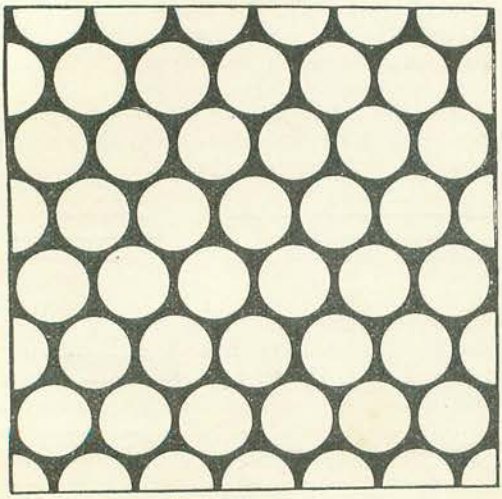

FIG. 9.
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hexagons like the cells of a honeycomb. If looked at by a short-sighted person just beyond the distance of distinct vision the irradiation will cause the discs to overlap, so that each disc appears to be surrounded by six large black dots, joined to each other by grey bars. Moreover, type should always be printed much darker than the background it is on, and the greater the contrast the better it is seen. It is for this reason that a newspaper which is printed on bluish-green paper cannot be seen as far off the eye as one printed on white or cream-coloured ground. In Paris the names of all the streets are printed in white type on a blue ground, which is a mistake, since the irradiation of the white type causes the letters to run into each other and appear confused. Had the letters been printed dark blue on a white ground the irradiation would merely have made the letters look smaller and thinner, but they would have been quite distinct, and could have been seen at a much greater distance.

If we look at the stars at night, they do not appear as points of light, but of quite appreciable size, and to short-sighted people immense. As a rule, in addition to the diffused brightness round the point, one may observe seven or more short rays pointing out from the centre. You will probably see the same thing if you look at a street light. These rays are due to the lines which traverse the lens of our eye from the centre to the circumference. They are usually from seven to ten in number, radiating from the centre like the arms of a starfish. As these lines are formed of lens-matter slightly denser and less transparent than the rest of the lens, they give rise to these rays of light (Fig. 10). That the stars are really points of light can be shown by looking at them through a telescope. The higher the power and the more perfect the telescope, the smaller do the stars appear, since they are so far off that no amount of magnification will make any appreciable difference to their size.

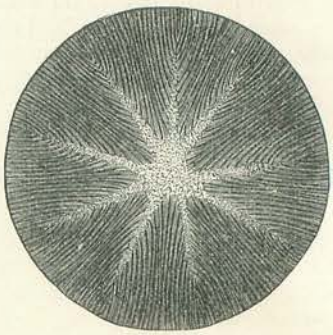

FIG. 10.
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The increased size of the stars is also partly due to the fact that the front of the eye is never a portion of a perfect sphere, but is slightly more curved in one direction than another, the direction and degree of the curves varying in different eyes. This is readily seen in the following figure, in which one pair of lines look grey and the other pair black. If now the page be held sideways, the lines which looked grey will now appear black, and the black lines have become grey (Fig. 11).

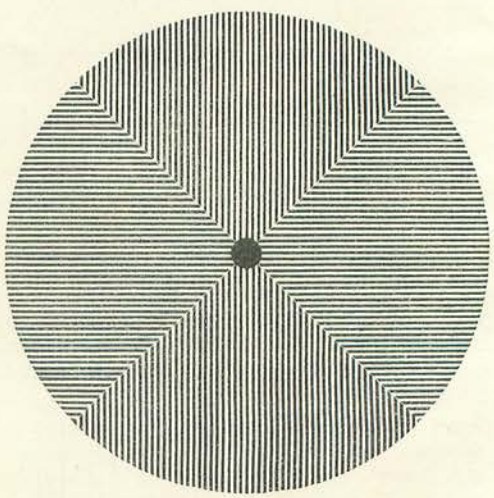

FIG. 11.

If vertical lines be drawn on a piece of paper and the paper be held nearly parallel to the line of vision (so that the eye, as it were, skims the paper) the lines appear immensely foreshortened. In this way writing which was

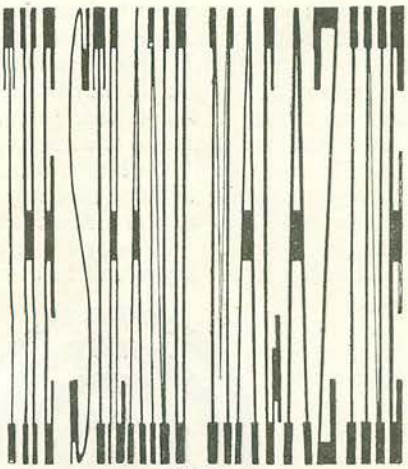

FIG. 12.

otherwise quite illegible becomes perfectly evident (Fig. 12).

