ART EDUCATION FOR HIGH SCHOOLS

A COMPREHENSIVE TEXT BOOK ON ART EDUCATION FOR HIGH SCHOOLS TREATING PICTORIAL, DECORATIVE AND CONSTRUCTIVE ART, HISTORIC ORNAMENT AND ART HISTORY.

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Preface

"ART EDUCATION FOR HIGH SCHOOLS" is planned upon the basic idea that the teaching of art is vastly more important than the teaching of drawing. It is believed that the study of art can be presented in the light of certain governing principles, which can be developed in such a way as to equip the high school student at the end of his four years' course not only with a knowledge of material things in the world about him, seen under various aspects and in various relationships, but with such a knowledge of art principles as will give him a better appreciation of the good work of all ages and a fuller understanding of art in its relation to his own life.

This book is not a course of study, but its scope is so broad and so comprehensive that many courses of study may be based upon it. The aim has been to provide in the several chapters a clear and definite presentation of each important division of the subject, and to suggest exercises which, if worked out, will assist the student in his understanding of the topic treated. These problems in themselves form an outline of work that might be taken as a course of study. The exercises given in Chapter VI stand as an illustration of this feature of the book.

The marvellous development of art education in public schools that has taken place in the last quarter of a century has manifested itself more particularly in the elementary grades. As a result of this interest there is no lack of literature on this phase of the subject. There are now available various published systems of art education for elementary schools, with text-books, drawing-books and a large amount of material constituting a full equipment for work. But when we look for similar aids to the further development of this work in high schools, academies and colleges, we find almost nothing of an organized nature. The teacher of art in a secondary school must plan his own course from a confused mass of material found in various places, and must transmit as much as he can of necessary information to the individuals or classes under his instruction.

To furnish the same kind of help to high school students and teachers as is now available to the pupils and teachers in elementary schools the present volume has been prepared. That it may fulfil in some measure this purpose, and that it may be of substantial aid in establishing art education as an indispensable factor in the higher education of the American people, is the earnest wish of those who have directed the preparation of this work.

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CHAPTER I

PICTORIAL REPRESENTATION

A Brief Course in the Fundamentals of the Subject

Modes of Expression. In pictorial representation there are three distinct forms or modes of expression. We can represent objects in color masses, in neutral values of light and dark, or in outline. Of these three modes, perhaps the most important is the problem of representation by means of light and dark masses. As this involves a knowledge of color masses, the student will soon find that outlines or contours can be satisfactorily drawn only when the masses themselves are understood.

Impressions Formed by Shapes and Values of Masses. Our

Fig. 1

FIG. 2

first impression of a tree, a person, a landscape, a house, an animal, or of any object is of a mass of color, seen either alone or in relation to other masses of lighter or darker color. We recognize objects by the shapes of their masses more readily than by their color or their details. An ink silhouette of the form of a tree brings to our mind the image of the tree just as directly as does a picture in color. By the characteristic masses of an oak, a maple or an elm, we are able to recognize the particular kind of tree that we see. We do not recognize the tree at a distance by its color, or by the shape of its leaves. A person approaching in the twilight is readily recognized, not only as a person, but as old or young, as a laborer or a professional man, or as possessing certain other qualities, even when no details whatever are seen (Fig. 1). Our impression is based upon the characteristic forms of the color masses, or values, and by values is meant the degree of light and dark that a color expresses. Pictures of twilight or moonlight owe their effect of restfulness and repose to the elimination of detail and to an emphasis of mass which permits the eye to rest undisturbed upon large essentials. This is illustrated in Fig. 2. Minor details, it is true, enable us to verify a first impression, as in the case of the tree, but they are subordinate to those things from which we obtain our first or general impression.

Study of Masses. The study of pictorial representation, then, should begin with a consideration of the characteristics of objects as expressed by their principal masses, — the size, shape, and values of these masses. Such consideration may be followed by a study of conditions that may further affect the appearance of these masses, such as sunlight and shadow, texture,

FIG. 8

FIG. 4

perspective, or the effect of distance and atmospheric conditions upon the local color of objects.

Pictorial Quality. Pictorial quality depends mainly upon the shape, arrangement and values of the masses of color within a given space; for example, opposing light and dark values contribute to pictorial effect, as in the placing of dark trees against a light sky, a dark figure against a light background, or a light figure against a dark background. We soon find that we cannot disassociate an object from its surroundings. The environment, the background, or the masses against which objects are seen are as much to be considered in picture-making as the shapes of the principal masses themselves, and although they occupy a subordinate place, they are important elements, and must be duly related to the whole. For example, Fig. 3 shows a pencil sketch of a tree, rendered in values of gray, but the effect obtained depends very largely on the contrast made by these values with the light paper. If this same drawing were made upon dark paper we can see that its beauty would have been lost. If we arrange any dark object against a light background and closely observe its appearance we shall see, essentially, a spot of dark color which we might recognize as the object simply by the shape of the mass. The object in Fig. 4 is easily represented by a simple pencil drawing of its dark mass with no consideration of background other than that afforded by the light paper. If, however, the object we select has also a mass of light, we must then arrange a sufficiently dark surface against which the light mass may be opposed. Fig. 5 shows a simple object drawn

FIG. 5

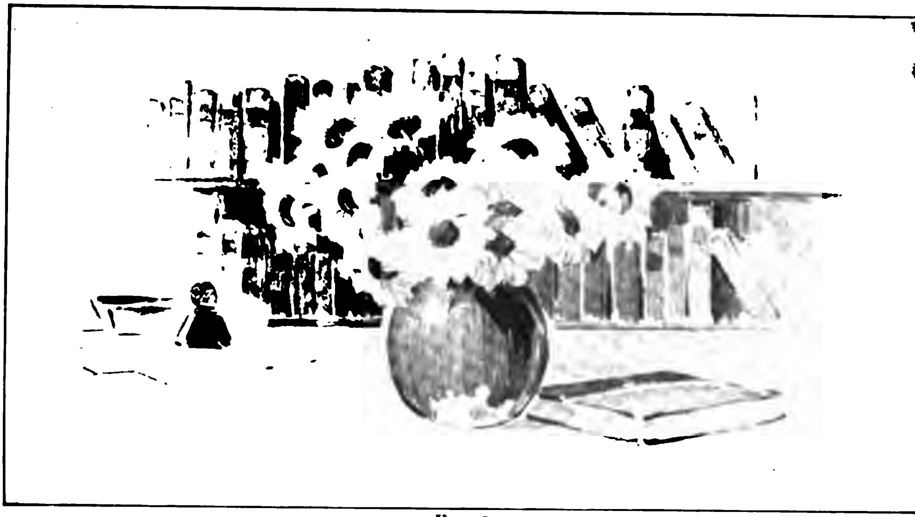


FIG. 6

FIG. 7

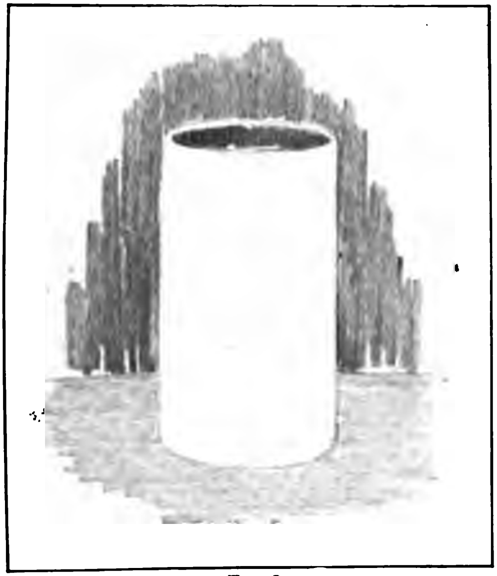


Fig. 8

against a background chosen to provide contrast for each of the two values found in the object itself.

Comparative Values. Let it be understood, then, that representation is a matter of comparative values, and that the surroundings of an object are important in the consideration of pictorial effect. It does not follow, however, that we must give the surroundings of an object equal importance with the object we have chosen for the main interest. Suppose, for example, that we are to draw from still-life, or from the human figure, or from some selected portion of the landscape, and that we do not wish the surrounding objects to appear prominent, or to appear at all; we must then reduce these surrounding objects to simple tones of color of the value necessary to bring out the quality, form and character of the object we have selected for our picture. This point is illustrated in Figs. 6 and 7. In our sketch of the vase of flowers we do not wish to show the books, which may be on the same table. We simply leave them out, substituting for them the tone or values we desire as a background for our study.

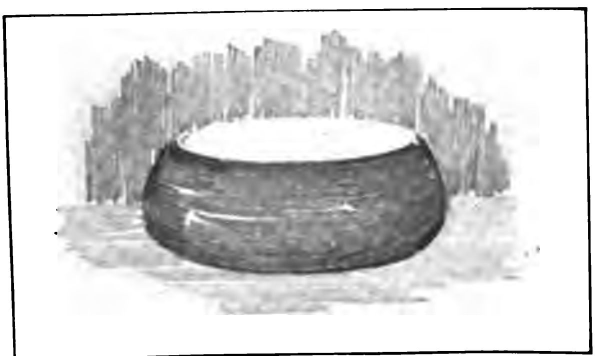


Fig. 9

Exercises. Many exercises in illustration of this process of elimination

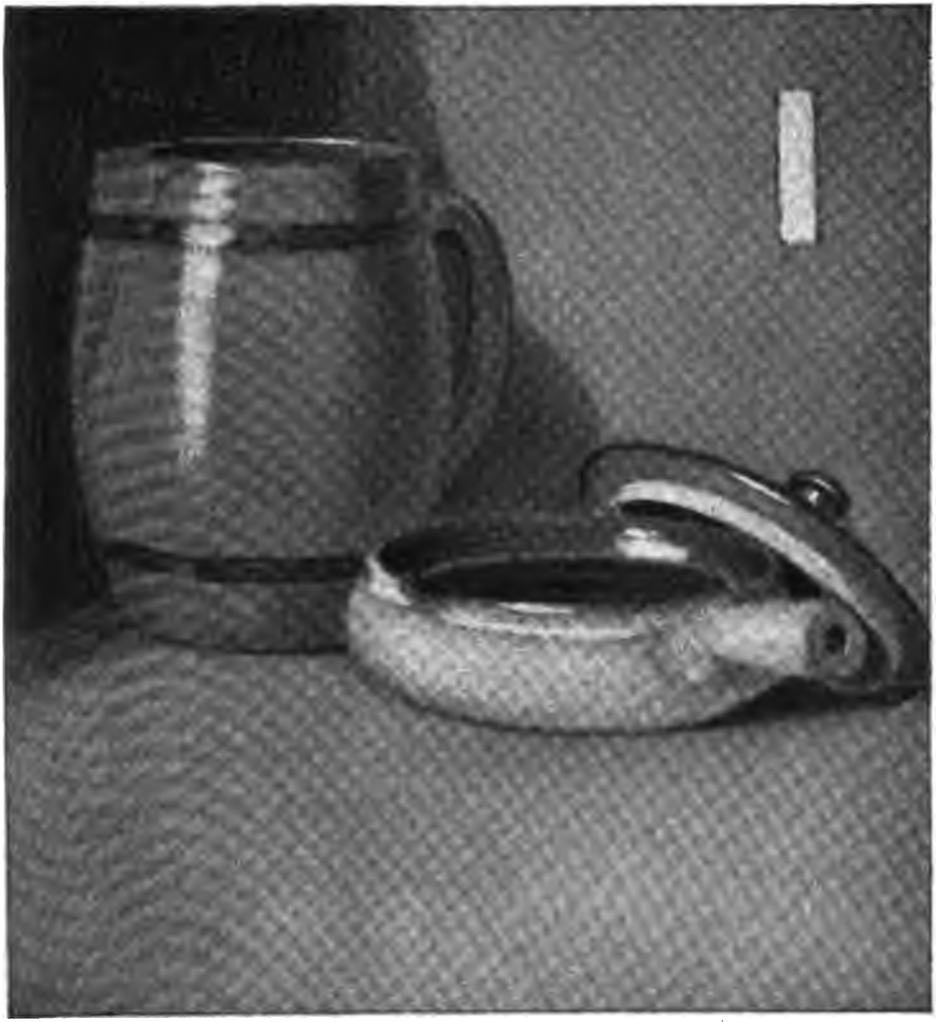


FIG. 10

should be drawn by the student, and for such exercises arrangements of still-life will be found convenient, since we can adjust backgrounds or other surroundings as we may desire. For first exercises, select, arrange and draw objects of one color, then try those having more than one color mass,

FIG. 11

selecting backgrounds whose values will best bring out the quality and character of the objects chosen, as illustrated in Figs. 4, 5, 8 and 9.

Contrasting Forms, Sizes and Color Values. When a reasonable degree of facility in rendering is acquired the student will be ready to undertake the drawing of groups composed of objects having contrasting forms, sizes and color values. This involves a more difficult problem, since, instead of the simple elements supplied by one object, the background and the surface upon which the object rests, we now have several masses of different shapes, sizes and colors, which must be considered first with relation to one another, and finally with relation to the background, or surrounding masses. Fig. 10 shows how one problem of this kind has been worked out.

Principal Masses and Masses of Lesser Interest. In drawing from the landscape we should select and draw carefully the elements upon which the interest centers, merely suggesting the elements of less importance, or substituting color values for them. Fig. 11 shows a photograph of a group of trees, in which there are many other things that do not improve the pictorial effect, but divert the interest, and thus detract from the effect of the trees of which a picture is desired. Fig. 12 shows a pictorial rendering of the same scene.

FIG. 12

Color Values. In the study of pictorial representation the question of color values becomes of immediate interest. If we observe the landscape in early autumn for instance, we may see a blue sky with light clouds, a hazy blue or purple color in the distance, and in the foreground, greens, reds, yellows and browns,— some bright in color and some grayed. If we photograph this landscape we reduce everything to values which are all gray or all brown, according to the color of the photographic paper. The only difference we can then see in the color of the trees, grass, sky and distant hills is in their light and dark qualities. We know that some colors photograph lighter than others, but we know also that an ordinary camera will not give us a translation of the true color values of all colors, for those hues which contain reds or yellows will photograph darker than their true values, and those dominated by blue will photograph lighter than their true values. By means of an isochromatic plate, however, this

FIG. 13

photographic defect is overcome, and it is possible to obtain true color values, as shown in Fig. 13. It is by this process that all paintings are photographed. In representing the landscape with charcoal or pencil we try to do what the isochromatic plate does in photography,—to reduce all colors to their true light and dark qualities, without regard to what is generally meant by color or hue.

Color Quality. In painting from the landscape or from other subjects, we must determine not only the value of a color, but we must know that the local or individual color of an object is affected by distance and by conditions of the atmosphere, or by both. We know that objects are affected by perspective,—that distant objects appear much smaller in proportion than those near by,—but we do not always appreciate that they are also changed in color. Between us and the distant hills, for example, is interposed a body of air that acts like a veil, and, as we look through it, distant local colors are rendered dimmer and grayer. Again, if on a clear day we look into the cloudless sky, we see that the color effect of the air is blue, but under different conditions this body of air may take on different colors, such as a tender violet, a faint yellow-green, a delicate rose-color or a subtle gray. Between the observer and a distant object is always interposed this body of colored air, which, as we look through it, affects the local color of all objects in greater or less degree, according to their distances. As distance increases, forms seem to grow smaller, and the shape and local color less distinct. As distance decreases, forms appear larger and more distinct, and the local color grows stronger and less gray, until, when the object is near the eye, its real local color may be determined.

In a fertile, cultivated country, where a moist atmosphere prevails, the color of objects at a distance is more affected than in a dry, desert country, where there is little or no moisture in the air. The dryer the atmosphere, the thinner the interposing veil, and the more distinct and local in their coloring are distant objects. For this reason, distances in a very dry climate are deceptive to one who is accustomed to the moist atmosphere of a fertile country. But in any country atmospheric conditions vary. On a bright day we see objects more nearly in their local color than we do on a gray day. Under ordinary conditions we can see, when we are close to a tree, that its mass of foliage is green, the local color. As we go from the tree we see the green through the atmospheric veil, and it is gradually grayed. At a great distance the line of houses, trees and hills is all merged into one mass of gray, and this gray may take on different hues, according to different conditions of the atmosphere. Observe the same view or landscape on successive days to see if the effect of the atmospheric conditions is not noticeable. In the study of objects that are close to us the atmospheric effect is not so pronounced, yet it is a matter of sufficient importance to warrant our consideration.

Light and Shade. Another modification of the appearance of an object is the effect of sunlight and shadow, or, as it is termed, of light and shade. An object when exposed to a bright light presents a light surface on the side near the light, and a darker surface on the side away from the

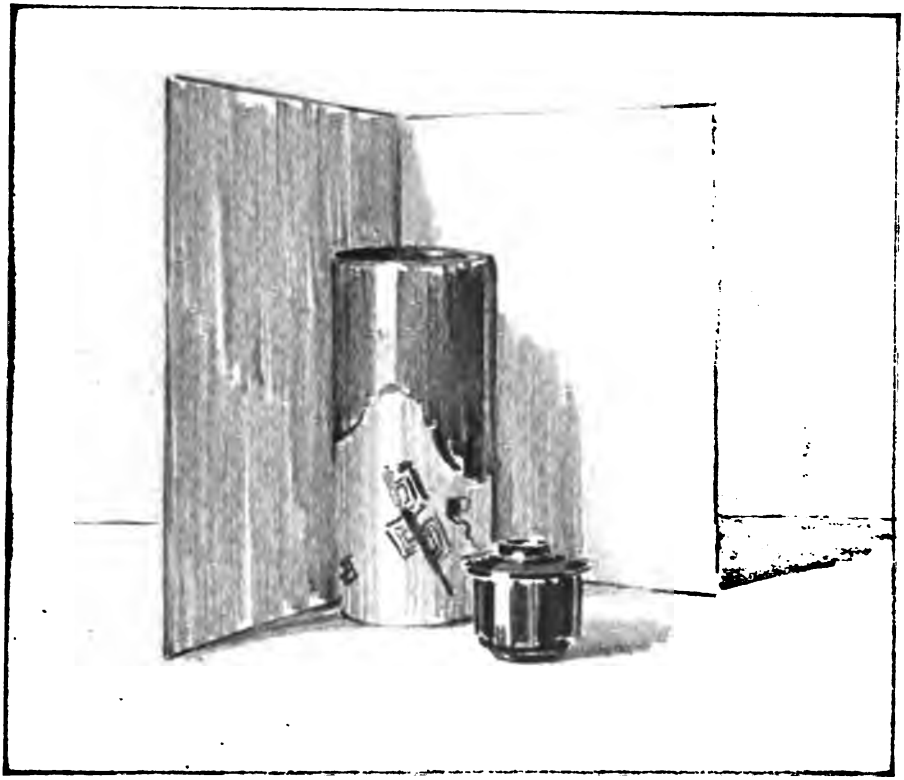


FIG. 14

light. Whatever the local color of an object may be, it is always influenced by this effect of light. Any object seen indoors, or where there is comparatively little light, appears much darker than it does when seen under direct sunlight. The real local color of an object is determined when it is seen under diffused light,— that is, under light that does not strike the object from some direct center, like a lamp or candle, or in the form of direct sunshine.

In arranging still-life objects or groups for the study of light and shade, we should avoid the extremes of too much or too little light. The diffused light of a room is best for the drawing of still-life, and by means of a shadow-box we can control the light effects upon a group. By fastening together two pieces of board (Fig. 14) and placing them in such a way as to exclude the light from all or a part of our group we can soften the effect of the bright light from the windows. The shadow-box, too, helps us to overcome the intermingled lights and shadows, or cross-lights, that proceed from several windows, or from several sources of light in a room. In elementary exercises it is best for us to work from light effects that show one light side, one dark side and one shadow only.

In a bright light, the contrast between the light side and the shaded side of the object will be strong, — we know that the bright light of noon-day, for instance, casts the darkest shadows. The dimmer the light, as at evening, the less contrast there is between the light and shaded sides of any object — the less distinct is the difference between the shaded side and the shadow. We can easily demonstrate this if we observe objects in a room that is lighted by gas. If the gaslight is gradually turned off, we can see that the shadows become less strong as the light grows dimmer. The length of shadows is determined by the position of the light, — the higher the light, the shorter the shadow. This, again, is illustrated in the comparison of shadows seen at midday with those seen in the late afternoon. Shadows also soften and become less clearly defined as they recede from the object that casts them, and in the same proportion that dark masses grow lighter, so light masses grow darker as they recede, or as distance affects them.

Reflections. Polished surfaces reflect, more or less perfectly, the images of objects placed upon them. A quiet pool of water, for example, will reflect the trees upon its banks with the fidelity of a mirror, but the slightest movement of the surface of the water will produce lines in the reflection which add to its artistic quality, even though they distort the perfect image. Colors, also, are influenced in reflections by the quality of the light overhead, and by the color of the water in the pool or stream, which varies from time to time, according to prevailing conditions.

In arranging still-life studies, objects made of glass or of polished metal, such as brass or copper, are often used in order to gain, through reflections, added variety and interest in foregrounds. Landscape painting, also, offers opportunity for the use of reflections, as the paintings of Corot, Inness, Turner, and of many other artists so well illustrate.

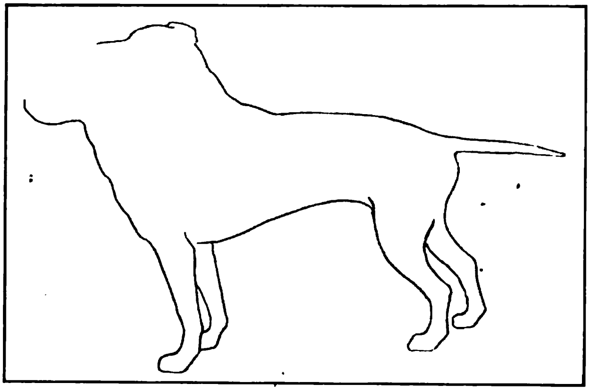


FIG. 15

FIG. 16

Outline Drawing. Although it is true that we see objects in color masses, and that we are able to distinguish one object from another by means of the size, shape and character of the various color masses presented, we know that representation is not confined to mass drawing or painting. Objects may be represented by outline drawing also, and although this method is more or less abstract, it is possible to express in outline all the characteristics of an object except its color. Textures, even, of various kinds, such as the hard surface of stone or of pottery, the woody quality of a tree-trunk or twig, the delicate petal of a flower, or the fur or hair of some animal, may all be expressed by means of outline drawing. To be able to so qualify a line as to make it express these characteristics requires skill and experience, and a knowledge of the characteristics of the mass which such an outline limits or bounds. We could not, for example, draw a map in outline unless we had a knowledge of the size, shape and topography of the area of country which the map was intended to represent. Sometimes, it is true, outline drawings are purely symbolic, as in the drawings of little children or of savage tribes, but in all technical and artistic work, outline drawing aims to express every quality of an object except its color.

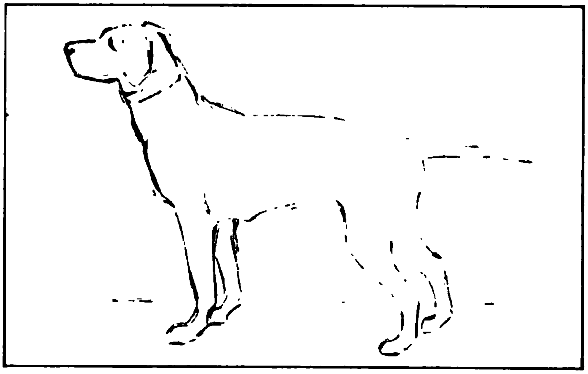


FIG. 17

Blocking in. In outline drawing, and sometimes in mass drawing as well, we often "block in" or sketch with light lines the general proportion and shape of objects. This enables us to make several estimates before placing the final line, and in this way we avoid the errors that result from the attempt to complete one part of the drawing before another part is studied or begun. If a drawing is faulty in its proportions, or in the relative positions of its various parts, no amount of careful finishing can correct the mistake. It is therefore best to sketch very simply, or block in, lines that will indicate the size, shape and position of parts, before spending any effort on technique of line, or upon the careful drawing of any one part.

Fig. 15 shows a drawing which might easily result if we should begin our study of a dog, for example, by drawing the nose first, and continue to the line of the head, back, etc. Our attention would probably be fixed on the line, rather than upon the general proportion, and the result would be a distortion. Fig. 16 shows a better way of beginning all studies of this nature. Fig. 17 shows the vigorous lines that are put in, with the lighter, block lines used as a guide.

When a careful drawing of an object is to be made in charcoal the form should be suggested by loose, light lines, drawn with a sharpened stick of hard charcoal. Hold the charcoal loosely, and "feel" for the form in a series of light lines, correcting, changing and redrawing without erasing until the right line is obtained. If erasures are made the tendency will be to repeat the error in a new line, but if all tentative or trial lines are kept, the error will be seen, and that error, at least, will not be repeated. In the finished drawing, all lines may be erased except those expressing the correct drawing of the form under consideration. Fig. 18 shows an outline

FIG. 18

drawing of a group studied in this way, before the trial lines are erased. Fig. 19 shows a similar group with the trial lines erased.

Composition. In every picture there should be a spot or center of particular interest, — a place where the eye pauses or rests. This center may be simply a combination of colors, or it may consist of some object, as a tree, a house, or the face in a portrait. If we wish to paint a picture of a tree we should first consider the placing of the sketch upon our canvas. There would be, also, various masses or shapes against which the tree would be seen, such as the mass of the sky, the mass of the distance, the mass of a hillside, or a barn, or of other trees, and the mass of the foreground. The right selection of all these shapes, the adjustment of their sizes, positions, proportions and color values is what is meant by composition. This adjustment can be determined only by much practice and experience, combined with a knowledge of the principles of design.

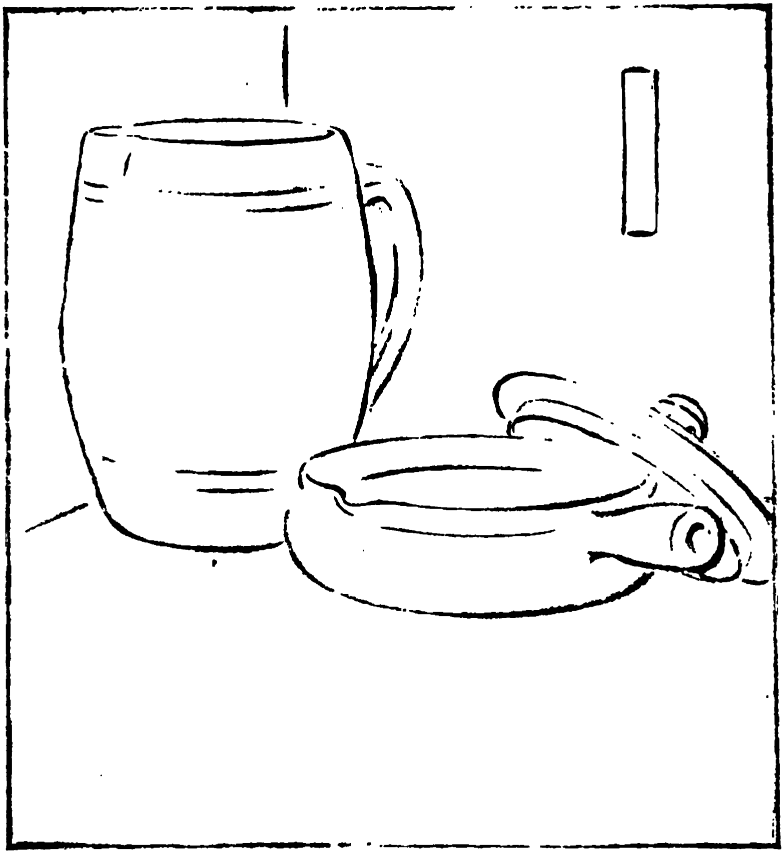


FIG. 19

A finder (Fig. 20) is a device that enables us to exercise our judgment in selecting a composition. If we look through the opening, changing its size and shape as we move the finder about, a variety of arrangements can be seen, and we can select and control the shapes which make up our picture. Sometimes the elements we wish to use will look better in a horizontal enclosure, as, for instance, in painting a broad expanse of the sea; and sometimes a vertical enclosure seems best, as when a ship with a mast or when tall trees or buildings are the important elements. The comparison

FIG. 20

FIG. 21

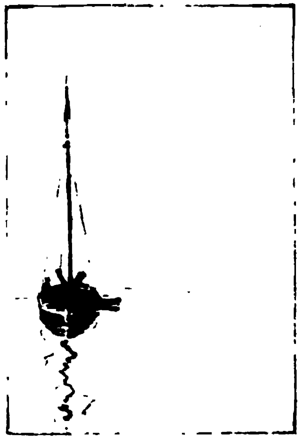


FIG. 22

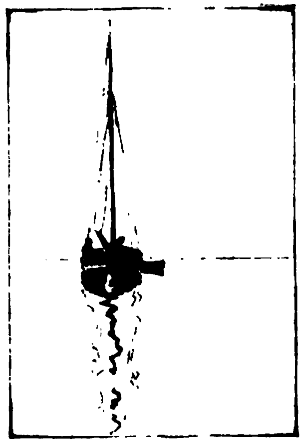


FIG. 23

of these effects and the effort to select the best of several arrangements develop artistic taste and judgment.

Exercises with the Finder. To test the efficacy of the finder as an aid to good composition, select some object around which you wish the interest of a sketch to center. Adjust the opening until you have obtained a good relationship of all shapes enclosed, considering not only the shapes in the object itself, but also the shapes made by the background, foreground and by all other elements included. The center of interest should not occupy the exact center of the composition, as such a position is apt to divide the background spaces evenly, and our picture would lack what is known as variety; the arrangement would be monotonous, as Fig. 21 illustrates. It is safe to avoid any arrangement that divides the background into equal right and left spaces, or into equal upper and lower spaces. Neither should the center of interest be placed too far at one side, as in Fig. 22. Interest, variety and balance are all secured by the arrangement shown in Fig. 23.

A little practice will enable the student to select with the finder good arrangements from the landscape. In still-life composition, also, may be found very interesting arrangements of shapes, of light and dark effects and of color. In arranging groups of objects we must remember that

FIG. 24

FIG. 25

FIG. 26

FIG. 27

interest depends largely upon variety in the objects chosen, in their relative positions, and in the unity or completeness of the group as a whole. After the objects are selected and placed, the group should be studied through a finder for the purpose of determining definitely the size of the background spaces, and of reviewing critically the whole arrangement before beginning to draw. The finder helps us to shut out surrounding and conflicting elements, and centers our attention and judgment upon the shapes seen through the opening. Its use in selecting and studying compositions is similar to the use made of a finder by the photographer, who studies the picture seen upon his ground glass, or finder, before his negative is exposed.

The student should practise making several arrangements of the same group, studying the different effects through the finder and trying to decide as to the best composition. Practise, also, from groups of different objects, changing the members of a group or rearranging them until good compositions are obtained. Such exercises will probably result in many deductions such as the following: —

Too many objects of equal importance in size, shape, color, character, etc., scatter the interest (Fig. 24).

Objects placed beside each other in a row give an arrangement that lacks unity (Fig. 25).

Equal divisions of space render the arrangement monotonous (Figs. 26 and 27).

Too great a difference in the areas gives an effect of unbalanced arrangement (Fig. 28).

One object placed directly in front of another gives an unpleasant effect of massing (Fig. 29).

There must be some relationship or harmony between the various objects in a picture. Although the objects in Fig. 30 make a good composition, so far as shape, arrangement, and values are concerned, the group is not harmonious because its members are incongruous. This is corrected in Fig. 31.

Landscape Drawing. Up to this point, what has been said in this chapter refers to the representation of all kinds of objects, as the illustrations indicate. After establishing these general principles, it will be well to consider some points bearing on the representation of particular classes of objects with which the student will be concerned. The landscape immediately suggests itself as a source to which we turn more frequently than to any other. The best possible conditions under which to study the landscape are reached when we go directly to it for this purpose. If we can look through a finder at actual trees, hills, houses, water and sky and find beautiful compositions of line, light and dark, and color, we may quickly gain both appreciation

FIG. 28

FIG. 29

FIG. 30

FIG. 31

of the beauty of nature and the ability to select a portion of that beauty for a picture. If these ideal conditions are not possible, however, we can use photographs of nature as a substitute, and it is to the photograph we must resort in the majority of schools. When this is done, every opportunity for out-of-door sketching should be grasped as an aid to the development of this preliminary study, based upon pictures. Whether we work from nature or from pictures, the fundamental principles and the method of following them will be the same.

We have spoken of the parts of the landscape as the *distance* (meaning the part farthest away), the *foreground* (meaning the part nearest), and the *middle distance* (meaning the part midway between distance and foreground). These are only relative terms, however, and must not be understood as meaning a definite, measurable portion of the landscape or picture space. But the student must understand how to locate masses or shapes in the several places indicated.

How to Begin a Study of the Landscape. Look through your finder and select an arrangement of light and dark shapes in the landscape, showing hills, trees and sky, or any other landscape elements. In first practice, work only for values, leaving out all details. With brush, charcoal or soft pencil put in the masses, keeping the composition very simple. Draw or paint in this way until you are able to produce from the landscape before you, or from a photograph of the landscape, a composition that is interesting in the selection of shapes, balanced in arrangement, and rendered in a few simple values, as illustrated in Fig. 32. Continue to make in this way arrangements from the landscape, keeping your rendering in flat tones, in a few values. Either color values or neutral grays may be used, with any medium preferred.

Color Added to a Pencil Sketch of the Landscape. Attractive compositions may be made with pencil on tinted paper, applying thin color washes over the pencil work. Fig. 33 shows a pencil drawing on tinted paper of some fishermen's huts, built upon posts or piles over the water. Notice the interesting treatment of the reflections, and the slight but telling suggestion of distance. The pencil sketch is a complete thing in itself; but the few strokes of water-color added in the plate facing page 24 open up a world of color possibilities which the pencil sketch can but faintly suggest.

FIG. 32

Details of the Landscape. Follow this practice by a careful study of individual objects, such as trees, clouds, fences, houses, etc. Make careful, suggestive sketches of such objects, treating them as notes or studies to be used in landscape painting or drawing, as occasion offers. Artists fill many note-books or portfolios with studies like those shown in Fig. 34. How to best use these notes is a matter requiring judgment and skill. Too much detail will render a picture photographic in effect, and this is not desirable; too little will show a lack of structural knowledge and of texture. We must know how to suggest that rocks are hard, that clouds are soft, that hills are solid and that water may show movement or present a

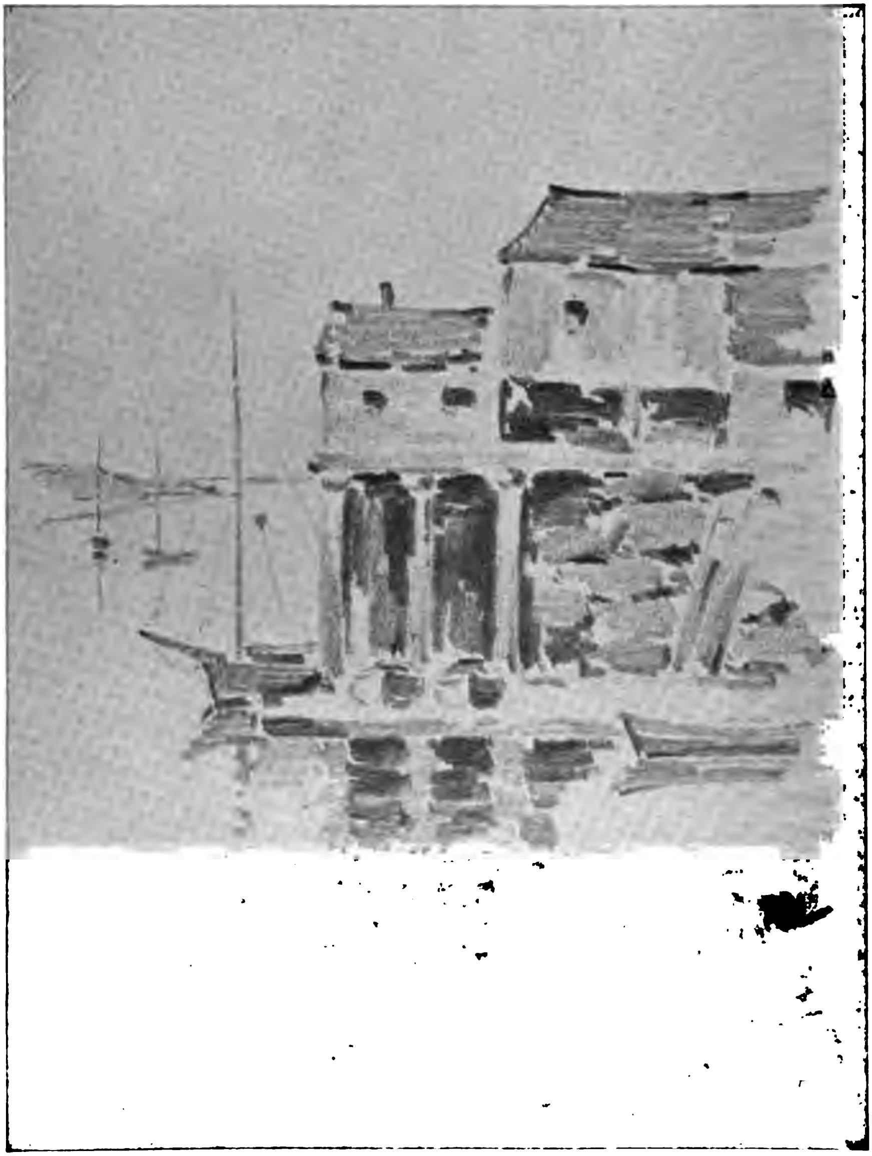


Fig. 33

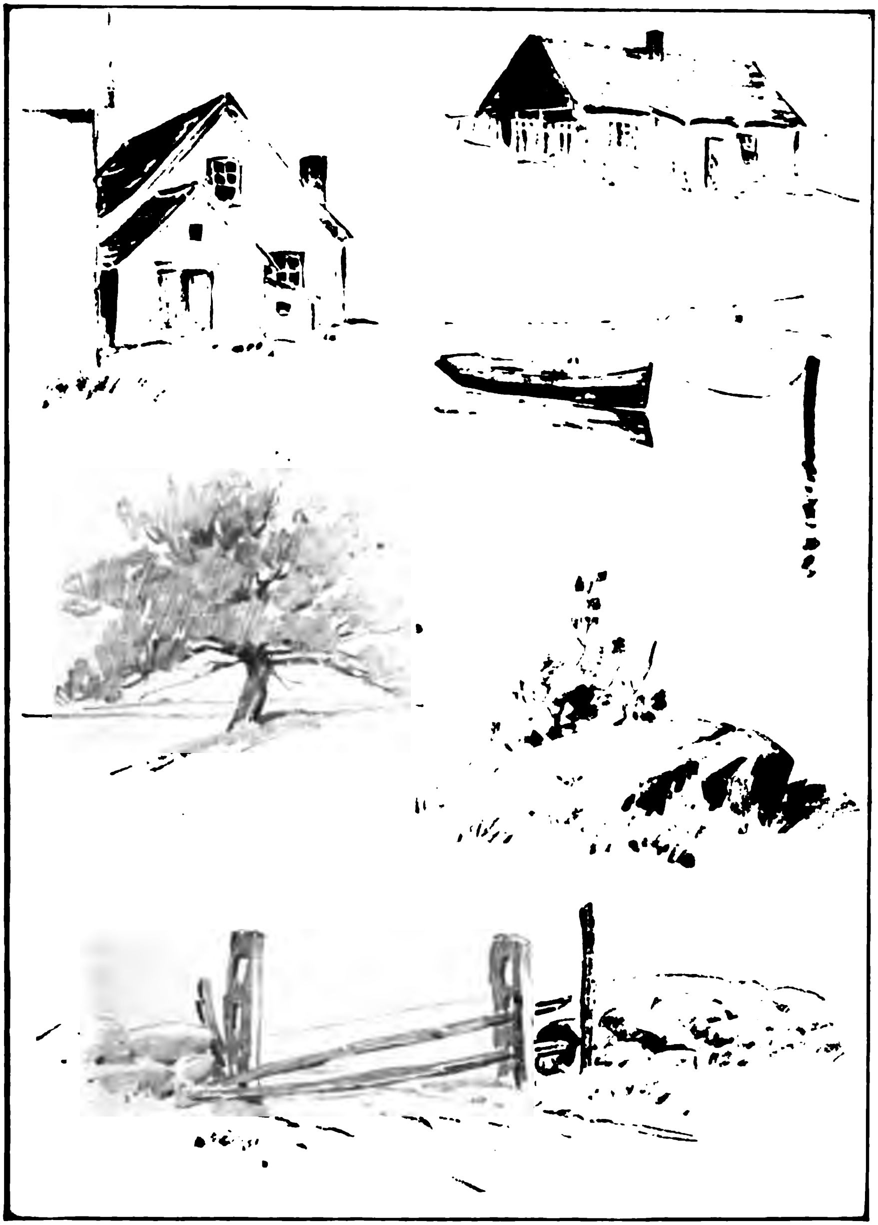


Fig. 84

mirror-like surface. We wish to show as much of texture and of the characteristics of the landscape elements as will add to the interest, variety, and beauty of our picture. A knowledge of the structural quality of the landscape is valuable, and necessary in the same way that a knowledge of the anatomy of the human figure is essential to good drawing from life.

Accents. In the studies shown in Fig. 34 you will notice sharp, black touches called accents, which are made with the full strength of the pencil and are placed wherever they seem needed. These are important in lending brilliancy and sparkle to the sketch, and they give, besides, a certain quality to any characteristics that an object may present. This is shown in the treatment of roof edges, openings in the foliage, undercuts in branches, or in the irregular depths of shade in doors and windows. When used without discrimination accents injure a sketch, but when skilfully placed they are indispensable.

