MODEL DRAWING

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INTRODUCTION.

THE value of a course in drawing when the subject is properly presented to the student can scarcely be over-estimated, but it must be confessed that much of the instruction given is such that its benefit is a matter of doubt. At the beginning of his art education the student should be taught to see correctly. When this has been accomplished, and he is able to represent truly what is before him as it appears, and not as he thinks he sees it, then he is in a position to advance, and his imagination may be cultivated. But as the first point to be gained is ability to see truly, it follows that we should from the very start demand truth; first truth of outline, next, truth of light and shade, and then truth of color. We wish to consider here simply truth of outline, but the student will find that the study of appearances, and their representation as fully as possible, even in so simple a medium as outline, will have in great measure prepared the way for the more difficult work in light and shade and color. The whole question is simply one of seeing, and the student should not trouble himself over technique, as he has enough to do to represent nature truly.

It is often said that in nature there are no outlines. In a way this is true, but it cannot be understood to mean that form is unnecessary or that it may be slighted. The student cannot learn to paint or to make pictures in any medium without drawing the forms of the objects. The defining of the lights and shades and the various bits of color which go to make the effect, is necessary to give solidity and character to a picture, and it is useless to think that anything can be accomplished with color or light and shade until exact representations of form can be made.

Every object has definite form and size, and though it may not be outlined it has boundaries. Although the representation of objects in outline only is at best a conventional and imperfect means of expression, so far often as even form is concerned, the student can be taught to observe effects and may succeed in conveying a fair impression of the character of the object and of varieties of surface and texture.

The student must work long and earnestly before he can separate facts from appearances, as the knowledge of the actual form prevents the mind from accepting its appearance. The impression conveyed to the mind of one not trained to accept the vision of the eye, is the result of a combination of what the eye sees with what is by far the greatest factor, what the mind knows concerning the actual condition of the object. The student must struggle continually not only against this influence of his mind, but also against the effect which one line exerts to change the apparent direction of others. This effect is sometimes so strong that even the practised eye of the artist is deceived, and we may safely say that the most perfect eye, with the longest training (of sketching simply) is not surety against mistakes. A knowledge of the perspective principles governing the appearance of form is thus absolutely necessary to the draughtsman who would be exact, and there is no reason why there should not be exactness and artistic rendering at the same time.

MODEL DRAWING.

FREEHAND DRAWING.

The most important points in freehand drawing are freedom, directness and accuracy. It is difficult to give directions which shall produce these results, as individuality will prevent all from working in a uniform way, and handling and technique are of little importance. Since the production of correct drawings is the end desired, it is of no consequence that such drawings are produced by different persons in different ways, but it may be well to give a few general directions, the most important being that the pencil should be held lightly, and the first lines of the drawing sketched in freely and very quickly. The paper should be not less than eleven by fifteen inches, and the drawings should be large. In beginning, it will be best to draw the full size of the objects, as small drawings will produce a cramped way of working. A long pencil will assist the student to freedom of movement. It may be held as a stick of charcoal between the thumb and first two fingers, and as far from the point as possible. The paper should be fastened to the board, with its edges parallel to those of the board. If the edge of the paper is not quite straight, a horizontal line should be ruled near the lower edge, so that directions may be referred to this line.

Before attempting to represent any object, the student should acquire the freedom of motion which is necessary to good work, by drawing lines in all directions. Curved lines will be produced by swinging the pencil from the wrist, elbow or shoulder, and straight lines by a motion of the entire arm. This movement should be practised until lines can be drawn instantly across the paper in any direction. This free motion is most important for all sketching, but in finishing or lining in a drawing whose proportions have been thus sketched, more pressure will be required, and the pencil may be held more firmly and nearer the point.

The first subjects should be the geometric solids, with the vase forms (such as are found in the models to be obtained at Art Supply Stores), but common objects, as boxes, etc., are equally good. We will explain the way in which these should be studied, by making a sketch from a box with its cover partly open (Fig. 1). First, nearly close the eyes, and try to see the box not as a solid, but as a silhouette, the outline of the mass of the box, as seen against the background, being what should first be carefully studied. A little practise with the eyes nearly closed will enable one to see the mass in this way. In order to see the direction which the edges appear to have, lines may be drawn in the air by moving the pencil point so that it passes in front of the edges. Care should be taken not to move the pencil away from the eye when this is done, that is in the actual direction of the edges, but to keep the pencil point where it would be if it were held upon a pane of glass placed directly in front of the student. This test is the most valuable of all, because it is the easiest and simplest to apply. It is really the same as the one of the thread explained on page 59, and nearly all other means of testing will at last be discarded in favor of this first and simplest. After careful study of the mass, its outline may be lightly sketched, no measurements of any kind having been made. The aim is to train the eye to exact seeing, and in order to do this the student must learn to depend on his eye, and put down its impression rather than the results of mechanical tests of proportion. *We must draw first, and afterwards test by measuring.* When the outline of the mass has been sketched then the inner lines may be drawn, and the result carefully studied to see that it agrees with the appearance. When it is as near as can be seen, it may be tested by measuring the proportions, as explained on page 53. If the sketch does not agree with these tests it must be changed. All changes are to be made not by erasing, but by drawing new lines, and the drawing must be carried on in this way until the correct lines are determined. The first lines must be very light, and as changes are made the strength must be increased to distinguish them, until the correct line is secured. The drawing now having been changed to agree with the measurement of the whole height and width, and tested by moving the pencil point to cover the edges, it will be well to test it by means of vertical and horizontal lines passing through all the angles of the box. Thus drop the pencil point vertically from point 1, and see where it cuts the lower edge, and carry the point horizontally from 2, and note its intersection with the front edge. When these tests have been made, the pencil point may be moved to cover, and made to continue the edges A, B, C, etc., until the points where they cut the opposite outline are noted. These tests may also be applied by the pencil held horizontal and vertical, and used as a straight edge to continue lines. Such tests, if carefully made, should give a drawing practically correct, and should be depended upon with the first measurement of the whole height and width, which should be very carefully taken. Any distances which are nearly equal, as E, F, and F, G, may also be compared, but as a rule very few measurements of proportion should be made, as short measurements, or a short with a long, cannot be made with sufficient accuracy to be of any value. The thread may be used instead of the pencil in making these tests, as explained on page 59. The thread gives a fine line, and its intersections with the various edges can be seen exactly, so that until the eye can be very closely depended upon the thread is preferable to the pencil. In all of this work the changes must be made *by drawing new lines and not by erasing.* This is most important, for the erasing of lines and thus the keeping of but one line throughout the various stages is most certain to produce a hard and inaccurate drawing, and even although it may finally be made to agree with all tests, it will still be lacking in spirit.

It is very difficult for most students to draw lightly enough to secure the correct result except in very black lines, but it is better rather than to erase to throw the drawing away and start anew, until the correct lines can be secured without too great heaviness. The reason for this way of working is, that we wish the student to depend as much as possible on his eyes, and if he erases, and has one line from the beginning, unnecessary time is given to its drawing, and he will hesitate before erasing it. If light lines are drawn and not erased, but others drawn as soon as there is doubt about the first being rightly placed, the student is much more free to change as each suggestion occurs, and toward the last he has his choice (as the tests indicate corrections) of the various lines already drawn. This is by far the quickest and most accurate way, and besides it prepares for quick and accurate sketching; indeed the student will not have to draw very long from the geometric solids before he will be able to produce correct sketches without drawing many unnecessary lines.

There is not much choice of pencils for this part of the work, but it is well to use always as soft a one as the nature of the work will permit. As no pressure should be used, the lead barely making a mark on the surface of the paper, and as all the lines except the correct ones must be erased, there is no reason why the student who has difficulty with the soft pencil should not use a hard one until the drawing is ready to line in.

When the correct outline has been found, it is necessary to finish the drawing. The paper must first be cleaned, all the lines except the correct ones being erased. The easiest way to reserve these lines will be to make them enough stronger than the others, so that they will show faintly when the latter have been removed. The drawing may now be lined in with a soft pencil (and here the pencil must be held more firmly and nearer the point), the attempt being not to produce a fine, even line, in imitation of a ruled one, but rather a line of medium strength, which may be easily drawn, and shall convey the idea of straight, unbroken edges. For the present it is better for the lines to be made of one strength, with no attempt at gradation, or the frequent conventional lining in of the nearer edges in heavier lines. This point will be considered later, but we wish now to advise the student, if he is already familiar with it, to forget it as quickly as possible, and to finish in uniform lines or in the way explained on page 17.

The method of work presented in these notes is that which should always be employed, and the student should draw from various objects, in different positions, until he is able to see them very nearly correct at first. The time required for this will depend wholly upon the pupil, and the care with which directions are followed.

GROUPS.

After the practise from single objects, prisms, pyramids, etc., two or three should be placed together, and here the method is the same as for a single object. The usual way, or that which the student would probably adopt, would be to draw, first the prism A, fig. 4; next the vase B; then the cylinder C; and last the frame D. The trouble with this way of proceeding is that the objects are drawn one at a time, and one added to the others, so that until the last is drawn the proportion of the whole group, that is, the greatest width in comparison with the greatest height, cannot be seen. Indeed, this is often not even considered, the student taking it for granted that since he has measured and tested each object as he drew it, the single objects are correct, and therefore the group. But from what has been said, it will be seen that each object is likely to be a little out of proportion, indeed, we may say, is sure to be so. This being the case the errors are multiplied, and if the height and width are compared, the proportion will be found to be far from correct. It is a principle commonly acknowledged now, that in all teaching the whole should be presented before its parts, so that it cannot be contradicted that adding one object to another, until finally the patch-work is complete, is a very uneducational way of proceeding. Practically it is also a very unsatisfactory one, as with each object the difficulties increase, and at last it becomes impossible to place the drawings where they belong. The only logical way is to draw the group all at once, first considering it as a mass and blocking in its proportions by straight lines passing from the principal points (see Fig 5). When these lines have been drawn and considered, they may be tested by measuring the whole height and width, and the directions tested by use of the thread or pencil as explained.

The proportions of the whole being thus determined as nearly as measurements can determine, the objects may now be sketched in by eye, the most important lines being drawn first; that is, the lines whose positions and directions are easiest seen. Such lines will be the longest lines, and those which are brought out distinctly by shade, and lines of one object which are nearly continuations of the lines of some other object. It is evident that in this way the drawings of the objects are proceeding at the same time, and the shorter and less prominent lines being drawn last, the group may be said to be drawn all at once.

While drawing, the student must think of the tests applied by the thread, the horizontal and vertical lines, and the continuing of lines; and the drawing in the air, or passing of the pencil point over the edge to be represented, will help greatly. The objects should be studied in this way, and changed as often as found incorrect, until no further changes can be made. It is now time to apply systematically the tests as explained in the drawing of the box, Fig. 1.

The first test is to measure the height and width of each single object of the group, and compare the same, and also to compare with the dimensions of the whole group. This test is the most important, and the greatest care should be taken with it. The best way will be, as soon as the proportions have been determined, to draw horizontal and vertical lines, forming a rectangle enclosing the drawing, and to be careful that these lines are not removed. As we have seen, slight inaccuracy can hardly be avoided, but these dimensions are the longest measurements, and can therefore be fixed more accurately than any others. This being so, the best that can be done is to make the drawing agree with these measurements; and by this time the student should be able to measure with the pencil or needle as accurately as any drawings will require. This test will generally change the drawing throughout, which should be done not by erasing but by adding lines, and without other measurements, until the eye can see no more changes. Then the thread may be used for the tests of horizontal and vertical lines first; and second, the continuing of all the edges; and third, for covering points in the group opposite each other, and chosen at random, that the intersections with the edges between may be noted. The thread used thus will discover every discrepancy except the slight deviations which only the accurate eye can detect. After the training which is given by these drawings made entirely by eye before any tests are applied, this accuracy will soon be secured. When the correct lines have been found, the others are to be erased as explained on page 10, and the lining in is to be done.

But now the student will do well to think of effect, and to see if more interest and expression cannot be given to the drawing than is done by the even outline. The student has, perhaps, been taught that the nearest objects are seen most strongly, and that the strength diminishes with the distance, and this is, of course, true in a general way. It is the effect of ærial perspective, or the changing of color by the intervening atmosphere. Thus, of a row of light objects, the nearest will be the brightest, that is, the lightest and most prominent, and of dark objects the same principle is true. The light object in the distance appears darker,* and the dark one lighter, so that in a sketch taking in any considerable distance this principle will be of assistance. But it must be stated so as not to convey the idea that there can be nothing in the distance which is stronger than anything in the foreground, for we do not see objects more or less distinctly according to their distance. Distance, in fact, has practically nothing to do with it. *We distinguish objects as masses of color, light or dark, according to the color against which they are seen.* This being so, it will be seen that a light object in the background, as a white house, seen against dark foliage, must be a much more prominent feature of a landscape than a near object which is seen against another of the same value. In general, when there is little or no contrast of color between objects, then are they difficult to see without regard to their distance.