In the next figure (Fig. 13) we have another illusion. If the book be held as above described, and the lines be looked at with one eye, the other being closed, they will appear to stand up out of the book like pins in a pincushion.

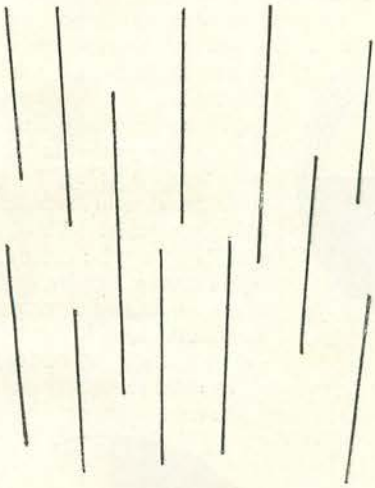

FIG. 13.

When we read type we imagine that we read the whole of the type—but that is not so; we only notice the upper half of each letter. You can easily prove this for yourself by covering up the upper half of the line with a sheet of paper (being careful to hold the paper exactly in the middle of the letters), and you will not, without great difficulty, decipher a single word. Now place the paper over the lower half of a line, and you can read it without the slightest difficulty

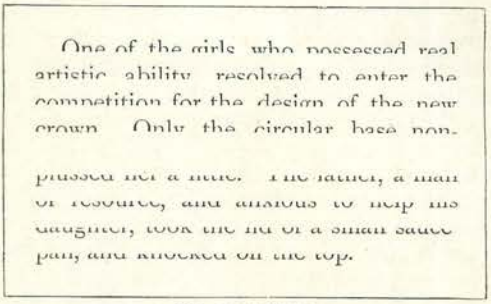

FIG. 14 A AND B.

(Fig. 14 *a* and *b*). It is curious in this connection to notice that the upper and lower halves of certain letters and figures appear the same size, and yet the lower halves are really much larger, as can readily be seen by inverting them thus: B K S 8, ꓭ ʞ S 8.

There are a number of curious illusions which may be noticed in connection with pictures. This might be expected, since the chief art of the painter lies in creating deceptions and illusions. The artist is obliged to represent the solid objects of Nature placed at various distances on to a flat canvas, and one of the chief objects is so to arrange the lines of perspective that the objects shall not only appear to be solid, but to stand out in stereoscopic relief at their proper distances. Turner, our greatest master of artistic deception, employed endless devices to this end. He loved to give infinite depth to his pictures by placing the sun nearly in the centre of his canvas, and arranging all the subjects in the middle distance so as to converge towards it as a focus.

It is a well-observed fact that the eyes of a

FIG. 15.

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full or three-quarter face portrait always appear to be gazing at one, no matter on which side of the figure one may be standing. This is due to the fact that the face is so painted as to look straight in front of the canvas, and as the pupil is usually drawn in the centre of the eye, it is obvious that wherever one may be standing the pupil will remain in that position, a condition which could only obtain in real life provided that the person turned his head round. Fig. 15 shows this most distinctly, the soldier aiming at the spectator in every position.

Another mental deception is the following. Roll up a piece of brown paper so as to make a tube about 6in. long by 2in. wide, and look at a picture or print through the tube with the other eye closed. If the picture be correctly drawn and represents several prominent objects in different planes, they will appear to stand out in stereoscopic relief. If both eyes be opened the illusion to a large extent disappears. This is, I believe, due to the fact that in Nature we see objects stereoscopically, because each eye sees an object from a different standpoint, but in the picture the two eyes see the objects the same, since they are all on the same plane. Now if we close one eye, and look through a tube, one sees the objects mentally in semi-relief, just as is the case when one sees objects in Nature with one eye closed.

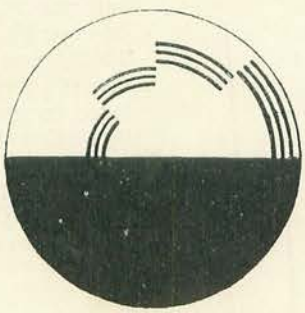

FIG. 17.