Figures in the Landscape. If the student is able to use human figures or animals in landscape compositions he will find his resources for interesting material much extended. All such elements of interest must be treated as part of the composition, and not as something added or thrown in after the composition is complete. The mass or shape of a man or a cow must be related to the other shapes of the picture, just as the mass or shape of a hillside or a house is related, and its size, position, value or color must be analyzed and made to take its place in the whole scheme. In using figures or animals, however, we shall have to decide whether the landscape interest or the figure interest is to predominate. If the former, we must reduce the size of the figures and give them secondary treatment, as in Fig. 35. If the latter, we use the landscape as an accessory, and give the figures prominence, as in Fig. 36. But in both cases the figures are treated as a part of the composition, and in neither case would the picture be complete without them.

Still-life Drawing. The class of material for art study known as still-life includes pottery, flowers, fruits, vegetables, utensils of various kinds, or any other objects selected for use because of some interesting problem which they may present or suggest. When we speak of a still-life study we mean an arrangement of objects that we can control, some group whose members we can select or combine to suit our purpose, and which, with

FIG. 35

some exceptions, can be kept for study for an indefinite time. In the landscape we know that conditions change, often very rapidly, and in drawing from the figure or from animals we are again limited in time by the endurance or by the mood or whim of our subject. Because of the stability of still-life material and because we can govern so directly its choice and arrangement, it offers the very best opportunity for thorough practice in drawing and for the study of the general principles which have been explained in this chapter. In this material we miss, it is true, some of the delightful effects of distance, atmosphere, and of certain kinds of perspective, but the student that is well grounded in still-life practice will be able to apply what he has learned in any direction that he may select. Still-life practice is to the artist what daily physical exercise is to the athlete; it gives greater power, and this insures better results.

Still-life Studies with Charcoal. It will be found that all kinds of paper do not take charcoal equally well, and a rough, unglazed paper especially prepared for this work, called charcoal paper, should be procured. For certain effects, cartridge paper or butcher's wrapping-paper is often used to good advantage.

Fig. 36

After carefully reviewing what has been said regarding masses, values, effects of light and shade, and composition, arrange a simple group of still-life objects and study it through a finder. When satisfied that your group answers the requirements, block in the main shapes, using a sharpened stick of charcoal of medium hardness. Then lay in the large masses, trying to express at once their true shapes and values (Fig. 37). After these masses are applied freely with the charcoal point, they may be rubbed lightly with the finger ends in order to distribute the charcoal evenly over the surface of the paper (Fig. 38). If the charcoal is rubbed too heavily the paper will present a smudged or smeared appearance, which of course should be avoided. After the surface has been lightly rubbed the masses that need strengthening should be gone over again and the necessary lights taken out with kneaded rubber. Tones that seem too dark or too aggressive may be wiped off or softened with a chamois skin or soft cloth. After the larger values are laid in, the smaller lights and darks, the reflections and other secondary elements should be studied, the student working with charcoal, chamois skin and eraser until the desired effect is obtained. Fig. 39 shows such a drawing completed. To preserve a drawing of this

FIG 87

FIG. 88

kind, it should be sprayed with a thin solution of white shellac and alcohol, called fixative. This makes a thin varnish which causes the particles of charcoal to adhere to the paper.

Pencil Studies. Any good drawing-paper with a hard surface will answer for pencil work, and interesting studies may be obtained from the use of the tinted pencil papers now so generally supplied. A soft pencil that gives a broad definite line at one stroke is best for general use. A pencil drawing must never be rubbed, as is permissible in charcoal rendering.

The attempt should be to gain the desired value by direct strokes, instead of by working over a mass more than once. Before attempting to apply a tone or value, study it carefully and practise with your pencil on an extra piece of paper until you are able to produce the full strength of the value by going over the surface of the paper but once. Then apply it freely to the desired area of your composition. Figs. 3, 4, 5, 14, 20, 33, 34 and 35 all show examples of pencil rendering. Study good pencil drawings, notice the kinds

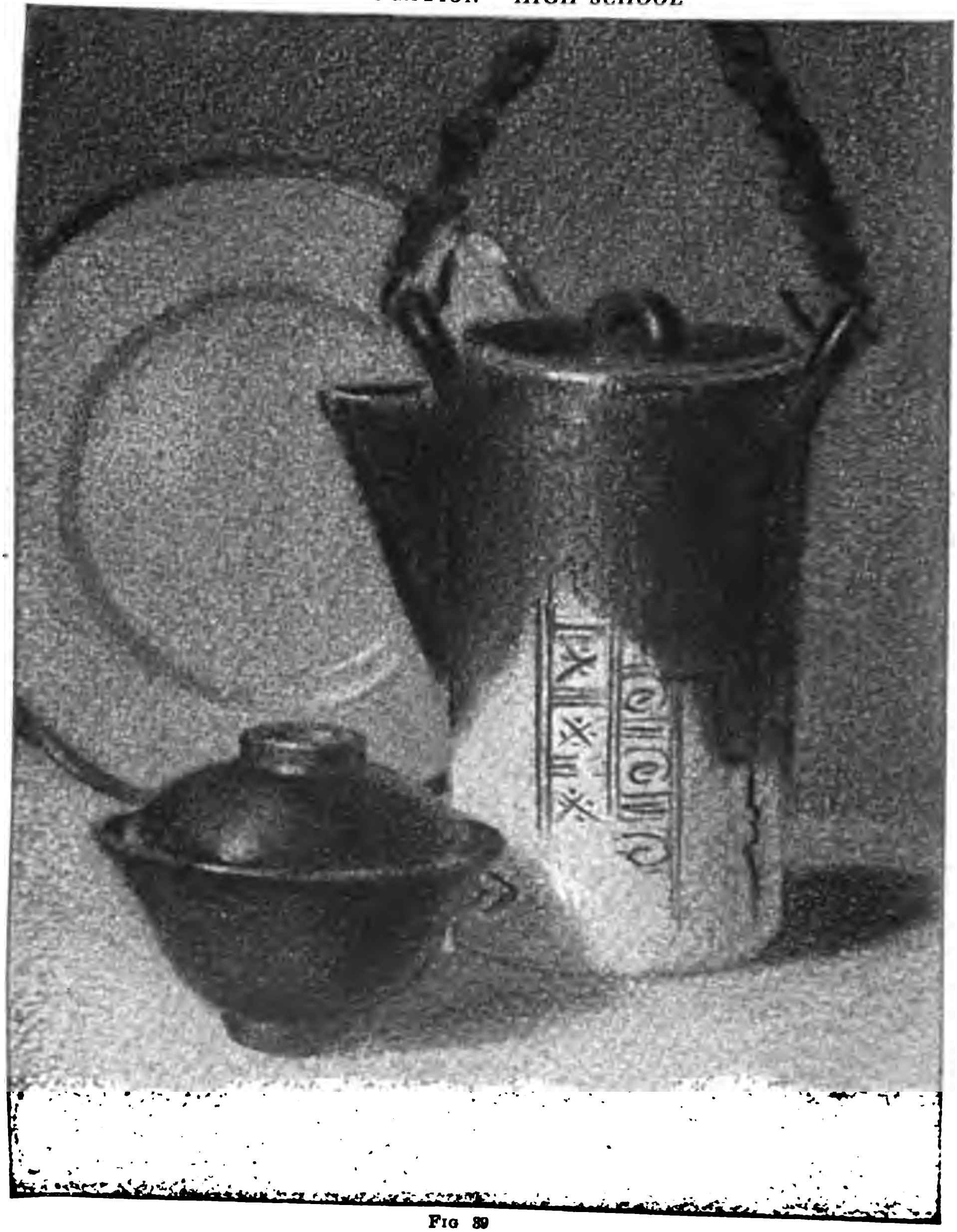


Fig 39

of lines used, and try for this quality in your practice. Pencil studies, also, should be well sprayed with fixative, to prevent them from rubbing.

Pencil sketches can be made still more interesting by being made on tinted papers. The pose for the subject of the sketch should be chosen first, and then the surrounding objects drawn from memory. After the figure with these environments has been blocked in, the dark values of the cap, coat, etc., should be laid on with definite, vigorous strokes. The lighter values in the pose are expressed by the color of the paper itself. The pencil sketch appears quite finished before the water color touches, which are tints rather than washes of full strength, have been added.

Water-Color Handling. There are many different methods of handling water-colors, each sanctioned by artistic authority. As the best method is largely a matter of individual choice, it will be wiser for the student to learn one method, and after he has become familiar with that, he can, by experimenting, and by study and practice, find out how the method he has learned may be modified or adapted to suit his particular needs. Some successful artists prefer to work upon paper that is previously made moist, while others, equally successful, prefer to work directly on dry paper. In good results of either method we would hardly be able to tell which one was used. It is the quality of the result that is important, not the method by which such a result is obtained. Whatman's hand-made paper is best for water-color work. This is somewhat expensive for beginners, however, and many other cheaper papers will answer. Good pencil paper of sufficient tooth will generally take water-color quite satisfactorily.

One Way of Using the Wet Method. Dip in water a piece of blotting-paper (cut slightly larger than the paper which is to receive your painting), and lay it upon your drawing-board. Upon this lay the water-color paper, which has also been dipped in water. With a dry blotting-paper of the same size as the water-color paper remove any superfluous moisture that may rest upon the paper. Then with a brush full of wet color (not too much water) lay in the masses, working with great directness. As long as the paper remains moist changes can be made, other colors or masses added, or lights removed by a dry brush, a soft sponge or a cloth.

The Dry Method. In the dry method of working, the color is

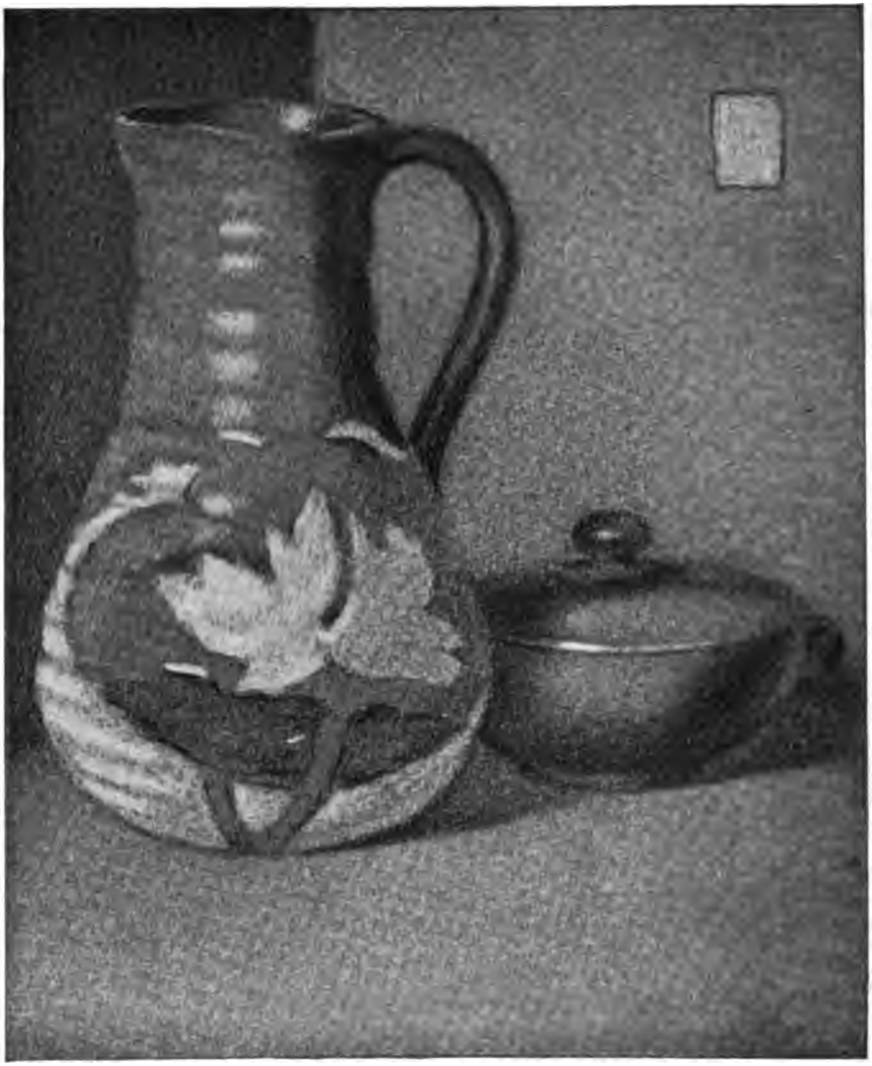


Fig. 40

applied directly to the dry surface of the paper, the brush being used wetter than it is when the paper is moist. In the wet method the water already on the paper helps to carry the color, and in the dry method more water is needed in the brush to sufficiently dissolve or thin the color. In working "dry," changes are not easily made, and should be avoided. Generally speaking, the wet method gives softer and more melting effects, while crisp and snappy effects are more easily obtained by the dry method.

It is usually found that the beginner succeeds better when he works upon wet paper until he feels some confidence in his use of color. He must learn by experience when the paper and colors are wet enough, yet not too wet, to produce the desired result. The more practice he has the more he will feel like making a combination of both methods in his work.

Color Added to Charcoal Drawings. Very interesting effects are obtained by applying water-colors to a charcoal or pencil drawing. Fig. 40 shows a charcoal study which is finished in values and in light and shade, and has been sprayed with fixative. Light washes of water-color were then added. Try this with some of the sketches you have saved from former practice. If you begin a study with the idea of finishing it in color, it will be well to keep the lights very light in the charcoal work, or the color will darken them too much.

The Use of Colored Chalks, or Crayons. Another interesting method of securing good color effects is by the use of Prang colored crayons. Tinted paper of good color and quality is taken as a foundation or background. The position and forms of the objects are blocked in lightly and the color masses are then laid on in a loose, free way, allowing the tint or color of the paper to shimmer through. The full force of color, laid on with bold strokes, is reserved for a few accents and high lights. Drawings of this character should be sprayed with fixative.

With colored chalks (which are opaque), either dark or light tinted papers can be used, but when water-color washes are to be applied, it is best to choose light tints of paper, owing to the transparent nature of the medium.

In all your practice, whether from still-life, from plant growth, from the landscape or the human figure, and in whatever medium you work, try to express simply and truthfully the character and spirit of your study.

CHAPTER II

PERSPECTIVE

PERSPECTIVE is the art of representing upon a plane surface the appearance of any object, without regard to the facts of its form and size. A perspective drawing generally shows the effect of a third dimension upon a surface, such as a sheet of paper, which has but two dimensions. Although perspective is an exact science and is governed by principles that can be demonstrated, a working knowledge of its laws may best be gained by observation from nature and from objects.

The knowledge gained by such observation and by practice is often spoken of as free-hand perspective, while the study of the mathematical laws which govern the appearance of objects is called scientific or mechanical perspective. In practising free-hand perspective the student strives to express what he sees or feels, and he is not restricted by attention to exact formulas and measurements. In scientific perspective he assumes a picture plane, a horizon or eye-level, a point of distance, vanishing points and distance points, and then proceeds upon a purely scientific basis. This process results in a technically correct representation of the object as it would appear under the assumed conditions.

Free-Hand Perspective. Perspective affects nearly everything that we see. If we look across a field, as illustrated in the color plate opposite, we observe that objects in the distance appear much smaller than they really are. The trees that are shown in the sketch, for instance, might all have been of the same size, but as they recede or are seen farther and farther away, they apparently diminish in size, and the tree in the foreground appears higher than the top of the distant mountain, although we know that in reality the mountain towers high above the tree which is near us. In the picture we notice, also, that colors are dimmer and grayer in the distance, and that the light and dark masses are less strong in contrast as they are seen farther away. These changes in values and in colors are due to what is called aërial perspective, — the combined effect of distance and of the atmosphere. Again, in our picture we notice that the shapes of the boats and the sails are not alike, although for our purpose the sketch was planned to show several sail-boats which in reality were exactly alike. The difference in their shapes, as shown in the sketch, is due to the different positions in which they are placed with relation to the observer. We see, then, that in making a drawing in perspective, we must consider both the distances of objects from us and their positions in relation to us. Another very noticeable effect of perspective is shown in the direction of the rails in the railroad. These are parallel in reality, but they do not appear so in our sketch. The rails seem to approach one another as they recede from the eye, until finally they converge at one point.

In our picture the stretch of land and the surface of the lake represent a horizontal plane, which, when seen at the oblique angle which its position in relation to the eye establishes, appears less wide than it really is. When a surface, because of its position, appears narrower than it really is, it is said to be *foreshortened.* The principle of foreshortening is the simplest and most obvious principle of perspective, for we see surfaces foreshortened more frequently than we see them in their true shape.

Deductions. From the study of a scene such as that represented we are able to make the following deductions, which are governing principles in the representation of objects: —

a. *Surfaces when viewed obliquely appear foreshortened.*

b. *Distance affects the apparent size of objects.*

c. *Distance affects the apparent color of objects.*

d. *Position affects the apparent form of objects.*

e. *Parallel lines, receding from the eye, appear to converge.*

The Foreshortened Circle. A circular face or shape, when held in different positions, illustrates the effect of perspective in a very clear and interesting way. Fig. 1 shows a hoop which is held or suspended directly in front of the observer, giving a full-face view of its outline. The shape of the view is, of course, a circle. If the hoop is held in a vertical plane so that its rim or edge is exactly opposite the eye-level, its appearance will

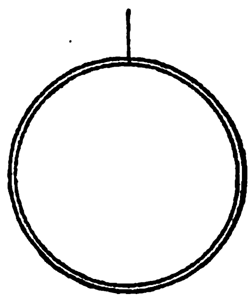


FIG. 1

FIG. 2

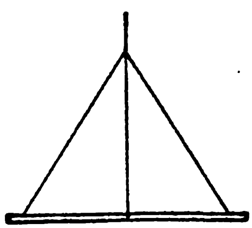


FIG. 3

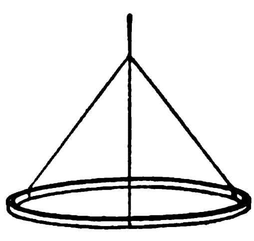


FIG. 4

be represented by a vertical line (Fig. 2). (The thickness of the rim of the hoop does not affect the principle illustrated.) If the hoop is held in a horizontal plane opposite the eye-level, its appearance is a horizontal line (Fig. 3). If the hoop is raised or lowered slightly the appearance is an ellipse (Figs. 4 and 5), and the width of the ellipse from front to back apparently increases as the hoop is moved farther above or farther below the eye. If the hoop is suspended in a vertical plane, and placed at the right or left of the eye, its outline appears as an ellipse whose long axis is vertical, and the width of the ellipse, measured by the short axis, increases with the distance of the hoop to the right or left (Fig. 6).

When objects whose bases are circles, such as cylindric objects, bowls, jars, vases, etc., are seen below the eye, so that the circular faces are neither directly under nor directly opposite the eye, the lower ellipse appears wider than the upper one, for the reason already explained. In preliminary practice it is well to sketch in light line the whole curve of an ellipse when but half of its outline is seen (Figs. 7 and 8).

The student should become thoroughly familiar with the principle of the foreshortened circle, and should draw many objects illustrating it, working both from the object and from memory or imagination.

Exercise I. Draw, from the object, a glass half filled with water, placed so that the upper edge is slightly below the level of the eye.

Exercise II. Draw, from the object, a lampshade above the level of the eye.

Exercise III. Draw, from the object, a cup and saucer in their usual positions.

Exercise IV. (*a*) Draw, without the object, a vertical cylinder with the lower face on a level with the eye; (*b*) with the upper face on a level with the eye; (*c*) with the lower face held slightly above the level of the eye; (*d*) with the middle of the curved face on a level with the eye.

From the study of the foreshortened circle we are able to make the following deductions: —

a. *A face view of a circle is always a circle.*

b. *An edge view of a circle is always a straight line.*

c. *A circle seen obliquely always appears as an ellipse.*

d. *The more obliquely the circle is seen the narrower the ellipse appears, — the more nearly it approaches a straight line.*

e. *The less obliquely the circle is seen the wider the ellipse appears, — the more nearly it approaches a circle.*

The Effect of Distance. The farther an object is placed from the observer the smaller it appears. This is easily discerned when we look at objects in the landscape, where the distance is great enough to make the difference in size very apparent. The law holds good, however, when the distance is slight, and it may be easily demonstrated: hold two 12″ rulers in a vertical position, directly in front of you, so that their edges touch throughout their entire length. The rulers in this position, and at the same distance from the eye, appear to be the same size. Now move the right ruler slowly away from you, keeping the ruler at the left

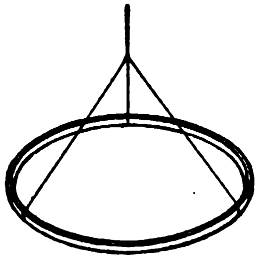


FIG. 5

FIG. 6

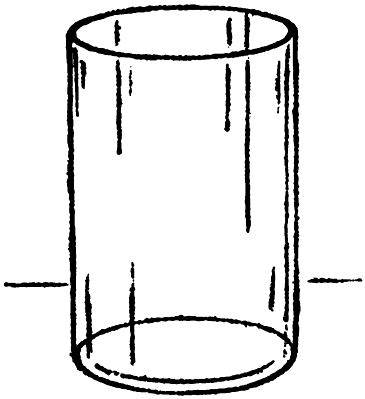


FIG. 7

FIG. 8

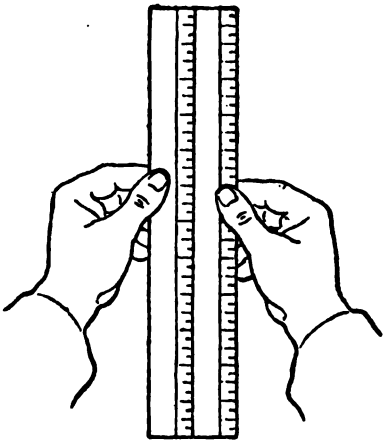


FIG. 9

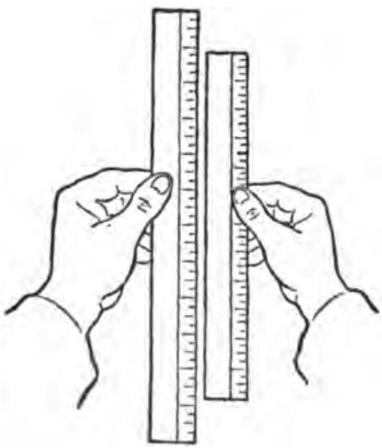


FIG. 10

stationary. The difference in the apparent length will be readily seen, and can be measured upon the nearer ruler (Figs. 9 and 10).

To demonstrate this principle in another way, place two objects of the same size on a table or shelf in front of you, so that either the tops or the bottoms of the objects are on the level of the eye. Move one object twice as far from you as the other. Test the apparent height of both, and you will find that the farther one appears one-half the height and width of the nearer object. If one object is four times as far away as another, it appears but one-fourth as high and wide; if ten times as far away, it appears but one-tenth the height and width of the nearer object (Figs. 11 and 12).

Place objects against or partly behind each other, and testing with the pencil held at arm's length, compare the apparent size of objects placed at different distances from the eye. Notice how the apparent difference in size is demonstrated in the photograph of the corn-shocks (Fig. 13).

The device of the rulers serves also to illustrate the principle of foreshortening. Place the two rulers together in a horizontal position on a level with the eye and directly in front of you. Hold the left ends together with the left hand, and with the right hand swing the upper ruler away from you, keeping the under ruler stationary. The apparent decrease in the length of the upper ruler, as measured on the under ruler, proves that lines and surfaces are foreshortened as they are turned away from the eye (Figs. 14 and 15).

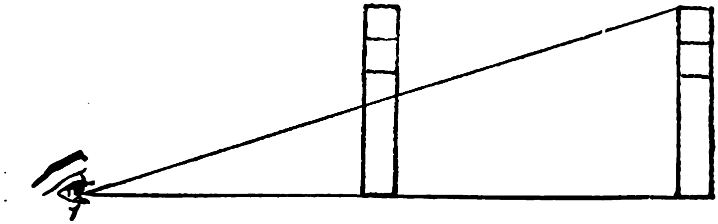


FIG. 11

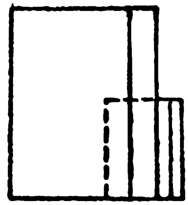


FIG. 12

The Horizon Line, or Eye-Level. If you stand upon the shore of the sea or of a large lake and look across the surface of the water it appears to rise as it recedes, until it reaches, in the distance, the level of the eye. If you should climb to the top of a cliff and look again across the water, its surface would still appear to rise until it reached the higher level which your eyes had attained in that elevated position. This distant level, where the earth and sky seem to meet, is called the line of the horizon, or the eye-level, and upon this level all horizontal planes or lines vanish. The floor and the ceiling of a room are horizontal planes receding from the eye, and if extended, they would vanish in the horizon line.

Note: The horizon line must not be confused with the sky-line, which is the line made by masses, such as hills, trees, houses etc., cutting against the sky. Except on a level plane the horizon line is not visible; the sky-line is always visible.

As all horizontal lines receding from the eye must vanish in the horizon line, those below the eye appear to slant upward as they recede, and those above the eye seem to slant downward, and if these receding lines are parallel they will seem to converge to a point upon the horizon line.

FIG. 13

Convergence. No line can appear longer

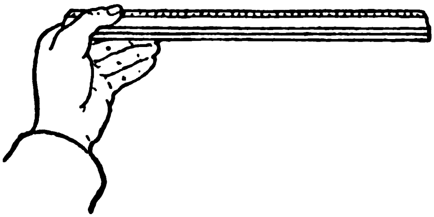


FIG. 14

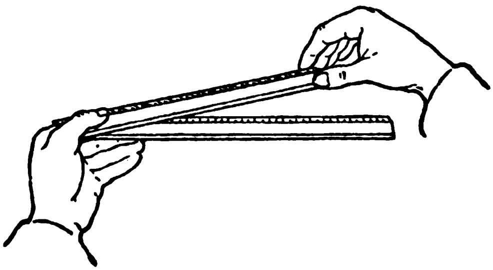


FIG. 15

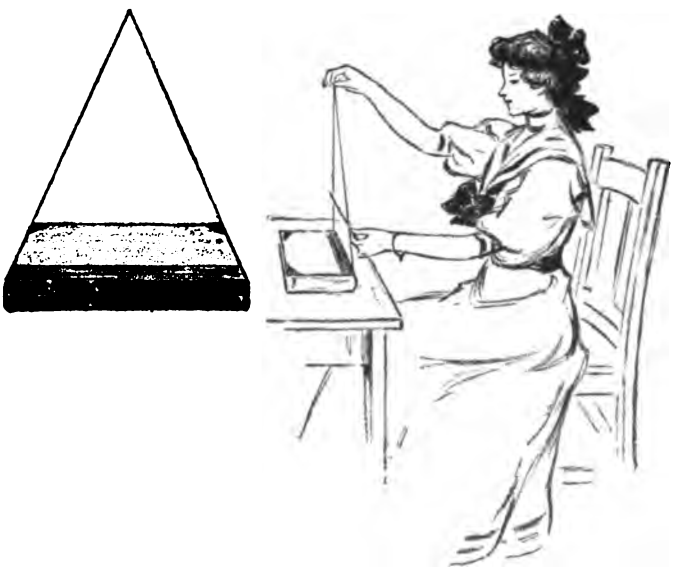


FIG. 16

than it really is, but under certain conditions it appears shorter, as has been demonstrated. A vertical line may be seen directly in front of the eye, or it may be seen above, below, to the right or to the left of the eye, but its apparent length depends upon its distance from the observer, and its perspective representation, for all artistic or pictorial work, is always vertical. All other straight lines may, under certain conditions, appear as "retreating" or "vanishing" lines. In the colored sketch already referred to, the railroad tracks are receding from us, and, although we know that in reality they are parallel, they appear to converge, and if they were extended over a level plane we would see that they would converge to a point on the horizon line and would vanish in that point. This principle is demonstrated in the horizontal lines of buildings, in street scenes, in room interiors and in roadways and

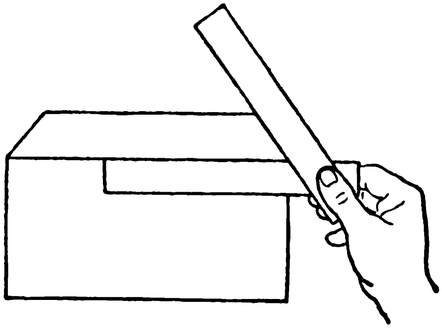


Fig. 17

sidewalks. In small objects the convergence of lines is not so apparent, but we can establish proof that it exists. Lay a book upon a table, with the back directly in front of you. Under the cover of the book place a string long enough so that both its ends may be held in one hand so as to hide from your vision the retreating horizontal edges of the cover (Fig. 16). The two ends of the string are seen to converge, thus indicating the true appearance of the ends of the book in this position. In Fig. 16 two of the four horizontal edges in the top of the book are parallel to the horizon line of the observer and do not seem to change their direction. It is only *receding* horizontal lines that seem to converge, and which, if extended, would meet in a point upon the horizon line.

The student should draw from many objects illustrating the convergence

Fig. 18

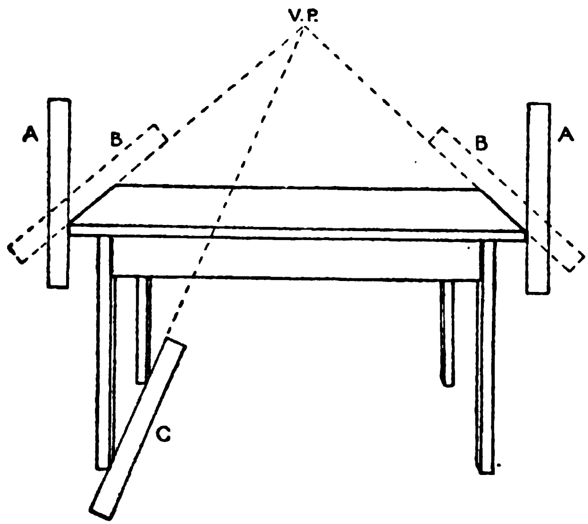


FIG. 19

of retreating horizontal edges. Two rulers or two strips of stiff paper may be used to test angles after the sketch is made, as shown in Fig. 17.

Parallel Perspective. When rectilinear objects are placed so that one set of lines is vertical, another set is parallel with the observer's horizon, and another set is horizontal and receding, converging to a point upon the horizon directly opposite the eye, as in Figs. 16, 17 and 18, they are said to be in parallel, or one point perspective. In Fig. 18, which is a photograph of a railway station, it is seen that the vertical lines of all the buildings, of the telegraph pole, and of the freight cars remain vertical; all horizontal lines that are parallel with the horizon remain horizontal; while the receding horizontal lines, such as the rails, the ridge and eaves of the roofs, etc., all tend toward the same point in the horizon line.

To Determine the Vanishing Point in Parallel Perspective. The vanishing point for converging lines may be determined by simply producing the lines until they meet. An interesting device for demonstrating this is illustrated in Fig. 19, and is worked out as follows: Sit in front of a table or desk, and at the two nearer corners hold two rulers in a vertical position, as at A and A, Fig. 19. Observe the top of the table as seen between the rulers, and then incline them until they hide from your sight the ends of the table, as at B and B. If the rulers, in this position, could be extended, they would meet at a point opposite and on a level with the eye. If you should imagine this done, and should fix a point on the wall beyond the table, locating the point at which they would meet, as at VP, you would find the vanishing point for all of the receding horizontal lines in the table. A ruler

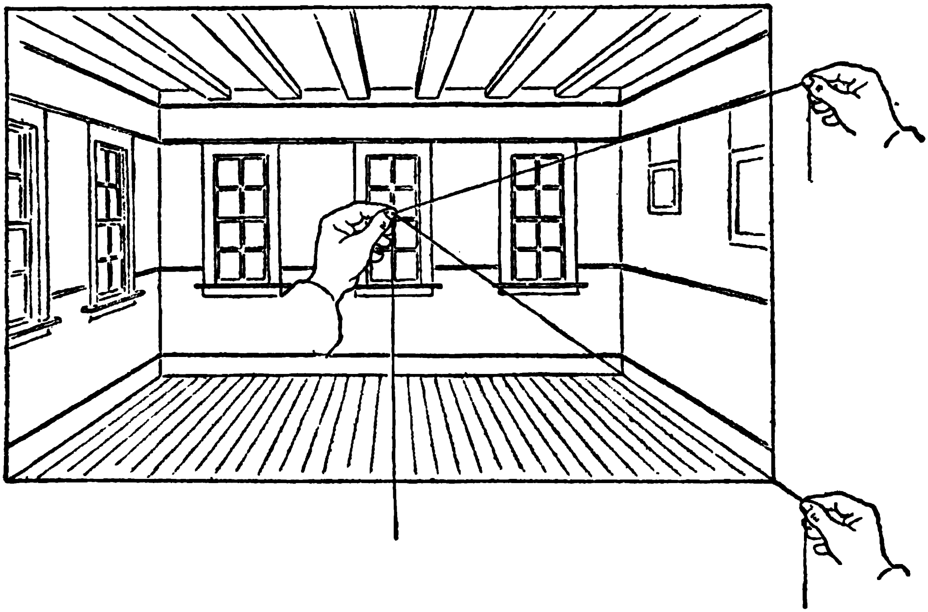


FIG. 20

held so that it hides from your sight a line connecting the bottom of the legs, as at C, will slant toward the vanishing point, VP, as shown in the sketch.

Again: Stand with your back against the wall of a long, narrow room and look toward the opposite wall, assuming a point on the wall exactly opposite your eye. With the thumb and finger of the left hand hold a string in a vertical position so that the thumb that holds it hides the assumed vanishing point. The string in this position hides from your sight the crack in the floor upon which you are standing; that is, the crack, which is a horizontal line receding from the eye, appears as a vertical line. Holding the thumb in the same position, take the other end of the string in the right hand and swing it to the right. You can then hide with the string the lower line of the base-board (Fig. 20), and by moving the string you can cover the upper and lower lines of windows, doors, blackboards, picture frames, the upper line of the wall, or any horizontal edge or line that is receding from you. The upper end of the string may be held in place with the right

BRIDGE ACROSS THE MISSISSIPPI RIVER AT THEBES, ILL.

FIG. 21

hand and the same experiments made with the lines at the left. An interesting illustration of parallel perspective is shown in the photograph of the bridge (Fig. 21).

Exercise V. Find the vanishing point in the picture (Fig. 22).

Exercise VI. Draw in parallel perspective an outline sketch of a book; a checker-board; a table; a chair; a strawberry box; a bookcase.

Note. If the student will place any object behind a vertical pane of glass or a fine wire screen and trace upon this plane the outlines of the object, he will have a correct drawing of its appearance, which will help him to understand the principles of perspective.

Exercise VII. Make a sketch similar in character to Fig. 22, from your observation of a street or railroad.

Deductions. From the foregoing the following deductions are made:—

a. *All parallel horizontal edges receding from the eye appear to converge.*

b. *All receding horizontal edges appear to incline toward the level of the eye.*

FIG. 22

c. *All parallel horizontal edges receding from the eye appear to converge to a point on the level of the eye, and if produced will meet in a point on the horizon line, or eye-level.*

d. *Any horizontal plane, when seen above or below the eye, appears foreshortened.*

e. *All planes viewed obliquely appear foreshortened.*

f. *The farther of two edges that are parallel with the observer's horizon appears shorter than the nearer edge, owing to the convergence of receding parallel horizontal edges* (*Fig. 23*).

Angular Perspective. When a rectangular object is seen cornerwise, so that its vertical faces appear foreshortened, as illustrated in Fig. 24, it is said to be in angular perspective. Under these conditions, there are two

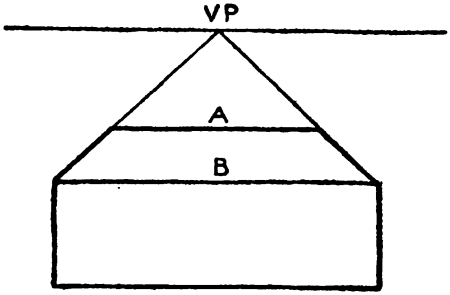


FIG. 23

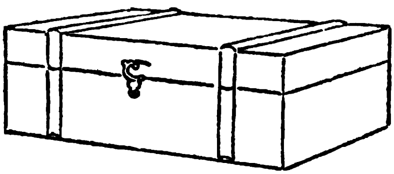


FIG. 24

sets of retreating horizontal edges, and their vanishing points may be found by continuing the lines of these edges until they meet. Fig. 25 shows a photograph of a building taken at an angle. The receding lines are seen to converge in two different directions. Those on the left of the near corner converge to the left, and those on the right of the near corner converge to the right. If these lines were extended, they would meet respectively in two points, and these points would both be located upon the horizon line. The student should demonstrate this principle by locating, with the string device or by some other means, the horizon line and vanishing points in buildings that he sees at an angle, and he should make these tests from different points of view and from different elevations.

The observation tower shown in Fig. 26 illustrates in an interesting and definite way the changes that occur in the inclination of horizontal retreating lines at different levels. In making this sketch, the artist ascended another high tower in the vicinity and looked out upon the platform that is marked A in the sketch. The platform was exactly opposite the level of his eyes and was, of course, on a line with the distant horizon. He saw no width from front to back upon this platform; the people, the stairways, the railing, the four corners, all seemed to be resting upon a horizontal line. The platform immediately below appeared in the shape of a long, narrow diamond, with its outlines slanting very slightly upward, the opposite sides inclining toward two different vanishing points upon the eye level. The next platform below appeared wider, with a greater inclination of its edges, and the lowest platform that the artist could see showed in its outlines a greatly increased degree of inclination. The highest platform of all and the roof of the tower showed that the apparent inclination was

FIG. 25

reversed, — the edges slanted down instead of up, although they still sought the same vanishing points on the horizon line at the right and left of the observer.

Objects at 45 Degrees. In making the sketch of the tower the artist was so located that he saw the structure very nearly at an angle of 45°. At 45° the degree of inclination of the right and left retreating edges is equal. We often see rectangular objects at some other angle, as shown in Fig. 27. When this is so, the inclination of the edges on the right and left sides is not equal; the side that is turned away more will show the greater inclination and the greater foreshortening. This should be demonstrated by the observation and drawing of many objects similar to those shown in Fig. 28.

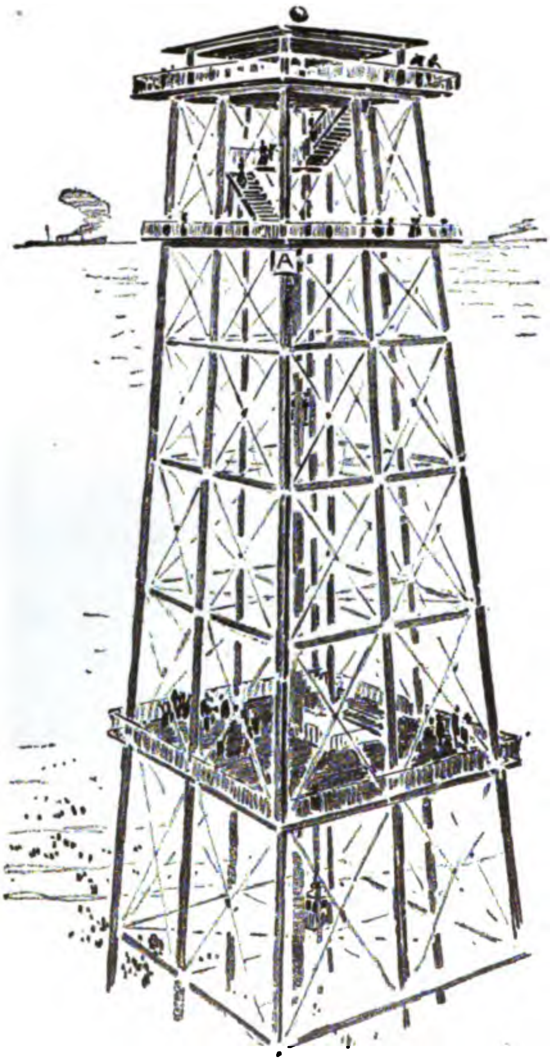


FIG. 28

The student should bear in mind the fact that when converging lines which represent retreating horizontal edges are produced until they meet, all lines that are parallel with them will meet at the same points, and that these points will be on the same eye-level.

Study of the Open Door. The drawing of an open door is an interesting exercise, as it requires a knowledge of the principles of angular perspective. A careful drawing should be made, studying the problem in the following manner: Sit in front of a door that opens outward or away from you, as shown in Fig. 29. Sketch first the casing and note the apparent width of the door in relation to the width of the opening. You will observe that the top of the door appears to slant downward from the near corner and that the bottom seems to slant upward. Sketch the outlines of the door. Now imagine the retreating lines at the top and bottom of the door to be extended until they meet. This point will be upon the level of your eyes, and at the left of your point of view. Open

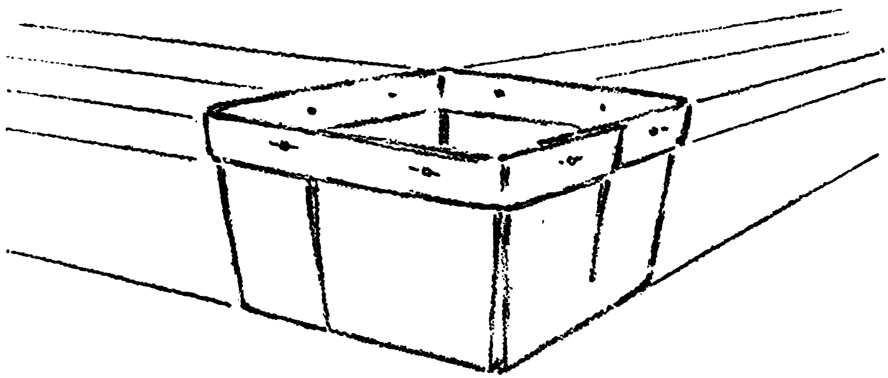


FIG. 27

the door a little more and study the effect upon the inclination of the top and bottom edges. It will be found that the vanishing point changes according to the angle at which the door stands, and that the degree of inclination changes in like proportion. Make a similar test with the door nearly closed. The nearer shut the door, the less will be the inclination of the top and bottom edges, and the farther away will be the vanishing point, *but this point will always be on the eye-level.*

Make a similar study from a door opening toward you (Fig. 30). It will be well to sketch the same door several times, until you can make an

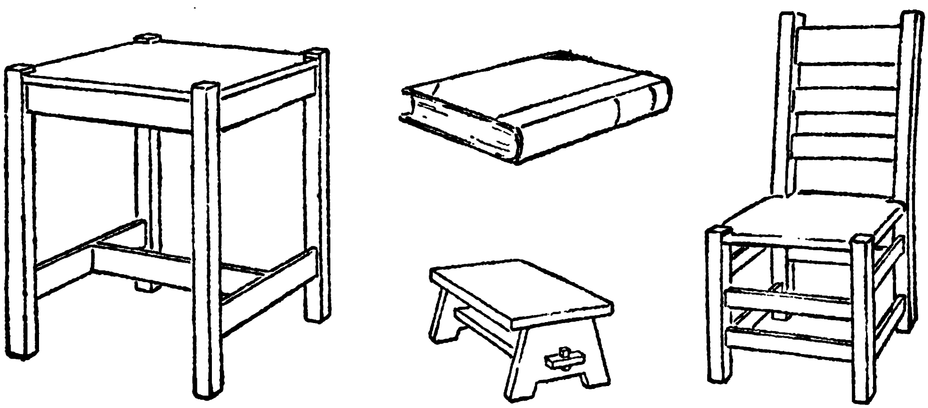


FIG. 28

accurate drawing of its appearance without testing, depending upon your eyes, your sense of proportion, and your knowledge of perspective principles.