Place a square of white cardboard centrally in front of a larger square of the same, the latter coming in front of the

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* Very light objects may change but little.

blackboard. The smaller can be seen very faintly, but in comparison with the distinctness with which the larger is seen against the blackboard the nearer plane is practically invisible. This experiment proves that we see objects to distinguish their form, through contrasts of color, and we have to consider what can be done in outline simply to render the effect of nature, for it is reasonable to expect from every medium its full possibilities. Can no more be done than to represent the outlines in an even line? The opinion seems to be general that more can be done. We find that instructions are often given to shade the nearer lines strong, the further ones light, and to grade the others between them. Apply the rule to the representation of the two planes of cardboard, and the nearer is lined in heavily and the further lightly. This we find to be in direct contradiction to the way we see the two objects, for the nearer is barely seen against the further white, while the more distant is distinct against the blackboard. In color we certainly should not think of representing the nearer darker than the further, or in any other way than as it appears, and the same is true of light and shade. Why should we not do the same with outline? No reason to the contrary can be given, for the difference in clearness with which the various lines are seen is the result, not of distance, but of contrast of light and shade. Of course we shall expect to find the strongest line among the nearer ones, but further than this we cannot go, and if we adopt the conventional lining in often recommended, we are working by rule and not by observation, and the result will be the production of hard, mechanical drawings.

Character appears in the outlines. An object, as a cast, having a smooth, hard surface, and an even outline shows these qualities in its outlines. They will be represented by smooth and even lines. A cube with smooth faces has sharp straight edges, which must be represented by straight lines. A box made of rough boards will have broken edges, and their character will be given by drawing the irregular outline in which one surface cuts into the other. A drawing from the figure can express the variations in the appearance of the outlines, some parts of which are sharp, some parts blurred by light showing through, or by a short growth of hair. The influence of light also affects the appearance of the outlines, in some places making them distinct, in other places indistinct. An even outline for everything disregards all these variations of effect, so also does any conventional variation of strength. If the student is allowed to disregard effects in outline work, he will have very great difficulty in seeing them in his later work. There is no more labor involved in representing the effects than in disregarding them, for one line is as easy to make as another, *observation only being required. The student who can see can perform*, and as long as any differences can be found between his drawing and nature he can learn to correct the errors.

In pencil, as in the other mediums, we should do the best we can to express what is before us, and the effect of the drawing should be considered as well as the forms represented. There is no reason why the student should not be taught to observe the effect, and if once started correctly he will advance rapidly, and will make drawings which, since they are representations of nature, will have variety of effect, will be true, and thus artistic. No rule can be given other than to study and represent simply what is seen, as far as possible as it appears. In outline, without light and shade, it is impossible to draw always just what is seen. For instance, some edges of the object may be so lost in the shade as to be entirely invisible, but without them the drawing would be incomplete and unsatisfactory. *A correct impression of the facts must be conveyed.* No important line, even though it be lost in shadow, can be omitted, but otherwise the lines should be represented just as they are seen. At first most students will have great difficulty in finding that there is any difference in the way in which the various edges appear. This is due to the fact that but a single point can be clearly seen at any one time. The eye passes rapidly over the whole extent of an object, so that it is all carefully observed, but we are unconscious of this motion. All parts of the object are seen distinctly, and the variety in the effect is not realized, and all points will continue to give the impression of equal strength in the effect, until the ability to see the whole of an object at once has been acquired. It is not possible, otherwise, to see simply and broadly, to realize effects and masses, and the student must practise until he can thus see before he thinks of success in any medium, for all demand equally a study of the comparative strength of detail.

The whole of an object of any size, or the effect of a group, can only be seen when the vision is blurred so that all parts are seen equally and necessarily indistinctly. This effect comes from looking with the eyes in focus for a shorter or longer distance, and is the same as that given by looking through a lens of ten or twelve inch focus. Opening the eyes and looking intently until the vision is blurred, is better than nearly closing them, for this cuts off most of the light and loses the color. In light and shade this point would not do harm, but it is better to study in light and shade so as not to be obliged to change for the more advanced work. After a little practise the student will be able to see the whole of the object without special effort, and it must not be forgotten that this is the only way in which effects can be seen.

Although no rule for lining in can be given, the effect will always be found to conform to the principle that *any detail which comes in either the mass of the light or the mass of the shade is unimportant*, that is, a light surface against a surface also light is not prominent, and an edge defining a surface which is in the shade against another surface, also in shade, is seen faintly. The important features, or the lines which are prominent, are those which come between the light and shade.

PERSPECTIVE PRINCIPLES.

Before beginning we will choose a term which shall mean the position in which any line appears of its real length, and any plane of its real shape. This will occur when the line or the plane is perpendicular to the direction in which it is seen, that is, is parallel to the picture plane. The words parallel to the picture plane might cause confusion, from the fact that in perspective the picture plane is generally vertical, and often takes in a wide field of view, while in model drawing the plane is perpendicular to the direction in which one looks, and is thus continually changing. We wish a term which shall mean any position in which any line or plane appears of its real shape, and will select the phrase, "directly in front." *Any line is directly in front when its ends are equally distant, and any rectangular plane when its angles are equally distant from the eye.*

Place a large cube horizontal, with its centre on a level with the eye, the cube being a few feet distant. The front face directly in front, with its four corners equally distant, appears of its real shape (Fig. 6). Now turn the cube so that its left side is seen very narrow (Fig. 7). It will be noticed that the upper end of the vertical edge, B, at the back appears below, and the lower end appears above the respective ends of the front vertical edge, A. In other words, the further edge appears shorter than the front, and the horizontal edges, D, E, connecting their extremities, must appear to converge, and if continued would meet. From this we see: *First*—That of two parallel and equal edges, the nearer appears the longer, the relative lengths being inversely as the distances. See Fig. 8, in which B, being twice the distance of A, appears one-half its length. *Second—That parallel retreating edges (all not directly in front) appear to converge or vanish at a point called their vanishing point. Third—That horizontal edges above the eye appear in retreating to descend or vanish downward, while those below the eye in retreating appear to ascend or vanish upward.* This is easily proved by the fact that the eye must be dropped in looking from a nearer to a farther point in the edge above the eye, and raised for the more distant point in the line below the eye. Lift the eye to the level of the top of the cube and it will appear a horizontal line, thus showing that *a horizontal line at the level of the eye appears horizontal, and that a plane so situated is seen edgewise and appears a horizontal line.* Now place the eye in the first position, on a level with the centre of the cube. The right hand vertical edge, C, is farther from the eye than the central edge, A. It must therefore appear shorter, and the horizontal edges, F and G, must converge as those at the left. If both these sets of edges are continued they will appear to meet at two vanishing points, and since the edges are equally above and below the eye, the upper and lower angles of convergence 1-2 and 3-4 must be equal on each side of A, and the vanishing points be on a level with the centre of the cube, that is, of the eye. Hence, we see that *parallel horizontal edges appear to vanish at the level of the eye.* We will now draw upon the end of a room,

Fig. 9, lines which continue the apparent directions of the horizontal edges at floor and ceiling, which are perpendicular to the end. We find them to intersect at a point which is directly opposite the eye. This point on the wall being the picture of the infinitely distant point in which the continued lines seem to meet, and the line from this point to the eye being parallel to the lines A, B, C, D, we see that *the vanishing point of any set of parallel lines is in a line parallel to them passing through the eye.* To draw these lines on the wall two students must work together, but the directions can be determined with a straight edge, and the students may work individually by drawing the interior of any room. This experiment is the best way to show that *to find the vanishing point of lines we must look in their direction.*

All parallel edges which have one end nearer the eye than the other must appear to converge, and the convergence must be in the direction of their farther ends. According to this statement, when the cube is above or below the eye its vertical edges must vanish. The edges do appear to vanish, but they are not so represented. *In a model drawing, vertical edges are represented by vertical lines.*

Place a small cube so that its top and front faces are seen, and its right side is seen as a vertical line (Fig. 10). The edges, A, A, A, are so nearly directly in front that they may be represented by parallel horizontal lines. Line B of the drawing will be found to be longer than line C, and yet C is nearer the eye. We see that the first statement illustrated by Fig. 8 must be qualified. A study of Fig. 11 will show that of two parallel and equal lines unequally distant from the eye, the nearer A-B *appears the shorter when its angle with the plane of the picture is greater than forty-five degrees,* and that of two lines, B-D and A-C, the nearer B-D *appears the longer when the angle of the lines with the picture is less than forty-five degrees.* This statement may not be exact for lines whose angle is very nearly forty-five degrees, but when there is a noticeable difference it is correct. The figure also shows that of two equal lines, A-B and B-D, perpendicular to each other and having one end common, *the one which makes the greatest angle with the picture appears the shorter. That which is nearest parallel appears the longer.*

Fig. 12 shows that *two lines perpendicular to each other, at equal angles with the picture and having their ends equally distant, appear of equal length.* The statement often found that of parallel and equal lines the more distant appears the shorter, has accomplished perhaps as much harm as good, for *it is only correct for lines directly in front and for vertical lines.*

In Fig. 13 line A-B represents the ground, and points 1, 2, 3, etc., equi-distant points situated in a line lying on the ground. The lines drawn from these points to the eye represent the rays in which the points are seen, and the intersections of the rays with the picture plane show that *the equal distances appear unequal, the nearest appearing the longest, the furthest the shortest, and the intermediate distances proportional between these lengths,* and this is always true of equal spaces on any retreating line.

It will be seen that there are three sets of parallel edges in the cube, and that they all appear to vanish, unless directly in front, and are so represented unless they are vertical, or situated as in Figs. 10 and 14. They vanish in the direction of their farther ends, and *these points are angles of the invisible faces of the solid.* If both ends of a line answer this condition, the line must be considered as directly in front, even if the eye is not exactly opposite its centre. In general, *parallel straight lines which extend on both sides of the spectator must be represented by parallel straight lines.* If the eye should be opposite one end as in Fig. 10, and the edges are short, they will be best represented by parallel horizontal lines. If the edges are long and near the spectator, it may sometimes be better to distort the nearer and smaller part of the object in favor of the farther and larger part, by drawing the more distant end smaller than the nearer Fig. 14. This, however, will seldom happen, and unless special permission to the contrary is given, *the edges are to be treated as if directly in front until a side face is seen.*

In nature there is no so-called parallel or one-point perspective, that is, parallel perspective is not true to appearances. It therefore should be avoided, and the difficulties which have just been considered will be best settled by moving so that the edge is directly in front, or so that a side face is seen and there are two vanishing points. When, however, this cannot be done, and parallel straight lines extend on both sides of the spectator, the student must represent them by straight lines, and in the case of horizontal edges by horizontal lines. Long parallel straight lines in nature appear curved. This is shown in the shadows of clouds at sunset, which sometimes may be seen extending across the sky, and converging in the east and west. In many drawings from nature of streets, etc., by our best illustrators, the curvature is so marked that it is most noticeable. The representation of straight by curved lines should not be allowed the student, and, as shown on page 72, straight lines may be substituted for the curved, changing the drawing but little when there are two vanishing points. When the end of a room is shown certainly no one would wish to represent the curvature, for the drawing should give the impression of nature, and this can only be done by straight lines.

THE CUBE.

These principles are illustrated by the cube (of four-foot edge, scale $\frac{1}{2}$ in. = 1 ft.) drawn in various positions:

First. The cube with four edges vertical, its under surface being on the level of the eye, one surface only visible, and the eye being opposite the centre of edge A-B. The under surface must appear a horizontal line. The front surface, although its upper angles are further from the eye than the lower, will, unless the eye is very near the object, appear practically of its real shape (Fig. 15).

Second. Lower the cube until its top is four feet below the level of the eye (Fig. 16). The receding edges of the top will vanish in a point on the level of the eye, and in a line drawn through the eye parallel to the edges. This places the point above the centre of the cube. The front face being below the eye will be foreshortened (as shown by Fig. 17), so that it will not appear of its real shape. The edge, E-F, being further from the eye than A-B, will appear shorter, just as C-D does. It will appear the length of 1-2, and the vertical edges, by connecting points A-1 and B-2, will be represented by inclined lines. The representation of vertical by inclined lines is not satisfactory, and the model drawing must have vertical lines. If the lines are drawn vertical from A and B, the front face will seem too wide; if from 1 and 2, it will be too narrow. The proper effect will be given by verticals midway between, or if they are drawn from A and B, the line 1-2 must be dropped to give the correct impression. It will be seen that the model drawing is not the exact drawing upon the inclined picture plane, but this drawing corrected by substituting vertical for inclined lines. When edges are situated on each side of the eye, as are A-C and B-D, they must always appear to vanish at a point which is directly opposite the eye, for *the vanishing point of a line is in a parallel to the line passing through the eye.*

Third. Place the cube with its vertical faces at forty-five degrees to the picture plane, its top being on a level with the eye (Fig. 18). The top is seen edgewise. The sides, since at equal angles, will appear of equal width. The edges, A and B, must vanish upward at equal angles, the angle depending wholly on the distance of the eye. If short, the convergence will be rapid, and the angle of convergence will decrease as the distance increases.