One of the most remarkable sensations which gives rise to false impressions is due to persistence of vision. An image of any bright object does not instantaneously disappear, but lasts an appreciable time, varying from one-thirtieth to a quarter of a second, according to the brightness of the object looked at. A rocket looks like a continuous trail of fire, whereas it is in reality merely a point of light, but one which travels so quickly that the first portion is hardly obliterated from the mind before the highest point of the stream of fire is reached. The cinematograph and zoetrope are illustrations of the same thing. There is a rare form of disease, of which I have seen two well-marked examples, in which the time elapsing before an image is obliterated is prolonged to several seconds. In such a case, as the person turns his eyes from one object to another the images become superposed, just as in photography when a careless operator exposes the same plate to several subjects in succession. The result to the patient is so confusing as to be almost terrifying. You can test this for yourself in a very simple way. Take a piece of jet black, or bright red, green, or blue paper, cut into the shape of some object, and place it on a piece of white cardboard. Gaze at it intently for about a minute, and then turn your eyes to the ceiling. Now wink the eyes rapidly, and you will see an enlarged image of the object in the complementary colour on the ceiling in whitish grey, green, red, or yellow respectively. If you wink several times as soon as the image begins to fade, it will return nearly as bright as before.

FIG. 16.
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If the accompanying figure (Fig. 16) be looked at, and the page be held horizontally and in that position rotated round and round a vertical axis, the spiral will appear to revolve round its axis in the same direction.

A very curious illusion is due to the fact that different wave-lengths of light arrive at their maximum sensation at different times. Thus if the disc (Fig. 17) be cut out (and made into a top by mounting it on cardboard and pushing a wooden match through the centre), it will be noticed that if spun from left to right the outer band will appear red and the innermost one blue. If the top be spun in the opposite direction, the colours will be reversed. This is known as Benham's colour top. In the same way, if the disc (Fig. 18) be made into a top

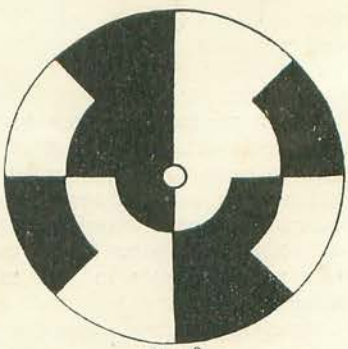

FIG. 18.
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and spun, the white band as it is spun from left to right will appear fringed with colours.

Another illusion of colour, discovered by Mr. Shelford Bidwell, F.R.S., is produced as follows : Cut out the disc (Fig. 19) and mount it on a card. Cut out the gap between A and B. Stick a long pin through the centre and push it up to its head. Now hold the pin by its pointed end so that the card is suspended a few inches above a page of small, sharp print. Spin the card at the rate of five or six turns a second by flicking it with the finger. If you look down on the page the black letters seen through the gap of the disc will appear a red colour, especially if you take the precaution to avoid shadows and to see that the print is brightly illuminated.

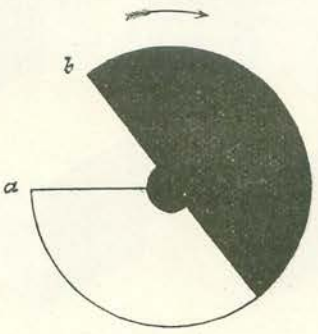

FIG. 19.

The most important, because the most frequent, deception of all is due to the errors made in judging the size and distance of objects. Thus, the moon is invariably drawn several times too large by artists. Its apparent size can easily be found. If, for example, a photograph of a distant landscape be taken with the moon represented in it, it will appear ridiculously small, yet undoubtedly correct.

If the picture embraces 60 degrees, the moon, which measures 31 minutes, will only occupy about the 116th part. In other words, if the picture were 3ft. long, the moon should only be about 1-3rd of an inch in diameter, and yet in a celebrated picture before me, it is actually drawn about twenty-five times too big.

If the greater part of the mountain be hidden by cloud or mist while the top and base are clearly seen, it will appear immensely higher than when it is free from cloud. On the other hand, snow mountains appear much nearer than when free from snow, and therefore appear much lower than they really are.