Turned Cylindric and Conical Objects. The principles of foreshortening and convergence enter into the representation of objects based in their construction upon the cylinder and the cone. In Fig. 31 the cylinders are represented as lying in a horizontal plane and turned at an angle, so that the near end appears as a foreshortened circle, or ellipse. The outlines of the curved surface become retreating horizontal lines and show convergence,

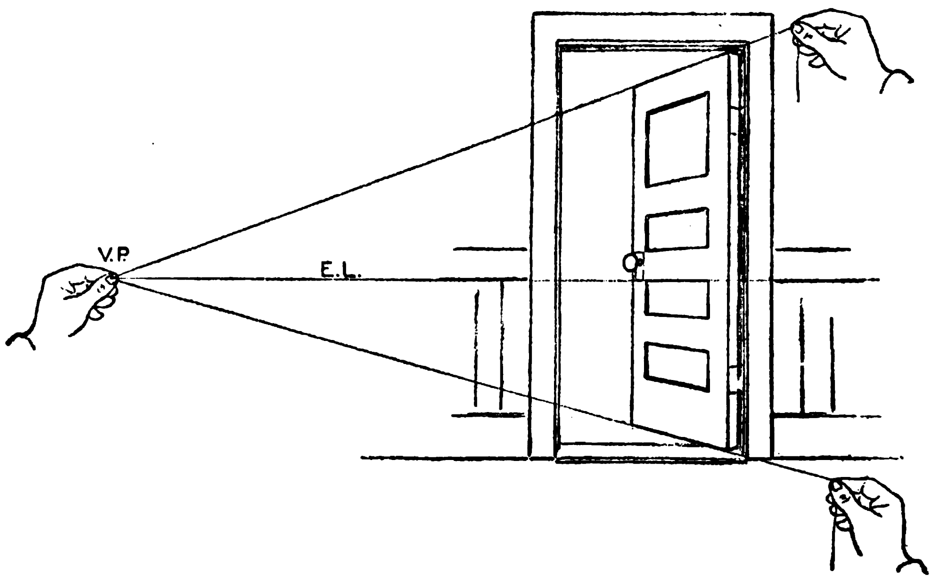


FIG. 29

as the lines of a rectangular box would do in a similar position. In drawing an upright cylinder, the straight lines of the sides seem to pass into the curve of the ellipse at the ends of its long diameter, forming a tangential union. (When a straight line passes without any perceptible change into a curve, the union is called tangential.) The axis of a right cylinder or a cone is always at right angles to the long diameter of the base, and this is true when the object is turned as well as when it is upright, or when its axis is parallel with the horizon line. When the cone is seen below the eye, as in

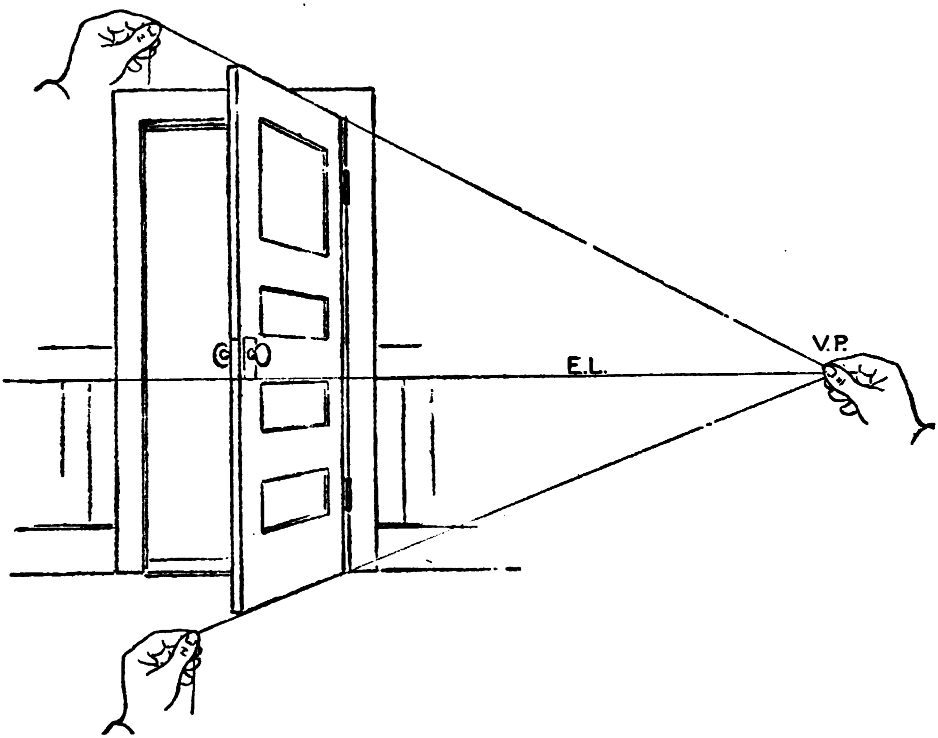


Fig. 30

Fig. 32, the straight lines (which are oblique) appear to form a tangential union with the curve of the ellipse, not at the ends of its long diameter, but a little farther back, and this is true of the turned horizontal cylinder as well, as shown in Fig. 31. The fuller or broader the ellipse of the base of

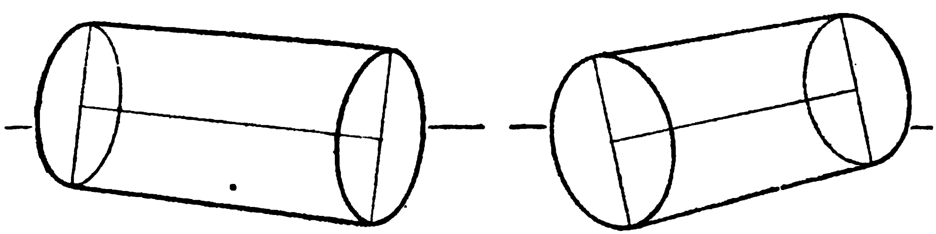


Fig. 31

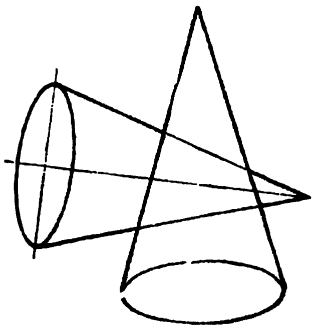


FIG. 32

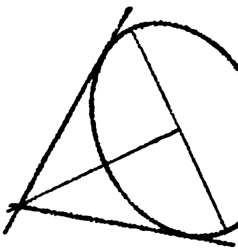


FIG. 33

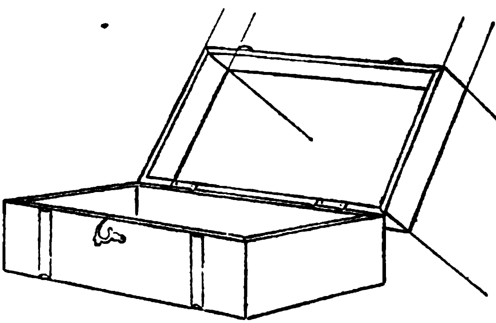


FIG. 34

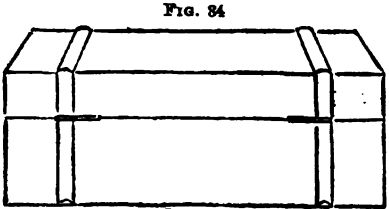


FIG. 35

the cone, the farther back from the ends of the long diameter will this union seem to be. Fig. 33 makes this clear.

Exercise VIII. Draw a flower-pot lying on its side and turned at an angle. Sketch its axis and both diameters of both ellipses.

Exercise IX. Draw a music roll turned at an angle, lying on a horizontal surface.

Exercise X. Sketch lightly one or two parsnips or carrots turned at an angle, and lying on a horizontal surface.

Oblique Perspective. When an object is in such a position that all or a part of its horizontal edges are oblique to the ground, as illustrated in the cover of the box shown in Fig. 34, it is said to be in oblique perspective. In the box cover, the retreating edges are slanting and parallel, and they seem to converge and to vanish in points above or below the eye-level at a distance proportionate to the inclination of the edges. The exact location of such points may be found, if desired, by the following procedure: Place a large box with a hinged cover directly in front of you, below your horizon line. Draw it first

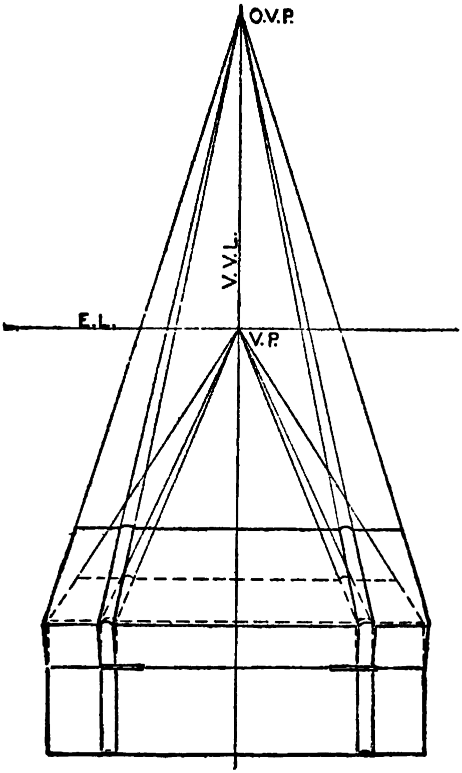


FIG. 36

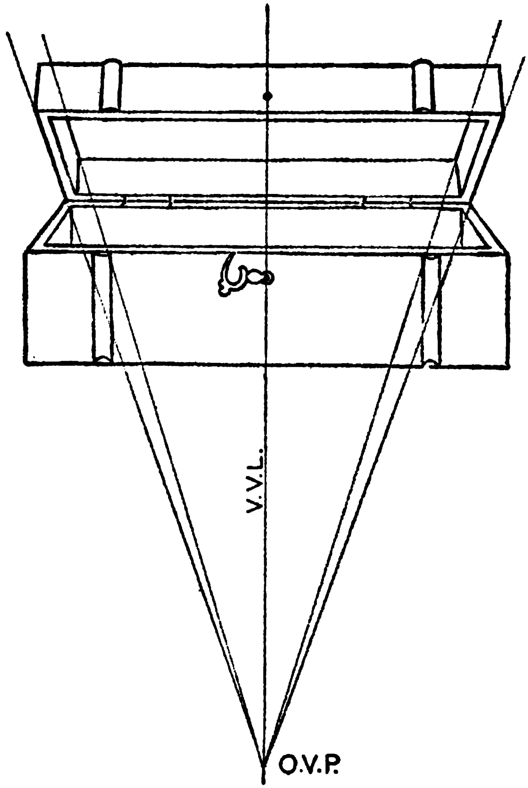


FIG. 37

in parallel perspective with the hinged edge toward you and the cover shut (Fig. 35). As you know, the retreating horizontal edges will appear to vanish in the horizon line. Raise the cover at an oblique angle (Fig. 36) and again draw the box. You will find that the vanishing point for the retreating edges is directly above the vanishing point for the same lines when they were horizontal (O.V.P., Fig. 36). Turn the box so that the hinged edge is at the back, and slightly raise the cover (Fig. 37). Sketch the box in this position, and you will see that the vanishing point for the oblique lines is directly below the vanishing point for the same edges in a horizontal position. Now turn the box at an angle and slightly raise

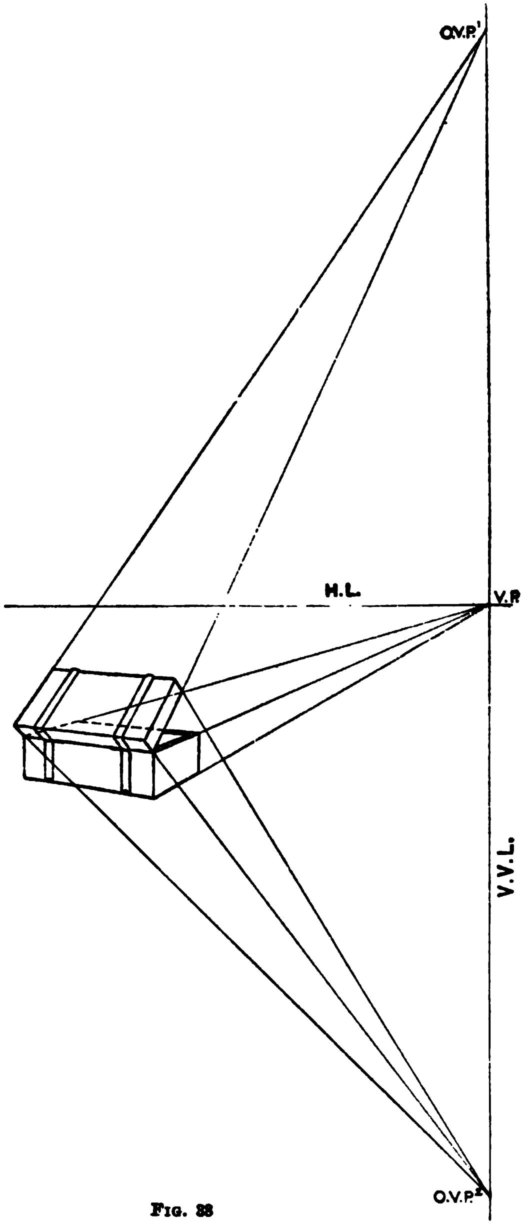


FIG. 38

the cover, as shown in Fig. 38. The retreating *horizontal* edges appear to vanish in the horizon line, and the retreating *oblique* edges at the ends of the cover appear to vanish in a point directly above the vanishing point for the horizontal edges with which these oblique edges were parallel before the cover was raised. The short oblique edges that show the thickness of the cover seem to vanish in a point directly below in O.V.P.[2]. The reason for this will be clear, when you remember the principle already established—that receding parallel planes vanish in a line. V.V.L., Fig. 38, is the vanishing line for the vertical planes in which the ends of the box cover lie. Therefore, all lines lying in those planes will vanish in that line.

We often find parts of buildings, such as slanting roofs and dormer windows, in oblique perspective. In Fig. 39, the ends of the barn and the ends of the house are in vertical planes which are parallel to each other. These planes vanish in a vertical

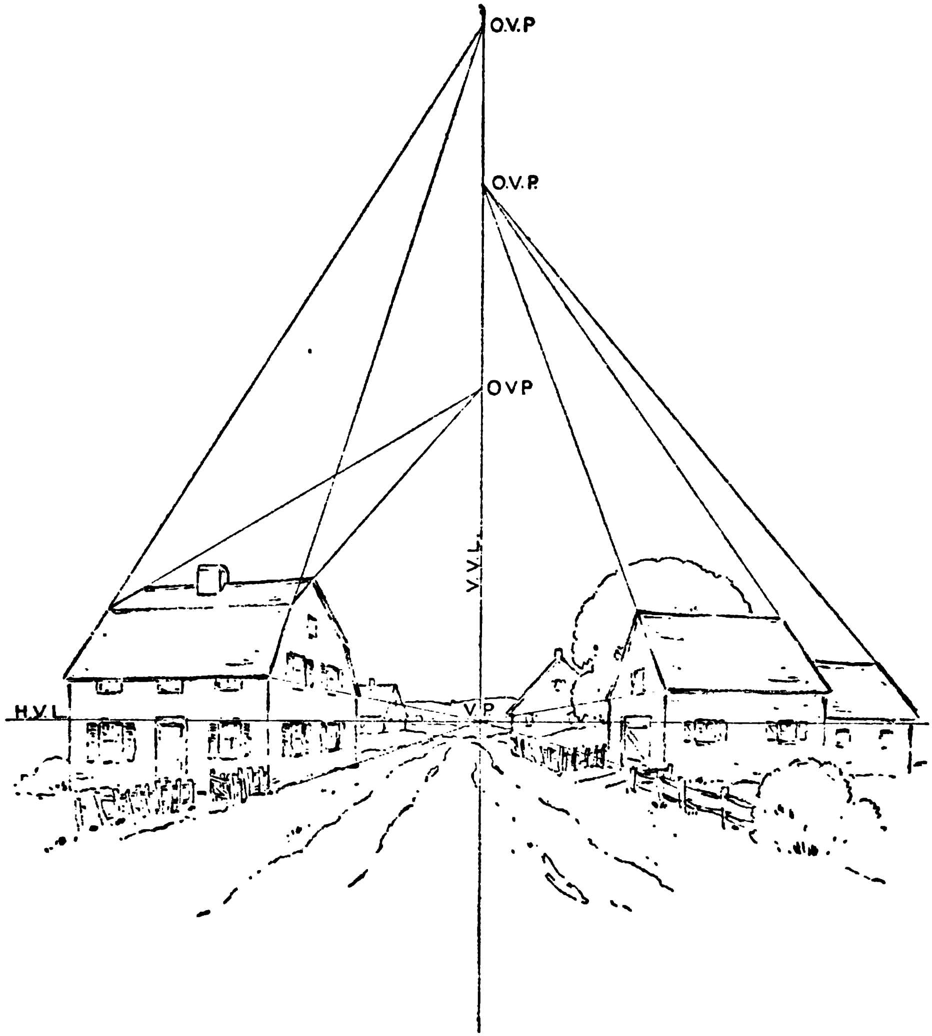


FIG. 39

vanishing line (V. V. L). All lines lying in these planes will vanish in certain points on the vertical vanishing line. Figs. 40, 41, 42 and 43 illustrate how vanishing points for various parallel oblique edges may be located.

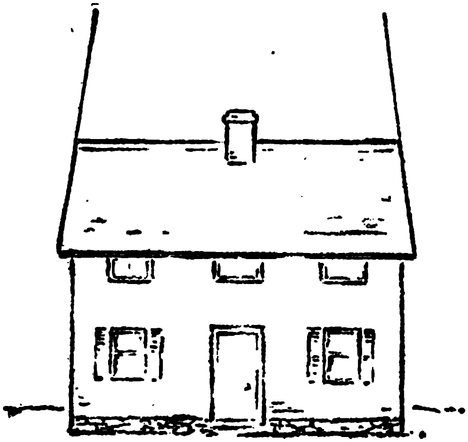


FIG. 40

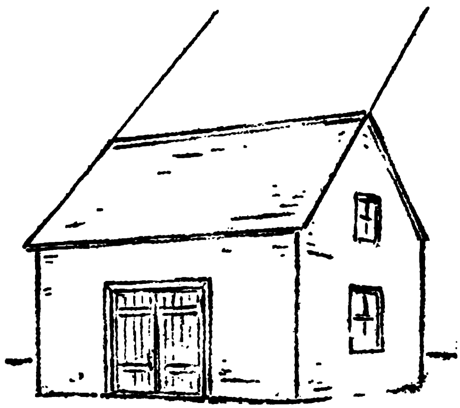


FIG. 41

Deductions. From the foregoing, these additional deductions may be made:

a. *Parallel horizontal edges receding to the left appear to converge to a point on the eye-level at the left of the object; those receding to the right appear to converge to the right of the object.*

b. *When rectangular objects are standing with their side faces turned equally away, the vanishing points are equidistant from the object; but when their side faces are turned unequally away, the two vanishing points are unequally distant from the object, according to the angle at which the object stands.*

c. *Farther vertical edges appear shorter than nearer vertical edges, although in reality they may all be of equal length.*

d. *Receding parallel planes, if produced, appear to vanish in a line.*

e. *Receding horizontal planes vanish in a horizontal line on a level with the eye, called the eye-level (E. L.), the horizontal line (H. L.), or the horizontal vanishing line (H. V. L.).*

f. *All lines lying in the same plane, or in parallel planes, vanish in the same straight line.*

To Find Perspective Centers. As objects or parts of objects appear smaller in proportion to their distance from the eye, the perspective centers of the foreshortened planes will appear a little beyond the geometric centers.

In Fig. 44 the top of the gable and the center of the door or the window are a little beyond the center of the end and side of the barn. To test this, draw the diagonals of the rectangles as shown in the illustration.

The altitude of a pyramid is obtained in the same way (Fig. 45). The apex will be directly over the perspective center of the base.

The long diameters of two concentric circles will not appear in the same line. The long diameter of the inner ellipse is a little above the diameter of the outer ellipse, as shown in Fig. 46, which was photographed from a drawing of two concentric circles. The diameters *ab* and *cd* were drawn on the photograph.

Because the farther half of a surface seen obliquely appears shorter than the

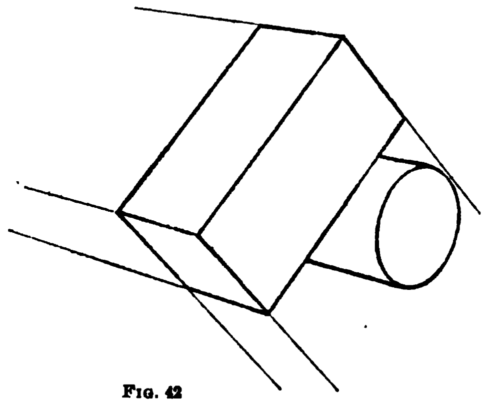


Fig. 42

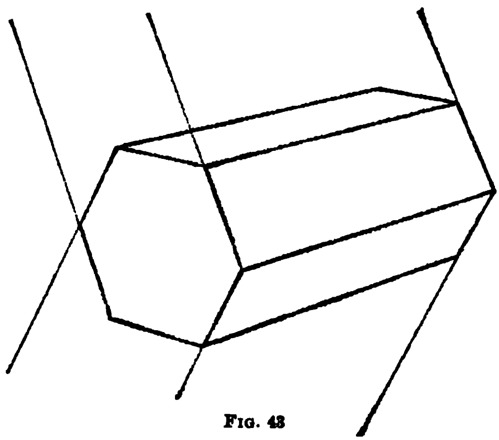


Fig. 43

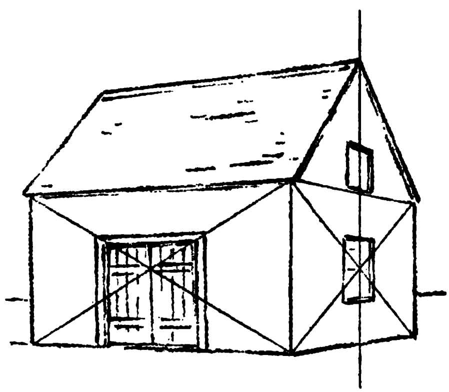


Fig. 44

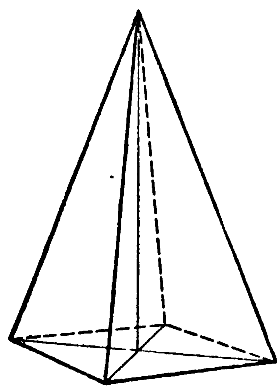


Fig. 45

nearer half, it is sometimes thought that the farther half of an ellipse (the appearance of a circle seen obliquely) should be drawn narrower than the nearer half. That a circle seen obliquely appears as a perfect ellipse is

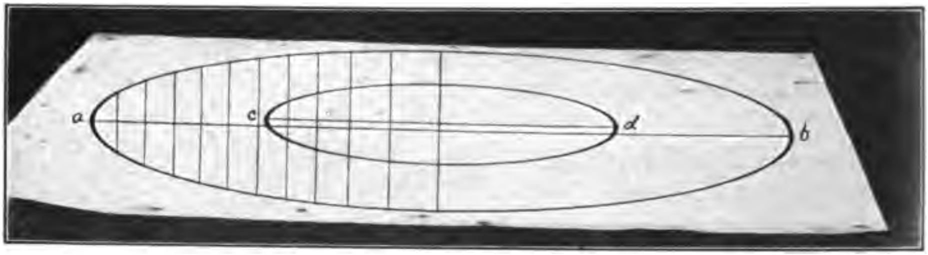


FIG. 46

shown by the photographs (Figs. 46 and 47), which were taken from drawings of circles.

It will be seen in Fig. 47 that the diameter *e f*, of the circle, which is also the diameter of the square, does not remain the long diameter of the

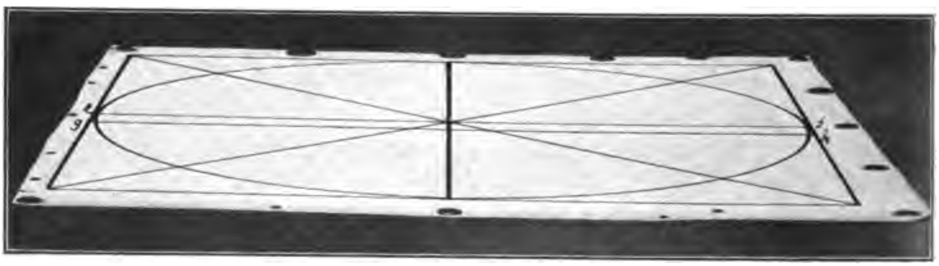


FIG. 47

ellipse. The line *g h*, which is the long diameter of the ellipse, was drawn through the exact center of the ellipse on the photograph. The two halves are exactly alike.

Mechanical Perspective

We have seen that freehand perspective is largely a matter of the close observation of objects as they appear under different aspects and conditions. We come now to the study of the theory of perspective, in which the principles deduced from our study of objects are proved by scientific methods. In mechanical perspective certain conventions are assumed which must first be explained.

Conventions. Imagine a sheet of glass to be standing in an upright position before you, through which you can see the various objects in the room. This glass extends, in imagination, from the floor to the ceiling, and from side to side of the room. A plane such as the glass represents is called the Picture Plane (P.P.). The edge that rests on the floor represents the Ground Line (G.L.). The position of your eye represents the Station Point (S.P.), and is always located at a given distance from the Picture Plane. The direction in which you are looking, represented by an imaginary line drawn from your eye to a point on the Picture Plane exactly opposite your eye, is called the Line of Direction (L.D.). The point opposite your eye, on the Picture Plane, is called the Center of Vision (C.V.). A horizontal line passing through the Center of Vision is called the Horizon Line (H.L.).

When we look at a fixed point before us, our vision is not limited to the point alone, but we see, more or less clearly, a certain field or area surrounding the point. This area is the field of vision, and its extent may be illustrated as follows: place the palms of your hands together and extend your arms directly before you. Look fixedly at some point opposite your eyes. Continuing to gaze at this point, slowly open your extended arms. You will observe that you can see your hands less and less distinctly as they move away from the point upon which your gaze is fixed, until finally the hands disappear from sight. The points at which your hands disappear mark the limits of your field of

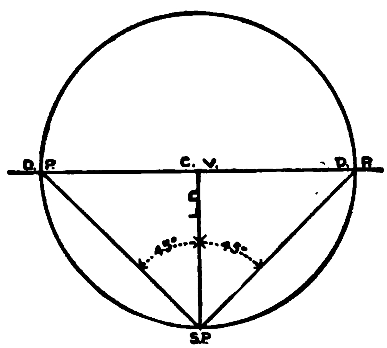


FIG. 48

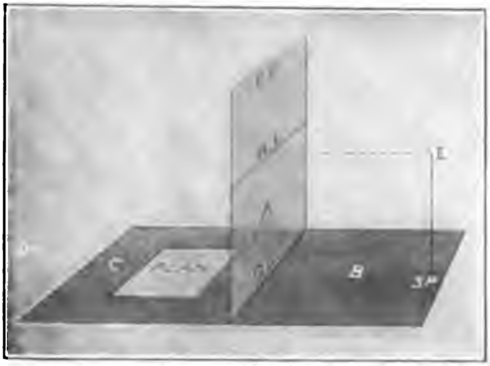


FIG. 49

vision and these points are reached when the arms are at an angle of 90° to each other, or at 45° with your Line of Direction. The field of vision, then, is the area measured by lines drawn from the Station Point at an angle of 45° with the Line of Direction. The points at which these lines meet the Horizon Line are called Distance Points (D.P.). These Distance Points are used as measuring points for certain lines, as will be shown later. (Fig. 48.)

The Relationship of Planes. In mechanical perspective we find that the two most important planes are the Picture Plane (the vertical plane upon which the picture is drawn) and the Ground Plane (an imaginary level plane of infinite extent, some distance below the level of the eye, upon which the object to be represented and the observer are supposed to stand). In Fig. 49, Plane A is the Picture Plane; C and B represent the Ground Plane; the observer stands on one side of the Picture Plane, at S.P., and E represents the position of the eye. The province of mechanical perspective is to project from plans or views of an object a mathematically correct perspective representation of that object. Part C of the Ground Plane (Fig. 49), which is behind the Picture Plane, is used to draw plans upon, and from these plans the perspective representation is projected upon the Picture Plane. It is, therefore, necessary for this part of the Ground Plane to be brought into the same plane with the Picture Plane, and so we must revolve it through a quadrant until it lies over or above the Picture Plane. For the same reason, Part B of the Ground Plane must be revolved through a quadrant until it lies below the Picture Plane. The path of these revolutions is shown in Fig. 50. Fig. 51 shows the arrangement of these planes as they must appear upon our paper, which is the plane upon which all these plans, views and projections must be drawn. Fig. 52 shows a perspective diagram, and Fig. 53 shows how a drawing in parallel perspective is made upon the diagram. In all problems in mechanical perspective there is one invariable rule which

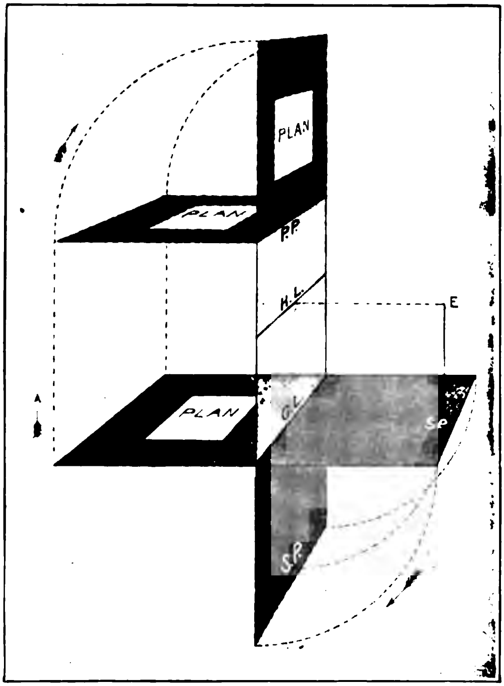


Fig. 50

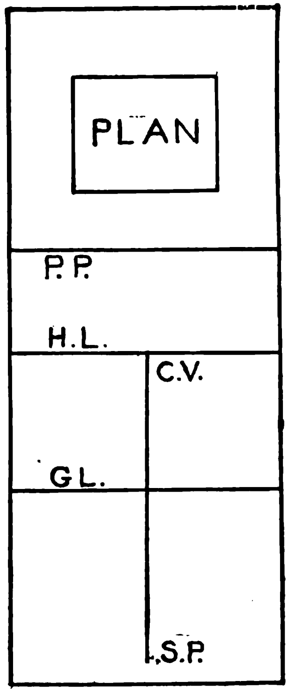


Fig. 51

must be followed: *All measurements must be made upon the Picture Plane.*

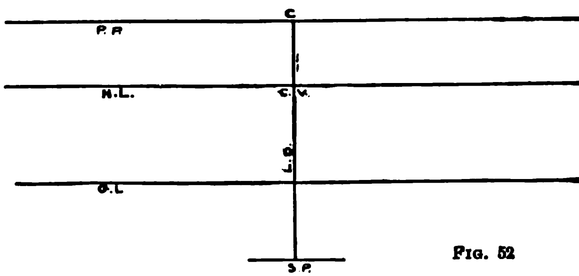


Fig. 52

Parallel Perspective. Parallel or one-point perspective refers to that position of the object which makes use of only one Vanishing Point, and this Vanishing Point is also the Center of Vision. In parallel perspective, the object stands parallel to the Picture Plane, as illustrated in Fig. 53. Here, two cubes of the same size are placed so that their faces are either parallel with or perpendicular to the Picture Plane. They are both at the left of the

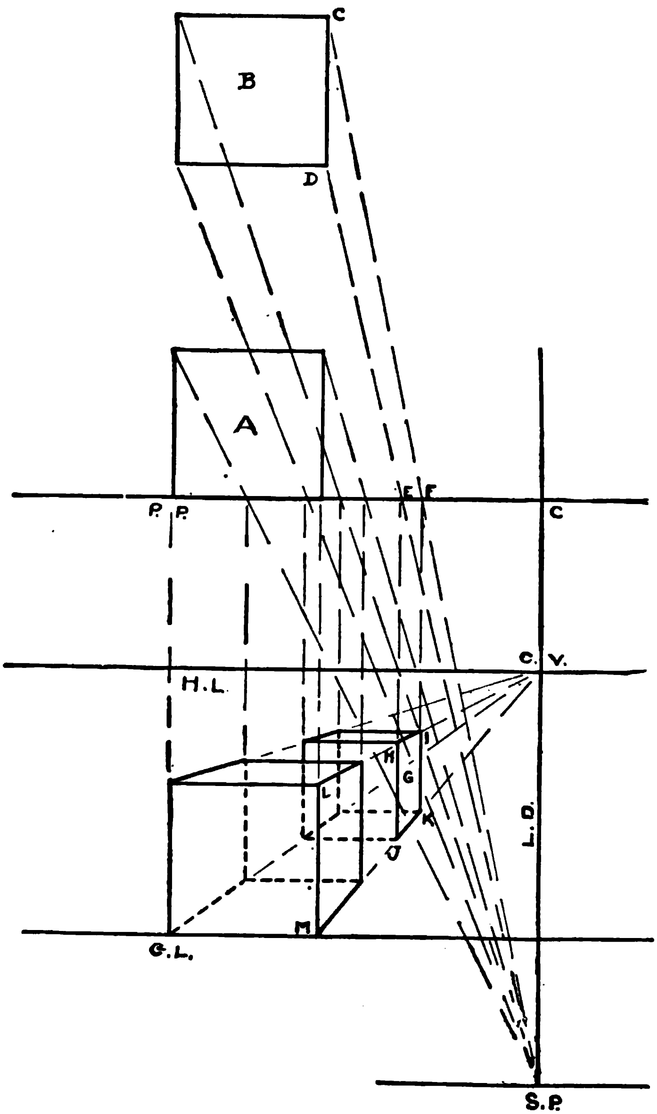


FIG. 58

Line of Direction (L.D.). One is placed against the Picture Plane and the other is some distance behind it.

In order to make a perspective drawing that is mechanically accurate, it is necessary to project all points from the plan to the Picture Plane. In this case A and B are the respective plans of the cubes. The nearest face of the cube is against or in the Picture Plane, and will be shown in its actual size and shape. The farther face of the cube will appear in the Picture Plane in its true shape, but smaller than it really is. The vertical lines remain vertical and the horizontal lines that are parallel with the Picture Plane remain horizontal.

The other faces of the cube are seen obliquely and will not appear in their true shape but will be foreshortened, and their horizontal retreating lines will vanish in the Center of Vision. The apparent width of the faces is determined by drawing lines from points on the plans to the Station Point. Where these lines pierce the Picture Plane will be found *on the Picture Plane* the apparent width of the foreshortened faces of the cube. Projecting these points downward gives us intersections with the vanishing lines that converge to the C.V. For example: lines from D and C drawn to S.P. pierce the P.P. at points E and F. From points E and F, lines projected downward until they intersect the Vanishing Lines from L and M, locate points H, I, J, and K, determining the foreshortened face G, of the second cube. The other foreshortened faces are located in a similar way.

In order to make a correct perspective drawing of an object, it is necessary to know the following facts: —

a. *The actual size and shape of the object.*

b. *Its distance from, and relative position to, the Picture Plane.*

c. *Its distance from, and relative position to, the Line of Direction.*

d. *Its distance from, and relative position to, the Ground Line.*

e. *The height of the eye above the Ground Line; this height also fixes the Horizon Line.*

f. *The distance of the spectator from the Picture Plane; this distance determines the Station Point.*

g. *The scale of measurements used.*

Angular Perspective. Angular, or two-point, perspective refers to that position of the object which makes use of two vanishing points, located upon the Horizon Line. All lines parallel with the Ground Plane, but at any other angle than 90° to the Picture Plane, are in angular perspective, and their vanishing points will be on the Horizon Line, but not in the Center of Vision.

An object in angular perspective is illustrated in Fig. 54. A square prism is placed at an angle of 45° to the Picture Plane, some distance behind it and some distance to the right of the Line of Direction, its top view or plan being represented by A. In drawing the diagram, the P.P., H.L., and G.L. must be parallel. The L.D. must be perpendicular to these lines. The distance between the P.P. and the H.L. may be assumed, and the S.P.

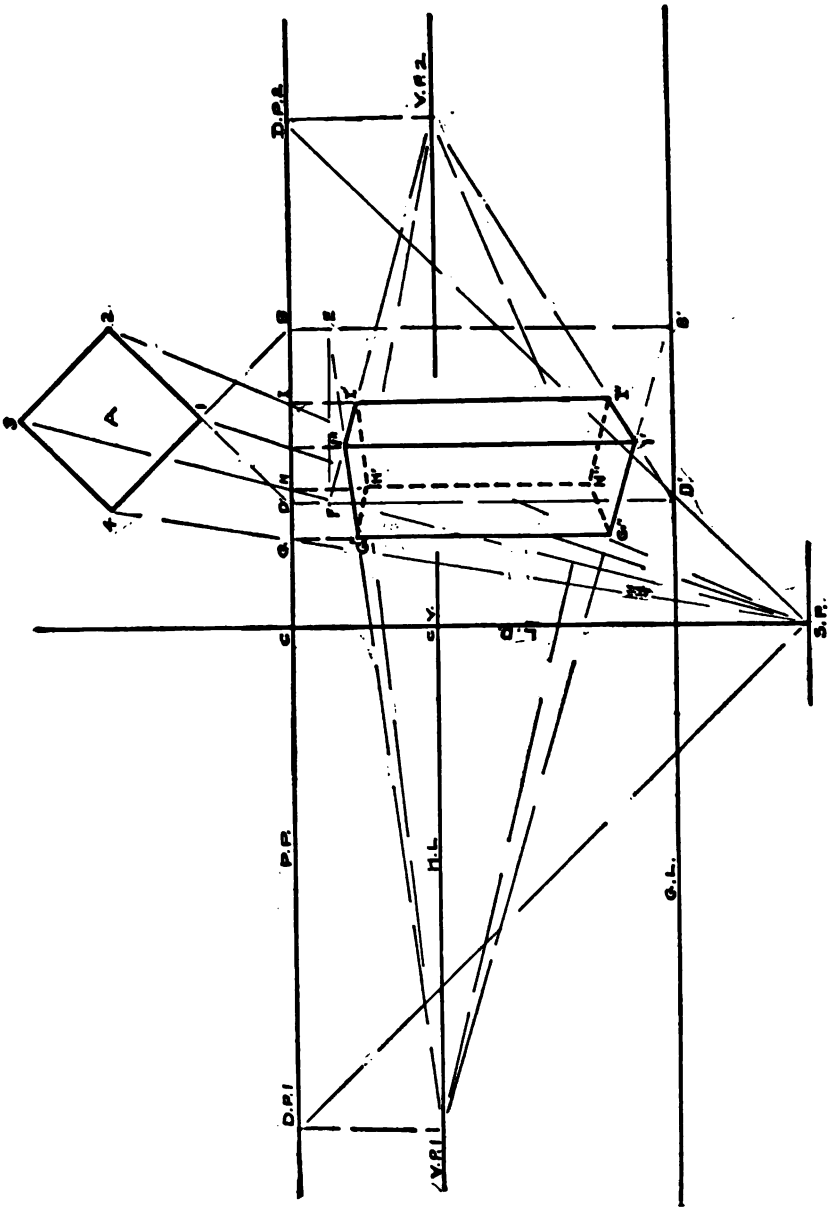


Fig. 54

must be located on the L.D. at an assumed distance below the G.L. The steps in working out the problem are as follows: —

1. Through S.P. draw a line parallel to 1–4, cutting P.P. in D.P.1.

2. Drop a perpendicular from D.P.1 to H.L. establishing the point V.P.1. This is the vanishing point for the perspective of the line 1–4, and for all lines parallel with it, as 2–3.

3. Extend 1–4 to meet P.P. at B.

4. Drop a perpendicular from B to G.L., establishing point B′.

5. Draw a line from B′ to V.P.1. The perspective of line 1–4 will be somewhere in this line. To find the perspective of point 1, the extremity of line 1–4, proceed as follows: —

6. Through S.P. draw a line parallel to 1–2, cutting P.P. in D.P.2.

7. Drop a perpendicular from D.P.2, meeting H.L. in V.P.2.

8. Extend 1–2 to meet P.P. in D.

9. Drop a perpendicular from D to G.L. establishing the point D′.

10. Draw the line D′–V.P.2. The perspective of point 1 lies in this line, D′–V.P.2, — and also in the line B′–V.P.1; therefore, it must be at their intersection, 1′.