Fourth. The cube, with its lower surface on the level of the eye, and its vertical faces at angles of thirty degrees to left and sixty degrees to right (Fig. 19). The left face, being nearest parallel to the picture plane, appears the wider. The edges, A and B, vanish downward at angles which depend on the distance of the eye, but that of A must always be less than that of B.

Fifth. The cube, with its top four feet below the eye, and its sides at forty-five degrees (Fig. 20). The sides must appear of equal width, and the angles of the lines on each side be equal. There are four parallel edges extending to the right, and four to the left. Parallel lines appear to converge at a point, and for horizontal lines this point is at the level of the eye. The two vanishing points will then be on the level of the eye, and must be equi-distant from the drawing. This distance depends on the distance of the eye, increasing equally with it. (For an angle of forty-five degrees the distance of the vanishing point is equal to that of the eye.) In this position of the square, which is the base of the cube, it will be seen that *one diagonal of the base is parallel to the picture plane, and appears a horizontal line.* The other diagonal appears a vertical line, and the further angle of the square is directly over the nearer one.

Sixth. The cube above the eye, with its horizontal edges extending to left, at sixty degrees, and to right at thirty degrees (Fig. 21). Both sets of lines will vanish at points in the horizon, the vanishing point at the left being the nearest to the drawing, for the line at the greatest angle must appear the shortest. The diagonals of the horizontal surface will also vanish. Of the diagonal 1-2, 2 is the nearest point, and the line must vanish to the left. Point 3 is the nearest end of 3-4, and this line vanishes to the right.

Seventh. The cube, resting on an edge on the ground, four of its faces being at forty-five degrees to the ground, being seen from above, and having three faces visible (Fig. 22). Let line 1-2 be the edge on the ground. For four faces to be at forty-five degrees to the ground, it is necessary that the diagonals of the two faces which are vertical, shall be vertical and horizontal. Vertical lines from 1 and 2 must be the vertical diagonals. The horizontal diagonals, 3-4 and 5-6, must bisect the vertical and vanish in the horizon. The edges parallel to 1-2 vanish at the left, at the level of the eye. From point 3 an edge extends downward, and another upward. The lines which are parallel must vanish respectively up and down to the right.

These principles will enable one not only to correct or test drawings made from the object, but what is more important, to design or draw without the objects. Thus, let line A, Fig 23, be the nearest edge of a cube, situated below the eye, with its faces at such angles that the width on each side extends to B and C. Drawing a horizontal through the end of A we know that the edge extending to the right must make a greater angle than that going to the left. Such practice will enable one to draw quite correctly without the objects.

THE SQUARE PYRAMID.

When the pyramid stands on its base, its axis being vertical, is drawn by erecting a vertical at the intersection of the diagonals of the square. When two sides of the base are directly in front (Fig. 24), one side only of the pyramid will be seen if its axis is long, or if it is above the eye. If its axis is short or wholly below the eye, two side faces may be seen, and will appear equally (Fig. 25). When two faces are seen all the edges of the base must vanish. When two faces are seen alike, the edges of the base are at equal angles with the picture plane. The slant edges at front and back appear to coincide, and one diagonal of the base is horizontal (Fig. 26).

When two faces of the base are seen unequally (Fig. 27), the axis of the pyramid will be perpendicular to a line which is parallel to the picture plane. A plan view of the square and the P. Pl, will show the position of the line a-b with reference to points 1 and 2 of the square. This line must pass behind point 2 (which point is nearer the eye than point 1), and in front of point 1. When the pyramid is vertical line a-b will be horizontal. When the pyramid is oblique (Fig. 28) the line may be a test, but not sufficiently accurate to be of value except when drawing without the object.

THE TRIANGLE AND PRISM.

When this figure is equilateral or isosceles, and rests on a base, the altitude is vertical, and intersects the centre of the base (Fig. 29).

The prism with equilateral ends, resting on a face on the ground.

First (Fig. 30). When neither end is seen, the long edges are directly in front, and must be represented by parallel lines. When one end is seen, and two sides equally (Fig. 31), the edge A of the end is directly in front. When an end and a side are seen (Fig. 32), the end will be tested by a vertical through point 1. This should come at point 4, the centre of the base 2-3, but 4 does not bisect the line 2-3, as the nearer half must perspectively appear longer than the further half. The edges must vanish in the direction of their farther ends. This direction is at once apparent, except in the case of 1-2, whose direction will be determined by seeing which point, 1 or 2, is nearest to the line 3-7. The point which is nearest is the nearest end of the line 1-2. Suppose the prism placed so that the edges of the face on the ground are at equal angles with the picture plane. They will vanish equally, and the line 2-3 will be equal to one-half of 2-6, the nearer half perspectively appearing a little longer than the further half.

THE REGULAR HEXAGON AND SOLIDS.

In the hexagon there are four sets of parallel lines, A, B, C, and D. The diagonal 0-4 is divided into *four equal parts* by the diameters D, D, and the diagonals B-C. A model drawing of the figure may be tested by seeing that the parallel edges vanish in the direction of their further ends, and that the diameters divide the diagonal into four *perspectively* equal parts.

In Fig. 33 the hexagon is shown directly in front. In Fig. 34 it is shown after it has been revolved back about the angle 0. Figs. 35 and 36 are the same, the hexagon being revolvèd about the side A. In Figs. 34 and 36 the lines a-a may be drawn, thus enclosing the hexagon by a rectangle. The intersection of the diagonals of any rectangle gives its centre. By drawing them in these figures and lines b, the angles of Fig. 34 are determined. In Fig. 33, to get points 1 and 3, it is only necessary to divide by diagonals each half.

To draw the hexagon on a given line, a-b, as diameter (Fig. 37). Draw the sides A and B, then the further diameter c-d. Draw the diagonals, and make the distance 4-5 less than 3-4, and 1-2 greater than 2-3.

To draw a hexagon on a given side, A-B (Fig. 38). Draw the diameters from A and B, and draw the further side, C-D. Draw the diagonals A-D and B-C, and the diagonal through 3. If A-B and C-D are directly in front, 1, 2, 3, 4 and 5 will be equi-distant points. If not directly in front, the points will be perspectively equi-distant.

In the prism and pyramid, Figs. 39, 40, 41 and 42, no more than three of their side faces and an end can be seen at any time. If two only are seen, the *diameters* of the base are directly in front. When three are seen, and the outer ones appear of equal width, the ends of the middle face are directly in front. When the outer faces are seen unequally, the narrower, A (Fig. 39), must be the more distant, and this shows the direction in which the edges, a-b and c-d, of the middle face vanish. The vanishing of the parallel edges must make the invisible end wider than the visible, as in the cylinder (page 35). The tests for the pyramid are the same as for the prism and the square pyramid. When three faces are seen and the outer ones equally, the axis is perpendicular to the longest diagonal. When two are seen equally, it is perpendicular to the diameter. When two or three are seen unequally it is perpendicular to a line between the diameter and the diagonal. The faces visible will show whether this line is nearest parallel to the diagonal or to the diameter. In Fig. 40 the question may arise, "Shall the nearer half, a-c, of the diameter, a-b, be a little longer than the further part, c-b?" It will be seen that doing away with the convergence of the vertical lines makes the equal distances a-c and c-b equal in the drawing.

THE CIRCLE.

The circle appears of its real shape when directly in front. It appears as a straight line when the eye is in its plane, and in other positions in which its entire circumference is seen, it appears as an ellipse.

Fig. 43 represents a square, two sides being directly in front. A circle inscribed in the square will be represented by an ellipse, which is tangent to the sides of the square, at the ends of the diameters of the square, in points 1, 2, 3 and 4. The centre of the square must perspectively come nearer the further side, C-D, and it is at once seen that *the centre of the circle is not the centre of the ellipse,* that is, that *the long axis of the ellipse is not a diameter of the circle.* This is shown again by Figs. 44 and 45.

Fig. 45 is a plan view, showing the circle, the eye, and the cone of rays from the eye to the circle, represented by its outer rays, a-a. Fig. 44 is a side view, showing the ground, B-D, the circle, C-C, the eye, and the cone of rays, b-b. The picture plane, at right angles to the central ray, A, shows the width of the ellipse at 1-2. The central ray intersects the ground at c, and this must be the position of the chord 3-4 of the circle (seen in plan view), which appears the long axis of the ellipse. Points 3 and 4 are not the tangent points of lines a-a.

All lines whose ends are unequally distant must vanish. It follows that in any circle there can be but one diameter which does not vanish. This must be the one which is perpendicular to the line of sight, and thus directly in front. A horizontal line directly in front appears horizontal, and thus a horizontal circle must appear as a *horizontal line*, or as *a horizontal ellipse;* for though the diameter directly in front is not the long axis of the ellipse, it is parallel to the chord of the circle which is the long axis of the ellipse. The line of any circle which is the long axis of its appearance is thus a chord of the circle which is directly in front.

When on the level of the eye the horizontal circle appears a horizontal line, and when below or above the eye, an ellipse, whose width increases with the distance of the circle from the level of the eye (Fig. 46).

The short axis of an ellipse is perpendicular to its long. It represents a diameter of the circle which is perpendicular to the chord which appears the long axis. This diameter will be found to appear to coincide with a line perpendicular to the plane of the circle erected at the centre of the circle. Hence, if two lines are perpendicular to each other, one is directly in front, and the other intersects the centre of the first, the right angles thus made will appear right angles until the second line is seen as a point.

The circle when vertical, at an angle with the picture, and its centre on the level of the eye, will appear a vertical ellipse. When the vertical circle is below the eye, the two equi-distant points in its circumference, which are the ends of the long axis of the ellipse, must be, the upper point behind the highest point in the circle, and the lower point in front of the lowest point. The chord (that is the long axis of the ellipse) connecting these points must be an inclined line. When the circle is above the eye, the ends of the diameter of the ellipse will be in front of the highest and behind the lowest points in the circle, and the axis of the ellipse will incline in a direction opposite from that which it has when below the eye.

The axis of the ellipse which represents a vertical circle on any level except that of the eye, must be an inclined line (Fig. 47). In this figure we have a circle A, vertical, and on the level of the eye, and circles B and C of the same size, directly over and below A, and in the same plane. It will be seen that the ellipses of B and C are tangent to verticals tangent to A, but that their short axes are shorter than that of A. To determine the inclination of the axis look for the two equi-distant points which are its ends, or look for the direction which a perpendicular to the circle at its centre would have, for *the long axis is perpendicular to* *this direction.* The latter way (which is the better) considers the circle the base of a cylinder whose direction determines the direction of its end.

THE CYLINDER.

Less than half the curved surface of the cylinder can be seen at any one time.

Fig. 48. When an end only is seen, it must appear of its real shape. When neither end is visible (A), the cylinder must be directly in front, both ends appearing narrow ellipses. When one end appears a straight line (B), the other must appear a narrow ellipse.

The long axis of an ellipse appears perpendicular to a line which is perpendicular to the circle at its centre. This line in the cylinder is its axis, and in drawing the cylinder and cone *the long axis of the ellipse of the base must always be at right angles to the axis of the solid.*

When the surface of one base of the cylinder is visible, that of the other must be invisible. The visible end being nearest the eye, the invisible must appear shorter, and the elements connecting them must converge as any parallel straight lines. The question of the comparative width of the visible and invisible ends has caused much trouble. A study of Figs. 11 and 12 will show this width to be dependent upon the position of the cylinder. When it is at a less angle than forty-five degrees with the picture, the invisible base will be the wider, but when it is at a greater angle than forty-five degrees, the invisible base will be the narrower. This, however, is not exact for angles very near forty-five degrees, and refers to positions in which the object is at a sufficient distance to permit its entire representation. For unusual conditions, as a very long object very near the spectator, or for a number of objects placed in a straight line and extending for some distance, it cannot apply, as the distortion caused by the use of any one picture plane would be very great. Such conditions, however, are not normal, and it is best not to attempt to draw an object which is so near as to create a visual angle of over thirty degrees. The invisible base is always at a less angle to the plane which gives its real appearance; that is, it is at a greater angle to the ray from the eye to its centre than the nearer end (Fig. 49), and, though narrower than the visible end when the cylinder is at a greater angle than forty-five degrees, is also shorter, and is always *proportionally wider* than the visible end. This is the only rule that can be given, the difference depending upon the distance of the eye, and decreasing as this distance increases. When this distance is short it is quite marked.

Figs. 50, 51, 52, 53, 54 and 55 show the cylinder in various positions, and all illustrate this principle. In these drawings, the length of the cylinder is supposed to be twice its diameter. In Fig. 50 the cylinder is horizontal, on the level of the eye, and extends to left at forty-five degrees to the picture plane. The short axis of the visible end must be perspectively one-half of the element a-b. In Fig. 51 the cylinder is at an angle with the ground, and still at forty-five degrees to the picture plane, the appearance being the same as Fig. 50. Figs. 53 and 54 show two cylinders, one being exactly over the other. In Fig. 52 the cylinder is below the eye, and extends directly back. The tendency will be to represent the ends by circles, but they can only so appear when no part of the curved surface is visible.

