Generally at the same time stars become visible on the photographic plate, through which, in association with the time of photographing, the direction of adjustment of the apparatus is ascertained (that is to say, the position of the axle of the apparatus is ascertained).

With regard to equatorial regions, it is of great importance that the exact time in which luminous night-clouds pass through them should be determined. According to the observations hitherto made, the passing through the equator may take place in the time between the beginning of September and the end of October, and the return between the beginning of March and the end of April. Under 20° S. lat., the time of passing through will, in that case, be from the middle of September until the middle of November, and from the middle of February until the middle of April, and under 20° N. lat. from about the middle of March until the middle of M ay, and from the middle of August until the middle of October. In consequence of the daily rotation of the earth round its axis together with the distinct movements of the earth, atmosphere, it may be that the passing through the equator does not take place in the simple manner here described. It does not seem to be unlikely that the periods are not limited as exactly as stated.

Moreover, it is probable that the luminous night-clouds consist of a gas which is condensed in consequence of the lower temperature prevailing in the altitude of 82 kilometres. On the question relating to the nature of this gas depend several other cosmical questions: for instance, with respect to the temperature of the air of the mundane space and the temperature of the atmosphere at the altitude of 82 kilometres, which will be answered through comparing experiments in the laboratory. For this reason, spectrographs of the sunlight at low altitudes of the sun, in the season in which the phenomenon of the luminous night-clouds is seen, are of great value. Such spectrographs should be taken in the evening shortly before sunset, and in the morning shortly after sunrise.

It appears that in the northern regions of the earth, in about 70° latitude, in the period from the middle of June until the middle of July, an especially great accumulation of clouds takes place, which, however, on account of the sun standing constantly *above* the horizon during this period, will be hardly visible. It will, therefore, be of special advantage for these regions to take spectrographs of the sunlight at low positions of the sun.

These short remarks regarding the importance of the phenomenon with reference to cosmical problems may serve to show that the observations necessary for the exploration of the subject are well within the sphere of astronomers and geophysicists. There can be no doubt that the observations necessary for the solving of these questions are far beyond the capacity of a single institution. Those who take interest in the furtherance of the questions we have indicated are therefore requested to assist through one or other of the kinds of observation above noted in the investigation of the luminous night-clouds.[1]

W. FOERSTER.
O. JESSE.

Berlin Royal Observatory, September 1892.

SOME OPTICAL ILLUSIONS.[2]

A STRIKING illusion, first described by Zöllner some thirty years ago, and usually called by his name, appears in Fig. 1. Of the four main lines each adjoining pair seems to converge at one end, and to diverge at the other, whereas in reality the lines are all parallel. The first step in an explanation of the illusion would be the determination of its essential factors, of its various forms, and of some general principle embracing under one formula its several varieties. The next step would be to correlate this formulation with some recognized psychological principle. The generalization is found

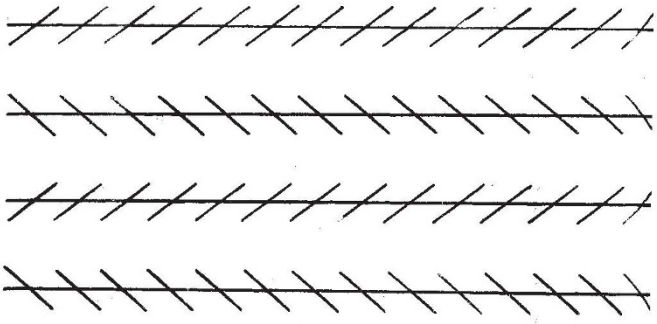

FIG. 1.

in the statement, that *the direction of the sides of an angle are deviated toward the direction of the angle*, and may be illustrated by reference to Fig. 2. In this figure the continuation of the left horizontal line seems to fall below the right horizontal line, and the continuation of the latter above the former; in reality the two are continuous. Similarly, if the continuations of the oblique lines be added, they will not seem continuous, but diver-

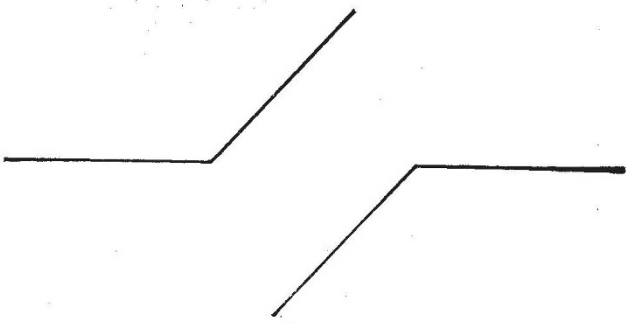

FIG. 2.