11. As this prism is assumed to stand upon the Ground Plane, at some distance behind the P.P., and as we have learned that all measurements must be made upon the P.P., we must measure the height of the prism (assumed to be 4 inches) up from B′, establishing point E.

12. Draw E–V.P.1. The perspective of the line 1–4 will be somewhere in the line E–V.P.1.

13. To find point 1″, measure 4 inches from D′ on the line D–D′, establishing point F Draw F–V.P.2.

The intersection of E–V.P.1 and F–V.P.2 locates 1″, the perspective position of point 1.

14. Draw 1′–1″, the perspective of the nearer edge of the prism.

15. The apparent width of the faces of the prism is determined by drawing lines from the points in the object, as 2, 3 and 4, to the S.P. Where these converging lines pierce the P.P., as in points G, H, and I, will be found the apparent widths. From these points drop perpendiculars to G.L. At the intersection of these lines with the vanishing lines already found, locate G′, H′ and I′, and below G″, H″ and I″.

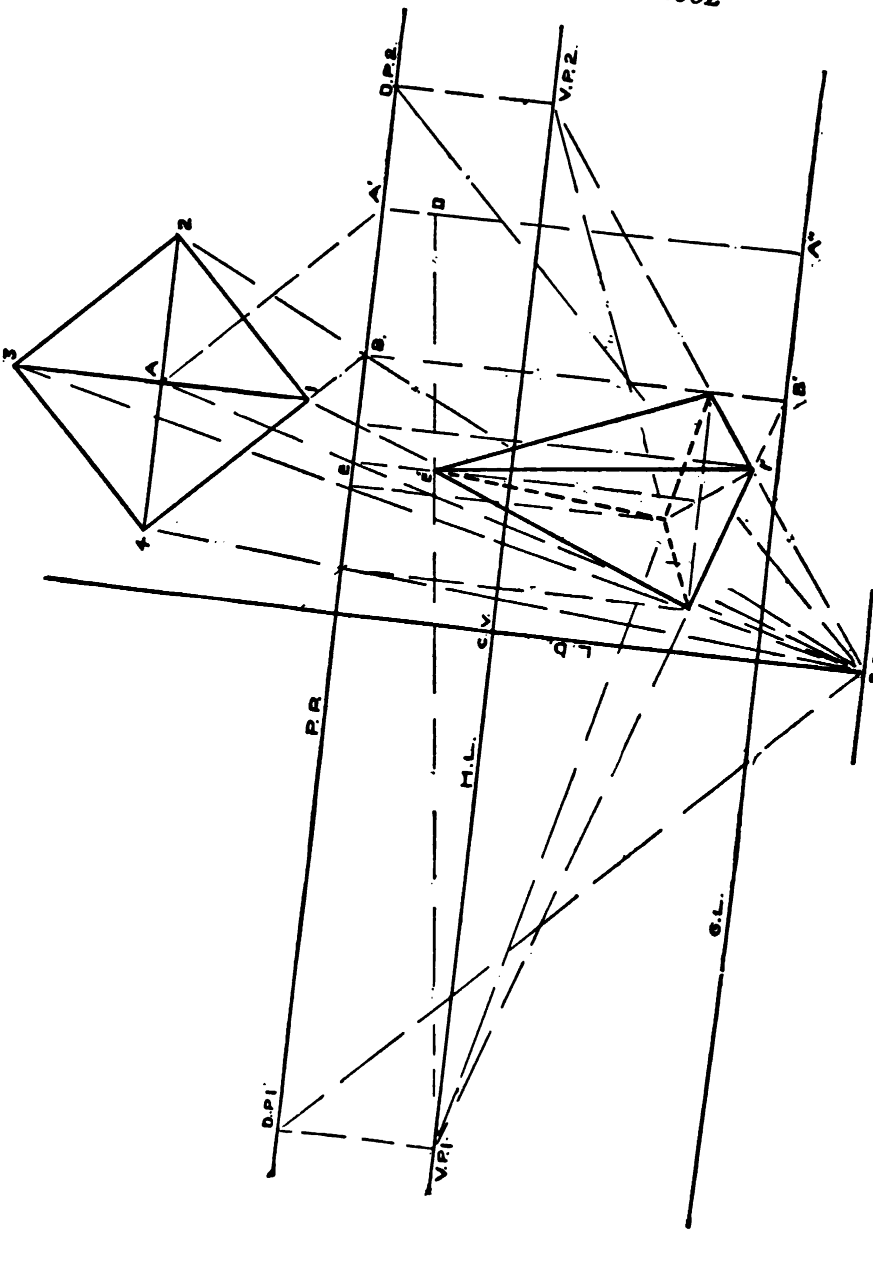


Fig. 55

16. Draw the necessary verticals connecting these points.

After a careful study of the foregoing explanation of Fig. 54, the student should work out simple problems, such as the following: —

Exercise XI. Draw a square plinth measuring 1 foot × 4 feet × 4 feet, placed at an angle of 30° to the P.P., 2 feet behind the P.P. and 2 feet 6 inches to the right of the L.D. S.P. is 10 feet in front of P.P., and 2 feet 3 inches in front of G.L. H.L. is 5 feet above G.L. Scale ¼ inch = 1 foot.

Exercise XII. A square pyramid measuring 2 inches × 2 inches at the base, altitude 3½ inches, is placed at an angle of 45° to the P.P. It is ½ inch behind the P.P. and ½ inch to the right of L.D. S.P. is 5 inches from P.P., and H.L. is 3½ inches above S.P. G.L. is 1 inch above S.P. Scale, full size.

This problem is worked out in the same manner as the problem of the square prism (Fig. 54) with the exception of the location of the apex of the pyramid in the perspective view. To find the perspective of the apex, draw A–A′, parallel to 1–4 (Fig. 55). From A′ drop a perpendicular to G.L., establishing A″. Measure 2½ inches up from A″, establishing point D. A″–D is the altitude of the pyramid, measured on P.P. Draw D–V.P.1. The perspective apex will be at some point on this line. Draw A–S.P., establishing point E on P.P. From E drop a perpendicular intersecting D–V.P.1 in E′. E′ is the perspective apex.

A Building in Angular Perspective. Fig. 56 shows a perspective view of a simple country church, and illustrates the process usually followed by architects in projecting measurements from plans and elevations. In order to obtain all the measurements necessary in making the perspective drawing, we need the side elevation A and the roof-plan B. The roof-plan is drawn at the angle assumed as the point of view of the observer. (In choosing a point of view for a perspective drawing select an angle that will show the building in as comprehensive and advantageous a position as possible.) In this case, the roof-plan is placed a short distance behind the P.P. The S.P. is assumed to be in front of the near corner of the building. D.P.1 and D.P.2, and V.P.1 and V.P.2 were established as in previous examples, already explained. All points from the roof-plan were projected to the P.P., and perpendiculars were dropped from the intersection of these points with the P.P., as in the preceding problems. All vertical dimensions

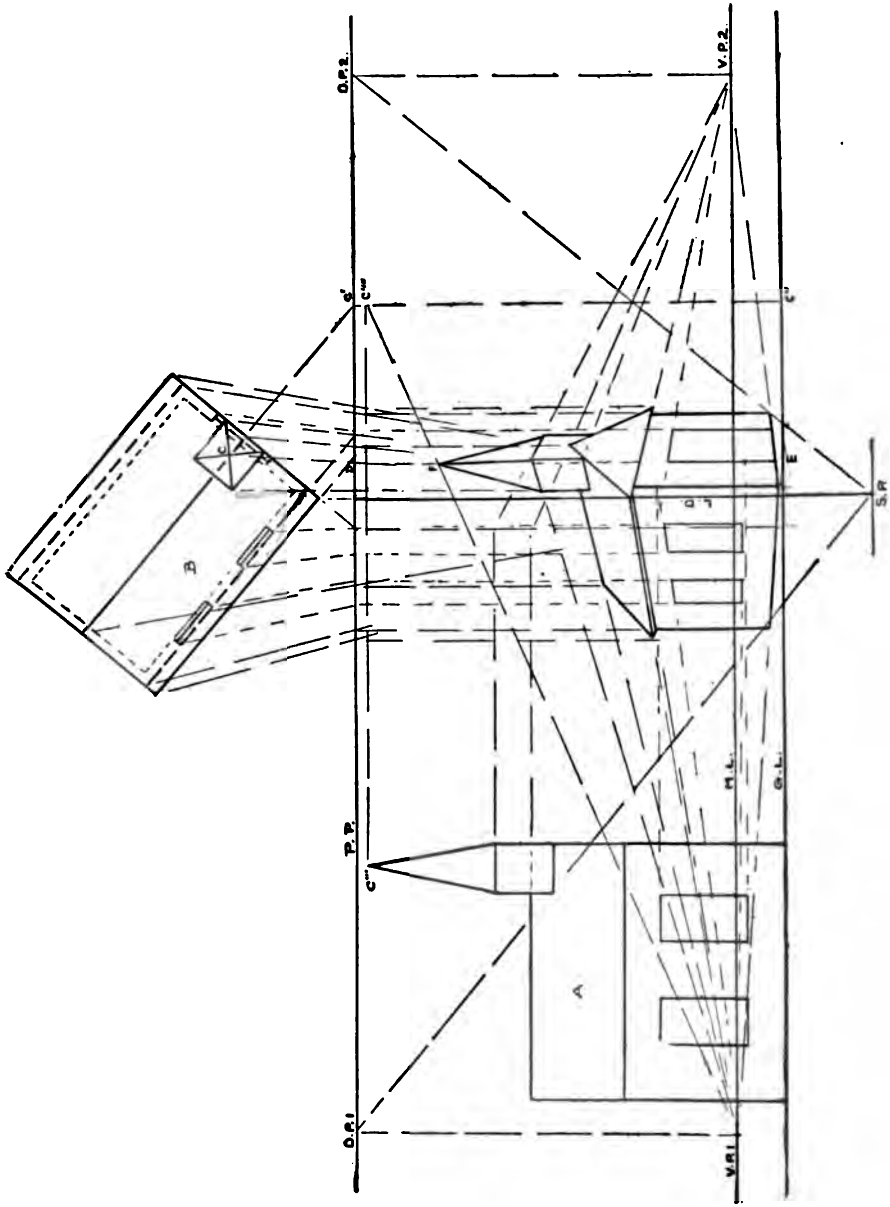


FIG. 56

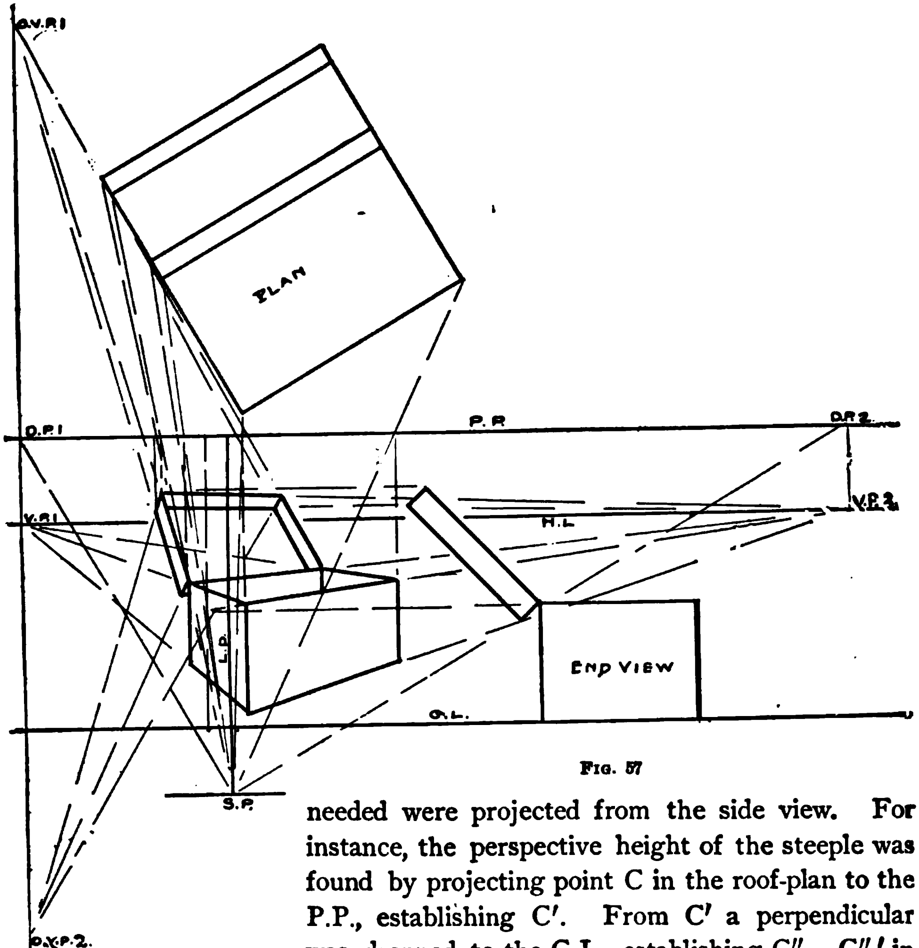


FIG. 57

needed were projected from the side view. For instance, the perspective height of the steeple was found by projecting point C in the roof-plan to the P.P., establishing C′. From C′ a perpendicular was dropped to the G.L., establishing C″. C″′ in the side view was projected to intersect C′–C″, in C″″. Then the line C″″–V.P.1 was drawn. The perspective of the apex of the steeple was at F, the intersection of the line C″″–V.P.1 with the line D–E.

The other points needed were found by a similar process, as shown in the drawing.

Oblique Perspective. All lines that are neither parallel nor perpendicular to the G.L. nor to the P.P. are in oblique perspective. (See "Oblique Perspective," pages 52 to 55.)

Oblique perspective is used mainly in getting the perspective of gables, hip-lines and roof valleys in architectural drawing.

Fig. 57 shows how a box whose cover is in oblique perspective may be drawn with mechanical accuracy, by means of the projection of dimensions and angles from a plan and a side view.

A Pen-and-Ink Sketch of a Building Drawn in Mechanical Perspective from an Architect's Plans

CHAPTER III

FIGURE AND ANIMAL DRAWING

A Brief Course in the Fundamentals of the Subject

Knowledge of Anatomy. In the anatomy of the human figure, as well as in the anatomy of animals, there are a few fundamental facts that may be gained through a brief study of the subject, the possession of which will enable the student to approach the problems of figure and animal drawing with a better understanding of its essentials than art knowledge alone can give him. Painters, sculptors and illustrators find that an extensive knowledge of the location and function of bones and muscles in the human figure is indispensable; for the high school student, however, such exhaustive study is not possible, nor is it necessary to the development of general art knowledge. Such acquaintance with the general proportions, construction and articulation of the human figure should be gained as will enable the student to draw the human form and the forms of familiar animals with intelligence and considerable accuracy.

General Proportions. The head is the basis of measurement and proportion in either the male or the female figure, and the average man measures 7½ heads in height. Fig. 1 shows the general measurements of an average figure as to the heights of the various parts. The upper measurements are: from the top of the head to the base of the chin, 1 head; to the deepest part of the chest, 2 heads; to the rim of the pelvis, 3 heads; to the base of the torso, 4 heads. (In the female figure the base of the torso is a little lower than this measurement.)

The lower measurements are: from the foot to the lower edge of the knee-pan, 2 heads; to the head of the thigh-bone, 4 heads; from the head of the thigh-bone to the base of the torso, ½ head. Adding these proportions, we find the sum to be 7½ heads, the height of the average human figure.

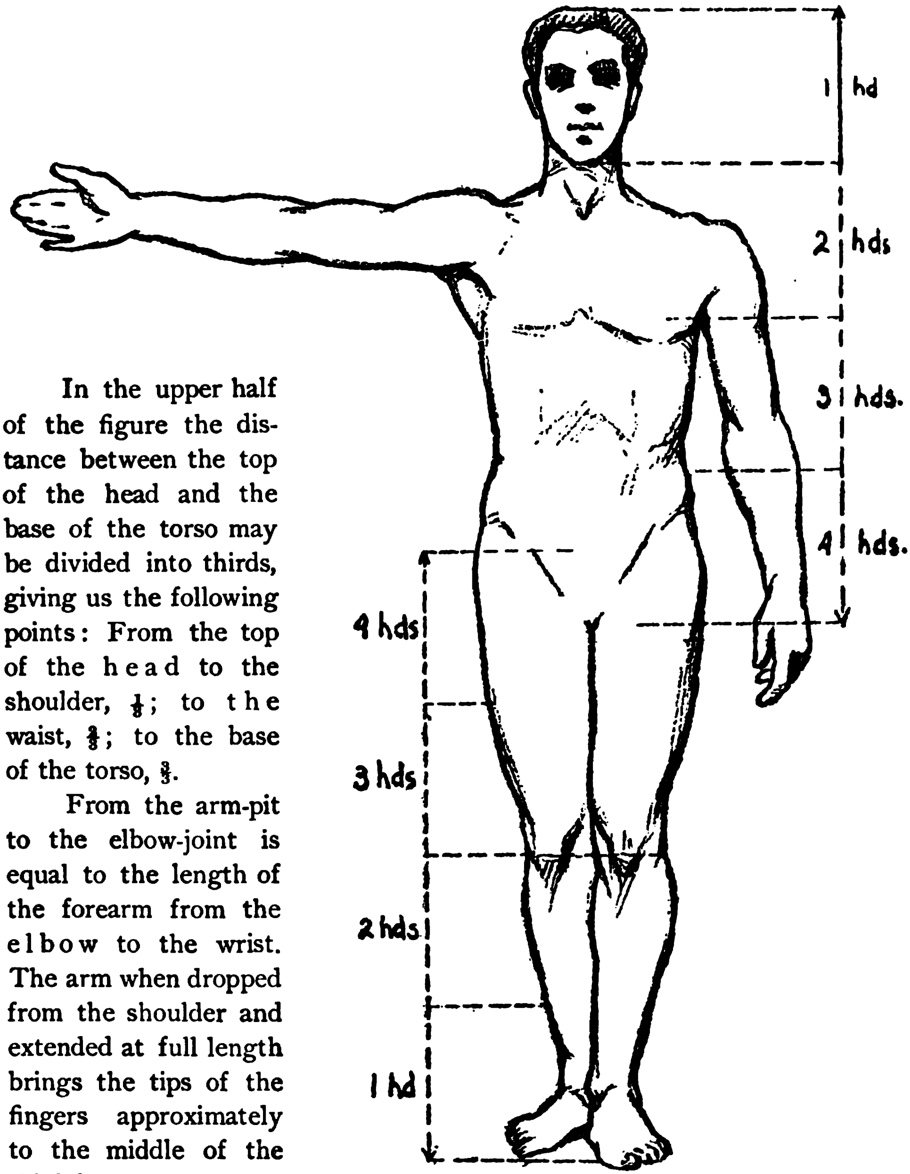


Fig. 1

In the upper half of the figure the distance between the top of the head and the base of the torso may be divided into thirds, giving us the following points: From the top of the head to the shoulder, ⅓; to the waist, ⅔; to the base of the torso, ⅔.

From the arm-pit to the elbow-joint is equal to the length of the forearm from the elbow to the wrist. The arm when dropped from the shoulder and extended at full length brings the tips of the fingers approximately to the middle of the thigh-bone.

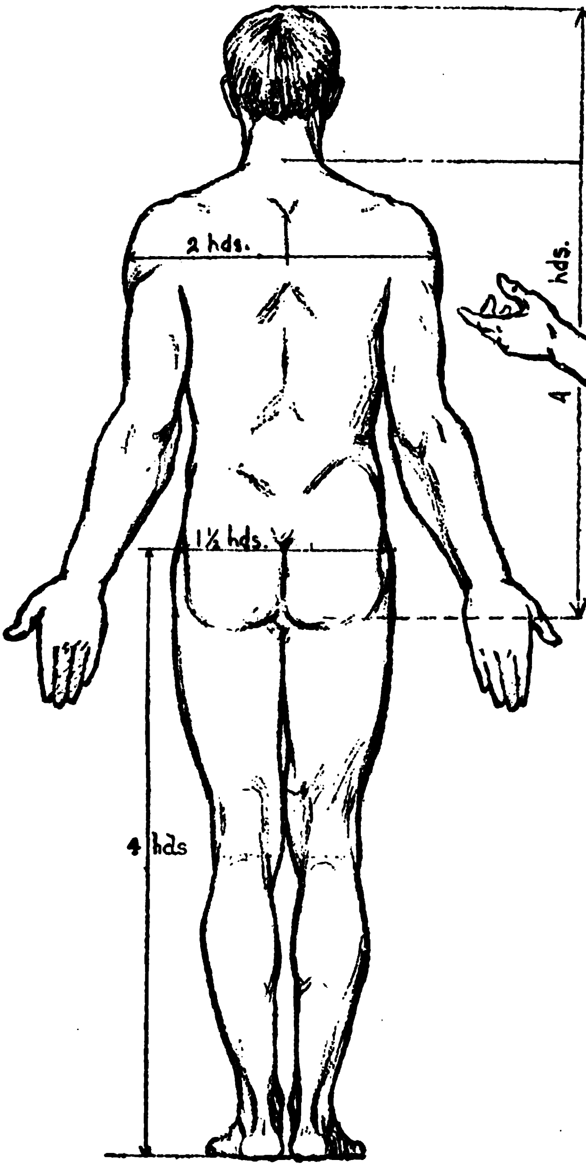


FIG. 2

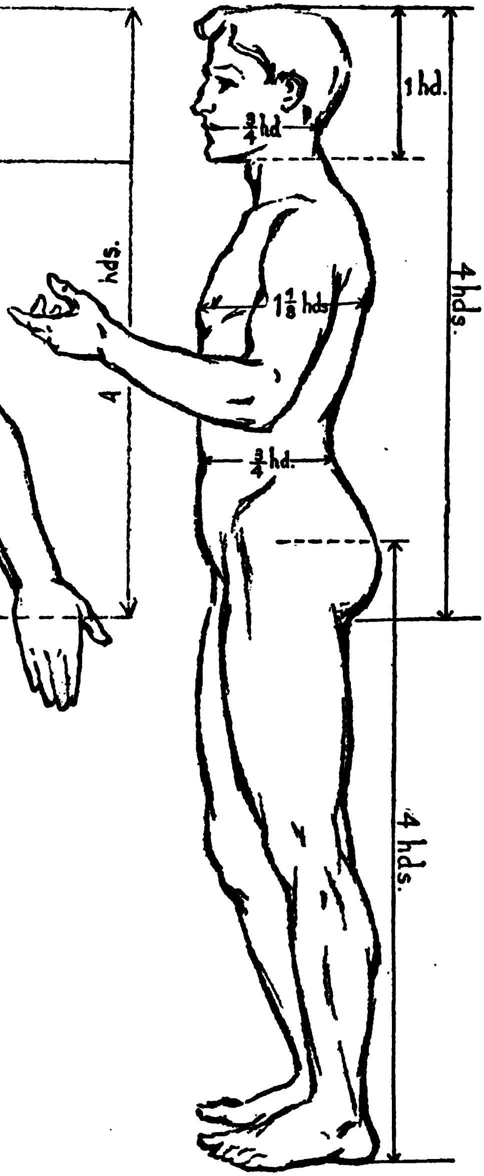


FIG. 3

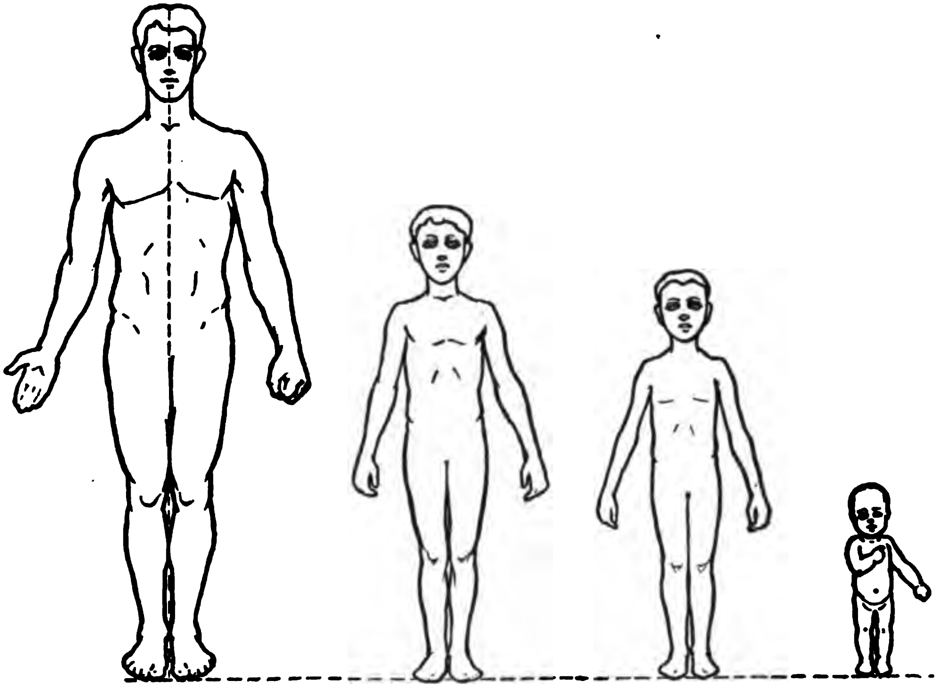


FIG. 4

Proportionate Widths. Fig. 2 shows a few of the important proportionate widths of the figure. The width of the head at the level of the eyes is $\frac{3}{4}$ of a head. The width of the shoulders at their widest point (slightly below the joints) is 2 heads. The width of the hips at the head of the thigh-bone in the male figure is $1\frac{1}{2}$ heads; in the female figure it is $1\frac{3}{4}$ heads.

Proportionate Depths. Fig. 3 shows the human figure in profile, and gives a few of its proportionate depths. From the lips to the back of the neck measures $\frac{3}{4}$ of a head. The chest at its greatest depth measures $1\frac{1}{8}$ heads. The depth of the loins at the rim of the pelvis measures $\frac{3}{4}$ of a head.

Proportions Vary with Age. The proportions of the human figure vary greatly according to age, the measurements already given being the average in the adult. In childhood, we find that the head is much larger, in

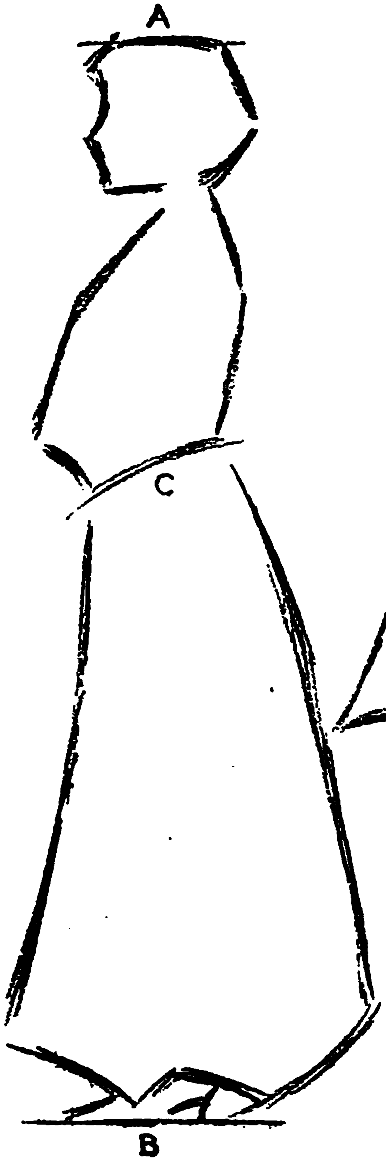


FIG. 5

FIG. 6

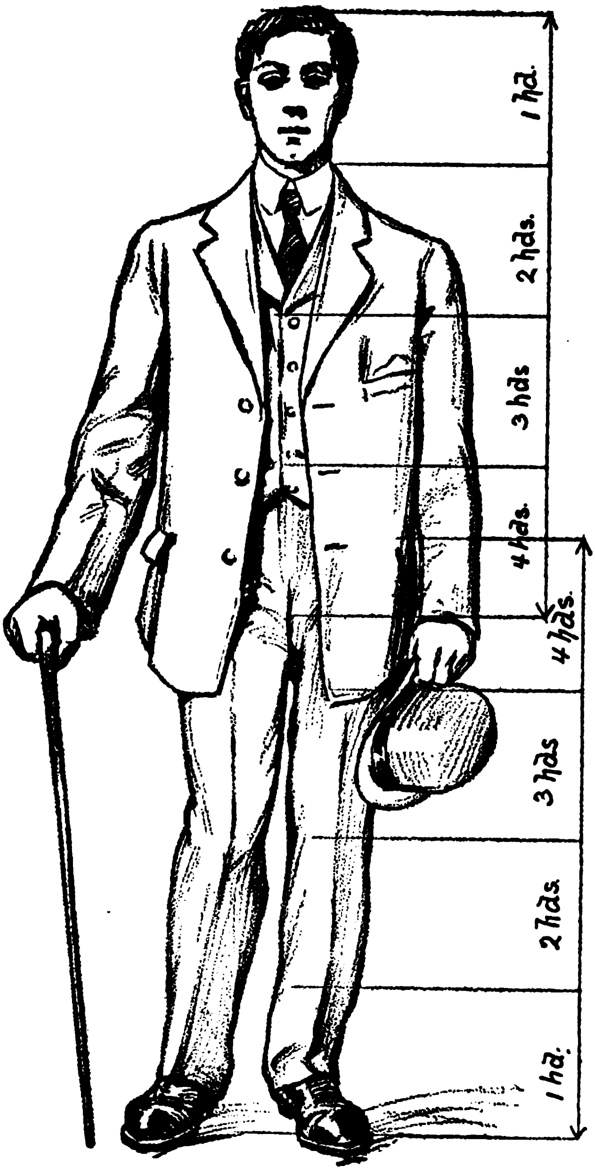


FIG. 7

proportion, than it is when the figure is full grown. Fig. 4 shows the relative proportions of the head to the body at the ages of six months, five years, nine years, and in the adult.

Exercise I. Make sketches from grown people, at home or in school, as shown in Figs. 5, 6 and 7. Begin by making dashes to locate the top of the head and the level of the feet, as A and B in Fig. 5. Locate some very apparent line, such as a waist-line, a vest-line, or the line of a coat or jacket, about midway between the dashes A and B. (See C, in Fig. 5.) Block in the main masses of the head, torso, skirt, etc. Verify these shapes and measurements by referring to the diagrams given in Figs. 1, 2 and 3. Show only proportions of the figure, not details.

Exercise II. From one of your schoolmates posed in profile make a

FIG. 8

FIG. 9

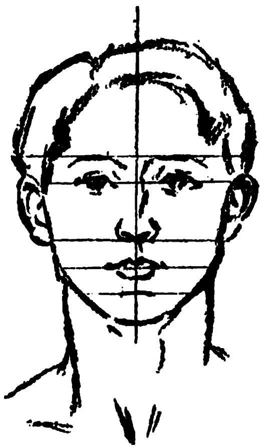


FIG. 10

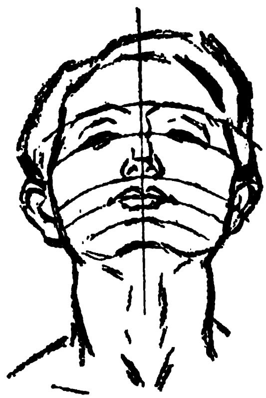


FIG. 11

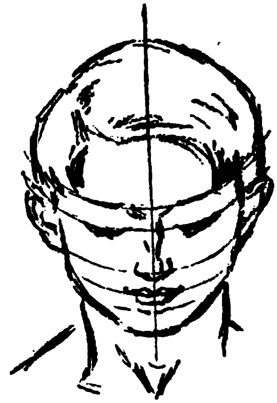


FIG. 12

similar study, as shown in Figs. 8 and 9. Remember that when the figure is not full grown, the head is larger in proportion to the body. The sketch shown in Fig. 8 represents a boy that was seven heads high.

Proportions of the Head and Features. The general shape of the head is like an ovoid with the greatest width at the top. The eyes are located half-way between the top of the head and the chin. The nostrils are half-way between the eyebrows and the chin. Dividing the distance between the nostrils and the base of the chin into thirds locates the opening of the mouth and the upper limit of the chin. (See Fig. 10.) The space between the eyes is equal to the width of an eye, which is also the width across the lobes of the nose. The top of the ear is about on a level with the eyebrow, and the lower edge of the ear is about on a level with the end of the nose. All these measurements must be considered as approximate only, but they are of great service as aids to accurate observation.

In Fig. 11 the lines that are drawn to locate the features may be considered as circles extending around the ovoid form of the head. When the head is tipped back, these circles become, in perspective, ellipses, and it is interesting to note that they still locate the features, and give us a correct idea of foreshortening. Fig. 12 shows the head tipped forward, and the lines of the ellipses take the opposite curve.

Exercise III. In order to become familiar with measurements given above, make enlarged copies of Figs. 10, 11 and 12.

Exercise IV. From the pose, make a drawing of the head, verifying the measurements given in Fig. 10. In finishing the sketch, the lines locating the features may be erased.

Action. When the figure is seen in different positions, such as in bending, kneeling, etc., the measurements and proportions of the different parts seem to be changed. This is because of the effect of perspective. The real proportions do not change. The human figure, in its various positions is affected by perspective in the same way that any other object is affected, and in sketching an attitude that brings foreshortening into the question we must remember that appearances are often very different from facts. In the statue shown in Fig. 13, all parts impress us as being in correct proportion, yet we could apply the unit of measurement (the head) only to the legs from the knee down, and to the upper part of the left arm, because all the other parts are turned, and are foreshortened. The head itself is bent forward, and does not appear in its true height. The torso is also inclined. The upper part of the right leg, the lower right forearm, the hands and the left foot are greatly foreshortened and are not measurable by ordinary means. Yet we know that the parts have not actually changed their proportions or measurements; — they only appear to have done so, in the same way that the faces of a cube retain their true measurements, although, in perspective their appearance is so much changed.

The side view of a sitting figure is not difficult to draw, as in this position there is little foreshortening, and most of the parts appear in their true length (See Fig. 14).

Exercise V. From the side view of a boy, sitting, and engaged in some action, such as whittling, hammering, fishing, reading or writing, make a sketch. Draw first light lines that will indicate the swing or direction of the figure, as shown by the lines A, B and C in Fig. 15. Upon these lines, block in the head, and the general shapes of the waist, the trousers, the legs, etc. Test the measurements, make the necessary corrections, and lay in the values, somewhat as indicated in Fig. 16.

Balance. In all standing figures the center of gravity should pass through the supporting foot, or between the feet, if they support equally.

FIG. 13

FIG. 14

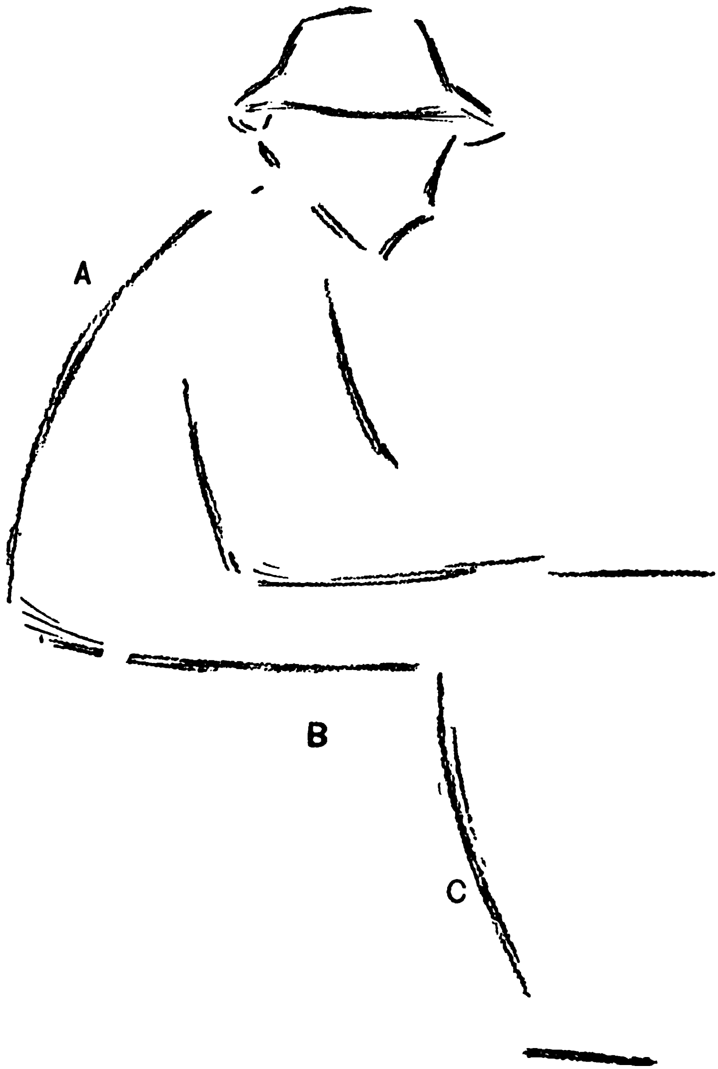


Fig. 17

FIG. 16

FIG. 17

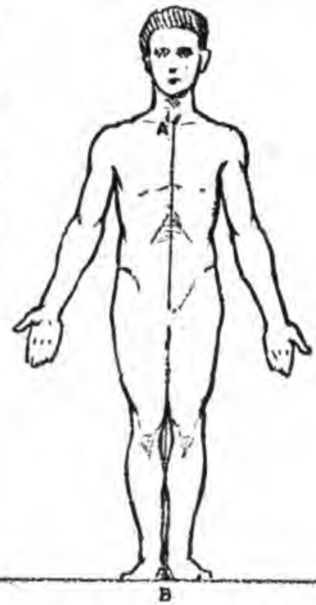


FIG. 18

FIG. 19

In a figure that is merely supporting its own weight this point is immediately below the pit of the neck (Figs. 17 and 18). The extent to which a figure is thrown forward, back, or to one side does not alter this rule, so long as the figure is stationary (see the line AB in Fig. 19). When a figure is carrying a weight, the line that indicates the center of gravity is shifted in a direction opposed to the force of the weight. For example, in Fig. 20 the weight on the back throws the line AB (which marks the center of gravity) to the right, and it falls outside the foot-base; in Fig. 21, the weight of the dumb-bells is held in front of the figure, and the center of gravity falls behind the feet; in Fig. 22 the weight is carried in the left hand, consequently the center of gravity is found at the right. If the weight in the left hand were increased, the center of gravity would fall still further to the right. We see that the figure is thrown out of normal balance in proportion to the force opposed to that balance.

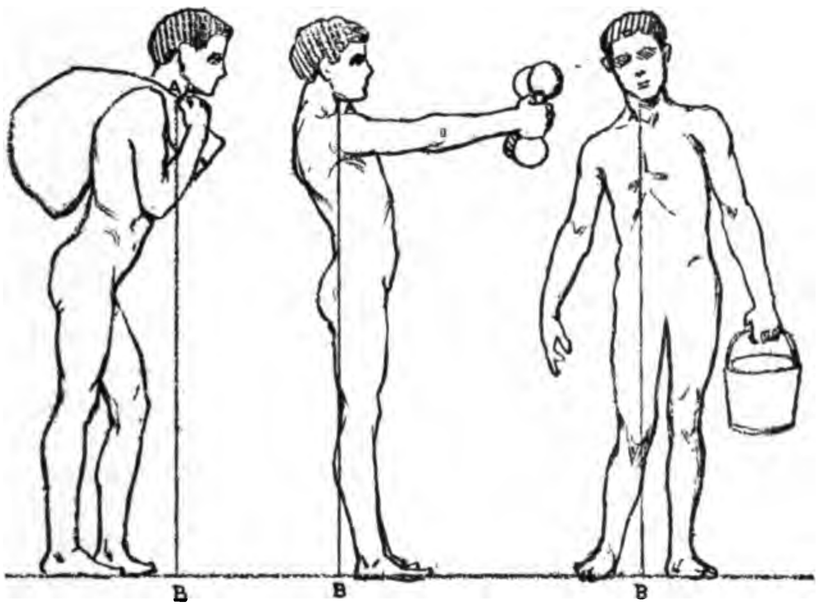


FIG. 20 FIG. 21 FIG. 22

A loss of balance creates motion; this may be voluntary, as in walking or running, or involuntary, as in falling. The extent to which a figure is thrown out of balance indicates the rapidity of the motion. This is shown in Figs. 23 and 24, where the motions of walking and running are illustrated. By comparing these two sketches it will be seen that the difference between these actions is not alone in the position of the legs, but that other parts of the body are affected as well. In running, the more intense action is shown in the forward thrust of the head, the stiffening of the muscles of the neck and back, and in the increased action of the arms. When a man throws a ball it is not alone by the position of his arms that the action is expressed, but by the position and action of the head, torso and legs; the torso is bent back and turned, the left leg is raised from the ground in the effort to balance the torso, and there is a combined action of all the muscles in the body, in the effort to hurl the ball (Fig. 25).