THE CONE.

The cone appears a circle when its axis is seen as a point; a triangle when its base is seen as a line. In other positions both the circle and the curved surface will be visible, the circle appearing an ellipse. The curved surface will be represented by the two contour elements, which must be tangent to the ellipse (Fig. 56). The entire curved surface will be visible when the axis is toward the eye. When the cone extends in the opposite direction none of the curved surface will be seen. Between these positions any part may be visible. The base of the cone being at right angles to its axis, as in the cylinder, it must appear as an ellipse whose long axis is perpendicular to the axis of the cone. In Fig. 56 more than half the curved surface of the cone is visible; in Fig. 57 less than half; and in Fig. 58 nearly all is seen.

To draw the cylinder, cone, or similar object, the method illustrated by the box should be followed, the mass being blocked in first. In the case of all symmetrical objects having an axis, this imaginary line should not be drawn first as is often recommended, but after the proportion and position has been secured, the drawing may be tested by a centre line before lining it in. On no account should this line be drawn first.

CONCENTRIC CIRCLES.

Fig. 59. Concentric circles must appear ellipses whose directions are the same, but since the centre of the circle does not appear the centre of the ellipse, the long axis of the larger ellipse, line A-B, comes in front of the long axis, G-H, of the smaller ellipse. The smaller circle is half the diameter of the larger, and a diameter, C-D, of the larger circle is divided into four equal parts by the inner circle. Although the diameters of the ellipses do not coincide, they are generally so little apart that the equal divisions of the diameter of the circle are nearly enough represented by equal spaces on the long axis of the larger ellipse. The equal distances on the diameter, E-F, appear perspectively equal (Fig. 13), so that practically we may say that if the distance, H-B, is one-fourth of the axis, A-B, the short axis, E-F, will have the distances E 1 and F 3 perspective fourths of the entire length, E-F. Thus, in Fig. 60 the distance, 0-1, is one-sixth of the long axis, 0-6, and the distance, a-b, is perspectively one-sixth of the short axis, a-g. This will enable us to test the drawing of the ring (Fig. 61), in which we must further see that the thickness (which is given by the lines 1-2, 3-4 and 5-6, all being equal in the object) shall in the drawing be so perspectively, the nearest 1-2 being the longest, and the farthest 5-6 being the shortest. This figure illustrates the fact that in most drawings from nature there will be but a very little distance between the axes of the ellipses representing concentric circles. In this drawing we see that the retreating parallel circles do

not appear to come together as they recede until the further half of the circle is reached. Thus we see that *curved, parallel retreating lines may appear to converge or diverge.*

FRUSTUM OF PYRAMID AND CONE.

When any pyramid is cut by a plane parallel to its base, the section is similar, and its edges are parallel to those of the base. When drawing this form this fact must be kept in mind; and also that the slant edges continued must meet in the axis of the solid. The legs of stools, chairs and tables present this form. The drawings of such objects should be tested by continuing the legs to see that they meet at a point over the centre of the base (Fig. 62).

The frustum of the cone (Fig. 63) is a form found in many common objects. Frequently there are rings about the cone (Fig. 64). As already shown, the visible curved surface of the cone may range from the entire surface to none. When there are circles or rings about its surface, they will show in the same proportion as the surface containing them. Thus, when the cone inclines toward the eye, more than half the ellipses representing the rings will be seen, and when the cone inclines from the eye a small part will be visible (Fig. 65). In this figure it will be noticed that, if the middle ellipse at the front comes midway between the top and the bottom, behind its position will be the same (perspectively). This, and the fact that the width of the ellipse must increase proportionally until the further circle is reached, will enable such lines to be drawn correctly.

In Fig. 66 the width of the band A seems greatest at the sides because there it is foreshortened less than in front. The width of the bands, A-A, will be greater or less at the sides according to the angle of the cone, and the direction in which it is seen. When the cone has its larger base visible (Fig. 65), the nearer part of the band will appear widest at its nearest point.

The drawing of the dish (Fig. 67) shows that the nearest part, since it inclines away, may appear narrower than the side of the dish at the back. However, it is impossible to state a rule for all the above shapes regarding appearance.

In the double cone (Fig. 68) the smaller circle A is common to both surfaces. Since one of the cones must incline away from the eye, less than half of the ellipse can be visible. The contour elements of each cone must be tangent to the ellipse, and those of the farther cone will intersect or pass behind those of the nearer cone.

The torus is a plinth with a circular top and bottom, connected by a surface whose section is a semicircle. This form is very common in furniture. It may be represented correctly by drawing first the plinth of which the plane surfaces are the ends. If a semicircle be drawn from the ends of the long axes of the two ellipses, and a line be drawn tangent to the semicircle and to the ellipses above and below, this line will be the outline of the torus (Fig. 69). When the ellipses are wide, and the drawing large, the outline will come a little outside that of the plinth at front and back.

THE RING OF CIRCULAR SECTION.

(Fig. 70). This object will be represented by two concentric circles when it is directly in front, but when foreshortened its outlines will not be ellipses. This is due to the fact that the rays come tangent below in front; and behind, above the centre of the ring, and the line on the ring which is on the contour is not a circle. When much foreshortened the further inner outline will pass behind and intersect the line which represents the nearer part. This drawing may be tested by the centre line of the object, which is a circle and appears an ellipse. Draw this ellipse, and suppose a sphere to pass around the circle. The centre of the sphere being in the circle, its surface must describe the surface of the ring. The sphere will be represented by circles whose centres are in the ellipse, the one behind being slightly smaller than the nearer. The ring must be represented by lines drawn tangent to these circles.

FRAMES.

Any objects of the geometric forms, constructed of pieces of uniform size, may be tested by means of the diagonals of the figure, for polygons whose sides are parallel and whose centres coincide have the same diagonals. Thus, in the frame, Fig. 71, if the line A be drawn, its intersection with the diagonals must give the extremities of lines B and C. In the cubical frame, by continuing the line A to the edge 1-2, a point in the line E is secured.

In the triangular frame the perpendicular from each angle to the opposite side gives the angles of the inner figure, and any side, as A, being drawn, the lines B and C will extend from 1 and 2, parallel perspectively to the sides of the outer figure.

In hexagonal and other frames the same principle will apply.

Fig. 74 presents forms frequent in furniture. The upper form A consists of a ring outside a cylinder, and is really the form found in the torus, explained on page 40. The lower form C is a v-shaped groove cut into the cylinder. This is the double cone explained on page 40. The inner form B is a semicircular groove. This will be represented by two ellipses, showing the circular edges, and when the ellipses are wide and the groove is narrow nothing but the ellipses can be seen, as at D. If the ellipses are narrow, and the groove is wide, the curved surface will be represented by a curved line (as shown in the figure), which ends above the diameter of the ellipse. A similar line is found in vase forms when the stem joins the base (Fig. 75).

VASE FORMS.

In Fig. 76 we have in elevation a common form, in which there are three circles represented by straight lines. Fig. 77 is a model drawing of the same form in which the circles are represented by ellipses. A common mistake is shown at the right side, where the outline of the body is drawn to the end of the long axis of the ellipse. The line is correctly placed at the left. It must come tangent to the ellipse at the back, and thus pass above the end of the long axis. Another point which is frequently unnoticed is, that when the handle of a vase seems to extend from its outline, it intersects the vase in a line inside the outline (Fig. 78), and the more the handle extends toward the eye the fuller the line of its intersection with the vase.

Fig. 79 is a side view of a vase. The exact dimensions of the model drawing (Fig. 80) may be obtained by supposing the eye at a certain distance, and drawing the visual rays to intersect the picture plane, which is placed at right angles to them (see side elevation). The top of the vase being against the picture plane, the long axis of the top ellipse will be very nearly the full diameter of the top. The circles below being behind the picture plane, a little must be allowed for the effect of perspective, as well as for the fact that the long axis of the ellipse is not a diameter of the circle. In this vase there are three plinths, A, B and C, whose circles will appear ellipses. The curve of the neck will intersect the under ellipse of the top, and will end below as in Fig. 75. The curve of the body of the vase must come tangent behind to the lower ellipse of the middle band, as explained in Fig. 77.

Fig. 81 shows the lower part of a vase. It consists of the spherical body and a cylinder with a round edge as base. The round edge is a thin torus, and should be drawn as illustrated by Fig. 74. The cylinder intersects the body in a circle, which appears an ellipse. If the ellipse is narrow, part of it will be visible, but the outline of the body must come tangent to it, and cover the ends of the axis of the ellipse (Fig. 82). If the ellipse is wide the curve may come tangent in front, as in Fig. 83, and if the ellipse is wider it will be invisible behind the outline of the body (Fig. 84).

Fig. 85 gives a side view of the top and bottom of another vase. The top consists of two cone forms, with a cylindrical band between them. There are five circles, and to represent the top, four ellipses and the ends of the fifth must be drawn. The body and the base are connected by a cylinder. The body will be represented by lines tangent to the upper ellipse at the front, as in Fig. 82. The curve of the base will be tangent to the lower ellipse behind, as in Fig. 77. The lower edge is the frustum of a cone, and in this form the straight lines tangent to the ellipses must not be forgotten, as is apt to be the case, especially when the ellipses representing the two bases intersect, as at the top when the straight line can hardly be seen, and when knowledge only will produce an exact drawing.

The principles which have been explained will enable one to see as it is impossible to see without them, and to draw without the objects, to draw from memory, and to design geometric forms of any size and in any position. They will be of so much use to the practical draughtsman that he cannot afford to be without them, even were it very difficult to obtain this knowledge. The principles are, however, so simple that there is no excuse for violations of the few essential ones; but such violations are found very frequently not only in the work of the amateur, but also in that of the professional draughtsman.

The student who has a knowledge of working drawings may test his ability to draw from a description of the form and its position, by taking any sheets of projection showing objects one after another, supposing them to be seen from a certain point, and making model drawings which shall represent them. Thus, Fig. 87 is a working drawing showing several objects, and their relations to each other, and the planes of the drawing, and Fig. 88 is a model drawing of the same.

We will suppose the objects to be seen from the left and from above so that three faces of the cube are visible.

The cube is the first object, and any drawing which shows the top, front and left sides answers the requirement. When the cube is correct the G. L. which is parallel to the edges extending to the right should be drawn.

The cone is the next object. Its base is a circle of the same diameter as the base of the cube. The best way to place the ellipse which is the appearance of this circle is to draw a square whose sides are parallel to the base of the cube. The ellipse must come tangent to the square at its diameters. The distance between the cone and the cube is equal to half the side of the cube. This distance 1-2, will be found by drawing the diagonals of the right front face of the cube, and set off on line A-B from 2 to 3 gives the nearest angle of the square.. Its sides extending to the right are continuations of and are perspectively equal to those of the first square; and the sides extending to the left are parallel to those of the first. It should be remembered that these lines continue and vanish at right and left in a horizontal at the level of the eye, and all parallel lines should be continued as far as the drawing will allow, so that they may be given the proper convergence. The student should not attempt to have the vanishing points come on the paper. The diameters of the base being drawn, give the tangent points of the circle and square, and through them the ellipse must pass. The circle is horizontal, and the axis of the ellipse must be a horizontal line. The distance between the centre of the ellipse and the centre of the square is so slight as to be hardly noticeable. The long axis of the ellipse must be, however, in front of the centre of the square; and in a larger drawing where the ellipse is wide, if the axis should be drawn through the centre, the error would be very noticeable. The axis passes through the centre of the square, and must be represented by a vertical line. Its length is readily determined by reference to the vertical edges of the cube, which are half as long as the axis.

The cylinder is next to be considered. The front circle is in the plane of the front face of the cube, and it will be best drawn by means of the square which circumscribes it. The sides of the square are parallel and equal to those of the front right face of the cube. Of course the distance 5-6 must be less than 3-4, as 3-4 is less than 1-2, and 4-5 is less than 2-3 (See Fig. 13). The diagonals of the square give its centre, and through this point the axis of the cylinder must pass. The vertical and horizontal diameters give four points in the ellipse, whose long axis is a little in front of the centre of the square, and at right angles to the axis of the cylinder. In the same way the further end may be drawn. The length of the cylinder being twice the side of the cube, the distance 7-8 is perspectively equal to 5-7.

The hexagonal prism is the last object. It is vertical with one face in the plane of the line A-B. A diagonal of its base is parallel to A-B. Its length may be placed on A-B from 9 to 10, perspectively equal to 5-6, the distance 6-9 being perspectively equal to 4-5. Points 11, 12 and 13 dividing 9-10 into four perspectively equal parts, being placed, the diameters of the hexagon will extend from 4 and 13 to the left vanishing point. The side 14-15 having been drawn, the diagonals 11-15 and 13-14 give the centre. Through this point the diagonal parallel to 11-13 passes, and the lines from 9-10 give in it the two remaining angles of the base 16 and 17. The left vertical face is the narrower. This shows that 16 is nearer than 13 and the diameter 16-13 inclines upward slightly from 16.