gent slightly to one side or the other. If now we call the direction of an angle the direction of the line that bisects it, then the deviation is what would result from a drawing up of the sides of the angle towards this central bisecting line; the left end of the left horizontal line would be drawn up, and the right end of the right horizontal line would be drawn down, and thus the two seem discontinuous. The same would happen, though to a less

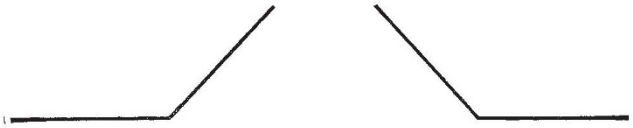

FIG. 3.

degree, if either oblique line were omitted. There are many other ways of illustrating this fact. Instead of drawing the right line horizontal, we may incline its right end downwards slightly, and then it will seem continuous with the left horizontal line. We may apparently incline both lines so that they would converge towards a point between and below them, as in Fig. 3 and the like. Two further points or corollaries should be noted: (1) that the

[1] A publication, "Die leuchtenden Nachtwolken," by O. Jesse, which may be expected within the next months, will contain details regarding the entire present position of these questions.

[2] Abstract of a paper on "A Study of Zöllner's Figures and other Related Illusions," by Joseph Jastrow, Ph.D. (with the assistance of Helen West), being a part of "Studies from the Laboratory of Experimental Psychology of the University of Wisconsin."—*American Journal of Psychology*, vol. iv. No. 3.

larger the angle the greater the deviation. Similar figures with acute angles substituted for the obtuse ones would show a scarcely perceptible illusion. (2) When obtuse

FIG. 4.

angles are combined with acute angles, the deviating effects of the former outweigh those of the latter. In Fig. 4 the effect of the angle ACD would be to make the

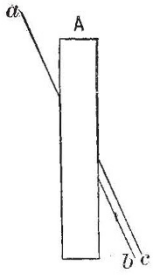

FIG. 5.

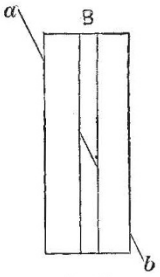

FIG. 6.

line AB if continued fall *below* FG, while the effect of BCD would be to make AB fall *above* FG; the former outweighs the latter, and the illusion appears as directed

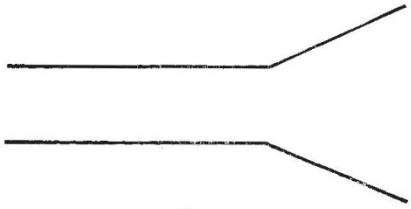

FIG. 7.

by the angle ACD. The angle BCE reinforces ACD, while ACE reinforces BCD. Angles greater than 180° do not come into consideration. When all the angles about a

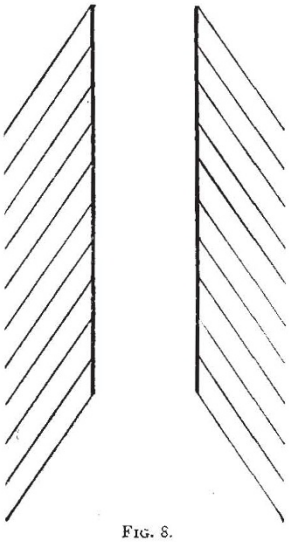

FIG. 8.

point are equal, *i.e.*, are right angles, the illusion disappears. Figs. 5 and 6 furnish other illustrations of the same principles. In Fig. 5 the line *a* seems continuous with *c* while it is so with *b*, and this because the obtuse angles formed by lines *a* and *c* with the vertical lines respectively, deviate the lines *a* and *c* towards the direction of the angles sufficiently to bring them in line with one another. Fig. 6 adds the further complication—explicable upon the same principles—that the line is deviated once in one direction and then in the reverse direction.