Exercise VI. Draw one of the school-boys in the act of carrying a

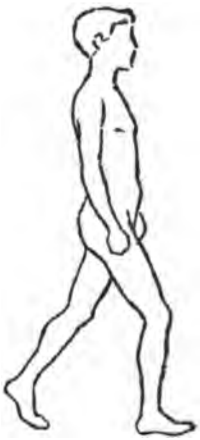


FIG. 23

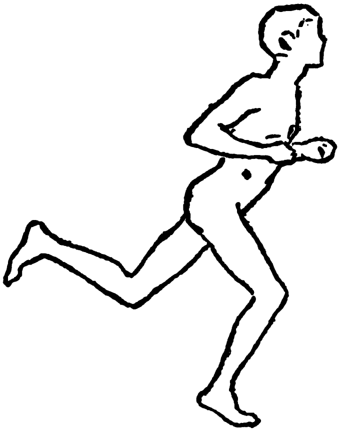


FIG. 24

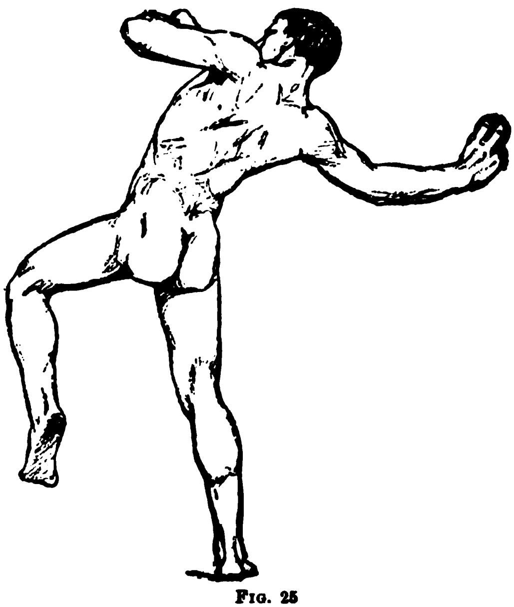


FIG. 25

pail of water or a valise. Note the location of the center of gravity, and the position of the head, torso, opposite arm, etc.

Exercise VII. Draw from the pose a girl sweeping or writing upon the blackboard. Sketch the action lines, and block in the main shapes, comparing one part with another, as you work. Finish the sketch in values.

Bone Construction. When we attempt to draw the figure in action, we find that a knowledge of the skeleton and its construction is essential, in order that we may know where and to what extent action may take place. Bones, we know, are rigid, and have of themselves no power to move. Action is produced when bones articulate with one another by means of muscular contraction. This articulation is much more pronounced in some parts of the body, as, for instance, in the arms, legs and neck, than it is in others.

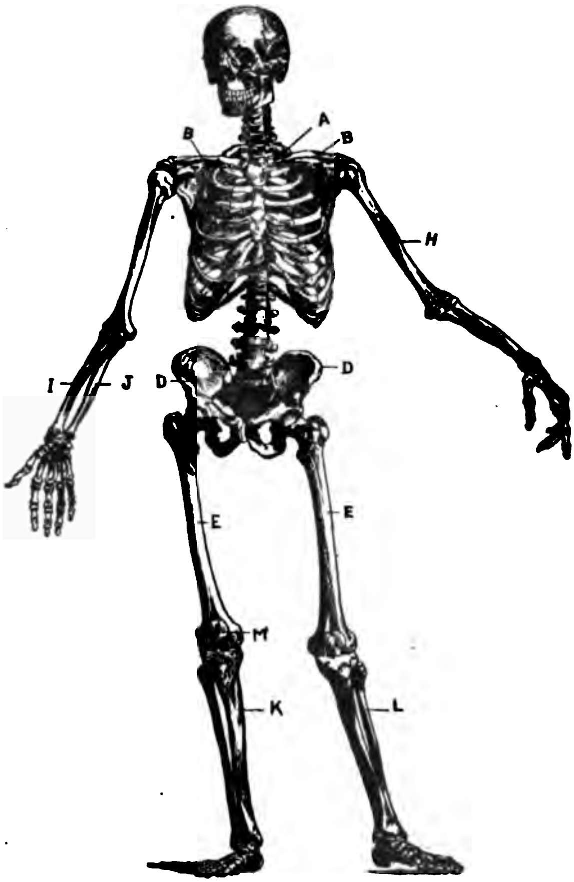


Fig. 26

Beginning with the skull, we find that it measures about $\frac{1}{8}$ of the height of the figure. The difference between this measurement and the measurement of the head, previously given, is accounted for by the allowance made for muscle and hair. With this exception, the measurements of the figure as before stated apply also to the measurements of the skeleton. Figs. 26, 27 and 28 show the front, side and back views. The skull is placed at the top of the spinal column or backbone, which is composed of bony rings, each capable of slight movement, one upon the other. It runs a little below the middle of the figure, and is slightly curved, as shown in Fig. 27. The spine is the supporting column of the figure, and to it the ribs are attached at the back (Fig. 28). With the exception of the two lower pairs, the ribs are attached in front to the breast-bone, or sternum (see A Fig. 26). The collar-bone, or clavicle (B, Figs. 26 and 28), is attached to the top of the breast-bone and reaches to the shoulder, where it forms a socket with an extension of the shoulder-blade, called the scapula (C, Figs. 27 and 28). The shoulder has no other articulation with the skeleton, its further attachment being by muscles only.

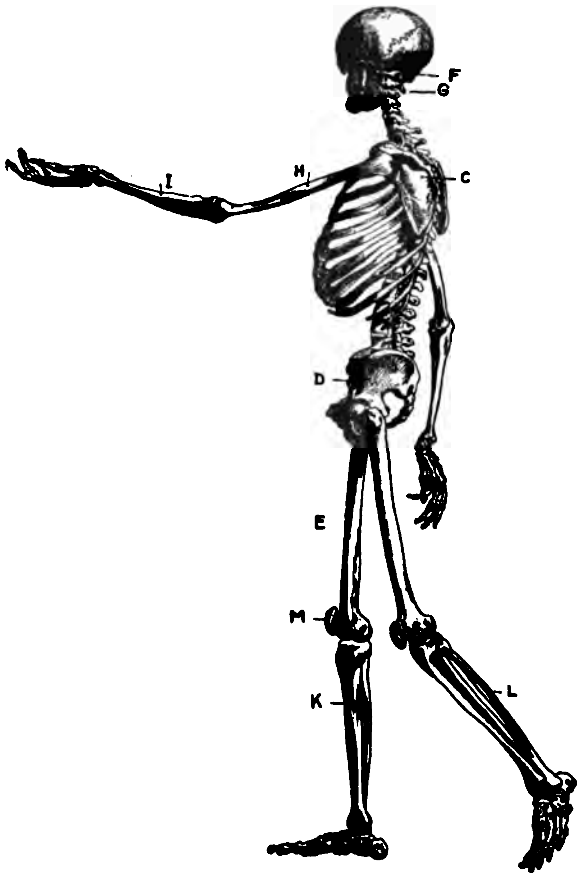


FIG. 27

The spine extends below the casing of the ribs, and is finally consolidated and joined to the pelvis (D, Figs. 26, 27 and 28), which is a basin-shaped bone supporting the spinal column. At its lower outside margin is a deep socket into which the thigh-bone, or femur (E, Figs. 26, 27 and 28), is inserted. Both the arm and the leg have one bone in the upper portions and two bones in the lower portions, as shown in the drawings already referred to.

In looking at these sketches of the skeleton, it is not difficult to see in what places motion is possible and in what places it is impossible. The two upper vertebræ of the spinal column are so constructed as to give unusual movement to the neck. The upper vertebra, called the atlas (F, Fig. 27), allows the head to move forward and back, while the second vertebra (G, Fig. 27), called the axis, forms a pivot-like joint, around which the head may rotate. The shoulders have great freedom of movement and can be raised to the level of the jaw, thrown forward or pushed back and depressed. In the ribbed portion of the trunk there is little motion, but at the waist the figure can bend forward and back, it can incline to either side, or it can partly turn with a rotary movement. The pelvis itself has no motion.

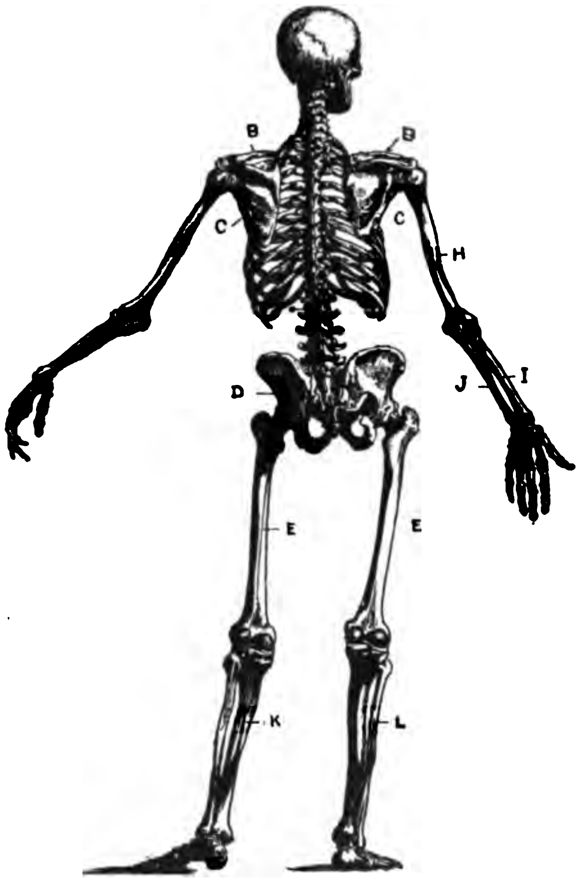


FIG. 28

In the arms there is far more freedom of movement than in the legs, because of the free articulation of the shoulder socket. The arms and legs articulate at the elbows and the knees. The upper bone of the arm is called the humerus (H, Figs. 26, 27 and 28). As has been said, in the lower portion of each is introduced a second bone, giving a rotary motion, and allowing the wrist and ankle to turn from side to side. In the arm, this second bone, the radius (I, Figs. 26, 27 and 28), rotates around the head of the ulna (J, Figs. 26 and 28), the bone that makes a hinge-joint with the humerus, and forms at the wrist a pivot, around which the radius rotates. This construction enables the hand to twist and turn. In the ankle there is less freedom of movement, as the bone tibia (K, Figs. 26, 27 and 28) makes both the knee-joint and the ankle-joint, and the second bone, called the fibula (L, Figs. 26, 27 and 28), while it permits some freedom of movement, is not able to communicate its action to the foot.

In the front of the knee-joint is a small, flat, round bone called the tympanum (M, Figs. 26 and 27), which is attached by tendons to the leg bones. This forms the prominent part of the knee.

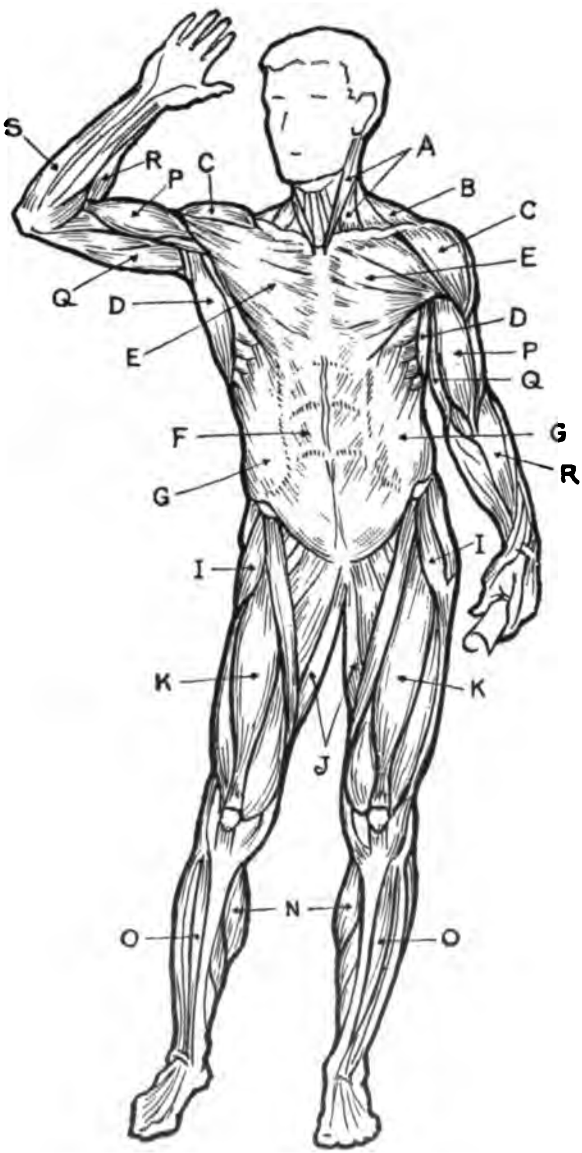


Fig. 29

Muscles. We have now a general idea of the human skeleton and of its capacity for action. The bones themselves, we have seen, have no capacity for action but depend for movement on muscular contraction. A student who desires to make a serious study of the figure should become familiar with at least as many of the muscles as are shown in Figs. 29, 30 and 31.

Figs. 29, 30 and 31 show the front, back and side views of the muscular system.

A, Figs. 29, 30 and 31, is the sterno-mastoid muscle, which draws the head forward.

B, Figs. 30 and 31, is the trapezius, which draws the head back.

C, Figs. 29, 30 and 31, is the deltoid, which lifts the arm.

D, Figs. 29, 30 and 31, is the latissimus dorsi, which draws the arm down and back.

E, Figs. 29 and 31, is the pectoral, which draws the arm and shoulder forward.

F, Fig. 29, is the rectus abdominis, which draws the body forward.

G, Figs. 29, 30 and 31, is the external oblique, which draws the body laterally and assists in the expiration of the breath.

H, and I, Figs. 30 and 31, are the gluteus and tensor muscles, which, when acting together, hold the body erect. When the gluteus acts alone, the thigh is drawn backward; when the tensor acts alone, the thigh is drawn forward.

J, Figs. 29 and 30, is the gracilis muscle, which helps to bend the leg, and assists in bringing it and the thigh inward.

K, Figs. 29 and 31, is the rectus femoris, which straightens and extends the leg.

L, Fig. 30, is the semi-tendinosus, which helps to bend the leg.

M, Figs. 30 and 31, is the biceps femoris, which also helps to bend the leg and assists in turning the

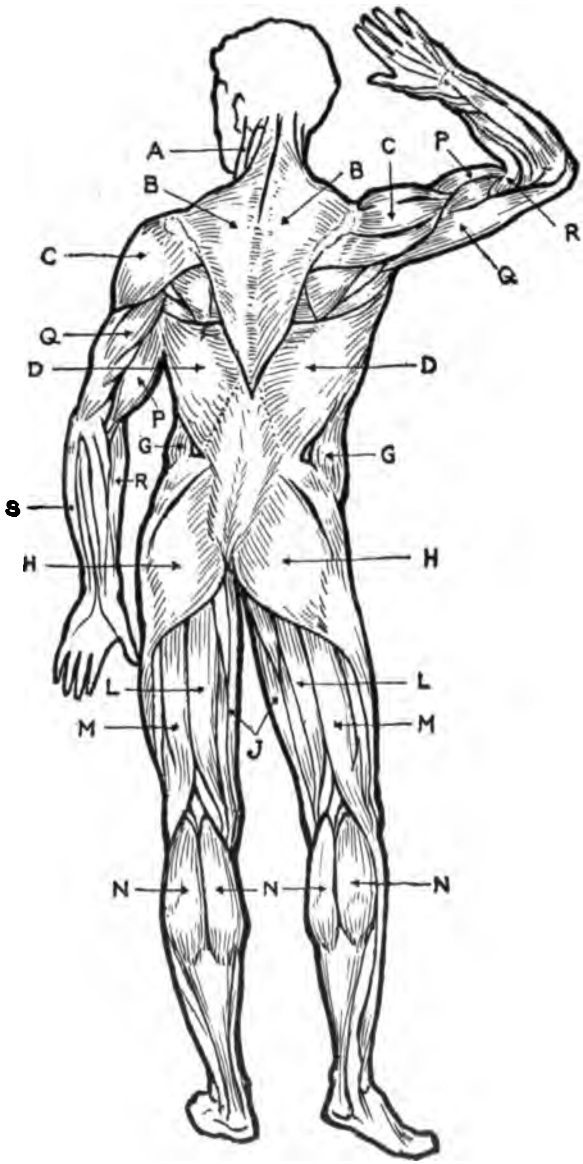


FIG. 30

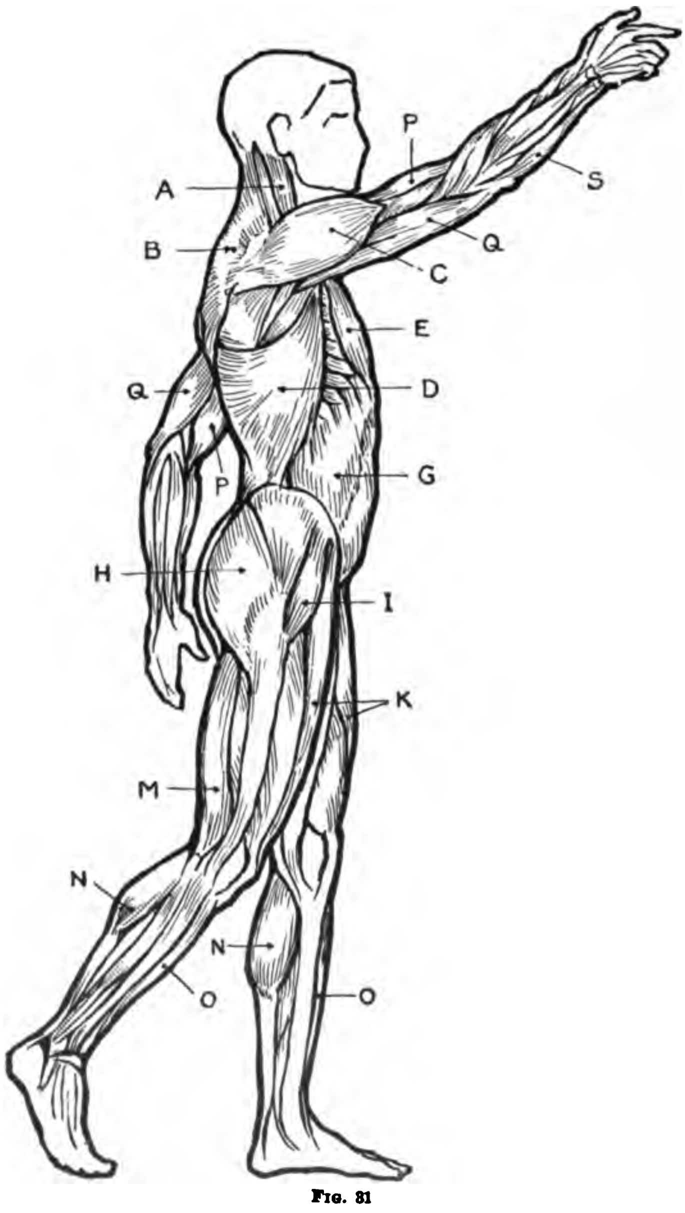


Fig. 31

leg and foot outward, when the figure takes a sitting position.

N, Figs. 29, 30 and 31, is the gastrocnemius, which ends in the tendon achilles, and raises the heel, as in walking, running or standing on tiptoe.

O, Figs. 29 and 31, is the tibialis anticus, which raises the front of the foot.

P, Figs. 29, 30 and 31, is the biceps, which raises the lower arm.

Q is the triceps, which straightens the forearm and opposes the action of the biceps.

R, Figs. 29 and 30, is the supinator longus, which rolls the radius bone outward and the palm of the hand upward.

S, Figs. 29 and 31, is the flexor carpi ulnaris, which extends the wrist and hand.

In applying the knowledge we have gained of the proportion, action, balance and construction of the human figure to drawing from the pose, we are often perplexed because the clothing obscures many of the principal joints and qualifies to some extent the ratio of proportions. The uncertainty of measurement in the clothed figure is, however, only additional proof that the student needs some definite knowledge of anatomy to keep him from making absurd blunders in locating or indicating important joints, etc. If we possess even a limited amount of scientific knowledge of the points covered in this chapter, we will look at the pose, not as a mass of unintelligible lines and uncertain proportions, but with an effort to locate the essential features of construction and action that every figure must contain. When we know where to look for these points we shall find that much of the construction of the figure is apparent through the clothing, and is often measurable.

Exercise VIII. On tinted paper make a pencil sketch from the pose of a boy sawing a board. The pose may appear with shirt sleeves rolled up, with a soft hat, and with some note of color, as for instance in the necktie. Sketch in the figure as heretofore directed, getting the action lines first, then blocking in proportions. Finish in values, adding suggestive touches of white chalk and color as the costume demands.

Exercise IX. On tinted paper sketch from the pose of a boy at a manual training bench. The pose should be in the act of planing, using chisel and mallet, boring a hole with brace and bit, etc. Use charcoal for this sketch. After the work has been sprayed with fixative, color effects may be added with thin washes of water-color (care being taken to lay them evenly and accurately).

Exercise X. Sketch from the pose of a girl drinking tea from a cup, holding the saucer in the left hand. The girl should be dressed in white, with a note of color, such as a tie, a bow in the hair, etc. (The cup and saucer might carry a note of blue color.) Sketch the outlines in pencil, and put in the mass of the costume in white chalk, modelling the waist, the sleeves and the skirt the same as in pencil rendering, instead of laying the chalk on in a flat tone.

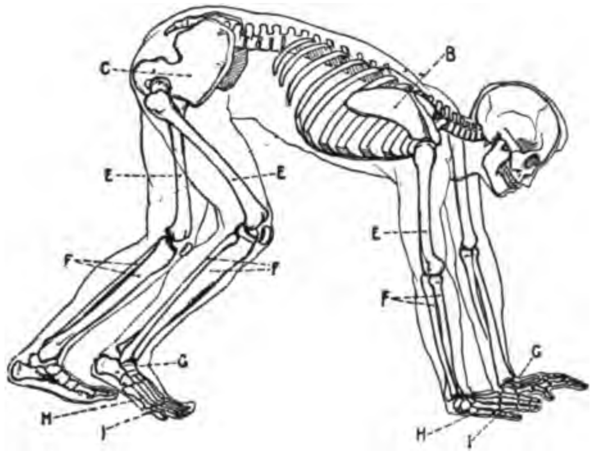


FIG. 32

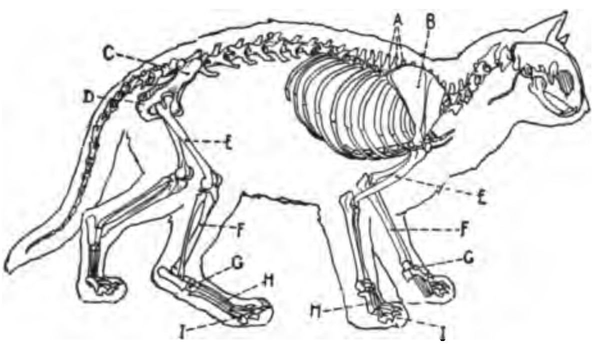


FIG. 33

Exercise XI. Sketch from the pose of a child pulling a toy horse, wagon, etc. Use tinted paper as before, and show a color note in the toy or in some part of the costume.

Exercise XII. Sketch from the pose of a child sitting or kneeling. (Marbles, building blocks, boat-sailing and looking at picture-books are suggested as interesting occupations.) Use tinted paper, pencil, chalk or color to gain effects.

Other suggestions for figure drawing are:

Draw from the pose of the teacher at her desk; from the teacher standing; from the teacher bending over an easel or desk; from the teacher arranging a group of still-life; from the janitor using his brushes and brooms; from the engineer at the furnace; from workmen about the building; from a boy playing hockey; from a girl stirring cake in a large yellow bowl with one or two blue bands; from a man reading a newspaper; from a woman sewing, or hanging up clothes, etc., etc. All of these suggestions are capable of interesting manipulation, if done on tinted or bogus papers, with charcoal, pencil, white chalk, colored crayons or water-colors.

Anatomy of Animals. If we are familiar with the bone construction and the muscular system of man, we shall find that we have a general idea, also, of the skeletons and muscles of the vertebrate animals, for between the anatomy of man and that of the animals there is much in common. Owing to the difference in posture and to the different habits of life, there is necessary in the animals some readjustment and modification of the parts, but the general plan we shall find to be the same.

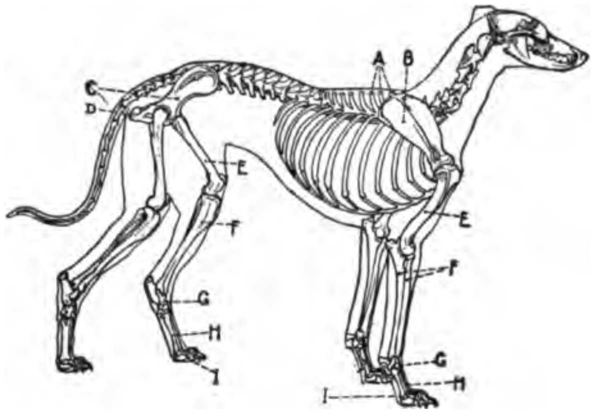


FIG. 34

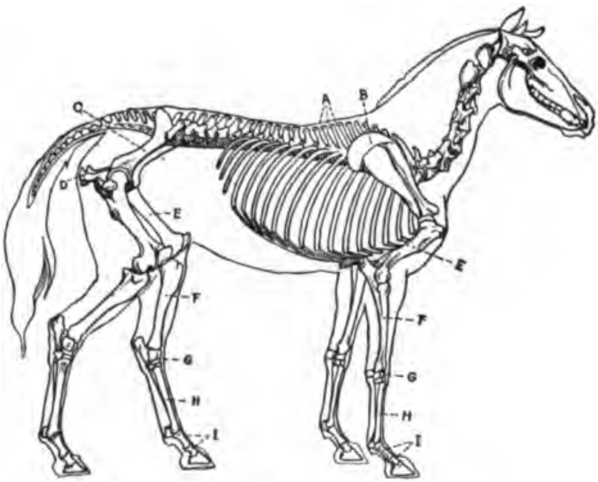


FIG. 35

Fig. 32 is the skeleton of a man in the position of a quadruped. By comparing this figure with Fig. 33, which is the skeleton of a cat; with Fig. 34, the skeleton of a dog; with Fig. 35, the skeleton of a horse; and with Fig. 36, the skeleton of a cow, we see at once the general similarity of plan. Each has a skull, backbone, ribs, pelvis and limbs. There are, of course, great differences in the shapes, sizes and proportions of the individual bones, for the habits and necessities of different animals vary greatly. The skull of man, for instance, has a larger brain capacity than we find in the animals, while the other parts of the skull, such as the jaws, the nose, etc., are much smaller in proportion. In the elongation of the spines of the vertebræ,

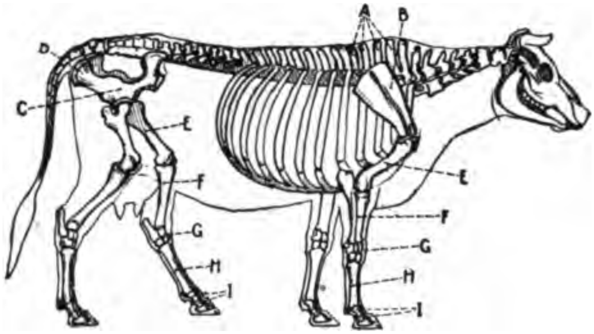


FIG. 36

shown at A, in Figs. 33 to 36, we see the provisions made for the attachment of the large muscles that are necessary to hold the head in a horizontal position. We note, also, a difference in the slant of the scapula, B, in Figs. 33 to 36. Its position is more nearly vertical than in man (Fig. 32), where the same bone is nearly horizontal, producing an effect of squareness in the shoulders. Again, animals have a larger ribbed portion than man, and this makes possible an increased lung capacity. The pelvis in animals (C, Figs. 33 to 36) is much smaller in proportion than is the corresponding bone in man. The large protuberances at the back of this bone (D) are for the attachment of the large muscles of the leg. The greatest difference between the skeletons of man and the animals is seen in the legs, although when we make a careful comparison we find, even in the limbs, a great similarity of construction. The arms in man may be said to correspond with the fore-legs of animals. While it is true that the bones in the upper leg of the animals (see E in Figs. 33 to 36) are much shorter than the corresponding bones in man, they closely resemble the human bones in other respects. In the bones marked F in the animal skeletons, corresponding to the two lower bones of the human arm and leg, there is a greater difference, and this variation continues in the animals themselves. The carnivorous animals, which are digitigrades (that is, animals with paws, and that walk upon their toes), still have the two bones in the lower leg, as will be seen in the bones marked F in Figs. 33 and 34. The herbivorous animals, which are ungulates (animals having hoofs) have the two bones in the fore-legs, although the second bone is somewhat rudimentary, while in the hind-legs the bones F are fused into one (Figs. 35 and 36). In Figs. 33 to 36 there is a group of bones marked G, corresponding to the human wrist and ankle bones. The bones marked H correspond to the tarsal and metatarsal bones—the bones of the human hands and feet.

In these last bones there is much variation among the animals. In the hoofed animals, they are fused into one, and are very much elongated; in the animals with paws they are still elongated, but remain separate. The bones marked I in the animal skeletons correspond to the finger bones in man.

We have thus seen how closely the animal skeleton resembles the skeleton of man. We have found that it has a corresponding bone, or its modification, for each bone in the human skeleton, with the single exception, in some cases, of the collar-bone. The cat has a collar-bone, and the dog a rudimentary one, but the cow and the horse have none.

The absence of this bone accounts for the restricted lateral movement of the animals' fore-legs.

Comparison of Muscles. As we have

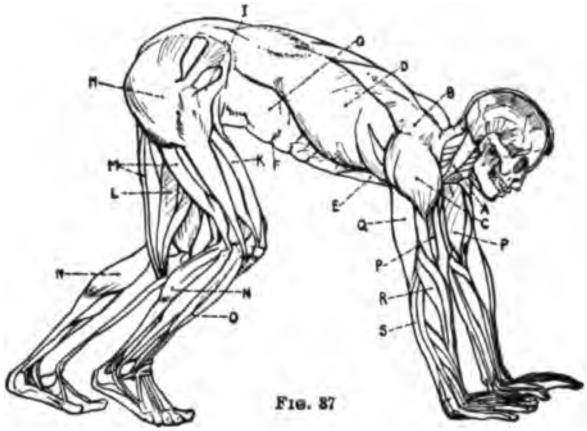


Fig. 37

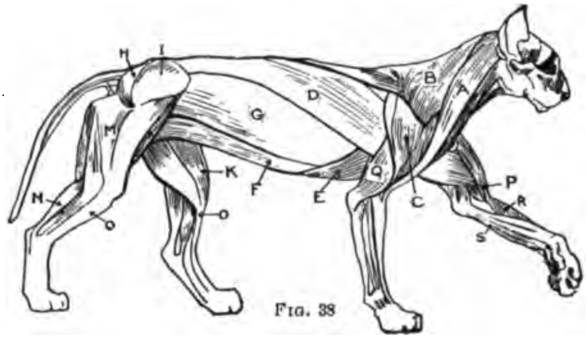


Fig. 38

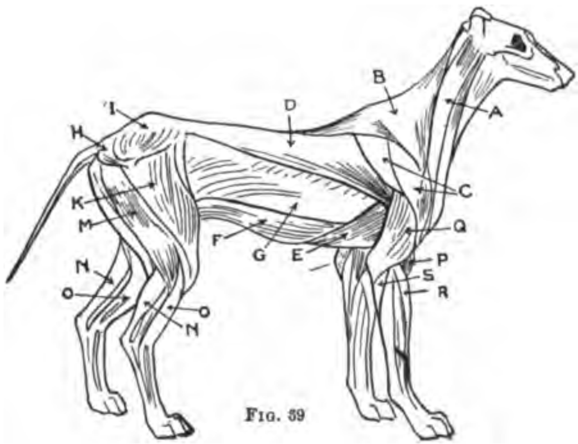


Fig. 39

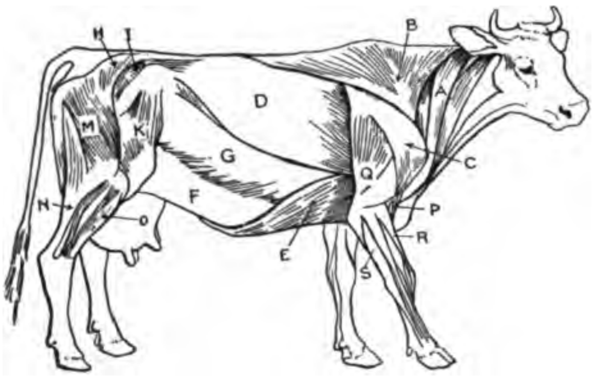


FIG. 40

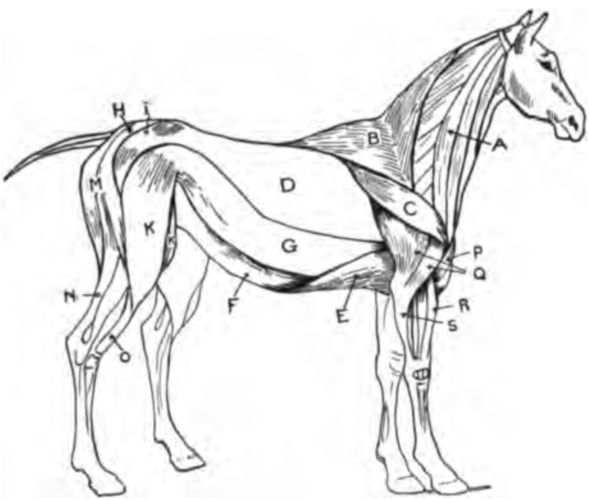


FIG. 41

compared the human and animal skeletons and have found great similarity, let us now consider the muscular arrangement in man and the animals. Fig. 37 represents man in the position of an animal. Fig. 38 is the cat; Fig. 39, the dog; Fig. 40, the cow; and Fig. 41, the horse. As each muscle in these five figures is indicated with the same letter, we may readily compare and name them, and by referring to the paragraph on Muscles, page 90, we may review the attachment and action of these same muscles in man.

A is the sterno-mastoid muscle.

B is the trapezius muscle.

C is the deltoid muscle.

D is the latissimus dorsi muscle.
E is the pectoral muscle.
F is the rectus abdominis muscle.
G is the external oblique muscle.
H is the gluteus maximus muscle.
I is the tensor muscle.
K is the rectus femoris muscle.

L is the semi-tendinosus muscle.
M is the biceps femoris muscle.
N is the gastrocnemius muscle.
O is the tibialis anticus muscle.
P is the biceps muscle.
Q is the triceps muscle.
R is the supinator longus muscle.
S is the flexor carpi ulnaris muscle.

We find in the muscles of animals, as in their skeletons, a construction similar to the human construction, with similar action; but the extent to which action is possible is greatly affected by the differences already mentioned — in the length and shape of the bones and in the size, shape and strength of the muscles. For example, in the animals the additional number of vertebræ in the neck and the length and strength of the neck muscles enable the animal to turn the head directly backward, or to lower the head to the ground, as in grazing. Again, the elongation of the tarsal bones makes it possible for the animal to reach its head with its hind hoof or paw. There are many other actions possible with animals which are traceable to structural differences.

Balance in Animals. The balance of animals is easily discernible, as the weight of the animal, when standing still, is borne at the four extremities of the trunk. When action occurs, either in locomotion, or to oppose some force, this balance is necessarily disturbed. In Fig. 42, the balance of the dog is destroyed,— that is, the dog could not stand in this position without the opposing force AB. In Fig. 43, the horse, pulling against the force AB,

Fig. 42

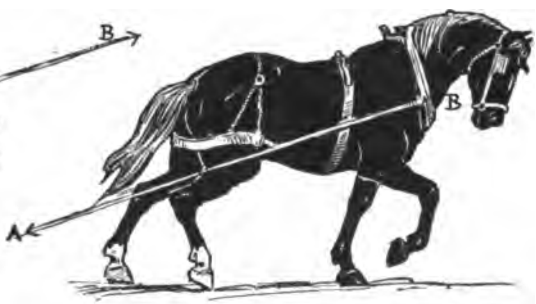


Fig. 43

FIG. 44

must throw his body forward to sustain equilibrium. The loss, regaining and changing of balance causes locomotion.

Locomotion. In walking, an animal has always two or more feet on the ground, and when two feet are suspended between the supporting legs,

FIG. 45

the suspended feet are laterals, that is, they are on the same side of the body (Fig. 44). When the suspended feet are one forward and one back of the supporting legs, the suspended feet are diagonals (Fig. 45). In trotting,


FIG. 46 FIG. 47

the diagonal feet move together, as in Figs. 46 and 47. In a gallop, the animal throws itself forward with a fore-foot, lands upon the diagonal hind-foot, places next on the ground the other hind-foot and lastly the remaining fore-foot. These movements are illustrated in the eight sketches shown in Fig. 48. The student should make a number of drawings, copying in pencil Figs. 44, 45, 46 and 47, until he is familiar with these various actions. He

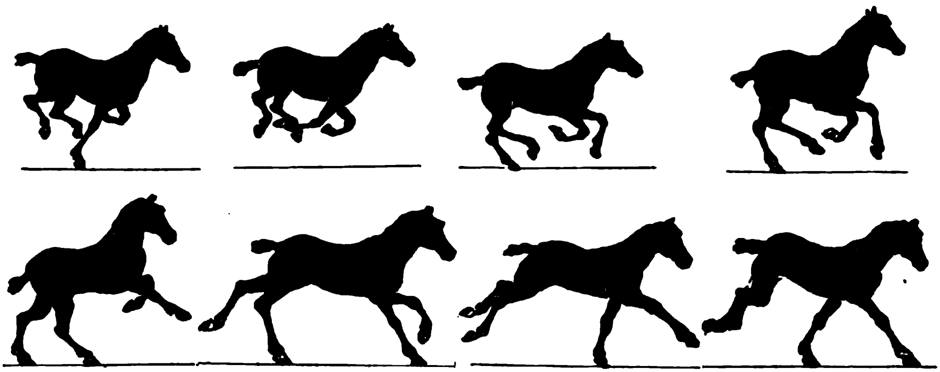


FIG. 48

should then verify his sketches by a close observation of animals, when he can see them in similar action. With this knowledge at his command, he can sketch animals from life without stopping to study the complicated actions involved in the walking, trotting and galloping common to all animals. When sketching from life this definite knowledge of the universal actions of animals can be used unconsciously, and attention can be given to those actions which are individual, or which are characteristic of the particular animal under observation. The more we gain of general knowledge in drawing, and the greater masters we become of certain universal laws of proportion, action, balance and construction, the freer we are to observe and express individuality, or that which is not universal. While we must have definite knowledge of the type, it is a certain departure from the type that makes a sketch interesting. The object, then, of this definite and scientific study is not to lead us away from nature, but rather to bring us back to nature, with keener appreciation and with a better understanding of the great simplicity of her universal laws.

CHAPTER IV

CONSTRUCTIVE DRAWING

Introduction

In carrying on the work of the world it is necessary that there should be a division of labor. The hardships of pioneer life are due very largely to the separation of man from his fellows. In building his shelter, for instance, the early settler must cut down his own trees, and, instead of the timbers which the saw-mill and the planing-mill could prepare for him, he must resort to logs laid one upon the other for the walls of his dwelling. He cannot develop the resources of the new country without the assistance of his fellow-man, and when more people are attracted to the locality he has chosen, there arises the demand for the architect, the carpenter, the mason, the plasterer, the plumber, the machinist and for all the other workmen which the building up of a community makes necessary. In order that all this constructive work may be carried on without confusion or loss of time, some definite and accurate means of conveying ideas is needed. Even if all men spoke a universal language, words would fail to convey with clearness and accuracy all the information that a body of workmen must possess in order to build a house, a bridge, or a piece of machinery. A drawing or picture is a language which men of all nations understand, but a picture of the appearance of an object, while it may give a general idea of that object, does not furnish all the facts of form, size, and structure which a workman must have if he is to construct that object. Hence there has been developed another kind of drawing, called constructive or mechanical drawing, which deals with the facts of an object, and not with its appearance. Mechanical drawing has certain methods peculiar to itself; and its symbols and conventions constitute a language for the transmission of ideas relating to construction. In order to acquire this language the student will need the following equipment: —

Materials and Instruments [1]

Drawing-board	Emery pad or sand-paper	Ink eraser
Paper	Compasses	India-ink
Thumb tacks	T square	Ruling pen
Scale	Triangles	French curves
Pencils	Pencil eraser	Penholder and pen

Drawing-Board. A drawing-board may be procured of any school-supply house.

Paper. The paper should be of good quality, and sufficiently heavy to stand the eraser. It may be either white or manila. Two good sizes for ordinary school use are 9″ x 12″ and 12″ x 18″.

Thumb Tacks. These are tacks with large, flat heads, used for fastening the paper to the drawing-board. Four tacks are sufficient for a sheet of paper of ordinary size.

Scale. For elementary work, a ruler marked off in inches, halves, quarters, eighths and sixteenths will answer; but for more advanced work

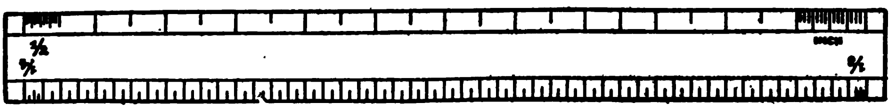


FIG. 1

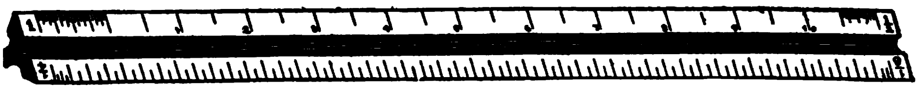


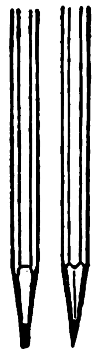
FIG. 2

where scale drawings are required, an instrument called a scale is necessary. Two scales used in ordinary practice are shown in Figs. 1 and 2.

Pencils. Two pencils, one medium hard and one hard, are necessary. The hard pencil, which is used for making fine lines, should be sharpened to a "wedge" point, as shown in Fig. 3. The medium-hard pencil,

[1] In elementary work, where inking is not required, the student will not need the last five items on this list.

which is used for lining in, for figures, for letters and for free-hand lines, should be sharpened to a conical point, as shown in Fig. 4. In both pencils the lead should be kept sharp by means of emery cloth or sand-paper, which may be glued or otherwise fastened to a thin strip of wood.