These drawings will call for lines at definite angles with the ground and the vertical plane. Such angles may be determined by means of the cube, and for this reason it will be well to draw this object first, even when it is not called for (Fig. 89). The edges of the cube being perpendicular to the two planes, the diagonals of its faces are at forty-five degrees. If smaller angles are desired they can be obtained by subdividing the angles of forty-five degrees. In making this division it must be noticed that *equal angles never appear equal when occupying different positions with regard to the picture plane.* Fig. 90 shows that equal angles appear unequal and *larger the more the lines of the angles are foreshortened,* so that to divide any angle, the part which is most nearly directed toward the eye, must be represented by the greater angle, and as equal angles approach the position of directly in front they will appear smaller. Such practice will more quickly than anything else show the student whether he really understands the principles, or has been merely memorizing them. The latter, which unfortunately is the only way many students study, will be found entirely useless, and those who have been working thus, must start again with the determination to see with their own eyes, and accept nothing which they have not verified by careful study.

INTERIORS AND GENERAL WORK.

All drawings, whatever the subject, should be carried on in the same way, first by blocking in the mass of the whole, and then the masses of the various parts, the detail coming last. In drawing from objects having curved lines, the student should be careful not to be content with the general effect of the line, but should in finishing see that he does not lose the character, which is given by the slight changes in direction which occur in many lines. Thus, in drawings from the cast, lines which at first glance seem of uniform curvature, will be found to be composed of many short lines, having different directions, and often straight or nearly so. The student will get the character only by looking for these short, straight lines; but this method of drawing curves must not lead him to put straight lines where none can be seen, as, for instance, in an ellipse.

After the groups of geometric solids, common objects, boxes, furniture, etc., should be taken. These may be arranged in groups; and here the student may study to make a pleasing arrangement. This work leads directly to the drawing of interiors. No principles other than those explained with the geometric solids are involved. The only question or difficulty likely to arise will come from the larger space to be represented. As this space is not definitely outlined, the whole cannot be blocked in as in a group of models. The best way will be to draw the central group or the most prominent mass of the subject first, and then add the surrounding parts. It will be well to take for comparison some long and important line of the central mass. If care is exercised in determining the proportions of the rest, with this line as unit, the smaller subdivisions of each space will come without trouble.

In this work, as in all, the aim should be to represent as nearly as possible the appearance of everything. The subject being larger, and the straight lines longer, their apparent curvature is often sufficient to be most noticeable, and as we do not wish to represent straight lines by curved, it is evident that we cannot draw everything just as we see it. See pages 24 and 71. It will be well to avoid the representation of a wall which extends far on both sides of the spectator, as this will make the drawing very different from the appearance. If one wall only is to be represented it is better to draw from one end of the room, and thus cause the lines to vanish. When two walls are shown they will both vanish. When three are to be represented the middle one must have no vanishing. Fig. 91 shows that were it to vanish the whole of the left wall (and of course the further edge, A, must appear shorter than the nearer, B) would be outside of both vanishing points of the drawing, and the distortion of all to the left of the left vanishing point would be most marked. In general, when any horizontal lines extend on both sides of the spectator, they should be represented by horizontal lines.

In interiors it is sometimes necessary to draw as the room would appear from a supposed position far enough away to show more than can be seen from any attainable position.

Such drawings will call for a thorough knowledge of all the principles.

In interiors and in street scenes there is not only the question of horizontal foreshortening to be considered, but also vertical. It is impossible to make a sketch which shall include an extended range of vision, and shall give the exact appearance of each part and also of the whole. We get the real dimensions of the appearance of any object on a plane which is perpendicular to the rays to the object. Carry this principle out, and the surface which gives the exact appearance of an extended range is that of a sphere which cannot be developed. This then is the reason why we cannot always draw just what we see.

The space which can be included in a model drawing, and which may be represented on a plane without noticeable distortion, should not include an angle at the eye of over twenty-eight degrees. If this is much exceeded, the questions of the curvature of parallel lines both for horizontal and vertical distances will arise, but as most drawings require a larger angle the question must be considered.

The mind, knowing lines to be straight, will hesitate to accept their representation by curved lines, or knowing them to be vertical, will not accept readily their representation by inclined lines. The drawing should give the impression of nature as far as possible, even when the eye is not at the proper distance. The impression of vertical lines is given by vertical lines, and of straight lines by straight lines. For this reason it seems best that the student should represent what he sees as nearly as possible, but in accordance with the perspective principle that straight lines shall be represented by straight lines. This will cause him to represent straight edges, which extend on both sides by parallel horizontal lines, and to substitute for the curved lines found in buildings, at angles with the picture, straight lines extending to two vanishing points. This will change the drawing very little, as shown on page 72.

In drawings of street scenes the lines are long and broken, and the curvature may not be noticed if each part is drawn as it appears. In these subjects also, one does not know what the conditions are (the edges might be curved in nature), and so there is not the contradiction between the knowledge of the facts and their appearances. If the artist chooses to represent straight by curved lines he has nature as authority, and the example of noted predecessors, and no one would wish to say that his drawing was not good, or that it would be improved by plane perspective. Whether or no, the foreshortening of horizontal and vertical distances shall always be given, is a question which can be answered only as it arises, and decided according to the conditions of the subject and the aim of the drawing. It is a question for the artist rather than the student, who should, until he has attained by long practice ability to judge proportions correctly, never be permitted to draw other than those he sees.

TESTS.

In beginning, the student should understand that the drawings are of no value in themselves, but are of use only as they train the eye to see correctly. The eye can be taught, or rather the mind can be made to accept the image of the eye only by depending upon it, and if the student begins by measuring and testing he will never be able to draw otherwise. This is undesirable for many reasons, the most important being that no measurements or tests can be applied which will take the place of correct perception, or begin to equal it in exactness. It is thus most important that the student from the beginning depend entirely for his first drawing upon his perception of its appearance.

The readiest way of determining the proportions of an object is by the use of a pencil, or other straight, slender rod, held at arm's length, and made to cover the lines to be compared. Thus the top of the pencil may be made to cover the top of the object, and the thumb-nail held against the pencil to cover the bottom of the object. If the pencil is then turned into a horizontal position, the height of the group may be compared with its width. If the measurement covering the height extends over one-half the width, the object appears twice as wide as high. In this way the proportions of any object or group may be determined. It is important that the student should see that such use of the pencil is simply to obtain the proportion of height to width, and not to determine the actual size of the drawing.

In fact this use of the pencil should not be allowed, for the eye and hand will be in different positions when taking the various measurements, and if they are transferred to the paper, as is the wish of many beginners, the drawings resulting will be entirely out of proportion. The slightest change in the distance of the pencil from the eye in comparing proportions will occasion great inaccuracy. The only way to be at all correct is to hold the pencil as far from the eye as possible, the arm being perfectly straight, and the pencil being turned by twisting the entire arm. The pencil must be at right angles to the direction in which we look for the measurement. Nearly all students have the idea that this means parallel to the side of the room or the bench upon which the object is resting. This, however, is wholly false, for the position of the object with reference to its surroundings is of no consequence, and must not be considered. If the student has a cube to represent he must look at it, and the plane which gives its real appearance must be perpendicular to the direction in which he looks, and the pencil must always be held thus when taking measurements. A good way is to find some position in the fingers in which the pencil will be perpendicular to the arm, and the arm being outstretched will bring the pencil into practically the correct position (Fig. 92). Those who cannot do this readily, and who do not hold the pencil rightly, will find that a pin stuck into the pencil at right angles to it, in such a position that it may be seen while taking the measurements, will correctly place the pencil. When the pencil is held so that only the head of the pin can be seen, it must be perpendicular to the direction in which the student looks (Fig. 93). But a much better device may be made by bending a piece of soft wire (a hair-pin), about a large knitting needle, as shown in Fig. 94, so that one end will project at right angles to the needle, and the other, after passing around the needle several times, shall extend back, and project a little distance perpendicular to the first end. The long end, at right angles to the needle, will place the needle correctly. The wire should press the needle just enough to keep it in position. It may be moved by the finger or thumb, and the measurement taken by sighting by the short end. This slide will be found of very great assistance, and as it is important that measurements should be exact, it is desired that every student be provided with this measuring rod. It will also be found a great help when, as is generally the case, one measurement is not an easily determined part of the other. In measuring, *the smaller measurement should be taken first*, and then compared with the larger. If the former is one-half or one-third of the latter it will be easily determined; but if the first goes once and a fractional part, as one-fifth or one-sixth, this part is not easy to determine, and if the two measurements can be secured in such a way that they may be compared at length, the proportions may be more surely determined. This may be done by taking the smaller measurement by the sliding wire, and the larger by the thumb, and in this way the two can be compared at leisure.

Much care must be taken that the distance of the needle from the eye shall be the same for all lines compared with each other. The distance is so apt to vary that unless each comparison be made several times with the same result, there is little chance of the measurement being correct. It is useless to think that tests not carefully taken are worth the time given them, and it is much better to take the one proportion of height and width carefully than to spend the time necessary to do this on half a dozen measurements, which are sure to contradict and do more harm than good.

It is impossible to compare accurately a short distance with a long. If the height is equal to or one-half the width, care will so determine it, but with every change of the hand in moving a short distance over a long inaccuracy is produced, so it is well to avoid all such comparisons. The inaccuracy arises from inability to hold the pencil at exactly the right place, also from the change in distance of the pencil, which every movement away from the first position occasions. This movement may be seen to occur by tying a thread to the pencil, and measuring the distance of the pencil from the eye, by holding the thread with a finger of the left hand against the brow. If the arm is dropped for the measurement of a near object, and the string is tight, it will slacken when the arm is raised, and in the same way it will change for horizontal movement. The only way then in which really exact measurements can be taken, will be by the use of such a measuring thread for the pencil, but we wish to simplify the subject as much as possible, and if reasonable care is exercised the variation of the distance of the needle may be made so slight as to be unimportant, at least in the first part of our work, which will consist in the drawing of small objects, singly or in groups.

Whenever possible all comparisons should be made by swinging the pencil from a vertical into a horizontal position by a motion of the whole arm from the shoulder, and avoiding a change of position of the pencil, *by swinging it about one end* of the first measurement. Thus, if the height and width of a table is desired, instead of measuring the width along the top, and then dropping the hand to take the vertical measurement (which will be done by almost all students, or what amounts to this, the measurement of the height and the lifting of the hand for comparison with width), make the measurement by taking the width along the top, and swing the pencil down about the thumb, thus not changing the distance of the hand. The easier way will be to take the measurement at the bottom, and swing the pencil up about the thumb (see Fig. 95). This way of measuring will be easily acquired, and will assist very greatly to correctness.

A short distance may of course be compared with a long with a degree of accuracy which varies with the student, but such measurements are not recommended, and are not necessary, as other tests will bring better results. Another way by which distances may be compared is by marking upon the edge of a straight-edge or bit of cardboard with a pencil, and then comparing at leisure. The use of the pin or the needle with a sliding wire may be necessary at first for most students, but after practise these helps will not be required, and the pencil will be held correctly without difficulty. If the back end of the pencil is used to measure by, the pencil will be placed correctly when the end is seen as a straight line, thus more simply producing the same result as the sliding wire on the needle.*

The above are the direct tests for proportions, and if carefully taken should give the correct mass of the drawing, but for the smaller proportions, and for the directions of lines, there are other tests which are more important. The lines with which it is most natural to compare directions are vertical and horizontal lines. A horizontal line, whose ends are equally distant, appears horizontal, and is represented by a horizontal line, while a vertical line appears vertical, and is represented by a line in the drawing which is perpendicular to the horizontal. If a straight-edge be held horizontal with its ends equally distant from the eye, it will represent a horizontal line in the drawing, and by looking over the ruler thus held, the directions of lines of the object may be compared with the horizontal. A piece of fine thread with a weight attached will serve as a plumb-line, and by holding it in front of the object its lines may be compared with the vertical. The thread is often better than the rule for the horizontal line. Care must be taken to hold the thread perpendicular to the line of sight. This position is easiest obtained by directly facing the group and extending the arms equally, so that both ends of the

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*When sketching from nature, if horizontal edges extend on both sides of the spectator and it is desired to make a perspective instead of a model drawing, its dimensions may be compared by holding the pencil parallel to the plane on which the drawing is supposed to be made.

thread are the same distance from the eye. But more care must be exercised to get the thread horizontal. This can only be done by looking at the thread alone, until it is levelled, when the student may look behind. If this is not done, the lines behind will be most likely to make the thread seem horizontal when it is not. If there are horizontal edges behind, which are parallel to the picture, they will appear horizontal, and will place the thread correctly, but if the lines are not directly in front they will not appear horizontal, and so will cause the thread to be out of level.