We have next to show that the illusion of deviation from

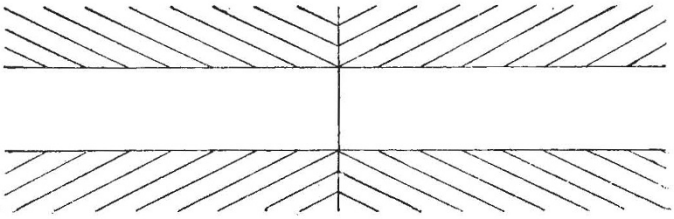

FIG. 9.

parallelism is similar to that from continuity. If the right-hand portion of Fig. 3 be rotated through 180° and placed below the left-hand portion, we have Fig. 7, in which we observe a tendency for the two horizontal lines to diverge on the left and converge on the right; this is just what our dictum demands. To strengthen this illusion we add more oblique lines, and thus more angles, the obtuse

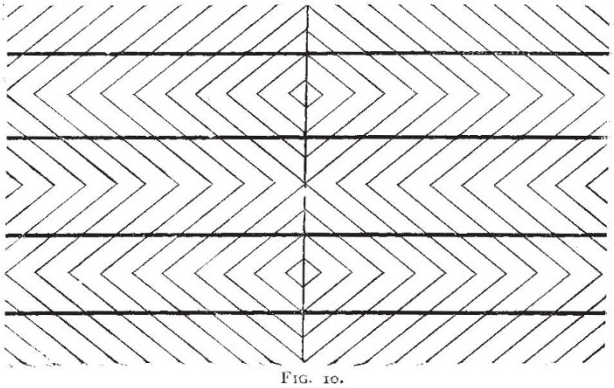

FIG. 10.

angles in all cases outweighing the acute ones—Fig. 8. We have now only to draw two figures like Fig. 8, side by side, and draw the oblique lines across the vertical ones (thus keeping the figure compact) to obtain Fig. 1, with which we set out. The possibilities of illusion do not stop here; by drawing the oblique lines in one direction on

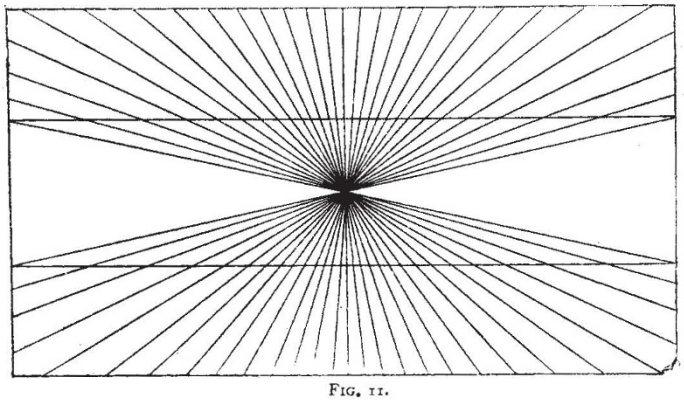

FIG. 11.

one side, and in the other direction on the other side, we can deviate the two halves of the same pair of parallel lines in opposite directions, as is done in Fig. 9; while most striking of all is the elaborate design of Fig. 10, in which it is difficult to realize that the four main lines are all straight and parallel. If the page be viewed with one

eye, and held horizontal nearly on a level with the eye, the true relations will appear. Fig. 11 is valuable for its conclusive demonstration that the deviation is proportional to the angle; the increasing angles gradually bend the straight lines away from one another, and give them the gradual change of direction of curves. These and other forms of illusion are all included in the generalization that the sides of an angle are deviated towards the direction of that angle.[1]

The psychological principle with which this general-

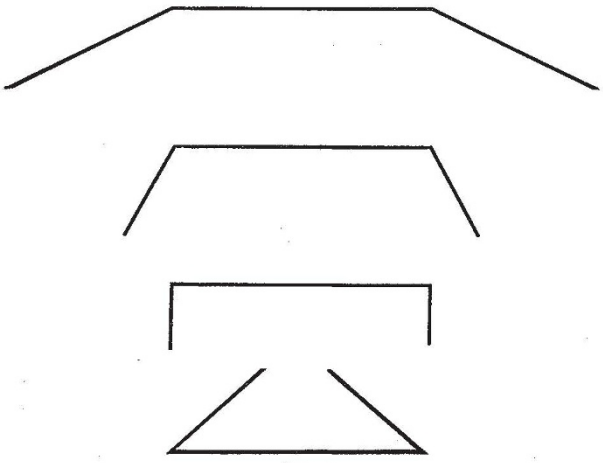

FIG. 12.