FIGS. 3 AND 4

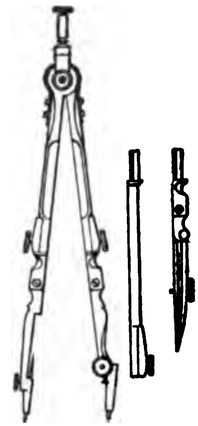


FIG. 5

Compasses. Compasses are used for drawing circles and parts of circles, and are provided with a needle point for fixing centers, a detachable pencil point, an inking pen, and a lengthening-bar, used for drawing curves of large circles (Fig. 5). Good compasses are jointed, thus allowing the legs to be bent in order that both blades of the pen may be perpendicular to the paper when in use. The lead in the compasses should be hard and sharpened to a wedge point, the flat face being set to coincide with the circle which it draws. In adjusting the lead, be careful not to set the thumb-screw too tight, as there is danger of "stripping" the thread.

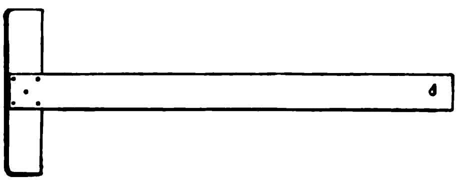


FIG. 6

T Square. The T square is an important instrument, used in drawing horizontal lines and in supplying an edge against which the triangles are placed in drawing vertical and oblique lines. It is made of two pieces, the head and the blade (Fig. 6).

Triangles. Two triangles are necessary: one called the 45° triangle, having angles of 45° and 90° (Fig. 7), and one called the 30° and 60° triangle, having angles of 30° and 60° (Fig. 8). Triangles made of transparent material, such as celluloid, are preferable.

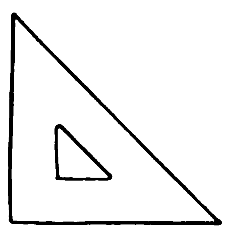


FIG. 7

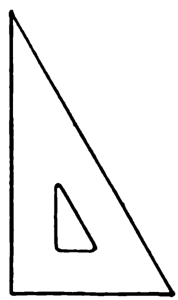


FIG. 8

Erasers. The pencil eraser should

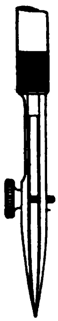


Fig. 9

be soft and pliable. The ink eraser or sand-rubber is needed for erasing inked lines.

Ink. Waterproof India-ink should be used for "inking in" mechanical drawings.

Ruling Pen. A ruling pen is used for inking in all lines. It has a thumb-screw adjustment by which the width of the line is regulated (Fig. 9). Arrow-heads, figures and letters are inked with a common pen; a No. 303 Gillott's pen is good.

Fig. 10

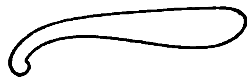


Fig. 11

Irregular or French Curves. These are made in various forms. The illustrations show some common examples (Figs. 10, 11 and 20).

Directions for Using Materials and Instruments

The drawing-board when in use should lie flat upon the desk, or it may be slightly inclined. Generally, the board should be placed with the long edges running from left to right. To fasten the paper upon the board, place it about in the center, and fix a thumb tack in the upper left corner. Set the head of the T square against the left edge of the board so that the upper edge of the blade coincides with the upper edge of the paper. Fix a second thumb tack in the lower right corner. Then fix tacks in the other two corners. In ruling lines, use the T-square blade, the edge of a triangle or a ruler. The scale should be used for marking distances, and not for ruling lines. If a line of a certain length is desired, it is best to draw a fine pencil line longer than the line required, and to mark off the exact distance on that line, rather than to try to make it the right length at the first trial. To mark off the exact distance, lay the scale on the line, and set the point of the pencil at the marks measuring the distance on the scale, making small pencil points on the line. When two equal distances are to be measured from a central point, or when several equal distances are to be set off on a line, it is better to use the dividers. Spread the points of the dividers until they measure on the scale the required distance. "Step off" these distances on the line, thus making at each point a slight puncture on the surface of the paper.

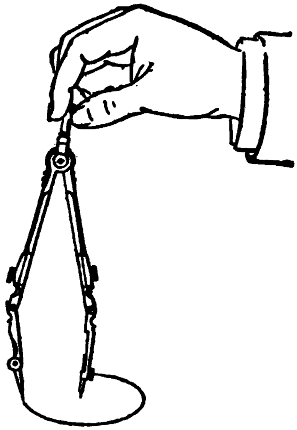


FIG. 12

To draw circles with the compasses, take the head of the compasses between the thumb and forefinger, or between the thumb, forefinger and middle finger, as shown in Fig. 12. The instrument should be placed so that the pencil point is at the left of and below the center, and held so that the pressure on the fixed point is very slight. In describing the circle, turn the hand to the right, so that the pencil point will take the same movement as the hands on a clock-face. The compass should be held at a slight inclination to the right and the pressure on the pencil point should be even throughout.

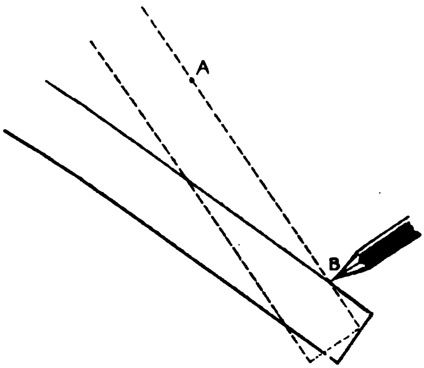


FIG. 13

In ruling straight lines from one point to another, as from point A to point B in Fig. 13, first place the pencil on one of the points, as B; slide the edge of the ruler up until it touches the pencil and also coincides with the other point, as A. Draw the line. Lines are usually drawn from left to right.

When the T square is in use, the head should be held against the left edge of the drawing-board. The upper edge of the blade should be used for ruling horizontal lines (Fig. 14). Vertical lines should be drawn against the edge of a triangle whose base is resting against the upper edge of the T-square blade

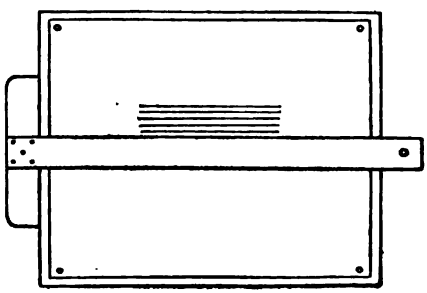


FIG. 14

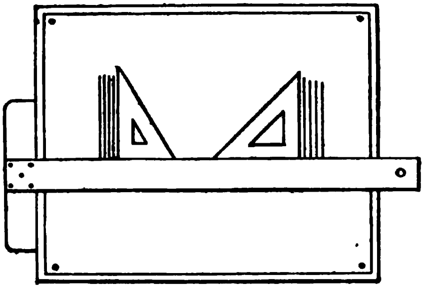


FIG. 15

(Fig. 15). To draw lines at 45, 30 or 60 degrees, use the triangles as shown in Fig. 16. For oblique lines at other angles, use the triangles as shown in Fig. 17.

The placing of marginal lines on a sheet of paper is important, and should be systematically done. Place the paper on the board, as previously explained. Decide on the width of the margin, as three quarters of an inch. Measure this distance in from each edge of the paper, placing the dot near the middle of the proposed line. Place the pencil point on the lower dot, and slide the T square up to meet it. Using the upper edge of the T square as a ruler, draw a fine line the whole length of the paper. Draw the upper marginal line in the same way. Make the side lines by using the T square and a triangle. Line in or strengthen the lines forming the rectangle, and erase the ends that fall outside.

All drawings should be done first with fine pencil lines, so that corrections can easily be made. When the drawing is to be finished in pencil,

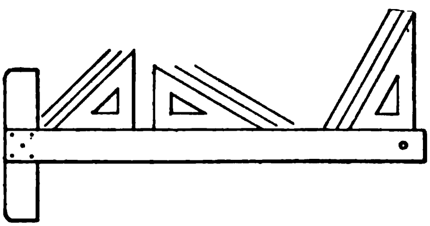


FIG. 16

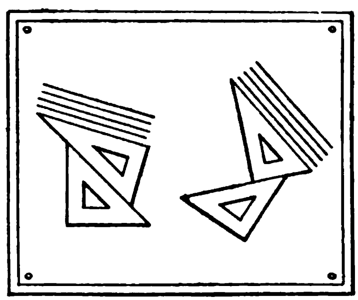


FIG. 17

the lines not wanted should be erased, and the others lined in with a medium-hard pencil, taking care to make all corresponding lines of uniform width. When a line that is to be erased is near another line, the line to be retained may be covered with a piece of paper, so as to protect it while the other is being removed. If the line to be erased is between two other lines, use, as a protector, two pieces of paper or cut a narrow slit in one piece.

The ruling pen,[1] used for inking in drawings, should be filled from the quill attached to the stopper of the bottle. The column of ink in the pen should not be more than a quarter of an inch high. All lines of the same width and kind on a sheet should be inked in with the same setting of the pen, and the pen points then changed for the next width of line by adjusting the screw. Try the lines on a waste piece of paper before inking the drawing.

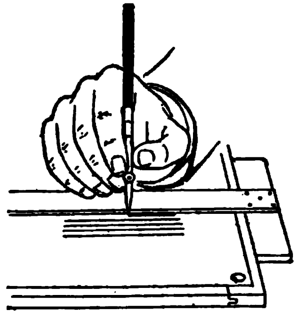


Fig. 18

In ruling lines, the pen should be held nearly perpendicular to the paper, inclined to the right, with the pen pressed slightly against the edge of the ruler (Fig. 18). Curved lines should be inked first.

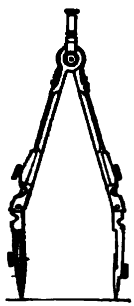


Fig. 19

In using the compass pen, the joints in the legs should be adjusted so that the lower parts of the legs are perpendicular to the paper (Fig. 19). Try the pen on waste paper before making the line on the sheet. If both points are not touching the paper, the line will be ragged on the side of the short point. In case a very fine line cannot be made with the pen, it is probably dull. To sharpen it, screw the points together and sharpen on the outside only, using a fine oil-stone.

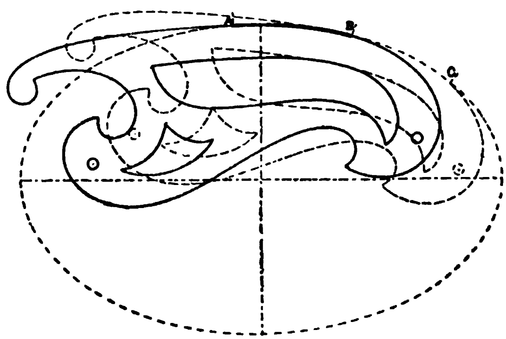


Fig. 20

For inking curves that are not circular it is necessary to use the instrument known as the irregular or French curve. The desired curve should be first drawn free hand, with a light pencil line. This must be

[1] Inking is sometimes omitted in the first year or in the first two years of high school work, for the sake of devoting more time to learning the principles of mechanical drawing, and to giving practice in pencil drawing.

done very carefully, as any error in the pencilling is emphasized in the inking. Lay the French curve on the line, so that it fits as large a portion as possible, as at A B (Fig. 20). Do not ink in quite as much of the line as coincides with the curve. Move the curve along, matching it with another portion of the line, as at B C and continue this process until the curve is accurately inked.

Geometric Problems

Geometry is the basis of accurate constructive drawing, and is frequently used in design; therefore the student should become familiar with those geometric constructions that are ordinarily employed. The working out of the problems that follow will prove a means of gaining this knowledge, and will provide opportunity for practice in the use of instruments. All geometric problems should be worked with the ruler and compasses, and every point found by geometric methods. The use of the T square and triangles follows later, when practical constructive methods are considered.

A problem in geometric drawing may be divided into three parts: first, that which is given; second, the construction; third, that which is required; and to distinguish these separate features, three kinds of lines are used. If the work is in pencil, make the given lines medium width (Fig. 21), the working lines very fine (Fig. 22), and the required or result lines strong and dark (Fig. 23). If the problem is to be inked in, draw all lines in fine, full pencil lines, then ink in as indicated above. Working or construction lines may be inked with fine, short dash lines (Fig. 24). In working the problems, mark the given lines and points with capital letters, and the constructive steps with numerals, in the order of procedure, thus: 1 will indicate the first step taken; 2, the second step, and so on. A problem thus worked will show at a glance what was given, the method of working, and the result (Fig. 27).

FIG. 21

FIG. 22

FIG. 23

FIG. 24

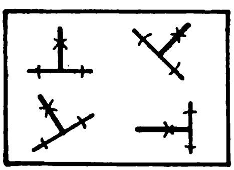


FIG. 25

In working geometric problems the student should at first make large drawings, not more than one on a sheet, or one problem worked two or three times, placed in various positions (Fig. 25). Later, the space within the margin may be divided into four equal parts, and a problem or exercise placed in each space (Fig. 26).

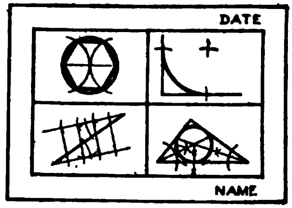


Fig. 26

Problem I — To draw a perpendicular to a line AB at a given point C in the line. (Fig. 27.) With C as center and any radius less than CB or CA, set off equal distances, C1 and C2, from C. With points 1 and 2 as centers, and with a radius greater than half the distance 1–2, describe arcs intersecting at 3. Draw the line 3C, which is the required perpendicular.

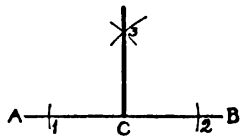


Fig. 27

Problem II — To draw a perpendicular to a line AB from a point C outside the line. (Fig. 28.) With C as center and any radius, draw arcs cutting the line AB in two points, 1 and 2. With 1 and 2 as centers and any radius, draw arcs intersecting at 3. Draw C3, the required line.

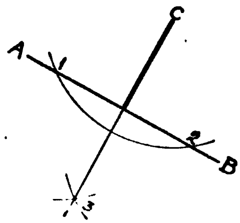


Fig. 28

Note. It must be remembered that a perpendicular line is not necessarily a vertical line.

Problem III — To draw a perpendicular to a given line AB, at or near its extremity. (Fig. 29.) With A or B as center and any radius, draw an arc (nearly a semicircle) cutting the line AB in 1. With 1 as center and with the same radius, cut this arc at 2. With 2 as center and with the same radius, describe the arc 3–4. With 3 as center and same radius, intersect 3–4 in 4. Draw 4A, the required perpendicular.

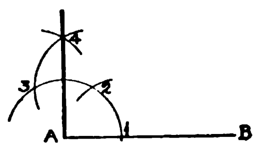


Fig. 29

Problem IV — To bisect a given straight line AB or an arc of a circle ACB. (Fig. 30.) With A and B as centers and any radius greater than half of AB, describe arcs intersecting at 1

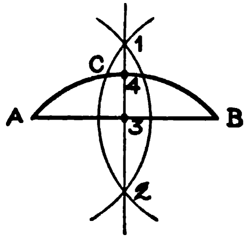


Fig. 30

FIG. 31

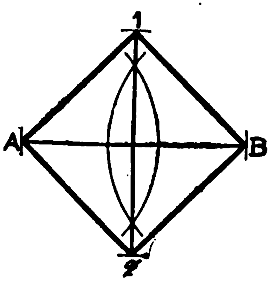


FIG. 32

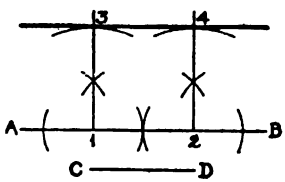


FIG. 33

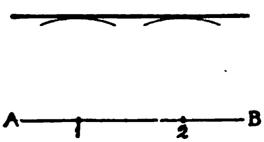


FIG. 34

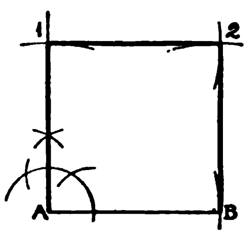


FIG. 35

and 2. Draw the line 1–2, which bisects the given line AB, the arc ACB, and is perpendicular to the line AB at its center.

Exercise I. Bisect lines and arcs in the positions given in Fig. 31:—

Exercise II. Construct a square on its diagonals (Fig. 32).

Problem V — To draw a line parallel to a given straight line, at a given distance from it. (Figs. 33 and 34.) Let AB be the given line and CD the required distance. Place two points in the given line AB, and from these points erect perpendiculars by Problem I.[1] With 1 and 2 as centers and a radius equal to the required distance, CD, draw arcs cutting the perpendiculars in points 3 and 4. Draw 3–4, the required line. In practice, the perpendiculars are sometimes omitted (Fig. 34).

Problem VI — To construct a square upon a given side, AB. (Fig. 35.) At A or B erect a perpendicular by Problem III. With A as center and AB as radius, describe an arc cutting the perpendicular, in 1. With B and 1 as centers and AB as radius, describe arcs intersecting in 2. Draw 1–2 and 2B.

Exercise: Construct an oblong, the sides being given; length, 3″, width, 2″.

Problem VII — To construct an equilateral triangle upon a given base AB. (Fig. 36.) With A and B as centers and AB as radius, describe arcs which intersect at 1. Draw 1A and 1B.

[1] If, in working out a problem, it becomes necessary to repeat a former problem, the steps of the problem referred to are not numbered.

Exercise I. Construct an isosceles triangle, the base and sides being given; base, 2″; sides, 3″.

Exercise II. Construct a scalene triangle, the sides being given; sides, 2″, 3″ and 4″, respectively.

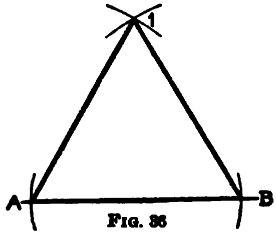


FIG. 36

Problem VIII — To bisect a given angle ABC. (Fig. 37.) With B as center, describe an arc intersecting AB and BC in 1 and 2. With 1 and 2 as centers and any radius, describe arcs intersecting in 3. Draw the line 3B, which bisects the angle ABC.

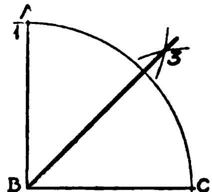


FIG. 37

Exercise: Bisect an acute angle and an obtuse angle.

Problem IX — To trisect a right angle ABC. (Fig. 38.) With B as center and any radius, describe an arc intersecting AB and BC in 1 and 2. With 1 and 2 as centers and the same radius, cut the arc in 3 and 4. Draw 3B and 4B, trisecting the angle.

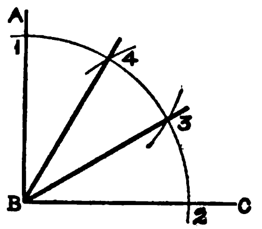


FIG. 38

Problem X — At a point A in a given line AB to draw an angle equal to a given angle CDE. (Fig. 39.) With D as center and any radius, describe an arc cutting the lines DC and DE in 1 and 2. With A as center and the same radius, describe an arc cutting the line AB in 3. With 3 as center and radius equal to 1–2, intersect the arc in 4. Draw 4A, the required angle.

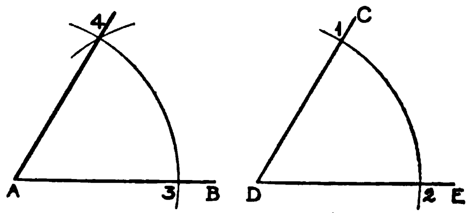


FIG. 39

Problem XI — To construct an angle of 60° at a given point A on the line AB. (Fig. 40.) With A as center and any radius, describe an arc cutting the line AB in 1. With 1 as center

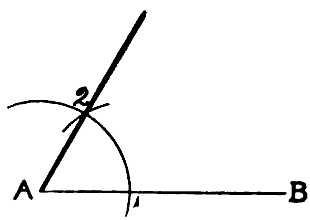


FIG. 40

and the same radius, intersect the arc in 2. Draw A2, making an angle of 60°.

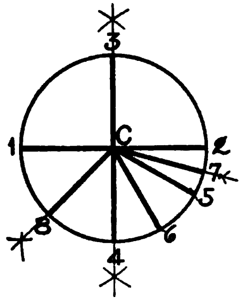


FIG. 41

Problem XII — To construct an angle of 90°, 60°, 45°, 30°, 15°, or of any other given magnitude. (Fig. 41.) The circumference of a circle contains 360°. Any diameter, as 1–2, divides the circle into two equal parts, each containing 180°. Two diameters at right angles to each other, as 1–2, and 3–4, divide the circle into four equal angles of 90° each. Trisect one of these, as 4C2, by Problem IX, obtaining angles of 30°, 2C5, and 60°, 5C4. Bisect 2C5 (an angle of 30°) and angles of 15°, 2C7 and 7C5 are obtained. Bisect an angle of 90° (Problem VIII) and obtain angles of 45°. Trisect, by spacing with the dividers, an angle of 15° and angles of 5° are obtained. Divide one of these into five equal parts and single degrees are obtained.

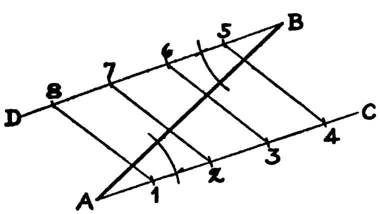


FIG. 42

Note. Any angle cannot be trisected geometrically; it must be spaced with the dividers.

Problem XIII — To divide a given line into any number of equal parts. (Fig. 42.) Let AB be the given line, to be divided into five equal parts. At A draw a line making any acute angle as BAC, with AB. At B draw a line making the same angle as DBA, with AB (by Problem X), but on the opposite side of the line. Beginning at A and B set off on the lines AC and BD as many equal parts, less one, as the given line is to be divided into,— in this case, four. Connect the first point, 1, with the last point, 8. Draw parallels to the line 1–8, connecting the other points. These parallels divide the given line AB into five equal parts.

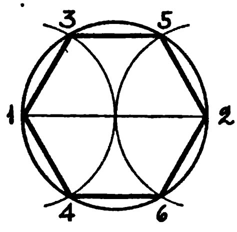


FIG. 43

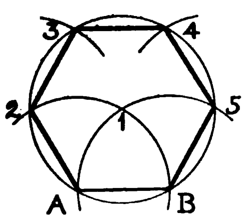


FIG. 44

Problem XIV — To inscribe a regular hexagon within a given circle. (Fig. 43.) Draw a diameter of the circle, 1–2. With 1 as center and the radius of the circle as radius, intersect the circumference at points 3 and 4. With 2 as center and the same radius intersect the circumference at points 5 and 6. Draw 1–3, 3–5, 5–2, 2–6, 6–4 and 4–1. The inscribed figure is the required hexagon.

Note 1. By joining alternate points an inscribed equilateral triangle is obtained.

Note 2. The radius of a circle spaced off on the circumference divides the circumference into six equal parts.

Problem XV — To construct a regular hexagon upon a given base. (Fig. 44.) Let AB be the given base. With A and B as centers and a radius equal to AB describe arcs intersecting at 1. With 1 as center and the same radius describe a circle. Set off the radius six times upon the circumference, and draw A2, 2–3, 3–4, 4–5 and 5–B, making the required hexagon.

Problem XVI — Within a given circle to inscribe a square. (Fig. 45.) Draw a diameter of the circle, as 1–2. Bisect 1–2 by Problem IV, and continue the bisector until it intersects the circle in points 3 and 4. Draw 1–3, 3–2, 2–4, 4–1, thus obtaining the required inscribed square.

Exercise: Within a given circle to inscribe a regular octagon (Fig. 46).

Problem XVII — To construct a regular octagon upon a given side. (Fig. 47.) Let AB be the given side. With A and B as centers, and a radius equal to AB, describe two semicircles. At A and B erect perpendiculars by Problem III. Extend the line AB in both

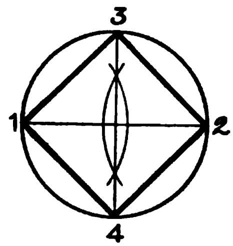


FIG. 45

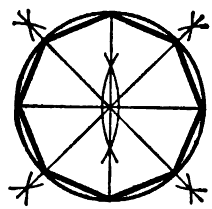


FIG. 46

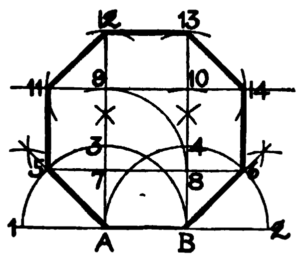


FIG. 47

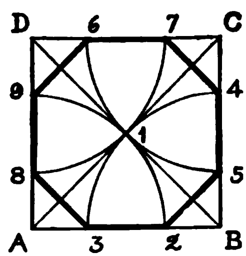


FIG. 48

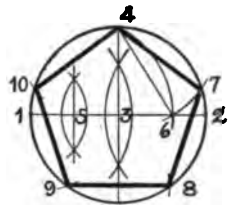


Fig. 49

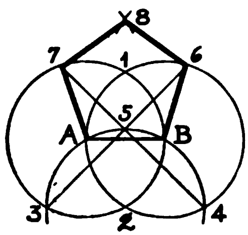


Fig. 50

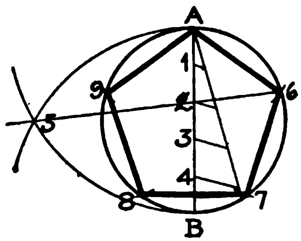


Fig. 51

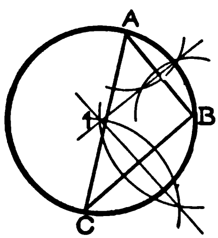


Fig. 52

directions until it meets the arcs in points 1 and 2. Bisect the right angles 1A3 and 2B4, by Problem VIII. Produce the bisectors until they meet the arcs in points 5 and 6. Draw the line 5–6, cutting the perpendiculars in 7 and 8. From 7 and 8 set off the distance 7–8 on the perpendiculars, in points 9 and 10. Draw through 9 and 10 a straight line, indefinite in length. Set off from 9 and 10 distances 9–11, 9–12, 10–13 and 10–14 equal to 5–7. Draw 5–11, 11–12, 12–13, 13–14 and 14–6, making the required octagon.

Problem XVIII — To construct a regular octagon within a given square. (Fig. 48.) Let ABCD be the given square. Draw its diagonals, intersecting at the center, 1. With A, B, C and D as centers, and A1 as radius, draw arcs intersecting the sides of the square in points 2, 3, 8, 9, 6, 7, 4 and 5. Draw 9–6, 7–4, 5–2 and 3–8, making the required octagon.

Problem XIX — To inscribe a regular pentagon within a given circle. (Fig. 49.) Draw a diameter, 1–2, and a radius, 3–4, perpendicular to it. Bisect 1–3 in 5. With 5 as center and radius 5–4, intersect 1–2 in 6. With 4 as center and radius 4–6, intersect the circle in 7. 4–7 is the side of the required pentagon. Set off this distance five times on the circumference, and draw 4–7, 7–8, 8–9, 9–10, and 10–4.

Problem XX — To construct a regular pentagon upon a given side. (Fig. 50.) Let AB be the given side. With A and B as centers and radius AB describe circles intersecting in points 1 and 2. With 2 as center, and the same radius, obtain the intersecting points 3, 5 and 4. Through 3–5 and 4–5 draw lines, producing them to points 6 and 7. With 6 and 7 as centers and radius AB describe arcs intersecting at 8. Draw A7, 7–8, 8–6, and 6–B.

Problem XXI — To inscribe a regular polygon of any number of sides within a given circle. (Approximate method.) (Fig. 51.) Suppose we wish to inscribe a polygon of five sides within a given circle. Draw a diameter, AB, and divide it by Problem XIII into as many equal parts as the polygon is to have sides, — in this case five. With A and B as centers, and radius AB, describe arcs intersecting in 5. From 5, draw a straight line through the second point 2, to intersect the circle in 6. A6 is a side of the required polygon. Beginning at 6, set off A6 upon the circle to obtain 7, 8 and 9. Draw A–6, 6–7, 7–8, 8–9 and 9A.

Problem XXII — To circumscribe a circle about a given triangle. (Fig. 52.) Let ABC be the given triangle. Bisect any two of its sides by Problem IV. Produce the bisectors until they meet at 1. With 1 as center, and radius 1A, 1B or 1C, describe the circle.

Exercise I. To draw a circle through three given points, not in the same straight line, construct a triangle by connecting the given points with straight lines, and proceed as in Problem XXII.

Exercise II. To find the radius of a given arc, or the center of any circle, assume any three points in the curve and proceed as above.

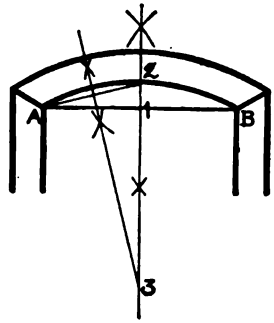


Fig. 53

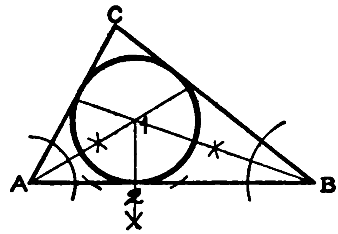


Fig. 54

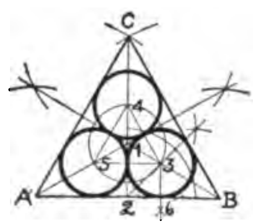


Fig. 55

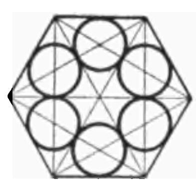


Fig. 56

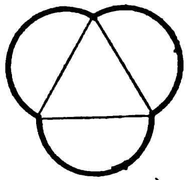


FIG. 57

Exercise III. To find the radius of the arch for a window, the width of the window and the rise of the arch being given (Fig. 53). Let the width of the window AB be 4″ and the rise of the arch 1–2 be ¾″. Find the center for the arcs.

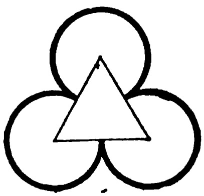


FIG. 58

Problem XXIII — To inscribe a circle within a given triangle. (Fig. 54.) Let ABC be the given triangle. Bisect any two of the angles by Problem VIII. The bisectors will intersect at 1. From point 1 draw a perpendicular to any one of the sides, by Problem II, obtaining point 2. With 1 as center, and 1–2 as radius, draw the required circle.

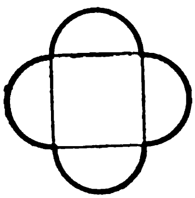


FIG. 59

Problem XXIV — To inscribe three equal tangential circles within an equilateral triangle. (Fig. 55.) Let ABC be the given triangle. Bisect the angles A, B and C by lines meeting at 1. Bisect the right angle 1–2–B, obtaining the point 3, the center of one of the required circles. With 1 as center, and radius equal to 1–3, describe a circle, obtaining the points 4 and 5, which are the centers of the other two circles. The shortest distance, as 3–6, from the center 3 to a side of the triangle is the radius of the required circles.

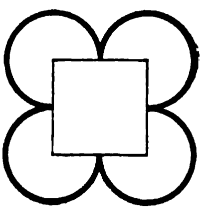


FIG. 60

Exercise I. Inscribe six equal tangential circles within a regular hexagon (Fig. 56).

Exercises: Construct Trefoils, Quatrefoils and Cinquefoils (Figs. 57, 58, 59, 60 and 61).

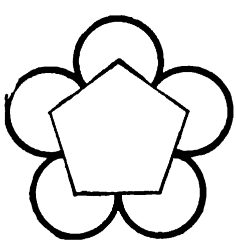


FIG. 61

Problem XXV — To draw a tangent to a given circle at a point A in the circumference. (Fig. 62.) Draw a radius, A1, and extend the line beyond the circumference. Erect a perpendicular at A by Problem I. BC is the required tangent.

Problem XXVI — To draw an arc of a given radius tangent to two lines forming a right angle. (Fig. 63.) With B as center and any radius, draw arcs cutting the sides of the right angle in 1 and 2. With 1 and 2 as centers, and the same radius, draw arcs intersecting in 3. With 3 as center, and the same radius, draw the required arc.

Exercise: Round off the corners of a given figure (Fig. 64) with curves of $\frac{3}{4}''$ radius, as in Fig. 64*a*.

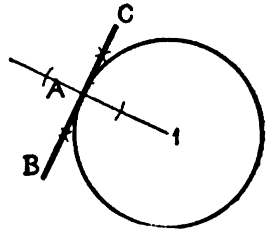


Fig. 62

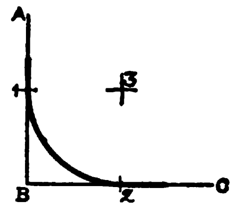


Fig. 63

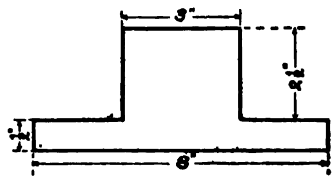


Fig. 64

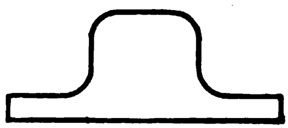


Fig. 64a

Problem XXVII — To draw an arc of a given radius, tangent to two straight lines forming an oblique angle. (Fig. 65.) Let AB be the given radius, and CDE the given angle. Bisect the angle CDE by Problem VIII, and draw a line FG parallel to DE, at a distance equal to the given radius AB. The intersection of FG with the bisector of the angle will be the center of the required arc. From point 1 draw lines perpendicular to the lines DC and DE, in points 2 and 3. These are the points of tangency. With 1 as center, and a radius equal to AB, draw the required curve.

Exercise: Draw a curve of $1''$ radius, tangent to two lines forming an obtuse angle.

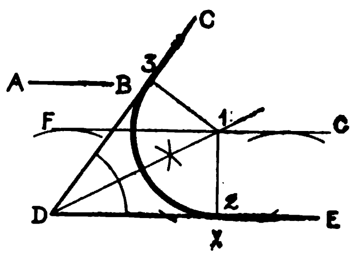


Fig. 65

Problem XXVIII — To draw an arc of a given radius, tangent to a given line and a given circle. (Fig. 66.) Let AB be the given line, C the given circle, and DE the given radius. Draw a line EF parallel to AB at a distance DE. Draw any radius of the circle C, as 1–2, and produce it to make the distance 2–3 equal to DE. With 1 as center, and 1–3 as radius, describe an arc intersecting the line EF in point 4. From 4 draw a perpendicular to the line AB

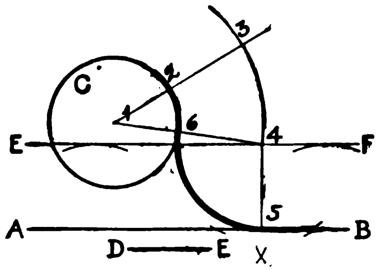


FIG. 66

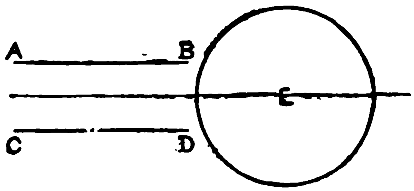


FIG. 67

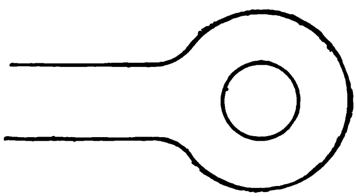


FIG. 67a

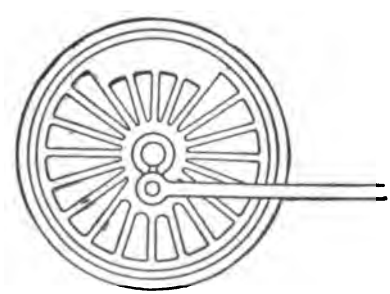


FIG. 68

in point 5, which is the point of tangency on the line AB. With 4 as center, and radius 4–5, draw the required tangential arc.

Exercise: Describe arcs of $\frac{3}{4}''$ radius, tangent to the circle E and the straight lines AB and CD (Fig. 67. Figs. 67*a* and 68 are applications of this problem).

Problem XXIX — To draw an arc of a given radius, tangent to two given circles. (Fig. 69.) Let A and B be the given circles, and CD the given radius. With the center of the circle A as center and radius 1–2, equal to the radius of A plus CD, describe the arc 2–3. With the center of circle B as center and radius 4–5, equal to the radius of B plus CD, draw the arc 6–5 intersecting the arc 2–3 in 7. With 7 as center and radius equal to CD, draw the required tangential arc.

Exercise: The centers of two circles whose diameters are 1″ and 2″, respectively, are 3″ apart. Draw a curve having a radius of 2″, tangent to the two circles.

Problem XXX — To construct an ellipse, its major and minor axes being given. (Fig. 70.) Place the axes AB and CD at right angles to each other at their centers, obtaining point 1. With 1 as center, describe circles upon the axes as diameters. Divide each circumference into the same number of equal parts, say twelve (Problem IX). Draw lines through the points in the large circle parallel to CD. Draw lines through points in the small circle parallel to AB. The points of intersection in these parallels, as 3, 4, are points in the curve of the ellipse. Draw a free-hand ellipse through these points, correcting it by means of the French curve.

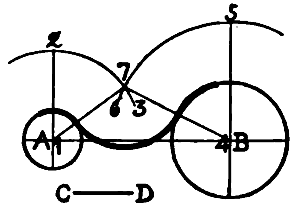


FIG. 69

Problem XXXI — To draw with a trammel an ellipse when the axes are given. (Fig. 71.) Draw the two axes at right angles to each other at their centers. Lay off on the straight edge of a strip of paper the length of one half of each diameter. Thus, 1–2 is equal to half of the short diameter, and 1–3 to half of the long diameter. Adjust the paper in relation to the diameters so that point 2 is on the long diameter, and point 3 on the short diameter. Place a point at the end of the paper at 4. Move the paper so that point 2 will move in on the long diameter and point 3 will move out on the short diameter. Mark another point 5 at the end of the trammel. Repeat this at frequent intervals on each quarter of the ellipse. Draw a free-hand curve through these points. Correct by use of the French curve.

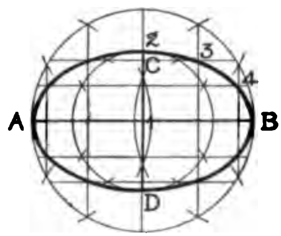


FIG. 70

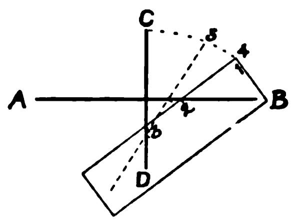


FIG. 71

Problem XXXII — To draw upon given axes an approximate ellipse. (Fig. 72.) Draw the two axes AB and CD perpendicular to each other at their centers. With 1 as center, and half the short axis, 1C as radius, describe an arc C2. Draw CB.

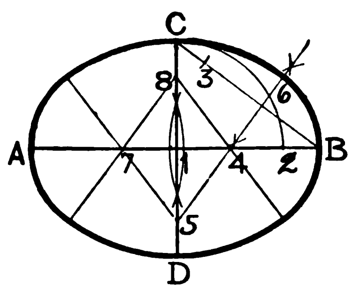


FIG. 72

From C set off C3 equal to 2B, which is the difference between half the short and half the long axis. Bisect B3, and continue the bisector until it intersects AB in 4, and CD in 5. With 4 as center, and radius 4B, describe an arc B6. With 5 as center, and radius 5–6, describe an arc that will pass through C, completing one quarter of the curve. From 1 set off 1–7 equal to 1–4, and 1–8 equal to 1–5. Draw lines connecting 5–7, 8–7 and 8–4, extending them as indicated in the figure. With points 4, 5, 7 and 8 as centers, complete the ellipse as already explained.

Geometrical Definitions


FIG. 73

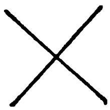


FIG. 74

FIG. 75

FIG. 76

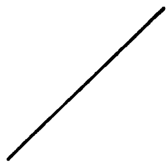


FIG. 77

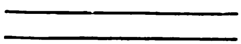


FIG. 78


FIG. 79

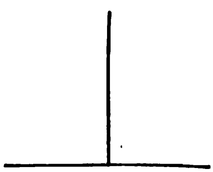


FIG. 80

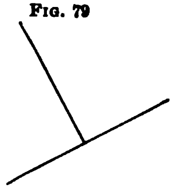


FIG. 81

A **Point** is that which has position without extension (Fig. 73). A Point is formed when two lines intersect (Fig. 74).

A **Line** is that which has length without breadth or thickness (Fig. 75).

Lines are either vertical, horizontal or oblique.

A **Vertical Line** is a line perpendicular to the plane of the horizon (Fig. 76).

A **Horizontal Line** is a level line parallel to the horizon (Fig. 75).

An **Oblique Line** is a slanting line, neither upright nor level (Fig. 77).

Parallel Lines are lines

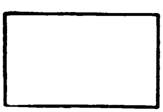


FIG. 82

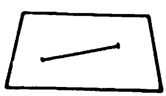


FIG. 83

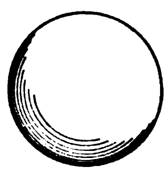


FIG. 84

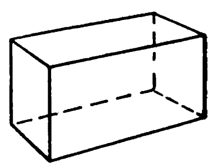


FIG. 85

running in the same direction, which, if produced, will never meet (Figs. 78 and 79).

Two straight lines are said to be *perpendicular* to each other when they meet at right angles (Figs. 80 and 81).

(Perpendicular and vertical are not synonymous terms.)

A **Surface** is that which has length and breadth without thickness (Fig. 82).

A **Plane** is a surface such that if any two points in it are joined by a straight line the line will lie wholly on the surface (Fig. 83).

A **Solid** is that which has length, breadth and thickness (Figs. 84 and 85).

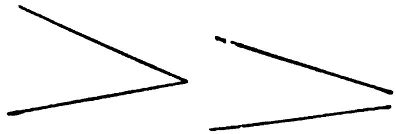
An **Angle** is the difference in the direction of two straight lines which meet at a point, or would meet if extended (Fig. 86 *a* and *b*). The point where the lines meet is called the *vertex* of the angle (plural vertices).

A **Right Angle** is formed by the meeting of two lines that are perpendicular to each other (Fig. 87 *a* and *b*).

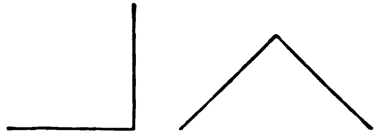
An **Acute Angle** is an angle which is less than a right angle (Fig. 88).

An **Obtuse Angle** is an angle which is greater than a right angle (Fig. 89).