It may seem that unnecessary space has been given to these directions, but it has been found almost impossible to make many students understand the matter, and hold the thread correctly, even with repeated explanations and illustrations. Some, after months of study, are found holding the pencil or thread at an angle of from ten to twenty degrees away from the correct position. Hence it is not thought that any explanation can be too careful. But the problem is so simple that any student who wishes to succeed should have no difficulty after giving careful attention to directions. Of this the student may be sure, that he will never learn to draw until he is able to discover his mistakes, and as the thread is a most important test it should be correctly applied.

Any object, as the cube (Fig. 96), having been drawn, it may be tested by the thread as follows: Hold the thread horizontal to cover 5, and note its intersection with 1-6 and 6-7. Now hold the plumb-line so as to cover point 3, and notice where it intersects 5-6. Then hold it to cover 6-7, and find its intersection with 2-3. Then hold the thread to cover 1 and 5, also 2 and 4, and compare the direction of the thread with the horizontal. Next cover 2-7, and see where this line continued cuts 5-6, then 4-7 to intersect 2-1. Now cover in succession any two opposite points, as 1-3, and 3-6, and 4-1, etc., and place the intersections on the inner edges.

Such use of the thread is simply a more exact method of discovering angles than drawing the lines in the air with the pencil point, the first method explained. When the eye is trained, the first, which is of course the simplest, will be all that is needed. But most students will find the use of the thread preferable, as it gives a fine line which can be made to exactly cover the edges of the object. Its intersection also with the edges can be seen much more readily than that of a line formed by the side of the pencil, whose size hides considerable of the object. If these tests with the thread are applied, they cannot fail to discover every error of importance.

Another and last test may be made by holding two pencils, or better two rulers, together, at right angles to the line of sight, and separating them until one covers 2-3, and the other covers 5-6. If great care is taken the directions of these lines with reference to each other may be seen, and the drawing tested by continuing these lines in the drawing.

We have dwelt thus carefully upon each test to be applied in the hope that the student may realize their importance, for he will learn to draw correctly only through his own efforts, gaining with each discovery of error. He can never become a draughtsman as long as he depends upon a teacher for corrections. Let him carry his drawing so far that a thorough application of all the tests explained will show no error, then, as it is simply a question of exactness to be determined by the eye, if the trained eye of the teacher discovers mistakes so slight that the student cannot rightly be expected to determine them for himself, these may be pointed out. As the chief benefit results from what the student sees and does himself, he will be much better off without a teacher than with one who does his work for him.

There are many who say that measurements and tests are mechanical, and that to learn to draw the student should draw by eye simply. It is true that measurements and tests, as unfortunately too many students are taught to use them, cannot fail to produce hard and mechanical drawings, and retard progress. Still, it seems better for the student when he can see no further to be shown by tests where his eyesight has failed, rather than to carry drawings only as far as he can by eye alone, and then put them away, and begin others which can be carried but little if any farther. Therefore the student is advised to apply the tests explained, after he has carried his drawings as far as he can see, and not to put any drawings away which the tests show to be inexact. This training, it is believed, will most quickly produce ability to draw correctly at sight.

THE PLANE OF THE DRAWING.

The mind through the sense of sight perceives form, the rays of light from any object entering the eye, and being focussed on the retina, and forming an image of the object as in the camera, except that in the latter the image is formed on a plane surface, while that in the eye is formed on a spherical surface. As but a single point can be seen clearly at any time, the image of the eye is practically the same as that of the camera. The problem for the artist is to make his drawing so that it shall convey the same idea of form, size and position as the objects which it represents. It is evident that this must occur when the drawing produces the same image in the eye as the objects, and to do this the drawing must be similar to the image.

The rays from any object to the eye form a conical body. If this cone of rays be intersected by any plane the intersection must be a picture of the object, which if the object be taken away will still create its image in the eye. If this plane of the picture be at right angles to the cone, the section (the picture) will be a true picture of the object, that is, be similar to the image of the eye. In Fig. 97 a circle, A, is placed vertical and in front of the eye. In the drawing it is represented by line A. The cone formed by the rays of sight is represented by lines b-b, and a vertical plane cutting through the cone of rays by line P. If the student will take any cone and hold it horizontal, it will perfectly illustrate the figure, the base of the cone being the circle A, and the eye being at the apex. With the cone the student will at once see that a vertical plane between the eye and the base of the cone will intersect it in a circle, and this circle is the picture of the base, A.

If now the plane of the picture be inclined to the axis of the cone (Fig. 98), the intersection with the cone will still be a picture of the circle, but in shape it differs from that in Fig. 97, which is a circle. This oblique intersection is seen to be an ellipse, but it is important to notice that it does not appear so to the eye at the apex of the cone, but appears a circle exactly covering the base of the cone. It will be seen that it makes no difference how the plane of the picture, P, is placed, or what the proportions of the ellipse resulting. The ellipse always must appear to the eye a circle, in fact the circle of the base, A. But when the eye is removed from the apex of the cone the ellipse will appear an ellipse, and will not then be a picture of the circle. The circle of Fig. 97 and the ellipse of Fig. 98 are pictures of the circle A, and both create in the eye, when at the apex, a circular image of the circle, but the former only is similar to the object A.

In looking at pictures we naturally hold them in front of us, and at right angles to our line of vision, as in the position of the plane, P, of Fig. 97. If plane P, of Fig. 98, is thus held, the ellipse upon it will be seen as an ellipse, that is, will create an ellipse as image in the eye. This cannot create the idea of a circle. We see that the first picture is much preferable to the second, for it is a circle, and wherever the eye is placed will create a circle in the eye. (It is of course understood that it is always looked at perpendicularly.) The first picture we will distinguish from the second, and from all others which might be made, by calling it a true picture, meaning, that it is similar to the image created in the eye by the object. It is seen that there can be but one position of the plane which will give a true picture, and this must be at right angles to the direction in which the object is seen. The plane, of course, cannot be perpendicular to all the rays, and by this is meant the central ray. A true picture of any object may be obtained by drawing upon a sheet of glass with a brush and color, or a pencil of soap, or on a wire screen with chalk, the glass or screen being placed at right angles to a line from the centre of the object to the eye, and the eye and screen being fixed and lines drawn to cover all the edges which are seen. It is desired that every student make drawings in this way, a small pane of glass and a pencil of soap being the best materials. The drawings should be made with the glass at right angles to the rays, and also when held obliquely, so that the drawings may be compared, and the student realize that the glass must be perpendicular to the direction in which he looks, for the drawing to give the real appearance of the object.

It will appear that a drawing on any plane or surface can create the correct impression only when the eye is in the position which it had when the drawing was made. All drawings, then, are best seen from some one point or distance. This distance the trained eye will naturally select. However, as drawings and pictures will be viewed by untrained eyes, and as the proper point may not always be accessible, it is very important that all be avoided which will cause marked distortion when the picture is not seen from the proper point. If the picture is a true picture, the distortion produced when it is viewed from a longer or shorter distance than the proper one will appear not in the shape of its parts, but only in the relative sizes of the objects represented. Thus, the distortion of a true picture is always less than that of a drawing on a plane which is oblique to the rays, and so the true picture is by far the best drawing that can be made for general use.

REPRESENTATION.

A Paper comparing Perspective and Model Drawing, read at the Annual Meeting of the Industrial Art Teachers' Association, January 5, 1889.

REPRESENTATION.

This term inclndes all drawings, constructive and decorative works, being as fully representations as perspective views, the geometric views conveying ideas of facts and actual dimensions, the pictorial of facts and apparent dimensions. We will consider simply the representation of appearances, and our subject is really "Pictorial Drawing."

The aim of such drawing undoubtedly should be to awaken in the mind of the beholder the same impression as to form, size and position as the objects themselves would create when viewed from the artist's position. Drawings to be appreciated require certain education or qualities, but pictures and illustrative drawings are so numerous that this education is unconsciously acquired, and, by the average intellect, photographs and pictures are readily understood.

Photographs and drawings such as isometric are often very different from the image which would be produced upon the eye by the objects, and yet they are accepted without difficulty, the mind having a conception of the form and giving to the drawing the most reasonable interpretation; so that a quite conventional or incorrect drawing, so far as appearances are concerned, may be almost as readily read and accepted as one more nearly agreeing with the appearance. This does not affect our decision as to the aim of the artist; it does, however, assist him in his work, which otherwise would sometimes be nearly, if not quite, impossible.

A drawing which produces upon the eye the same image as the object mnst be one whose proportions agree with the appearance, the angles between the visual rays to the drawing being relatively the same as between the rays to the object. If the horizontal or vertical angles should be greater to the drawing than to the object, the drawing would be correspondingly too wide or too high. In the light of this statement let us consider a plane perspective drawing, a drawing upon a vertical plane in which the eye being fixed, each line of the drawing covers the edge of the object which it represents. Fig. 1 is a pers. drawing representing vertical and horizontal prisms. Fig. 2, which is a side elevation, shows that the visual rays to the vertical prism intersect the P. Pl. obliquely, and that the measure of the angle between them will be not in the P. Pl., but in the plane L M, perpendicular to the rays,* and thus the perspective drawing A is too high, the correct height being the distance 1–2 and the difference seen by comparing A with B. Suppose the perspective drawing A upon the vertical plane and the shorter B upon plane L M, the spectator's eye being fixed at S. P., both must appear alike, and convey the same impression as the object, but as ordinarily viewed from a point not S. P., the first must create a wrong impression of the proportions of the prism. In the same manner Fig. 3 proves that the perspective drawing D of the horizontal prism is too wide, E being the real appearance. From these drawings we see that a plane perspective drawing is as the object really appears only when the object is directly in front, the representation of objects in all other positions being distorted, vertically, when the object is above or below C. V., horizontally, when at the side, and obliquely, that is both ways, for all other positions. Of course when the eye is at S. P. the distortion is not noticed, but as this is rarely, perhaps never the case, it follows that a perspective drawing generally cannot give a correct impression of the sizes of the objects.

By Fig. 2 we find that a drawing of the prism to agree with the appearance must be made upon plane L M at right angles to the rays; this is a perspective drawing upon a plane oblique to the ground, and as parallel retreating lines appear to converge we find that the vertical edges of the prism which are oblique to the P. Pl. are represented by converging lines. Vertical lines must appear to vanish as any other retreating lines, but in order that these lines in the drawing may not seem to represent edges actually inclining, the eye, as it should be for

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* The central visual ray.

any perpective, must be at S. P.; from any other position the drawing will tend to give the impression of inclined lines in nature, which is as serious a matter as the distortion vertically of the perspective drawing upon the vertical plane, and the drawing is thus no better than the first. Our aim is to obtain a drawing which may be viewed naturally, whose proportions shall agree with the appearance and *which shall give a correct impression of the facts.* This we shall accomplish if we change the drawing B by substituting vertical for the inclined lines representing the vertical edges. Thus corrected we will call it a "model drawing," which term we use in the sense of the best drawing—the drawing which to the ordinary observer shall convey the same idea of form, size and position as the objects themselves, not necessarily a drawing of the geometric forms, but of any subject whatever. If we attempt to make such a drawing from an extended range of objects we shall find that the P. Pl., in order to be at right angles to the rays to all, will become the surface of a sphere; this is undevelopable and although a drawing might be made which would give the exact appearance of every object, it is evident that it could not give the relative positions, and would be no more a picture than a canvas covered at random with smaller sketches. It follows then, that a drawing which shall comprise a wide field of view and give the appearance and the relations of everything drawn is an impossibility.

What can be done to produce a drawing whose proportions shall agree with the appearance and which shall give correct information of the relations of objects within a reasonable limit? There is often less of height than of width to be represented, and the system known as curvilinear perspective results. In this the P. Pl. is vertical and cylindrical, S. P. being in the axis. This surface is developable, and a drawing upon it will have its horizontal distances correct, though the vertical must be distorted as in Fig. 1. Fig. 4 is a plan view showing S. P., the curved picture plane and three cubes. The P. Pl. being curved, the angles of the cubes with it increase with the distances, and in the drawing F their lines converge the quicker the further we get from the cube in front, and thus we find straight lines represented by curved.

This drawing will give the impression of curved lines in nature and is not a satisfactory solution of the problem, the perspective drawing G upon plane O P being much more acceptable in its representation of parallel straight lines by straight lines converging to one vanishing point. Now if we change the drawing with curved lines by substituting straight lines tending to one V. P., we shall have a drawing H whose horizontal distances are correct and which gives a true idea of the facts, and if as shown by Fig. 2 we make the correction for the heights, the drawing H will agree in proportion with the appearance and will convey correct information of the facts, and this "model drawing" answers the conditions. We see that it is neither a plane nor a cylindrical perspective, but a combination of the good qualities of each, further improved by having the vertical dimensions agree with the appearance. It may be considered a plane perspective whose widths and heights have been corrected to agree with appearances. This drawing comes very near to perfect agreement with appearances, the image created by it upon the eye being practically the same as that caused by Nature herself, and we must accept it as the best possible to obtain.