ization may be correlated is the law of relativity. This law emphasizes the fact that a sense-impression is not the same when presented alone and when in connection with other related sense-impressions. We cannot judge the direction of lines independently of that of the angles whose sides they form. As a further illustration of this principle it may be shown that angles will affect the apparent *lengths* of lines as well as their apparent *directions*. If in Fig. 12 we compare the horizontal portion of the uppermost figure with that of the lowest, it is

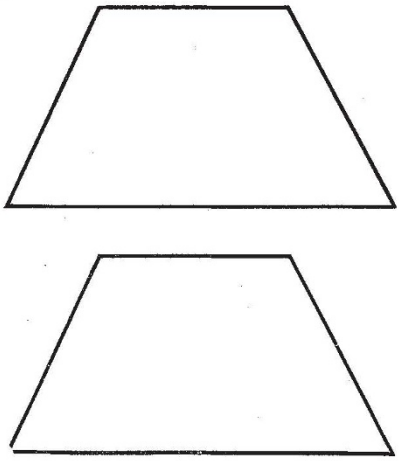

FIG. 13.

almost impossible to believe that they are of equal length. The intermediate horizontal lines seem intermediate in length, and thus illustrate the fact that the apparent length of the horizontal lines is directly proportional to the size of the angles at their extremities. The illusion would persist if we converted these figures into truncated pyramids by adding a line parallel to the horizontal line, and would then illustrate the fact that equal lines may be made to appear unequal by the effect of the areas whose contours they help to form. A converse effect is illustrated in Fig. 13. Here the upper figure seems larger than the lower, because its larger parallel side is brought into juxtaposition with the smaller parallel side of the lower figure. This illusion and others show especially well when cut out of paper and held against suitable backgrounds. As the figures are moved about one another the upper constantly becomes the larger. More than two figures may be used, and a variety of such contrasts may be formed.

The subject is by no means fully considered in these illustrations nor is the explanation offered as final or adequate. If it seems to direct investigation into fruitful paths its chief purpose will be accomplished.

[1] The reader is referred to the original paper for further illustration of this dictum, as well as for explanations of apparent exceptions and a discussion of the conditions affecting it.

THE NEW SATELLITE OF JUPITER.

THE new number of the *Astronomical Journal* contains Mr. Barnard's account of his discovery of this additional member *of our system*. We make the following extracts:—"Nothing of special importance was encountered until the night of September 9, when, in carefully examining the immediate region of the planet Jupiter, I detected an exceedingly small star close to the planet, and near the third satellite. I at once suspected this to be a new satellite. I at once measured the distance and position-angle of the object with reference to satellite three. I then tried to get measures referred to Jupiter, but found that one of the wires had got broken out and the other loosened. Before anything further could be done the object disappeared in the glare about Jupiter. Though I was positive the object was a new satellite, I had only the one set of measures, which was hardly proof enough for announcement. I replaced the wires the next morning. The next night with the great telescope being Prof. Schaeberle's, he very kindly gave the instrument up to me, and I had the pleasure of verifying the discovery, and secured a good set of measures at elongation. In these observations, and those of the succeeding night, only distances from the following limb of Jupiter could be measured. These were observed with the wires set perpendicular to the belts. The planet was thrown outside the field, the satellite bisected, and then the limb brought in and bisected also. This method would not permit any measures from the poles of the planet for latitude. On the 12th I inserted a strip of mica, carefully smoked, in front of the field-lens, for occulting the planet. This served admirably, permitting the satellite and planet to be both seen at once, and measures from the polar limbs could be made with great ease. The observations of the satellite from the 12th were all thus made.

"To avoid any personal equation I have on each night measured the diameters of the planet, for use in reducing the observations to the centre of Jupiter. Since the 12th, these have been measured through the smoked mica, so as to avoid introducing any error from the reduced brightness of the planet. The diameters were measured by the method of double distances. Just what the magnitude of the satellite is, it is at present quite impossible to tell. Taking into consideration its position, however, in the glare of Jupiter, it would, perhaps, not be fainter than the thirteenth magnitude. It will only be possible to settle this question with any certainty by waiting until some small star of the same magnitude is seen close to Jupiter, and then after determining its magnitude when away from the planet. In general the satellite has been faint—much more difficult than the satellites of Mars. On the 13th inst., however, when the air was very clear, it was quite easy.

"It is scarcely probable that this satellite will be seen