A **Right-angled Triangle** is a triangle which has a right angle (Fig. 90).



a Fig. 86 *b*



a Fig. 87 *b*

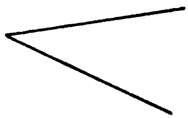


Fig. 88

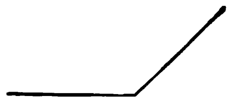


Fig. 89

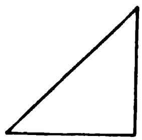


Fig. 90

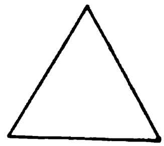


Fig. 91

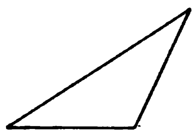


Fig. 92

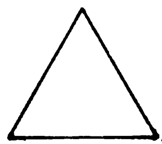
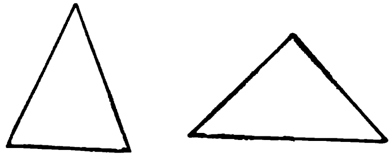


Fig. 93



a Fig. 94 *b*

Fig. 95

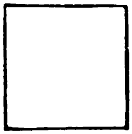


Fig. 96

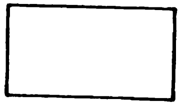


Fig. 97

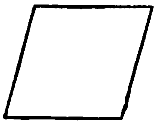


Fig. 98

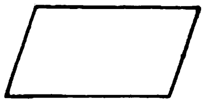


Fig. 99

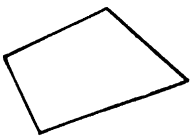


Fig. 100

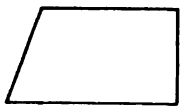


Fig. 101

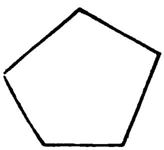


Fig. 102

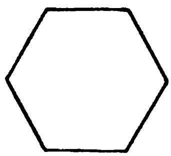


Fig. 103

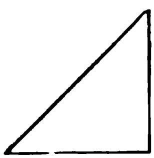


Fig. 104

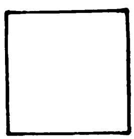


Fig. 105

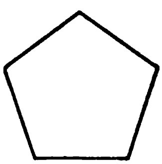


Fig. 106

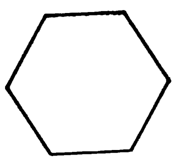


Fig. 107

An **Acute-angled Triangle** is a triangle which has three acute angles (Fig. 91).

An **Obtuse-angled Triangle** is a triangle which has one obtuse angle (Fig. 92).

An **Equilateral Triangle** is a triangle which has three equal sides (Fig. 93).

An **Isosceles Triangle** is a triangle which has two of its sides equal (Fig. 94 *a* and *b*).

A **Scalene Triangle** is a triangle which has no two of its sides equal (Fig. 95).

A **Quadrilateral** is a plane figure bounded by four straight lines (Figs. 96, 97, 98, 99, 100 and 101).

A **Square** is a quadrilateral having four equal sides and four right angles (Fig. 96).

A **Rectangle** is a quadrilateral whose opposite sides are equal and parallel and whose angles are right angles (Fig. 97).

A **Rhombus** is a quadrilateral whose sides are equal but whose angles are not right angles (Fig. 98).

A **Rhomboid** is a quadrilateral whose opposite sides are equal and parallel and whose angles are not right angles (Fig. 99).

A **Trapezium** is a quadrilateral which has no two sides parallel (Fig. 100).

A **Trapezoid** is a quadrilateral which has two sides parallel (Fig. 101).

A **Polygon** is a plane figure having any number of sides (Fig. 102).

A **Regular Polygon** is a plane figure having any number of equal sides and equal angles (Fig. 103).

A **Polygon** of three sides is called a triangle (Fig. 104); of four sides, a quadrilateral (Fig. 105); of five sides, a pentagon (Fig. 106); of six sides, a hexagon (Fig. 107); of seven sides, a heptagon (Fig. 108); of eight sides, an octagon (Fig. 109); of nine sides, a nonogon (Fig. 110); of ten sides, a decagon (Fig. 111).

A **Perimeter** is the boundary of a plane figure (Figs. 96 to 111).

A **Diagonal** is a straight line in any polygon which connects angles not adjacent (Figs. 112 and 113). In regular polygons, diagonals are called *long* when they pass through the center, as AB in Fig. 112, and *short* when they connect angles and do not pass through the center, as CD in Fig. 112. In a regular polygon with an even number of sides a line joining the centers of two opposite sides is often called a diameter (Fig. 114).

A **Circle** is a plane figure bounded by a curved line called the *Circumference*, all points of which are equally distant from a point within called the center (Fig. 115).

A **Diameter** of a circle is any straight line passing through the center

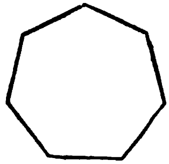


Fig. 108

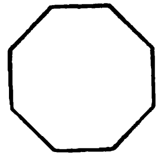


Fig. 109

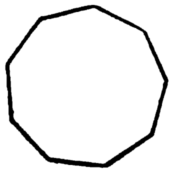


Fig. 110

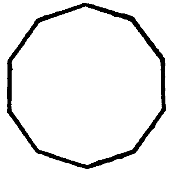


Fig. 111

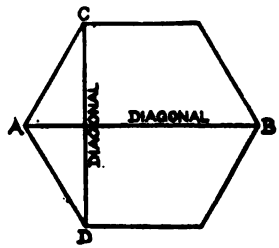


Fig. 112

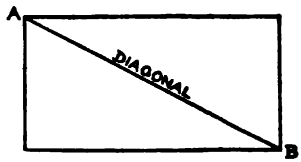


Fig. 113

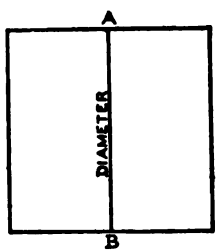


Fig. 114

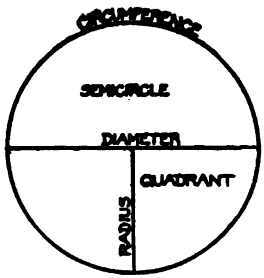


FIG. 115

and terminating in both directions in the circumference (Fig. 115).

A **Radius** (plural radii) of a circle is any straight line extending from the center to the circumference (Fig. 115).

An **Arc** of a circle is any part of the circumference (Fig. 116).

A **Chord** is a straight line joining the extremities of an arc (Fig. 116).

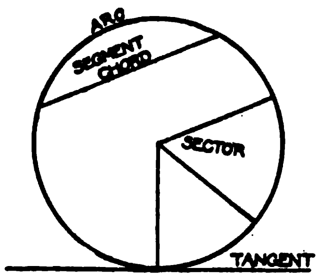


FIG. 116

A **Semicircle** is half of a circle (Fig. 115).

A **Quadrant** is a quarter of a circle (Fig. 115).

A **Sector** is a part of a circle bounded by two radii and the included arc (Fig. 116).

A **Segment** is a part of a circle included between an arc and its chord (Fig. 116).

A **Tangent** to a circle is a straight line which touches the circumference but does not cut it, however far produced (Fig. 116).

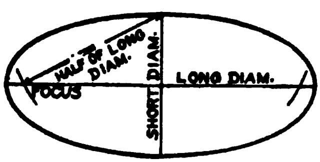


FIG. 117

An **Ellipse** is a plane figure bounded by a curve, every point of which is at the same combined distance from the two points within, called the foci (Fig. 117).

A **Sphere** is a solid bounded by a curved surface, every point of which is equally distant from a point within called the center (Fig. 118).


FIG. 118

A **Cube** is a solid bounded by six equal square faces (Fig. 119).

A **Cylinder** is a solid bounded by a curved surface and by two opposite faces called bases. A cylinder is named from the shape of its bases, which may be circular, elliptical or other curved shapes. The circular cylinder is the one ordinarily used (Fig. 120).

A **Prism** is a solid whose bases are similar, equal and parallel polygons, and whose sides are parallelograms. Prisms are named from the shape of their ends, as triangular, square, pentagonal, etc. (Figs. 121, 122 and 123).

A **Pyramid** is a solid of which one face, the base, is a polygon, and the lateral faces are triangles, having a common vertex called the vertex or apex of the pyramid (Figs. 124, 125 and 126).

A **Cone** is a solid bounded by a plane surface called the base (which is a circle, ellipse or other curved shape), and by a lateral surface which is everywhere curved, and tapers to a point called the vertex or apex (Fig. 127). A cone is named from the shape of its base.

A **Truncated Cone** or **Pyramid** is that portion included between the base and a cutting plane, which may be either parallel or oblique to the base (Fig. 128). When the cutting plane is parallel to the base the section between the cutting plane and the base is called a frustum (Fig. 129).

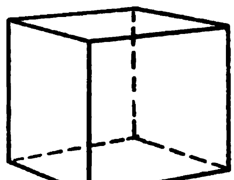


Fig. 119

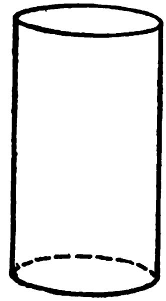


Fig. 120

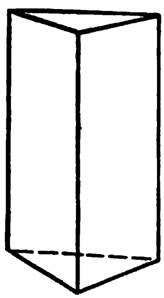


Fig. 121

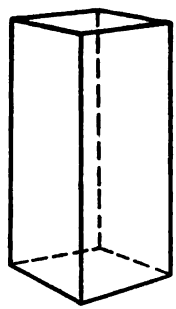


Fig. 122

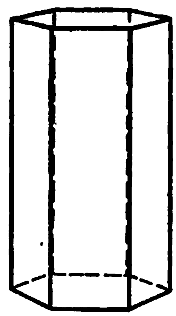


Fig. 123

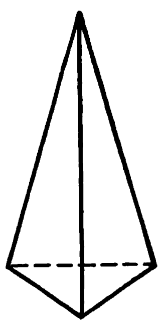


Fig. 124

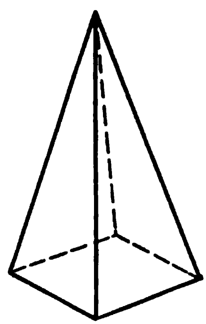


Fig. 125

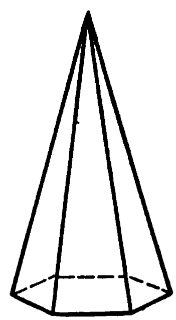


Fig. 126

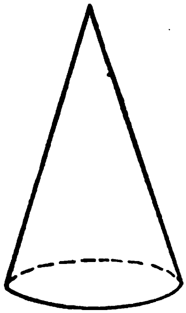


Fig. 127

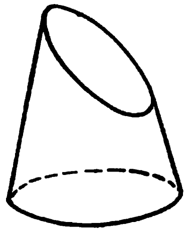


Fig. 128

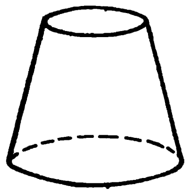


Fig. 129

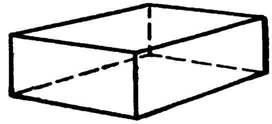


Fig. 130

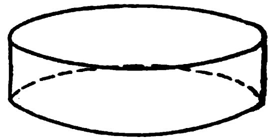


Fig. 131

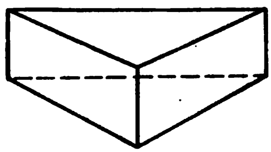


Fig. 132

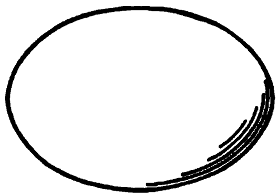


Fig. 133

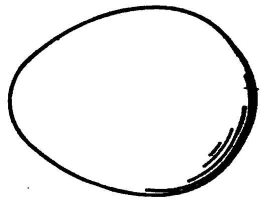


Fig. 134

A **Plinth** is a cylinder or prism whose axis is its least diameter. Plinths are named from the shapes of their bases, as circular, square, triangular, etc. (Figs. 130, 131 and 132).

An **Ellipsoid** is a solid, all plane sections of which are ellipses or circles (Fig. 133).

An **Ovoid** is an egg-shaped solid (Fig. 134).

Working Drawings

Working drawings are drawings which deal not with the appearance of an object, but with its facts. They must furnish all that a workman needs to know in regard to its form, size, proportion, the material to be used and the method of manufacture or manner of construction, in order to make that object. In Fig. 135 is a perspective picture which gives a general idea of the three dimensions of a boat, but such a sketch would not furnish a builder with the necessary facts which he must know if he wishes to make a boat like this. He must know its actual length, its actual width and its actual depth. These facts cannot be accurately expressed in a perspective picture, but must be shown by means of geometric views — that is, views which would each give two of the actual dimensions of the object. These different views are named from the part represented. The front view is obtained by looking directly at the front of the object; the top view, by looking directly at the top; the end views, by looking directly at the ends, and the bottom view, when used, by looking directly at the bottom. In a working drawing, as these groups of views are called, the top view is placed above the front view; the bottom view below the front view, and the end views at the right and left of the front view. Fig. 136 shows

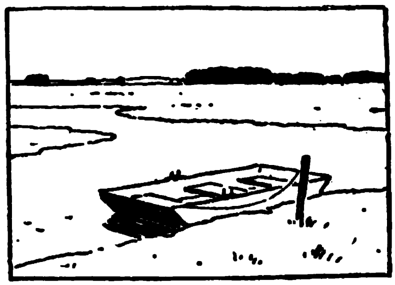


Fig. 135

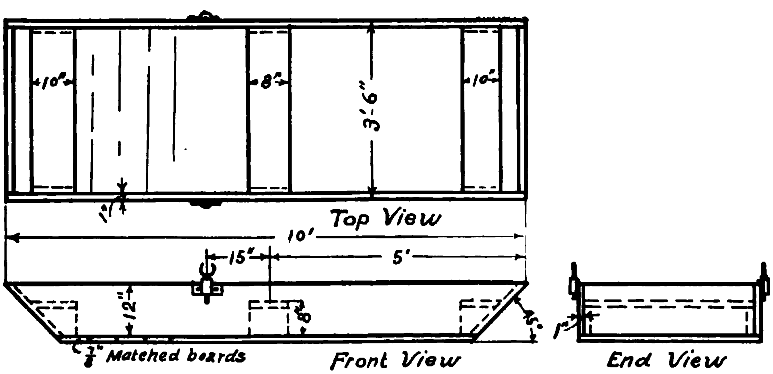


Fig. 136

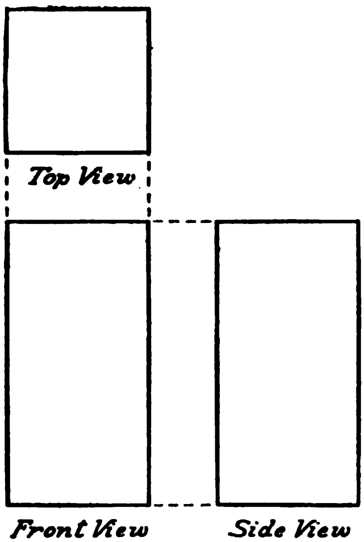


FIG. 137

a working drawing of the boat. The front view shows the length and depth of the boat, the slant of the ends and the position of the rowlocks. The top view shows the width and length, the placing of the three seats and their dimensions, and the position of the rowlocks in relation to the middle seat. The end view shows the depth and the width of the boat and the angle which the sides make with the bottom, which in this case is a right angle. The separate views in a working drawing are also called projections, and whichever view is drawn first, forms the basis of projection of all the other views. The terms "top view," "front view," "side view" and "end view" are only relative, for the same face may be a top view, a front view or an end view, according to the position of the object. For example, Fig. 137 shows three views of a square prism, standing vertically. The top view is a square, and the front and side views are oblongs. In Fig. 138 the position of the square prism is changed, and the front and top views are oblongs, while the end view becomes a square.

In making a working drawing of an object the views should be placed in

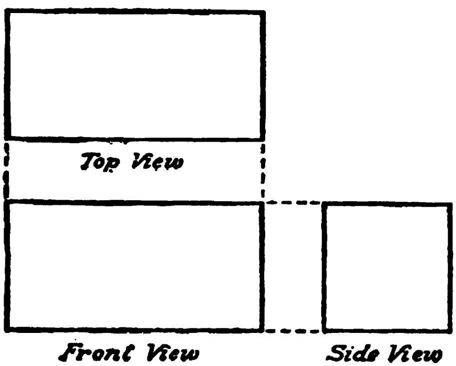


FIG. 138

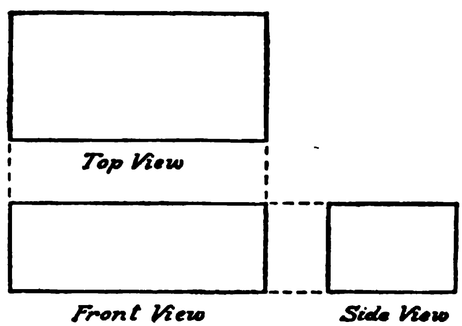


FIG. 139

their natural positions. For example, a brick usually rests on one of its largest faces, and to represent this, the views should be drawn as shown in Fig. 139. In drawing the views of a chimney, however, the front view should be expressed by the upright wide oblong, because that is its natural position (Fig. 140).

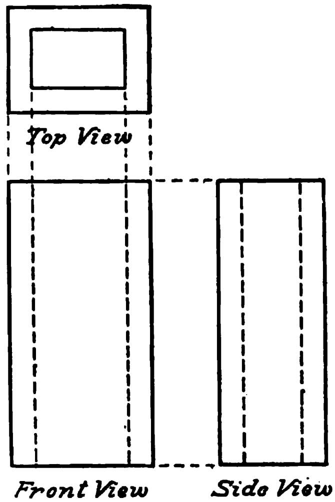


FIG. 140

In the representation of the different faces of objects, the eye is not supposed to be fixed at one point, as in perspective representation, but it is assumed to be opposite each point in the surface to be represented. When the faces are perpendicular to the line of sight, they are represented in their true shape, but when the faces are oblique to the line of sight, the oblique faces are represented as foreshortened. This is illustrated in Figs. 141, 142 and 143. Fig. 141 shows the top and front views of a cube placed directly in front of the observer. The two views are of the same shape, but they express different dimensions. The front view shows the height and the width from left to right, while the top view shows the width from left to right, and the width from front to back. These facts must always be shown by the front and top

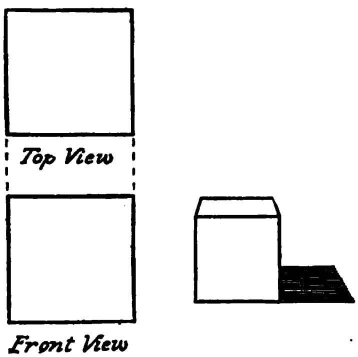


FIG. 141

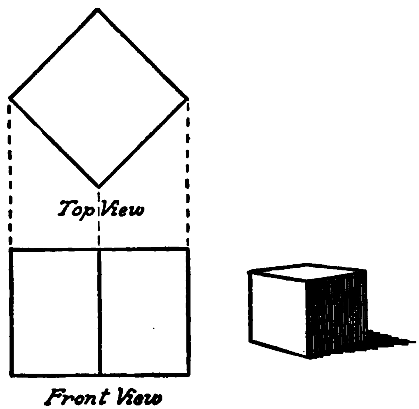


FIG. 142

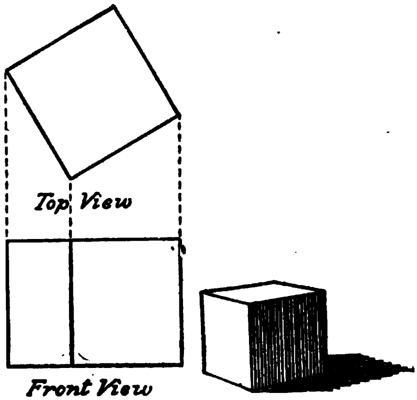


FIG. 143

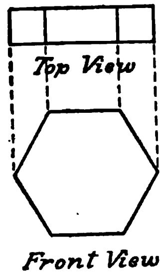


FIG. 144

views of any object, in any position. Fig. 142 shows the front and top views of the cube placed at an angle of 45°. The front view shows the height, as before, and also, as before, the *actual extension or width of the solid from left to right.* This width is expressed by horizontal lines, and the result is that the two oblique faces are foreshortened in the front view. The same point is illustrated by Fig. 143, which represents the front and top views of a cube turned at 60° and 30°. In drawing geometric views of objects showing oblique faces, the view that shows a true shape should be drawn first and the other views should be projected from it. In Figs. 142 and 143 the top views were drawn, at the proper angle, first. The width of the front face was determined in both cases by lines projected from the angles of the top view. In the views of the hexagonal plinth (Fig. 144), the hexagon must be drawn first, as the faces in the top view are foreshortened and must be projected from points found in the view furnishing a true shape. In drawing views of cylindric objects, the circle should be drawn first (Fig. 145).

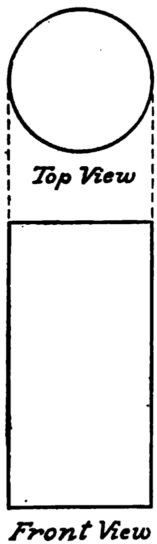


FIG. 145

Working drawings must be expressed by means of conventions that have been accepted for general use, because they are the most concise and accurate way of conveying certain facts. These conventions or symbols vary slightly in usage, but never to a degree that would make the meaning of the drawing unintelligible. The conventional lines and symbols used in mechanical drawing are shown in Fig. 146.

Dimensioning. In working drawings, dimensions are very important. The size of each part must be indicated by plain figures, placed either outside or inside the drawing, wherever they will be most readily understood. Dimension lines are drawn light with a space left in the middle for the figures. Arrowheads are placed at the ends of dimension lines (Fig. 146). When there is not room enough for the arrowheads to be drawn, they should be placed outside (Fig. 147). When the lines are too close together for the figures to be drawn, as in Fig. 148, they should be placed outside. They should read from left to right and from the bottom upward. If a dimension is stated upon one view, it need not be repeated upon another view unless the drawing should be large and the views some distance apart. "Over all" dimensions should be shown in a separate line (Fig. 149).

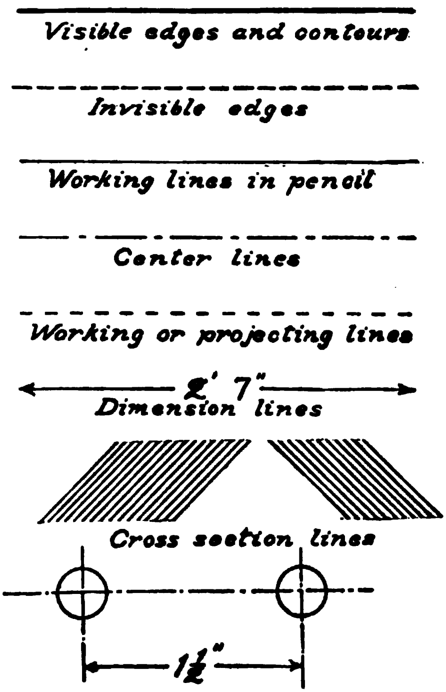


FIG. 146

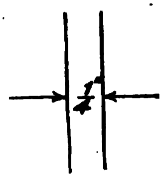


FIG. 147

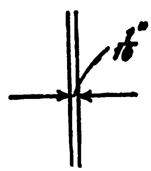


FIG. 148

Drawing to Scale. Working drawings are seldom made the exact size of the object to be constructed. They are sometimes made larger, as in the drawings from which a watch is to be made, and, more frequently, smaller, as in drawings that show the plans and elevations of a house. The size

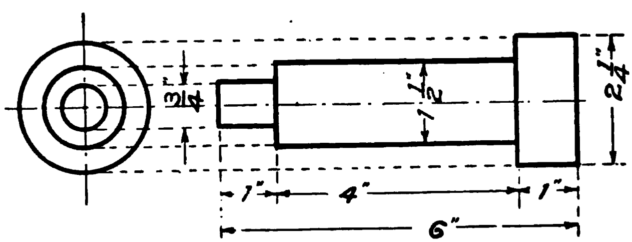


FIG. 149

of the drawing is a matter of convenience, but it is necessary that a reduced or enlarged size be accurately drawn according to the proportion or scale chosen, and that all parts of a drawing be made to the same scale. Drawings of ordinary objects, if not made full size, are usually made $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ or $\frac{1}{16}$ the full size of the object, and these proportions can, with some calculation, be laid off with an ordinary ruler divided into inches, halves, quarters, eighths and sixteenths. If a working drawing of a box measuring 16″ long, 8″ wide and 4″ high were to be made in a scale one-fourth full size, it would be easy to estimate the scale and make the drawings 4″ x 2″ x 1″. But in case fractions are involved in the measurements, or it is desired to make a drawing in some proportion not so easily determined, the problem would become involved. It is better, therefore, to be provided with a scale and to determine all reductions by its use. To make a full-sized drawing, a scale divided into inches and fractions of an inch is used. To make a half-sized drawing, a scale is used on which each six inches of its length is divided into twelve equal parts, each division standing for one inch. Following the same method, a quarter scale has each three inches divided into twelve equal parts, each part standing for an inch. To make a drawing in one-eighth full size, each inch and a half on the scale is divided into twelve equal parts, each part representing an inch. For a drawing one-sixteenth full size, each three fourths of an inch is divided into twelve equal parts, each part representing an inch.

These proportions or reductions are indicated in the drawing thus: "Scale, Half-Size," or "Scale, 6″=1 foot"; "Scale, Quarter-Size," or "Scale, 3″=1 foot"; "Scale, Eighth Size," or "Scale, $1\frac{1}{2}$″=1 foot," etc. When a drawing is made full size, the statement would be: "Scale, Full Size."

But sometimes it is necessary for drawings to be made even smaller than one-sixteenth actual size, as in drawings of houses, bridges, and of machinery. In these cases, we may take any measure as a unit. For instance, one inch may be taken to represent a foot, or one half, one fourth, or one eighth inches may represent a foot. The scale would then be stated: "Scale, 1″=1′"; "Scale, $\frac{1}{2}$″=1′"; "Scale, $\frac{1}{4}$″=1′," etc.

To Make Working Drawings with Instruments

Exercise I. To draw three views of a square prism standing vertically (Fig. 150). First draw the top view, using the blade of the T square for the horizontal lines, and a vertical edge of one of the triangles set against the upper edge of the T square for the vertical lines. Measurements are set off with a scale or compasses. From the top view, project downward, vertical lines for the vertical lines of the front view. Measure off the proper length, and with the T square draw the horizontals, projecting them indefinitely for the side view. The distance between the front and top views should be sufficient to allow for the placing of any measurements without the appearance of crowding. In order to locate the side view, place the needle point of the compass at 1, and with a radius equal to the distance between the front and top views, as 1–2, draw an arc that will revolve point 2 in the top view to its position in the side view. With point 1 as center and a radius equal to 1–3, revolve point 3 in the top view to its position in the side view. 2–3 is the width of the side view. Complete the rectangle. Place the figures and dimension lines as indicated.

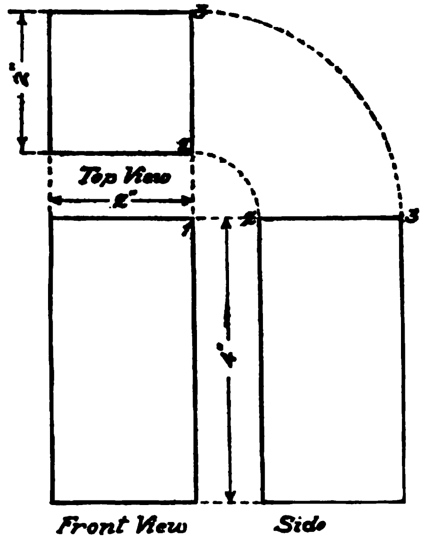


FIG. 150

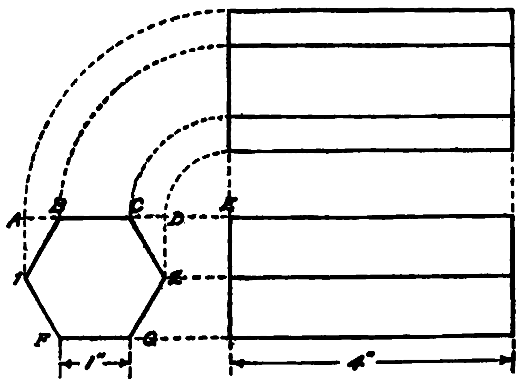


FIG. 151

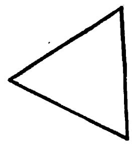


Fig. 152

Exercise II. To draw three views of a horizontal hexagonal prism (Fig. 151). Draw the end view first by Problem XIV, page 114, or with the 30 and 60 degree triangle. Project the horizontal lines in the end view indefinitely, thus locating the horizontal edges of the front view. Locate the vertical edges of the front view. At 1 and 2 erect perpendiculars to intersect the upper horizontal in A and D. With E as center, and with radii DE, CE, BE and AE, draw quarter circles to intersect projected verticals from the front view. These points locate the edges for the top view. Finish as shown in Fig. 151.

Exercise III. Draw three views of an upright, equilateral triangular prism, placed with one face in front. In this case, one edge is invisible and must be represented by a dash line.

Exercise IV. Draw the same prism named in the previous problem, placed so that two oblique faces form the front view.

Exercise V. Draw three views of an upright equilateral triangular prism, with the top view at the angle indicated in Fig. 152.

Exercise VI. Draw the end and front views of a horizontal hollow cylinder. Indicate invisible edges.

Note. In practical shop-work only as many views of an object are drawn as are necessary to show all the facts of the object. Two views are sometimes sufficient, but three or four views are often required to show the shape of all the parts. In the cylinder but two views are necessary,—the end and front views of a horizontal cylinder, or the top and front views of the upright cylinder. Other views would give no more information regarding the facts of the object.

Exercise VII. Draw three views of the cylindric object shown in Fig. 153. On one end is a square projection and on the other end is a round projection. In this case three views are necessary,—the front and two end views,—as the front view would not show whether the projections at the ends are round or square.

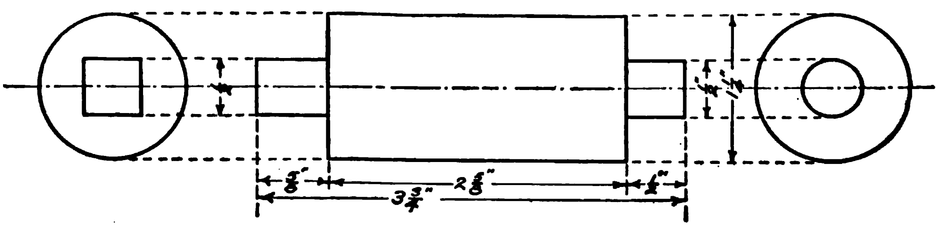


Fig. 153

Exercise VIII. Draw two views of a horizontal cylinder, in one end of which is a circular socket width and depth one eighth of the length of the cylinder. In the other end is a square socket of the same dimensions.

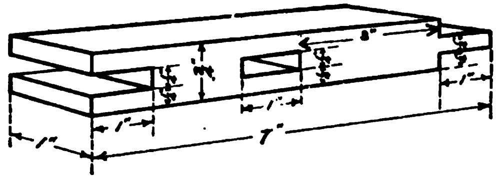


Fig. 154

The end views in this case will be exactly the same as the end views in Fig. 153. Show invisible edges in front view.

Exercise IX. Draw front, top, and two end views of the object represented in Fig. 154.

Exercise X. Make a working drawing showing three views of a wall bracket. Choose your own dimensions and draw to scale.

Plates I and II show a number of joints used in wood-working. Working drawings may be made from these sketches or from actual joints found in the construction of furniture and in carpentry. On Plate III, page 140, is shown a working drawing of a library table, drawn to scale. Sketches showing the construction of the various parts are also given, drawn in a larger proportion. These sketches are not working drawings, and are not to be copied. But working drawings should be made of these parts, with the proper dimensions marked upon the drawings. A working drawing of a kitchen table may be made in a similar way, the student either designing the proportions or taking the measurements from the object. If all constructions are not made clear in the views, detail drawings should be made, giving the necessary information.

Plates I, II, III and IV show sketches which may form the basis of working drawings. These drawings must show, either in views or by means of detail drawings, all the facts necessary for a workman to know in order to construct the object. Students may determine all measurements and proportions, stating them in their proper places on the drawings.

Free-hand Constructive Drawing

Although a finished working drawing is almost invariably made with instruments, it is a mistake to suppose that free-hand drawing has no place in connection with construction. In practical life the valuable man is the

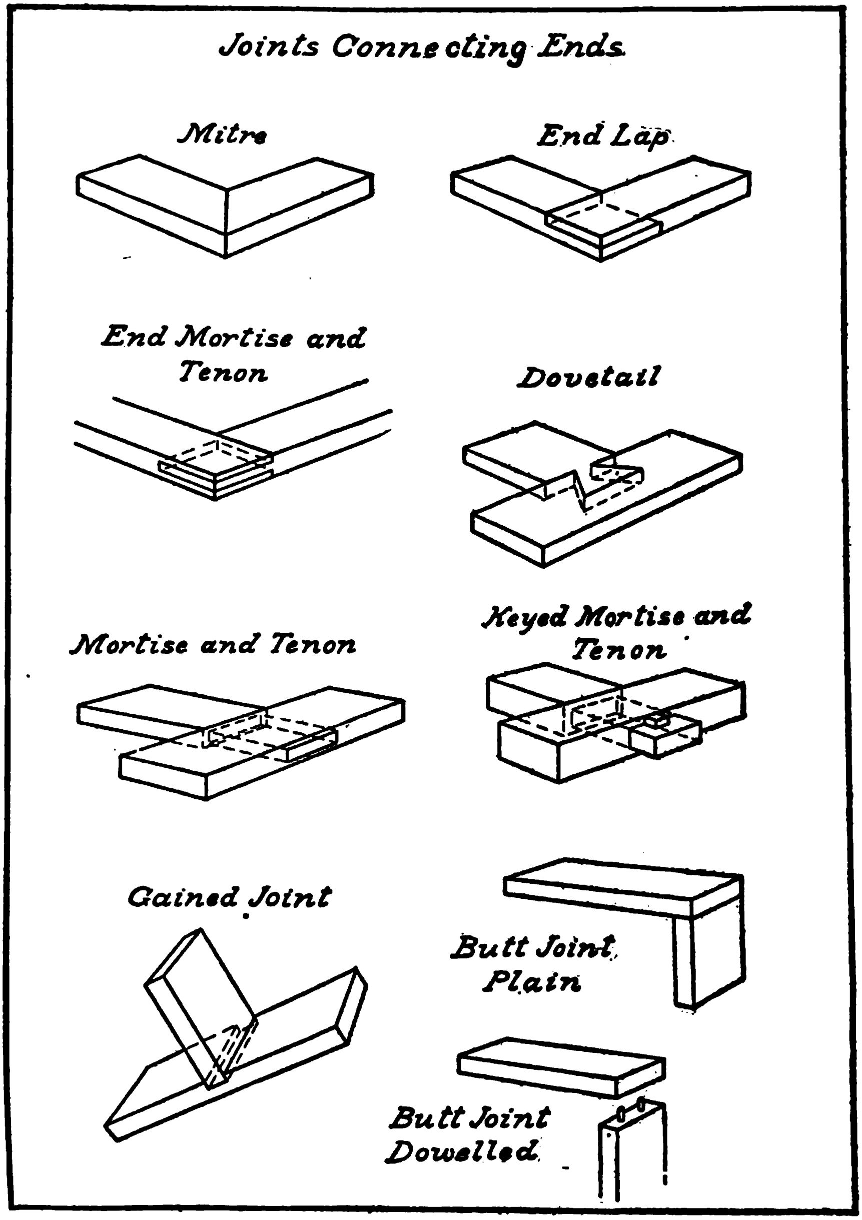

Joints Connecting Ends
Mitre
End Lap
End Mortise and Tenon
Dovetail
Mortise and Tenon
Keyed Mortise and Tenon
Gained Joint
Butt Joint, Plain
Butt Joint Dowelled

PLATE I

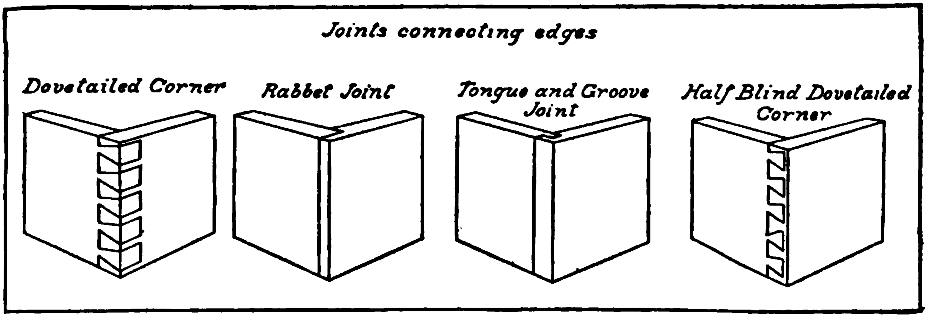


PLATE II

man who can make a design or plan of some problem of construction. These initial ideas are nearly always set down on paper by means of free-hand sketches and working drawings, which may afterward be given to a draughtsman who can work them out carefully with instruments, thus rendering the drawing accurate, and furnishing all the detailed information that a workman must have. The free-hand sketch is the test of a student's understanding of the problem, and this understanding is even more important than the ability to use instruments with technical skill.

Students should be able to sketch readily from any of the objects considered in this chapter, making either pictorial representations or free-hand working drawings, as the problem demands. They should also be able to draw, with reasonable accuracy, circles, ellipses, spirals and other curves, rather than to depend upon compasses and the French curve.

Free-hand Working Drawings

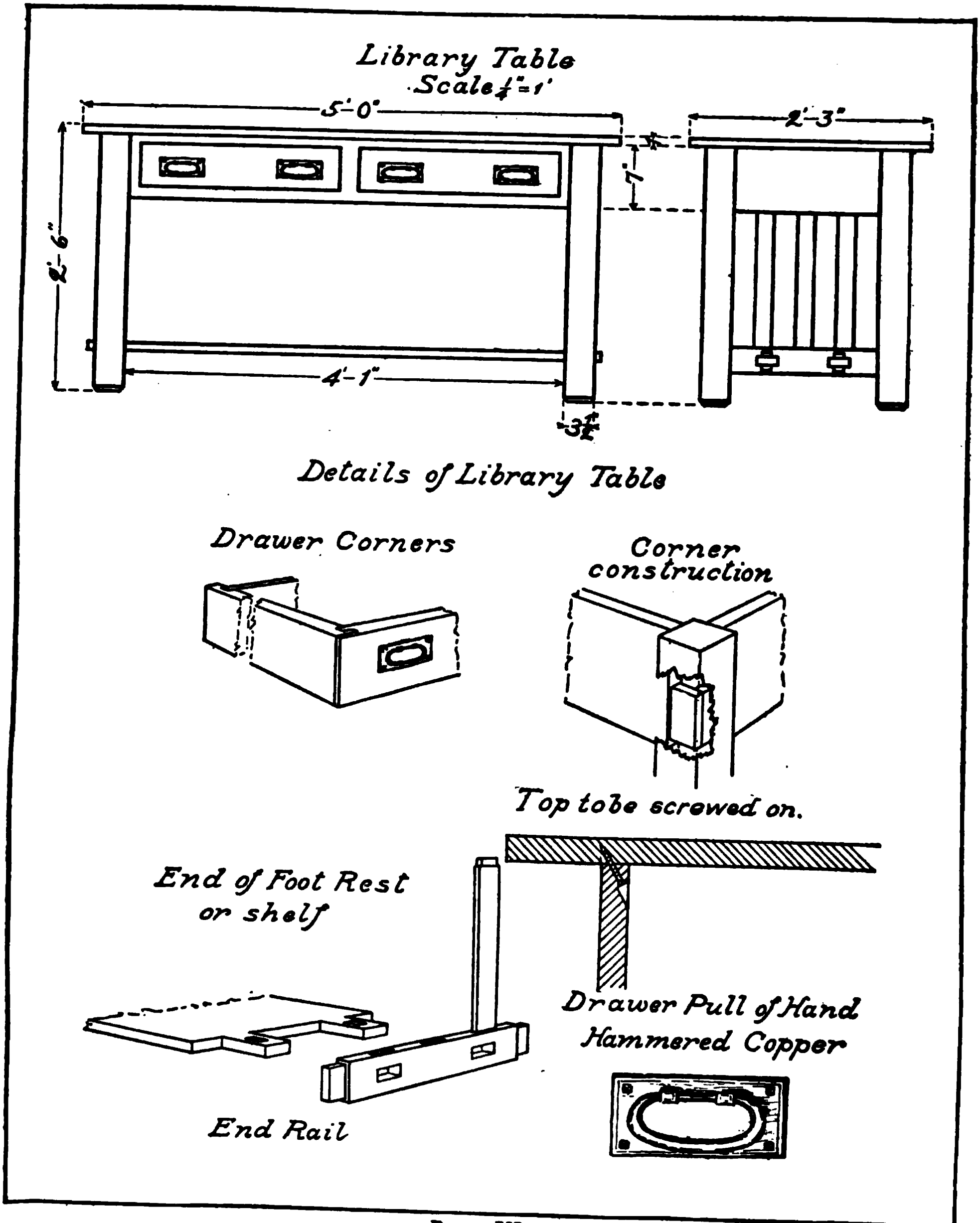
Exercise I. Draw the front, top and end views of a pencil or chalk box.

Exercise II. Draw the front and top views of a sphere.

Exercise III. Draw the front, top and right end views of a horizontal cylinder.

Exercise IV. Draw the front, top and left views of an equilateral triangular prism, placed with two oblique faces forming the front view.

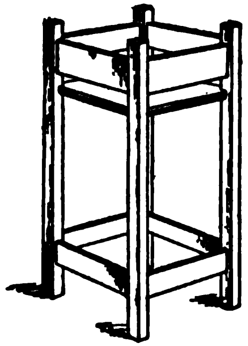
Exercise V. Draw the top and front views of a square pyramid, turned at 45°.