In Switzerland, in the winter, when everything is buried in snow, the Alps look much nearer and smaller than in summer, owing to the absence of any marked contrast or object to judge distance by. The clearness of the air is also an important factor in making objects appear nearer. Why does the moon always appear so much larger when near the horizon? That it really looks larger anyone can prove for himself. I believe the following to be the real explanation. If you look into a fish tank with straight glass sides, you will notice the fish and stones always look much bigger in the water than they do when you take them out, because, the refractive index of water being very much greater than that of air, you see the objects apparently nearer, so that they appear bigger, being observed at a larger angle. Thus, if you look at the moon near the zenith, you are looking at it through a stratum of air which becomes rapidly more and more rarefied; whereas, if you look at the moon near the horizon, you see it through a stratum of air which is much denser and very much more extended. So that in the latter case you really see the moon, as it were, through a magnifying glass. But there is another reason. When the moon is high in the heavens you have no object near to compare its size with; whereas, when near the horizon, we naturally compare it with objects on the earth which appear in its vicinity. If, for example, the moon appears near a tree on the horizon, we notice it looks bigger than the tree; and the mind, knowing how large a tree looks when close to, and what a large angle of view it takes up, gives the moon credit for looking much bigger than when it stands alone in the vast expanse of sky.

One of the most striking illusions that I know of is to be frequently met with when driving or riding along a straight road. In France, where the roads are usually made mathematically straight for miles at a time, and bordered by rows of tall poplar or lime trees, the illusion may be seen to perfection. The only requirements necessary are that the road should descend along a slight incline and then ascend at a corresponding or, better still, a greater angle. When you arrive nearly to the bottom of the incline, the ascending portion of the road, which must be in a perfectly straight line with the portion you are on, will appear so steep as to seem quite inaccessible; but as you proceed the road appears to become less and less steep until it becomes nearly level. The reason for this is twofold. In the first place, when a road ascends directly in front of us it appears foreshortened. Now, we have no means of judging the amount of foreshortening, and the imagination leads us to think it is much steeper than it really is. Again, when we are walking down a gentle incline

we identify it (when keeping our eyes on the ascending road) as a level surface which we take as our ordinary standard from which the incline of the ascending road is estimated, and hence the road appears *at least* as steep again as it really is. When, therefore, the apparent increase of steepness is doubled by the error of judgment produced by the descending road, the inclination of the road in front appears frightfully steep—at least, if the observer be pursuing his way on a bicycle.

In the same way streams, which are often conducted along wooden troughs by the roadside, appear to run up-hill. If we are walking down a hill, and the stream close by has a more gradual fall than the road (since we take the road to be a level base), the diminished incline of the stream causes it to appear to actually run up-hill against gravity.

These are a class of cases where our conception of an object can be interpreted in more than one way. Our imagination can accept either one or the other of these interpretations at will. This property of alternating conceptions is called intuition. For example, if we look at Fig. 20 it may be interpreted as consisting of one cube resting on the edge of two cubes underneath, having their darkest sides facing the right and their upper surfaces visible, or as two cubes with their brightest sides facing the right and having their under surfaces visible, and their upper surfaces turned away from the observer. As the one group changes to the other a distinct muscular movement inside the eye will be felt.

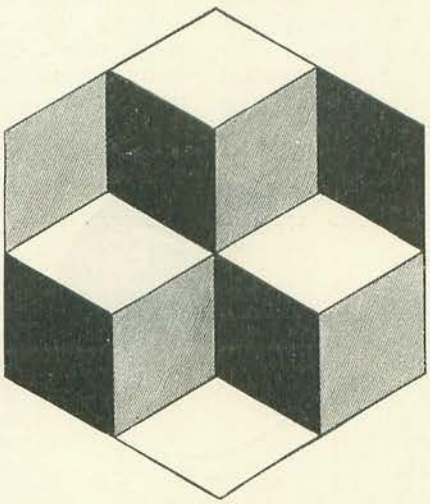

FIG. 20.

Fig. 21 is another example of the same phenomenon. Thus the figure may be interpreted as a truncated cone (*i.e.*, a cone with the top cut off), or as a long room seen from the front in perspective.

In the same way, Fig. 22 may either be considered as a six-sided geometrical figure or as one triangle resting on a second.

We have only dealt thus far with some of the simpler optical illusions. In another article we may consider those which require accessory apparatus, or which at least are of a more complicated nature.

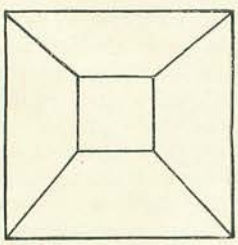

FIG. 21.

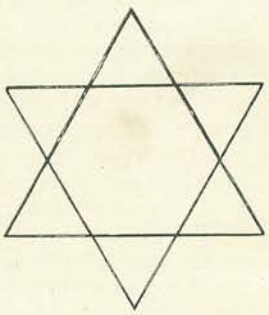

FIG. 22.