What is the practice of our illustrating artists? We find that they do not measure the lengths and angles of all lines, and constructing a diagram work out their drawings by perspective rule, but that they generally work almost entirely by appearances, and often refuse to admit that perspective can be of assistance to a person who can see and who wishes to record his feelings. As the artist endeavors to represent real appearances, the sketches illustrating perspective distortions must explain why his opinion is thus. Upon examination, the drawings from some of our best illustrators will be found to be so exact as regards relative proportion and direction of lines, that the curvature resulting from representing each part of a straight line as it appears, will be plainly seen, and the drawings thus are good examples of curvilinear perspective, except that they are as correct vertically as horizontally, and if straight lines should be substituted for the curved they would be exactly what we have decided to be the best representation of both the facts and the appearances.

What is the best training to enable one to draw freely and correctly? The artist will often say, "continued practice," and consider scientific study of little or no value. The teacher will say, "present the facts of form with the principles of perspective," and each will argue strongly that his method is the most satisfactory. We must judge by results, and if we find that the best drawings are made by the artists, then their opinions are entitled to consideration. It may be said that the artist understands how to draw and the teacher to instruct, and that we should not expect to compare the teacher's drawing with the artist's. Still until the teacher can present work equalling or excelling that of the artist and not the result of the artist's method of work, an impartial judge must decide that any criticisms of the artist have founda tion.

Representation is defined as the art of delineating objects as they appear to the eye. The eye sees all objects as surfaces, the mind can only infer that they have thickness, and thus to represent the appearance it is only necessary to determine the direction which the edges appear to have. For this the artist says, "practice," the teacher, "facts of form and perspective principles," both agree, then, that the eye unpractised and unassisted is not to be depended upon. Two elements, physical and intellectual enter into all drawing, the first, the exercise of the eye and hand, the second, the habit of observing with exactness and memorizing observations, so that the mind may compare and reason, the latter obviously of the greater importance: the child of six years who, seeing a drawing carried on, said, "that drawing was thinking and then drawing around the think," having most clearly defined the subject.

The work in our schools is based upon a study of the facts of form and of perspective principles. A knowledge of the facts is the first obtained by the student, who certainly has a very practical idea before a study of theory or of appearance may be made. There can be no question but that this knowledge is a hindrance when he attempts to represent the appearance; thus how many, if any, ever represent a foreshortened horizontal surface by too little, or even little enough of vertical distance; and who ever realized without a special effort that the long axis of the ellipse representing a vertical circle above or below the eye is not a vertical but an inclined line (see Fig. 5), and the tendency must always be that the image of the eye be overthrown by the conception of the mind. Does the study of perspective counteract the effect of this knowledge of the facts, and are its principles presented in a way to assist correctness of observation? We have seen that a perspective drawing gives the real appearance only when the object is directly in front; the illustrations have been in angular perspective, but the study is introduced by parallel perspective. Fig. 6, K is a parallel perspective drawing of a cube. In this the edges parallel to the P. Pl. are represented by horizontal lines, but the cube being at the left, three faces are visible, and it is evident that these lines can not appear horizontal; the real appearance is shown by P, and the distortion of the parallel perspective drawing is more serious than that of the angular perspective drawing.

Instrumental perspective introduced by numerous drawings in parallel perspective must create a wrong idea of the appearance of form. This is generally uncorrected by any statement of the instructor, and the *knowledge of perspective attained at the cost of an entire misconception of appearances can be of little value in free-hand drawing.* Instrumental perspective is the latter part of our public school course. Is the preceding work such that the student may acquire the power of careful observation which is not given by the study of the facts of form or of perspective? We find that as in perspective later, the first work is from objects in which but one set of horizontal lines vanish, the directions being to draw a horizontal line representing the level of the eye (the horizon), determine the proportions by pencil measurement, and see that the retreating edges meet at a point in the horizon. So many illustrations of this nature are to be found, that one wonders where the favored schools may be which have plinths, prisms, etc., for every student, for this is almost a necessity where neither end of the object is to be seen, and if not thus placed the drawings made must be copies of the illustrations and not from the object. Next comes the use of two vanishing points, as before the horizon is first to be drawn, and the retreating edges are to meet at points in this line, their angles being determined by strips of paper held, one horizontal and the other to cover the edges. It is easy for the student to follow these directions so that perspectively the drawing is correct; but is it easy to determine how far below the horizon the drawing shall be placed, or where between the vanishing points? Directions (measurements) may be given, but if so he is not making the drawing; and if he measures the angles of the retreating edges and continuing them to cut the horizon thus locates the points, how may he be sure of the angles? Certainly not by the use of the paper strips. This must be admitted by any candid observer who has seen students measuring proportions and angles with the pencil or paper held parallel to retreating edges, and in all positions except correctly at right angles to the line of sight. From the beginning of this free-hand work, perspective principles are explained and all the illustrations and explanations give the student the impression that the drawing is made upon a vertical plane, and this the student comes to think of as parallel to the wall of the room or to the edge of the table supporting the group; an inevitable conclusion by which the plane for almost all is from 20° to 45° away from the position which will give the correct appearance; and it seems that perspective is made an instrument whereby a certain number of drawings may be produced, which the students accept as the appearance of the objects from which they are supposed to be drawing, the teachers evidently thinking that so long as perspective principles are illustrated the discrepancy between the perspective drawings and the actual appearance is of no consequence. In the work from groups following there is a difference of opinion as to the steps. Some say draw the upper object first, others, the lower or principal one. This is an interesting question in view of the statement so strongly made by educators that a subject must be considered as a whole before its parts are taken up, and yet we are told that we must determine the width and length of each object before beginning to draw, and there is no certainty as to whether we shall draw first, the upper, lower, or principal object. If the statement that a subject must first be treated as a whole is true in one case, it must be for all, and especially for art, and without further dicussion the absurdity of these questions is made evident. But we will now follow a student in his study of the group of models illustrated by Fig. 7. Following the directions given, the student draws the vase first, determining its width and height and getting the outlines symmetrical about the vertical centre line; this done he takes the prism, then the cylinder and last the frame, treating each in the same manner as the vase. What is the result? — He completes his drawing before he can tell whether its entire width is correct for its height, and often without even considering the question, and working as he does, is led to think of the appearance of each object by itself, and not in its relation to the whole. The proportions of each object having been determined before drawing there is nothing to be done but to make the drawing to these measurements. He does not understand that measurements at best can only *assist* not *perform* the work of the eye, and that as he depends upon them they are more likely to give incorrect than correct results; but he makes the drawing, thinking that since each object is made of its determined proportions that when the last is complete, the group must be correct, and though perhaps a suspicion that it is not, flashes upon him as he surveys the finished drawing, he refuses upon reflection to entertain the idea, for has he not made sure of each object as he drew it, and the thought of erasing his finely finished lines convinces him that if his drawing does seem a little queer it is correct, and that he cannot see rightly. This drawing, a whole obtained by considering and adding to one another its various parts, entirely out of proportion, awkward and mechanical, is put away as a work of art, and we find that the free-hand work is free-hand perspective and not model drawing, that *the power of observation has not been trained or depended upon,* that perspective rules come first and cause a subordination of appearances to mechanical and uneducational means, and as a result the student even after graduating has no facility in drawing, and if put before a new subject is entirely at a loss as to how to proceed. Is it to be wondered at, if in continuing this work and being brought to practically consider these questions, and to discover that he has been working in ignorance he decides that perspective is a snare to be carefully avoided?

Having seen that perspective drawings are distortions and having followed the changes in the positions of the plane, and the corrections by which a model drawing is produced, is it possible to explain them to the student and to make model, instead of perspective drawings? I answer to the first part of this question, most decidedly no, but that this is not necessary or at first desirable, and that *it is possible to teach model drawing without this special theoretical consideration of the plane of the drawing or of perspective principles,* and that practically the differences resulting from a change in the position of the plane can be shown as follows: Give the student a frame covered with wire gauze, and have him mark upon it the appearance of the object, the frame being held vertical or in any position oblique to the visual rays, and then at right angles to the same. On comparing the drawings, the student will readily see that only the latter gives the real appearance, and as a result of this experiment will understand that the pencil, where measurements are taken, must be perpendicular to the direction in which he looks, and that when held horizontal in this position, it will be represented by a horizontal line, as will also any line of the object which it then appears to cover. Having realized this most important point, which the present teaching never does, our aim should be that the student acquire as quickly as possible the ability to see correctly, and not at first abstractions and theories, but facts of appearances. This power of correct observation must be the result of a continued perception, through his own efforts, of the imperfections of previous observations. It follows, then, that we must furnish practical means for correction and be sure that their proper use is understood. The pencil and a thread with weight attached are all that is required and may be used as follows, see Fig. 9. The outline of the appearance should first be sketched by eye, and then tested by the pencil, its entire height with the width, then all visible lines lightly sketched and the test made by holding the pencil or thread horizontal, and thus taking horizontal lines through the angles of the object and noting where these lines cut the front and opposite side, and comparing with the drawing. It is almost impossible for many students to hold the pencil correctly at right angles to their line of sight, but this difficulty may be avoided by driving a large needle exactly at right angles into the centre of the pencil; when only its end is seen the pencil is in the proper position. By the plumb-line vertical lines may be taken through the angles of the objects, and the points where they cut the opposite side noted as of the horizontal lines. These tests are simple and will discover all mistakes, but to insure correctness the thread may be held to cover and continue all edges of the object so that their intersections with the opposite side may be noted, the direction of diagonals and of any lines whatever connecting points on opposite sides be determined, and their intersections with intermediate lines, and last two straight edges held to cover any two parallel lines will show the apparent angles between them. These tests will surely point out any differences between the drawing and the appearance and are all that should be employed until, the student having acquired control of the means and being able to make fairly good drawings, occasion may be taken, as the nature of the drawing presents, to call attention to perspective principles which are illustrated in the finished sketches, but it will be better to delay such explanation than to incur the risk that the students may utilize the principles to avoid the careful observation necessary to give correct judgment and freedom in drawings. Drawings made in this way may not at first be as successful perspectively as if drawn by rule and the vanishing points, but they will be much more educational and will enable the student to see correctly, that is to accept the image of his eye as the real appearance. It will be seen that the use of the thread in this way lays especial importance upon the actual construction (the facts), as an aid to its representation (thus continuing all edges and diagonals and noting intersections, is simply making use of the actual construction to test its representation), but in all cases the drawing should be made by the eye before any tests are applied. The eye should be depended upon and thus trained to correct observation before abstract principles are presented, I should rather say let the principles present themselves, or be deduced from the drawings, as may easily be done, for instance — when a drawing representing several parallel horizontal lines whose V. P. comes on the paper has been completed, the student may be shown that these lines continued intersect, and that the point is on a level with his eye. In this way by practically discovering perspective truths they will be understood in such a way as to be of value.

Fig. 9 shows this method applied to the group before considered. The proportions of the whole group being first sketched by light lines joining the principal points, the entire width and height then determined as carefully as possible, and the objects then drawn all at once, by seizing the important lines of each and considering them with reference to the group as a whole, the cord being frequently used as explained to determine the correctness of recorded observations. The pencil, which must be long, being held freely and the lines drawn with a quick movement, and when found to be incorrect others drawn beside them, until, the proper position having been verified by careful use of the thread, all other lines are erased at one time. Working in this way the student not having the false idea that it is possible to determine exact proportions and slight differences before drawing, will depend more upon sight, will expect to change his first lines, and will do so as each test indicates. He will soon find that each line tests many others, that he can see more readily than measure the fine effects necessary to exactness, and that a group is not more difficult than a single object. It will not be necessary for the vanishing points to come on the paper that he may be sure of his drawing, or that he crawl over a floor twenty feet square used as a drawing board to test a half imperial paper. In this connection I wish to suggest that if instead of lining in with lines of one strength, or conventionally, the nearer edges being represented by the stronger lines, the students are made to study, and represent the edges as they appear, some brought out by shade or shadow strongly, others in the light or shade, and perhaps barely visible, lightly, they will be started in the direction in which only they can advance and make artistic sketches from nature, and the observation involved will be of the greatest value when light and shade is taken up. This dependence upon sight trained by these tests is the only way to prepare for practical work from nature, and the student, whatever his training, who acquires facility, must come to depend upon it largely, and any one who attempts to formulate rules to govern the production of art works will soon find his task beyond him.

It may be said that this dependence upon individual observation is not possible for public school work as each student would require attention which it would be impossible for him to receive. Although this objection has force, still there is no doubt that the proper use of the thread and pencil could be insisted upon by the teachers and secured; this attained, the efforts of the students would be in the right direction, and if not perfect, would be more valuable than any attempt to work by rules which in most cases can be simply memorized, not understood.

Having seen that the study of the facts of form and perspective causes a neglect of appearances, and the working in an impractical way, shall we decide that perspective and science are useless? Because perspective drawings to give the correct impression require to be seen from S. P., and because perspective principles have been misused, are not sufficient reasons for not teaching the subject. As shown in the first illustrations, drawings must conform to perspective principles to be acceptable and some drawings must be parallel perspective.* A knowl-

*See Fig. 10 which represents the two nearer cubes shown in Fig. 4, and a third cube at the right of the spectator and in line with the others. We have seen that representing straight lines as they appear (curved) is not acceptable and we must determine the direction of a straight line which shall represent the horizontal edges nearest parallel to the spectator. It is evident that a horizontal line will equalize the distortion and give the most satisfactory result, and whenever objects are in line with one another and on each side of the spectator this drawing must generally be made. I say *generally* because the judgment and good sense of the artist should be depended upon and in drawings from large subjects out of doors where the lines are broken the curvature of the lines may not be noticed and may sometimes give the best result, as much in Fig. 10 as in Fig. 4. In Fig.

edge of perspective must then assist the draughtsman, and as a study to be taken up after the students have acquired ability to represent appearances fairly well, and with the distinct understanding that perspective drawings do not do this, I think that perspective should be taught, just when, depending upon circumstances, although it seems that in all but the higher grades the time might be given with better advantage to model drawing.

We have stated that many illustrations are so correct in representing the exact appearance of nature that the apparent curvature of straight lines may be seen. On the contrary many more drawings, while in the main correct as to proportions, are so full of discrepancies that hardly three of a system of parallel lines can be found to intersect at the same point, and often these points for horizontal lines will be above or below the horizon, and geometric forms are distorted. Errors such as these, of greater or less importance, are to be found in the work of even the best illustrators and noted artists, the most perfect eye with the longest training not being surety against carelessness or the influence

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10 the question will arise shall we make a perspective drawing throughout or shall the foreshortening of horizontal distance at the right and left, and of vertical distance above and below the centre be given. This again is a question which the artist must decide as each case arises. But for the work in the public schools it is not necessary that the question be considered — let straight lines be represented by straight lines, straight lines extending on each side by horizontal lines and insist upon the pencil being always at right angles to the visual rays when measurements are taken, and unless an unusually bright student draws from a cube directly in front so that he sees only the top and front faces, the question will never occur as the foreshortening of the vertical face is so little ordinarily that in any figure except the square it will be hardly noticed.

It will be seen that parallel perspective introduces many more puzzling questions than angular, and if objects are to be drawn with only two faces visible it would be well not to take the cube, as the student should, from the first and all the time, be made to determine the angular dimensions of the appearance of objects, which can only be done with the pencil held at right angles to the rays to the parts as they are drawn, and when he completes his course he should be able to harmonize these dimensions with perspective appearances which are necessary to most drawings.

which one line has to change the apparent direction of another. We remember the criticism of a picture which showed the full moon and setting sun in one sky. This is no more serious a contradiction than many which are apparently unnoticed, such as shadows or sunlight in the shade, and the shadows in part of a picture advancing, indicating the sun in front of the spectator, while in another part they retreat and show the sun behind. These mistakes may pass unnoticed because of an uneducated or lenient public, still there can be no question but that the drawings would be better true. Perspective is the remedy for such mistakes, and an extensive scientific knowledge is not required ; no more is really necessary than an observance of the principles as they are illustrated in the simplest sketches which may be made from nature, though there can be no question but that the broader the knowledge the better, and that a course in plane and solid geometry, especially intersections, perspective, shadows, reflections, etc., will benefit any draughtsman. He may not apply or make use instrumentally of his knowledge, but unconsciously as he works its influence, will produce drawings, which, while giving the proportion and the feeling will not transgress laws of nature or of perspective, but in designing it will have its greatest value, since when nature cannot be studied knowledge must be depended upon.

We must conclude then, that the best method of instruction is that which adds to a practical way of working from the object, a knowledge of the facts of form and of perspective principles, which may supplement the power of sight to produce correct drawings.

In closing I quote a sentence from a work of the 18th century by Gerard DeLairesse : "I conclude then, that pictures exhibiting nature contrary to what she ought to be are liable to censure, and that we ought to seek the truth by reasoning, and then waiving old customs and prejudice to believe our own eyes."

ANSON K. CROSS.

BOSTON, December, 1888.

NOTE.

The illustrations, which have been reduced from the hasty sketches prepared for blackboard use, are from the notes for the perspective lectures which have been given the last four years in class B of the Massachusetts Normal Art School.

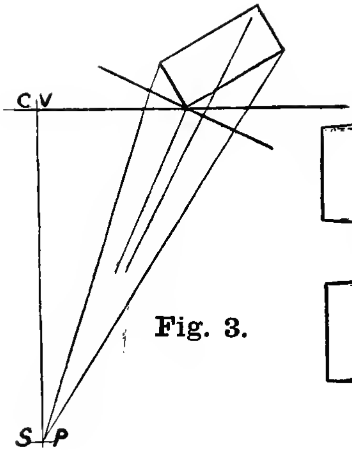
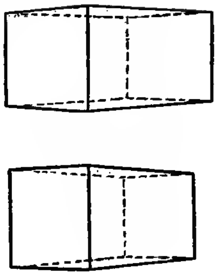


Fig. 3.



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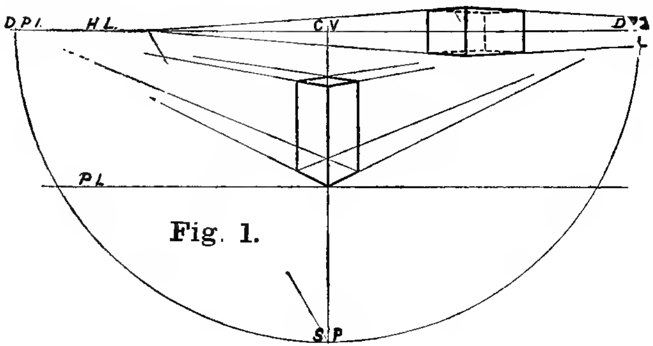
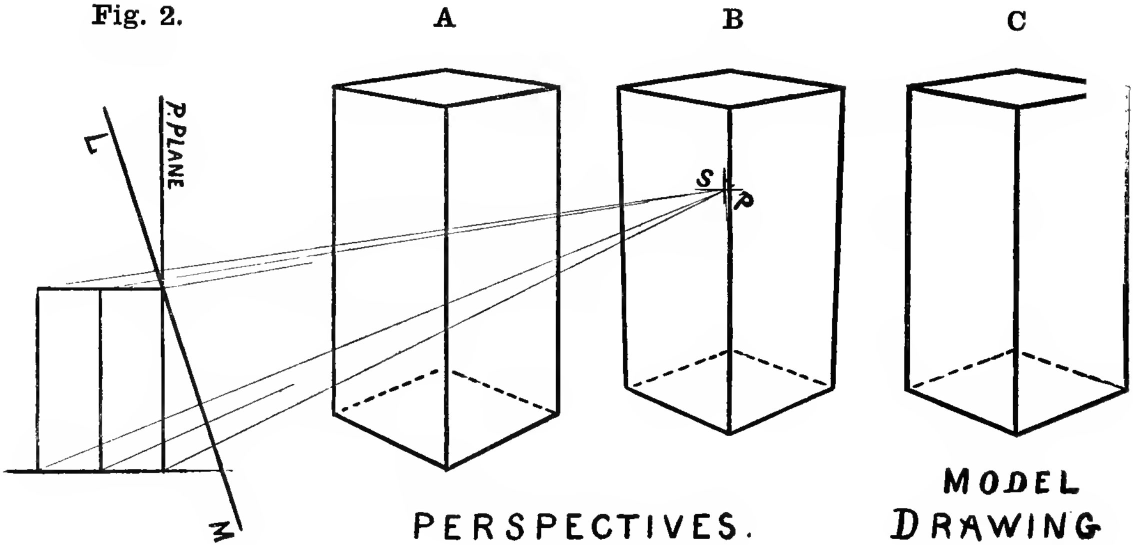


Fig. 1.

Fig. 2.



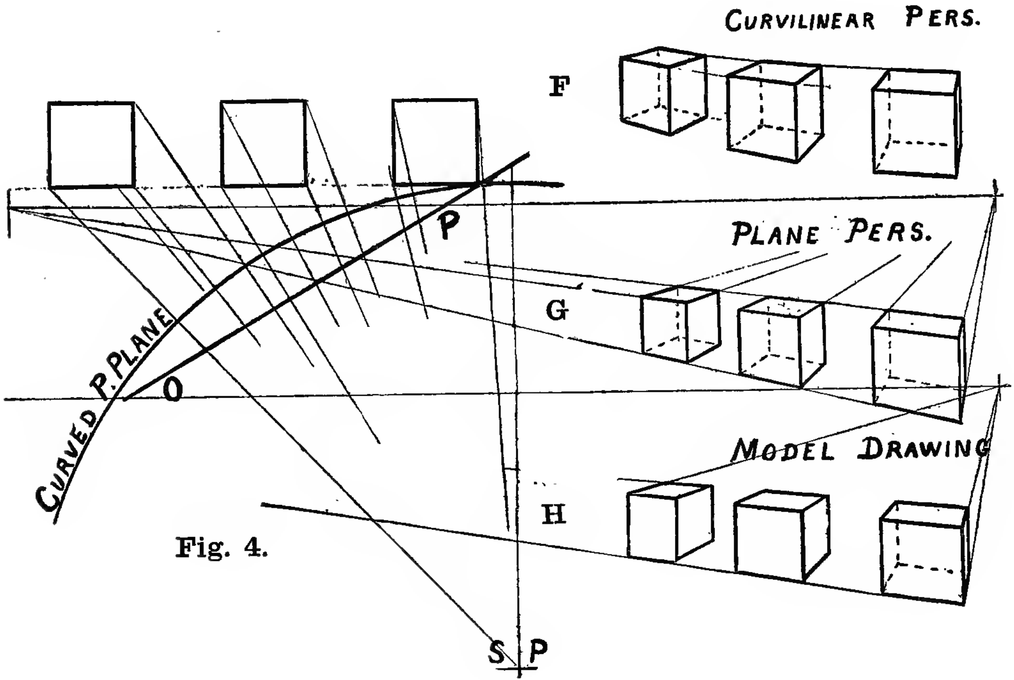

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Fig. 4.

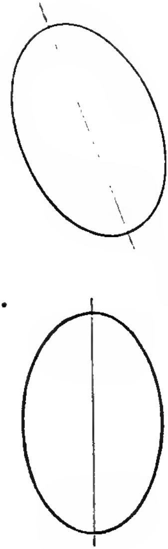

Fig. 5.

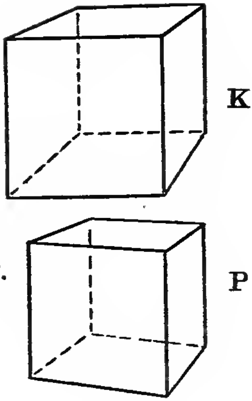

Fig. 6

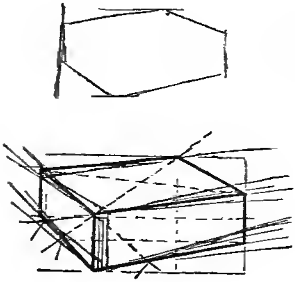

Fig. 8.

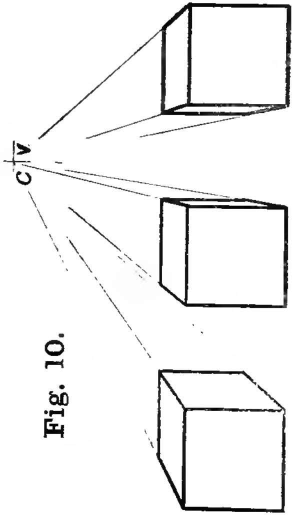

Fig. 10.

Fig. 7.

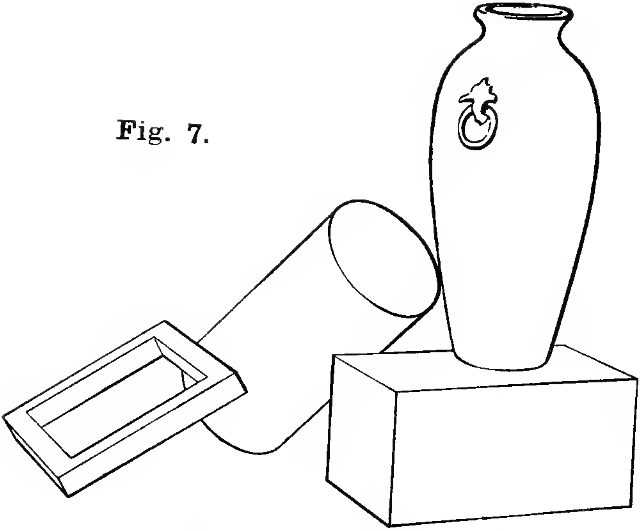

Fig. 9.