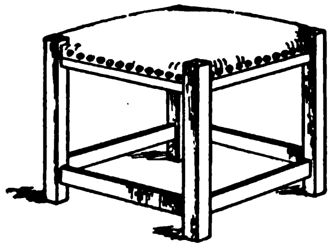
Library Table
Scale ¼" = 1'
5'-0"
2'-3"
2'-6"
7"
4'-1"
3½"
Details of Library Table
Drawer Corners
Corner construction
Top to be screwed on.
End of Foot Rest or shelf
End Rail
Drawer Pull of Hand Hammered Copper

PLATE III

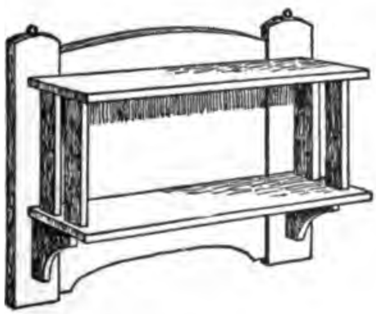
Exercises for working drawings



Plant Stand



Stool



Wall Shelf

PLATE IV

Exercise VI. Draw the front and top views of a hexagonal prism standing upright.

Exercise VII. Make free-hand working drawings, showing as many views as are necessary, of the objects represented in Figures 155, 156, 157 and 158.

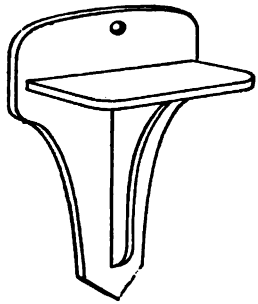


FIG. 155

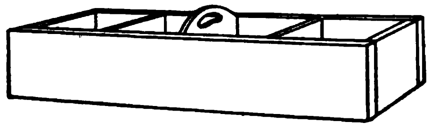


FIG. 156

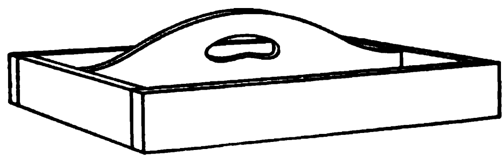


FIG. 157

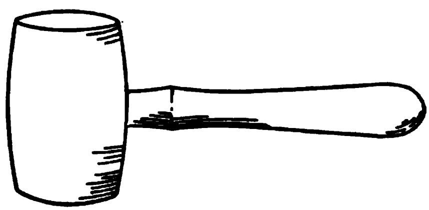


FIG. 158

Theory of Orthographic Projection

Working drawings are usually based upon orthographic projection. Orthographic projection is the art of representing an object by means of projections or views made upon different planes at right angles to one another. In order that the student may understand the theory of the preceding working drawings, a demonstration should be made by means of the following device: Take two panes of glass (the proportions suggested by the sketches that follow) and lay the long edges about a quarter inch apart upon a strip of cloth ¾ of an inch wide. The cloth should have received previously a coating of glue. To make the fastening more durable, glue another strip of cloth on top of the edges, so that the edges of the glass are between a double thickness of cloth, as shown in Fig. 159. If these pieces of glass are held so that one is vertical and the other horizontal, they will represent the imaginary planes upon which the top and front views of an object are supposed to be projected or drawn. Call the vertical plane, V, and the horizontal plane, H. The lines of intersection of these two planes is called the Ground Line (G. L.). Place some object, as a square plinth, behind V and below H, holding it so that the square faces are horizontal and parallel with H, and the front face parallel with V (Fig. 160). By looking directly down from above it will be seen that if a tracing is made on the glass following the outlines of the top surface of the plinth, the result will be a square. If the planes are held directly

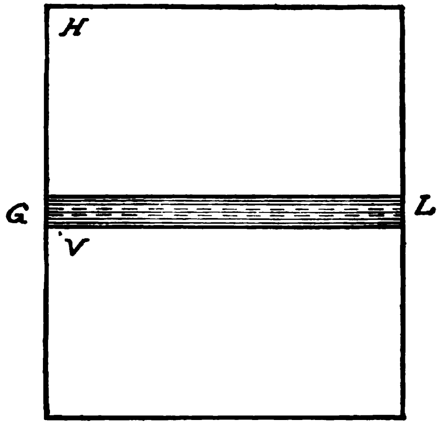


FIG. 159

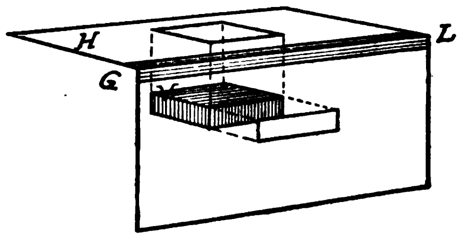


FIG. 160

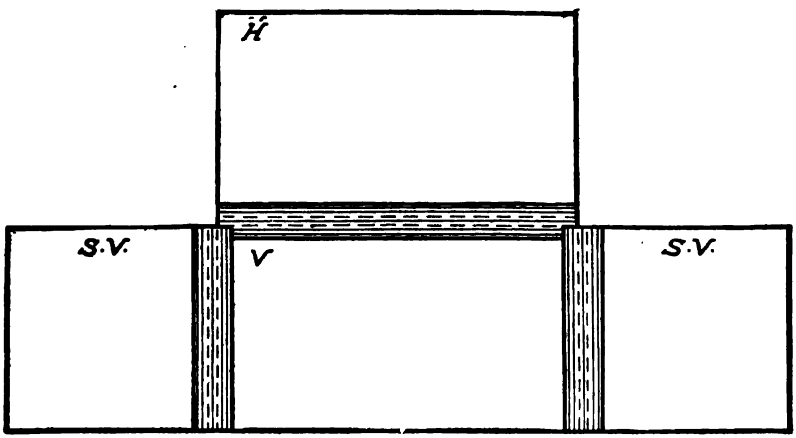


FIG. 161

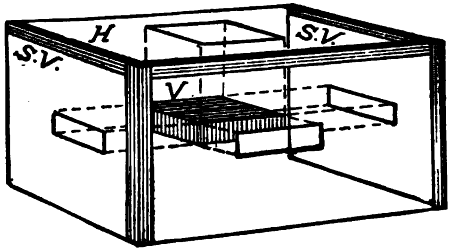


Fig. 162

in front, so that the center of the front face of the plinth is opposite the eye, a tracing of the outlines of the plinth would be an oblong (Fig. 160). To demonstrate the theory of side views, fasten a piece of glass to the right edge and one to the left edge of the vertical plane, as shown in Fig. 161. Place these planes in the form of a box open at the back and at the bottom, as shown in Fig. 162. Within this box, hold the plinth as before, and, looking through each plane in turn, a face of the plinth will be seen on each of the four planes. If a tracing of a face were made on each plane, and the group of planes were then spread out on a flat surface, as in Fig. 163, the arrangement of views used in working drawings would be seen. Eliminating the planes, the views appear as in Fig. 164.

The projection of lines may be demonstrated in a similar way. Place the glass planes on a board in the position shown in Fig. 165. Procure a piece of wire, about the size of the lead in a pencil. Bend one inch of this wire over, to form a right angle. Bore a hole the size of the wire through the middle of a small smooth stick the size of a lead pencil, or

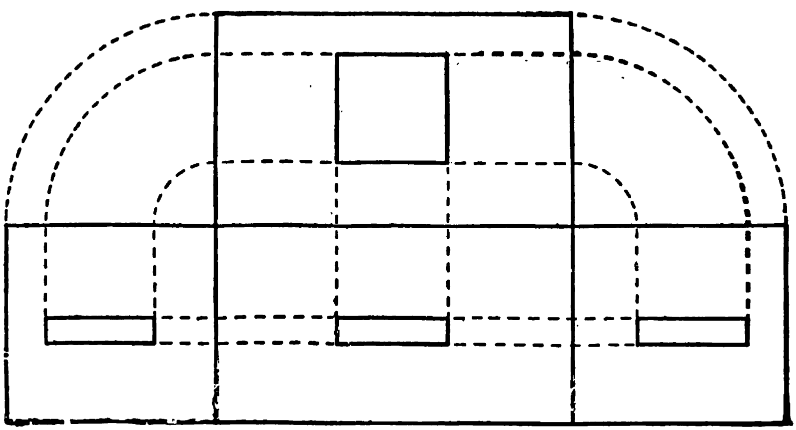


Fig. 163

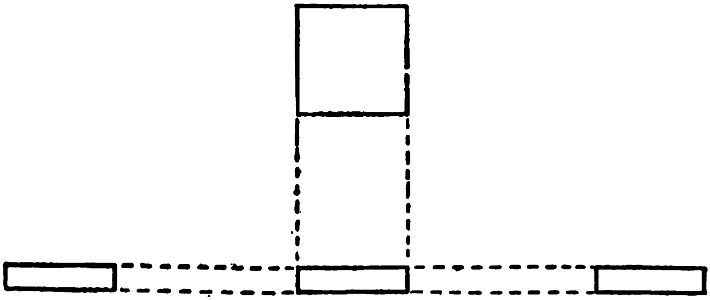


FIG. 164

smaller (Fig. 166). (The small wooden skewers used in meat shops are excellent for this device). Place the bent end of the wire through the hole in the stick (Fig. 167). Insert the straight end of the wire into a small hole in the center of the board under the glass (Fig. 165). This device will permit the stick to be turned at any desired angle.

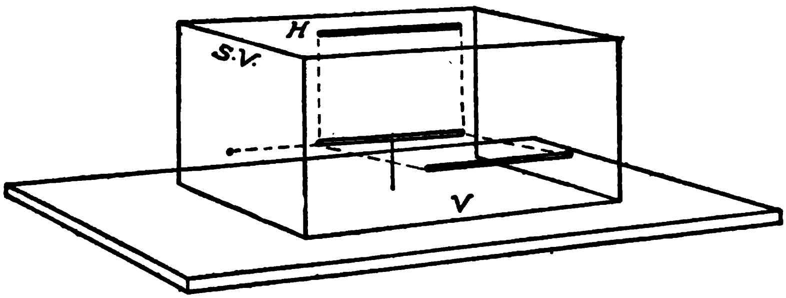


FIG. 165

First place the stick in a horizontal position, parallel with both V and H. Look at it through the planes, and the stick, which stands for a line, will appear as represented in Fig. 168. It will be seen that when a line is parallel with either plane, it appears and would be drawn on that plane in its true length. It will also be seen that when a line is perpendicular to one of the planes (as the pencil is perpendicular to SV in Fig. 165), it appears as a point on that plane.

Turn the stick on the wire so that, while it is still horizontal, it is perpendicular to V. It will appear as a point in V, and as a line on H and SV (Fig. 169).

FIG. 166

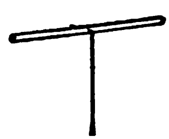


FIG. 167

Without regard to the glass planes, and in order to demonstrate this point still more clearly, hold a pencil in a horizontal position with the end facing you, and draw its top, front and side views.

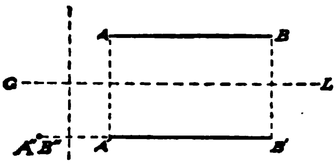


Fig. 168

Turn the stick so that it will be parallel with V but will make an angle with H and SV, and draw the projections or views as they appear on the planes (Fig. 170). It will be seen that when a line is oblique to any one of the planes, the projection or view on that plane is foreshortened.

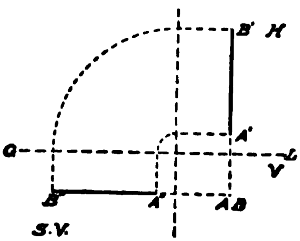


Fig. 169

Turn the stick so that it will still be horizontal but will make an angle of about 45° with V. Its projection or views will now be changed. The top view will be a line, showing its true length and the true angle it makes with V. The front view will be a horizontal line foreshortened, because it is seen obliquely. The side view will also be foreshortened into a horizontal line. Hold your pencil in this position and draw its different views.

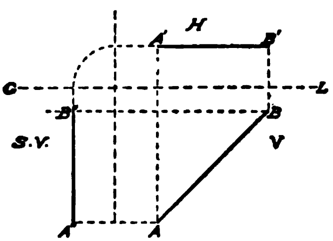


Fig. 170

Turn the stick so that it will be parallel to SV and oblique to both the other planes. The stick will now appear in its true length on SV, and this view will show also the true angle the line makes with the other two planes (Figs. 171 and 172). In cases like this, the side view must be drawn first, because it is that view which shows the true length of the line.

Draw the views of your pencil held so that it is parallel to SV and oblique to both the other planes.

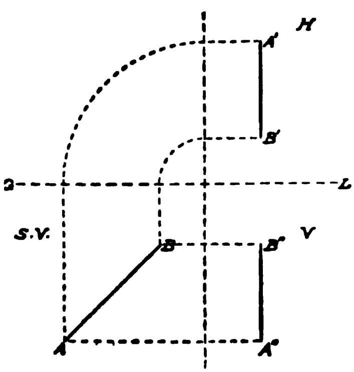


Fig. 171

If the stick is placed so that it is oblique to all of the planes, it will be seen that the line does not appear in its true length in any view, for all of its views would be foreshortened. Neither will a true angle be shown in any view (Fig. 173).

From the foregoing the following principles may be deduced: —

1. When a line is parallel with one of the planes, whether real or imaginary, it appears in its true length on that plane.

2. When a line is perpendicular to one of the planes, it appears as a point on that plane.

3. When a line forms an oblique angle with one of the planes, it appears foreshortened on that plane.

4. When a line is oblique to all the planes, it is foreshortened, and does not appear in its true length on any plane.

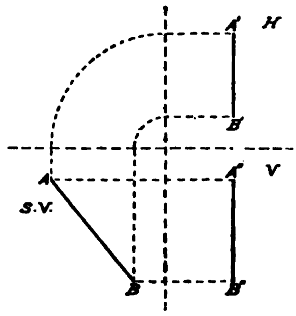


FIG. 172

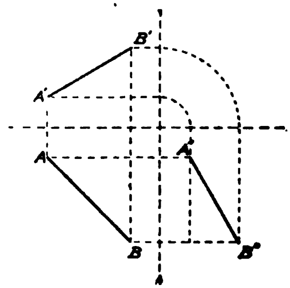


FIG. 173

Let us review these lines as they occur in an object with which we are already familiar.

In the prism shown in Fig. 174, the line AE is parallel with both V and H, and perpendicular to SV. Therefore, it appears in its true length in the top and front views, and as a point in the end view. The line CB is parallel with H and SV, and is perpendicular to V. It appears in its true length in the top and side views, and as a point in the front view. The lines AC and AB are parallel with SV, but make oblique angles with both V and H. They appear in their true length in the side view, and are foreshortened in both the other views (Fig. 175).

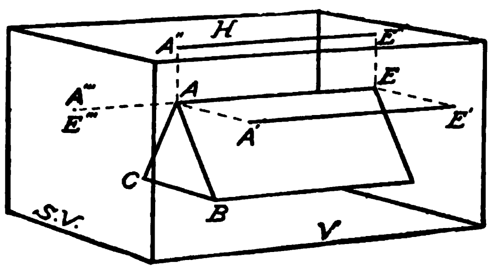


FIG. 174

The square pyramid (Fig. 176) offers another example of lines and faces

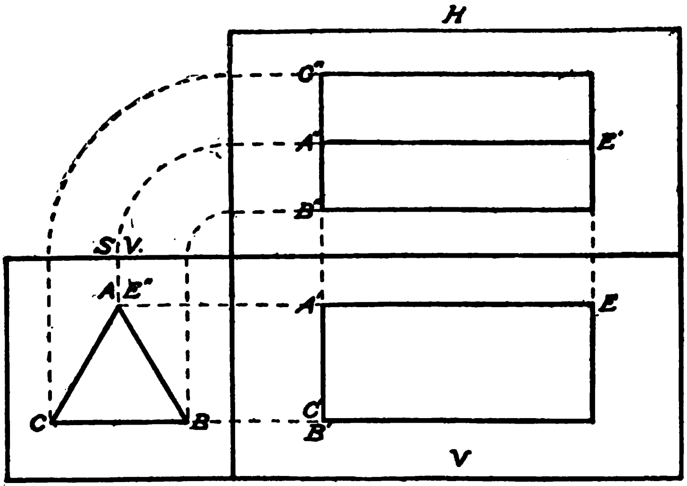


Fig. 175

oblique to the planes upon which they must be represented. The lines AB, AC, AD and AE are oblique to all the planes, and are therefore foreshortened in all the views. To find the true length of a line in this position, the line must be revolved until it is parallel with one of the planes of projection. With A as center and AB as radius, revolve point B until the line used as radius is parallel with V, and the point B″ is found. The point B″ when projected to its position in the front view, will be B′″, and the line A′ B′″ will be the true length of the line AB, which is one of the long edges of the square pyramid. This process of revolving a point until the line is parallel with one of the planes is equivalent to turning the object one quarter around. When drawing the developed surface or pattern of a square pyramid, it is necessary to ascertain the true length of edges, as shown in Fig. 240.

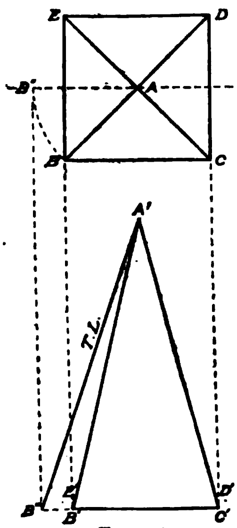


Fig. 176

From the foregoing examples deductions may be made by which the true length of a line may be found when it makes angles with both V and H. With either end of the line in either view as center, and with the length of the projection or view of the line as radius, revolve the other end of the line until the line is parallel with the ground line. Draw the other view of the point revolved, and connect the points as shown

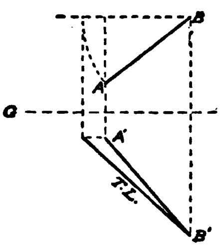


FIG. 177

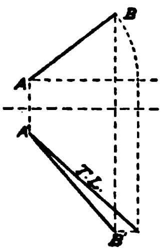


FIG. 178

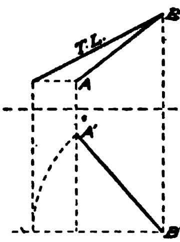


FIG. 179

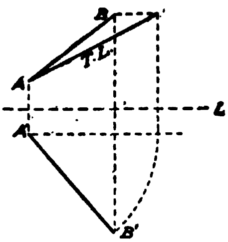


FIG. 180

in Figures 177, 178, 179 and 180.

Exercise I. Find the true length of the lines shown in Figures 181, 182, 183 and 184.

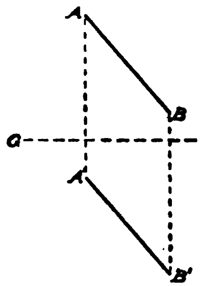


FIG. 181

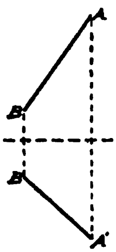


FIG. 182

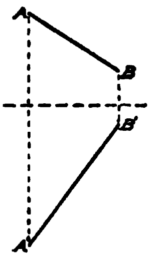


FIG. 183

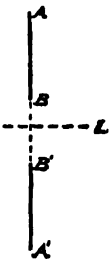


FIG. 184

Exercise II. Find the true length of the line AB in Fig. 185.

To draw oblique views of an object; for example, the square pyramid, the base

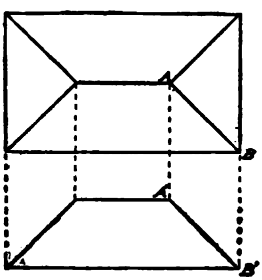


FIG. 185

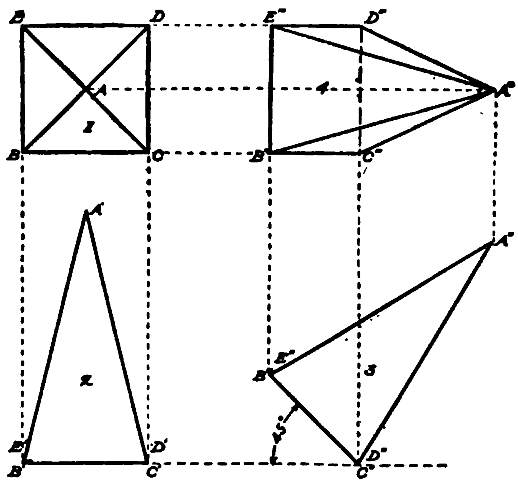


FIG. 186

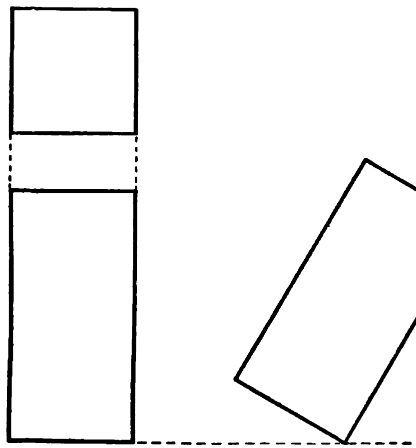


FIG. 187

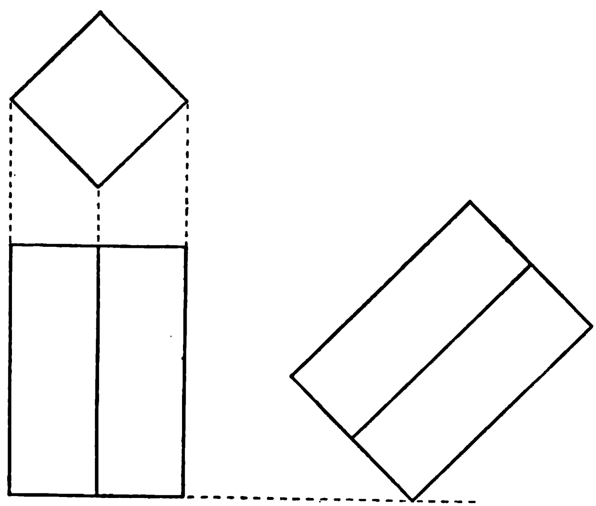


FIG. 188

inclined at 45°. Obtain the front and top views of the pyramid, as shown in 1 and 2, Fig. 186. Letter all points, bearing in mind that the letters in the front view must fall directly under the corresponding letters in the top view. At the right of the front view repeat the drawing at an angle of 45°, as shown in 3, Fig. 186. Place letters in 3 to correspond with the letters in 2. Project the points in 1 to the right, and project the points from 3 upward until they intersect the lines from 1. For instance, the intersection of the lines projected from A in 1 with the line projected from A″ in 3 will give A′″ in 4. Repeat with all other points, and finish the drawing. The student will be greatly assisted if he has the model and can hold it in the position indicated.

Exercise III. Draw corresponding views of a square prism. (Figs. 187 and 188.)

Exercise IV. Draw the corresponding views of an equilateral

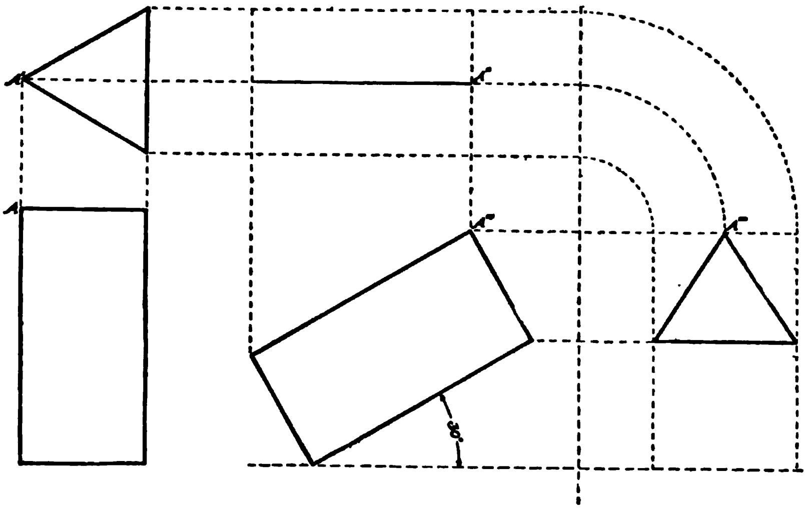


FIG. 189

triangular prism, inclined at 30° and 60°, and draw also the side view as shown in Fig. 189. (Not completed.)

Exercise V. Draw the same views of a square pyramid, inclined at the same angle.

Exercise VI. Draw the same views of a hexagonal prism, inclined at the same angle.

Exercise VII. Draw the same views of a cylinder, inclined at 30° and 60° (Fig. 190. Not completed.)

Note: In drawing oblique views of a circular surface it is necessary to establish certain points which may be projected

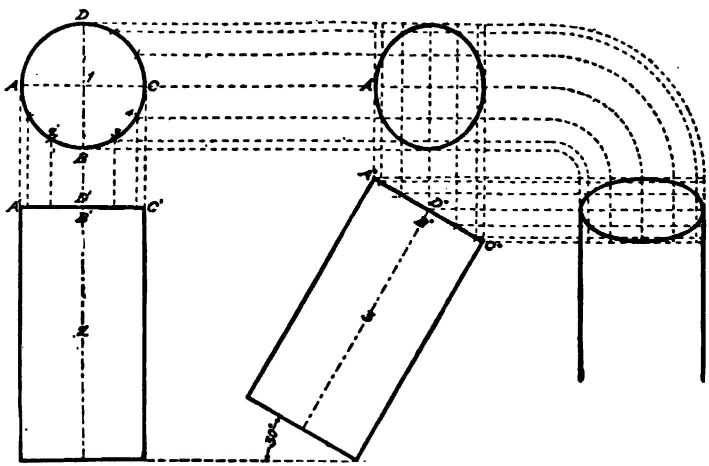


FIG. 190

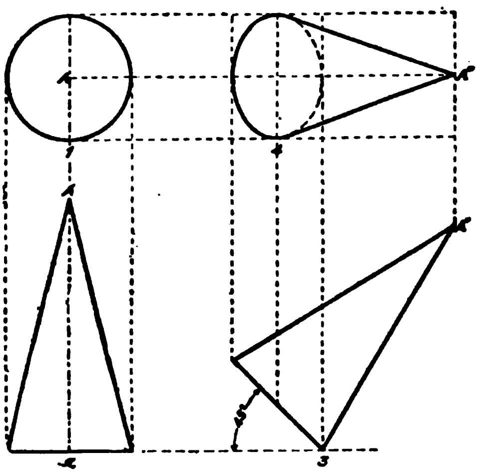


FIG. 191

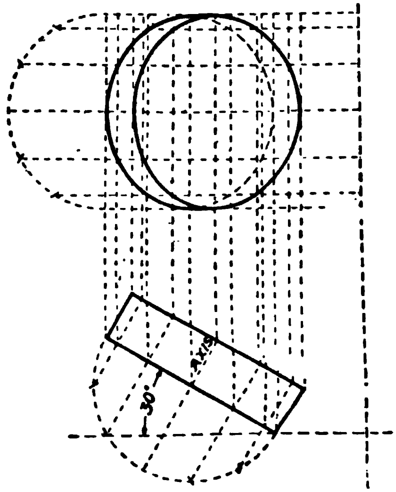


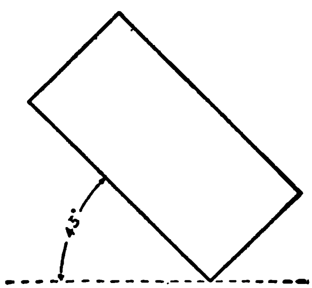
FIG. 192

from one view to corresponding views. To do this, divide the circle into twelve (or more) equal parts, as shown in 1, and project the points to the front view. Transfer the points to 3, and proceed as in the foregoing examples.

Exercise VIII. Draw the same views of a cone. Notice that the contour lines from A′′ (Fig. 191) are drawn tangent to the ellipse and not to the ends of the diameter.

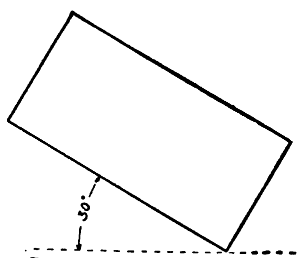
Exercise IX. Draw the top and side views of a circular plinth, whose circular faces are perpendicular to V, and at an angle of 30° with H (Fig. 192).

Exercise X. Draw the front, top and side views of the objects represented in Figures 193, 194 and 195.



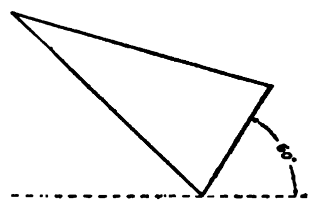
Front view of a square prism

FIG. 193



Front view of a cylinder

FIG. 194



Front view of a square pyramid

FIG. 195

Cutting-planes, Intersections of Solids and Developments

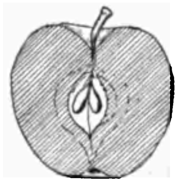


Fig. 196

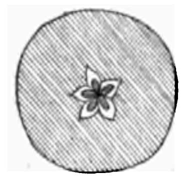


Fig. 197

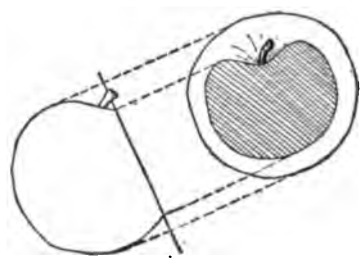


Fig. 198

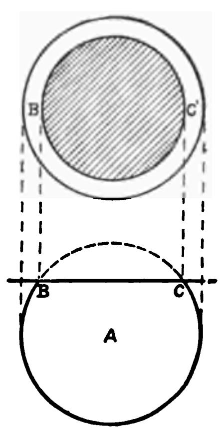


Fig. 199

It is often necessary to show in a drawing some part of an object that cannot be seen on the outside of the object. In order that the interior construction may be seen, the object is supposed to be cut by a plane, called a cutting-plane, and one part removed. When the cutting-plane is parallel with the axis of the object the section found is called a longitudinal section. When it is perpendicular to the axis the section found is called a transverse section. When it is oblique to the axis the section is called an oblique section. These sections can be illustrated in a very simple way. If we cut an apple down through its center we pass a vertical plane through it. Removing one half, and looking directly at the part freshly cut, we see the longitudinal section, as represented in Fig. 196. If we cut an apple by a horizontal plane (using the knife at right angles to the axis) and remove the upper half, we find the transverse section, as represented in Fig. 197. If we pass the knife through an apple at an angle which is oblique to the axis we shall find an oblique section, as represented in Fig. 198. These sections show the true shape of the apple at the place where it is cut. They show also the arrangement of the seeds, and the growth of the core, and thus give a better idea of the structure of the apple than could have been gained by a study of the outside alone.

Note: Sections that show the interior growth or construction of other objects, such as a seed-pod, any fruit or vegetable, a branch of a tree, etc., may be sketched, showing the result of longitudinal, transverse and oblique cutting-planes. The section in a drawing is indicated by covering the surface with light parallel lines, usually at an angle of 45°.

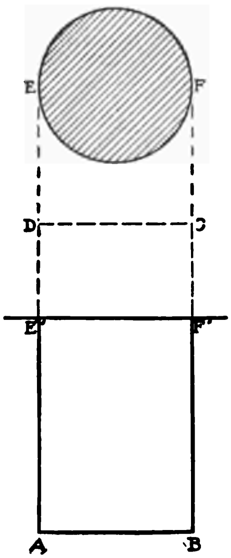


FIG. 200

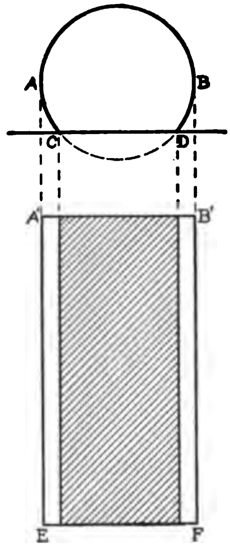


FIG. 201

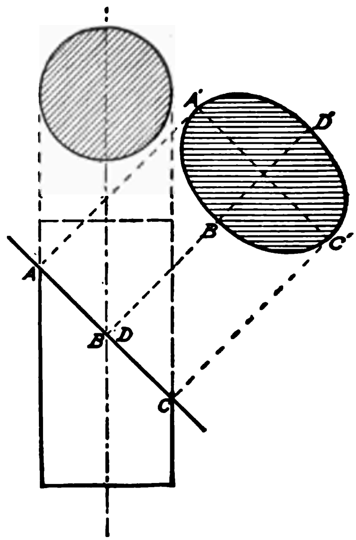


FIG. 202

The true shape of the section of a sphere cut by any plane, is a circle (Fig. 199). A cylinder when cut parallel with its base, shows a section whose shape is a circle (Fig. 200). A cylinder when cut parallel with its axis, shows a section whose shape is a parallelogram (Fig. 201).

A cylinder when cut oblique to its axis, shows a section whose shape is an ellipse (Fig. 202). An oblique sectional view is revolved 90° upon an axis parallel to the cutting-plane. This is done in order that the true shape of the section may be projected from the cutting-plane shown in Fig. 202.

A cone when cut by a plane coinciding with its axis, shows a section whose shape is a triangle (Fig. 203), when cut parallel with its base, the section is a circle (Fig. 204), when cut oblique to its axis, so that all the elements[1] of the cone are cut, the section is an ellipse (Fig. 205). When cut parallel with one of its elements, the section will be bounded by a parabola[2] (Fig. 206). If a cone is intersected by a plane which makes a greater

[1] Any straight line drawn on the surface of a cone and passing through the apex, as AB and AC (Fig. 205) is called an element.

[2] The curve formed by the intersection of a cone by a plane, parallel to one of its elements is called a parabola, as the curve B″ A″ C″ in Fig. 206.

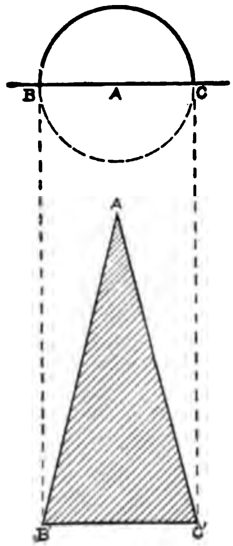


FIG. 203

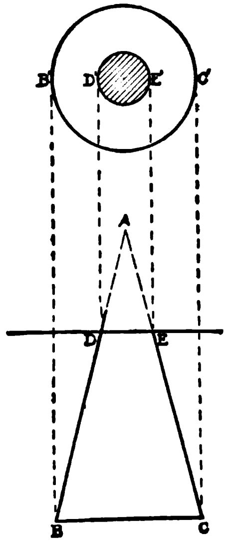


FIG. 204

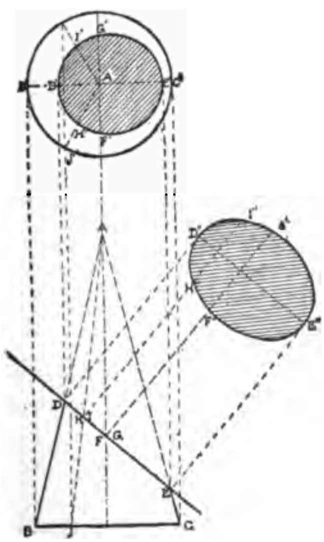


FIG. 205

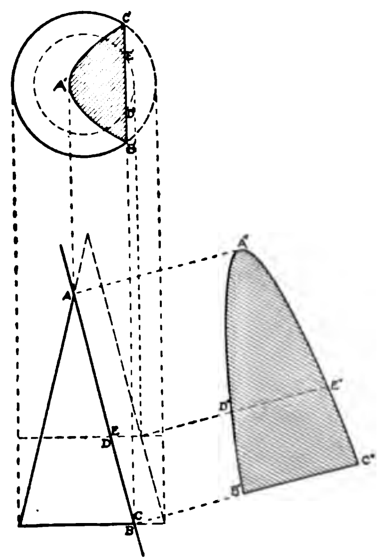


FIG. 206

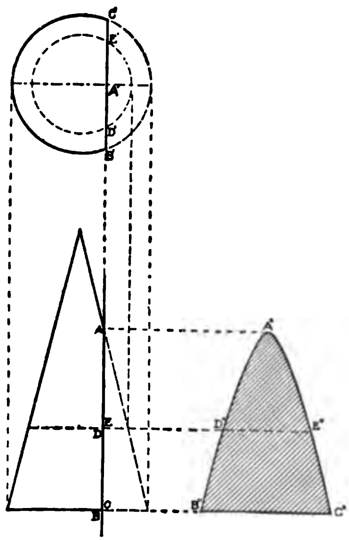


FIG. 207

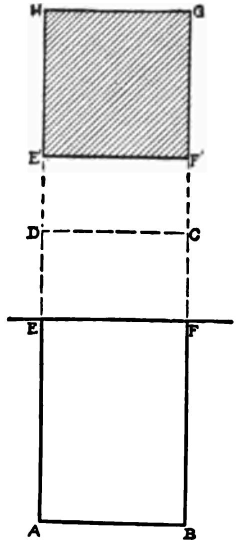


FIG. 208

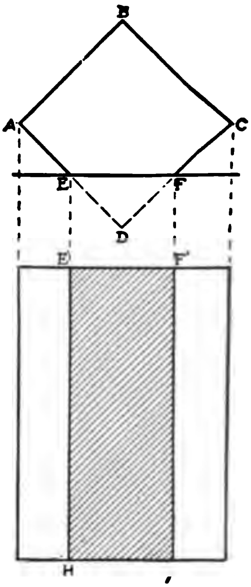


FIG. 209

angle with the base than do the elements, the section is bounded by a hyperbola[1] (Fig. 207).

When a prism is cut by a plane parallel with its bases, the section is the same shape as the base (Fig. 208); when cut parallel with its axis, the section is a parallelogram (Fig. 209); when cut oblique to its axis, the section is an irregular polygon (Fig. 210). When a pyramid is cut by a plane coinciding with its axis, the section is a triangle (Fig. 211); when cut parallel with its base, the section is the same shape as the base (Fig. 212); when cut oblique to its axis, the section is an irregular polygon (Fig. 213).

Sometimes a section shows two adjoining pieces of material, and when this is so, the different pieces are indicated by lines drawn at 45° in different directions, as in Fig. 214. If more than two pieces are shown in the section, lines drawn at other angles, as 30° and 60°, may be used (Fig. 215).

[1] When the cutting-plane intersects the base of a cone and is not parallel to any element the curve of intersection is called a hyperbola, as the curve B″ A″ C″ (Fig. 207).

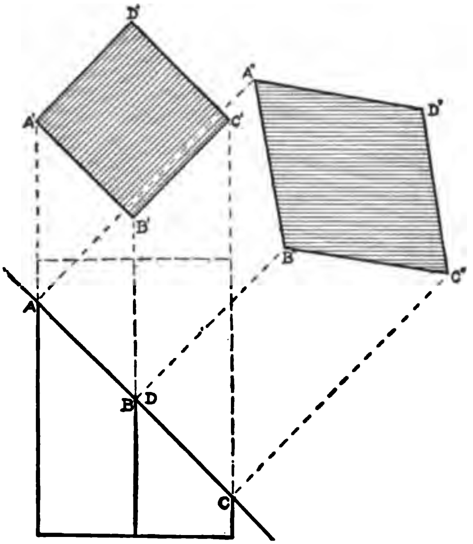


FIG. 210

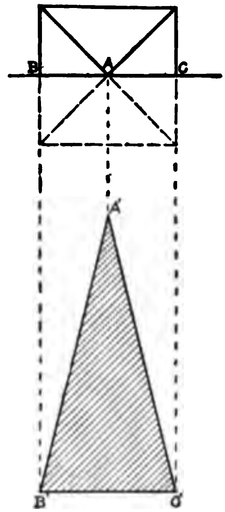


FIG. 211

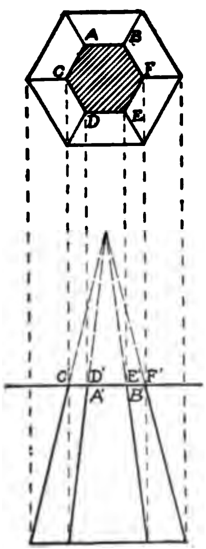


FIG. 212

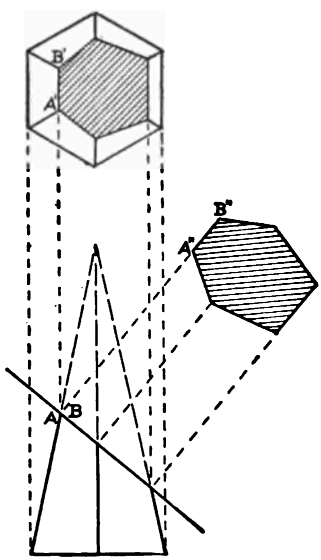


Fig. 213

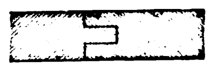


FIG. 214

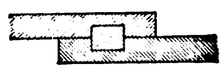


FIG. 215

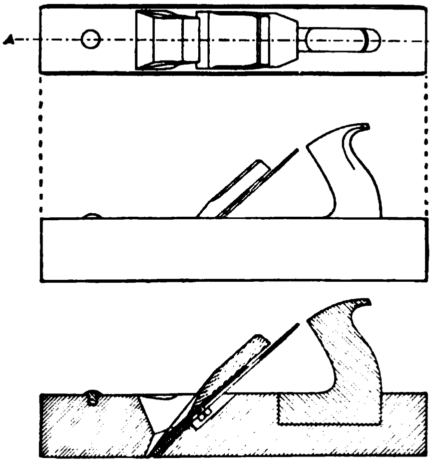


FIG. 216

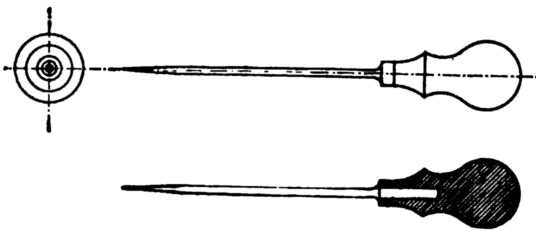


FIG. 217

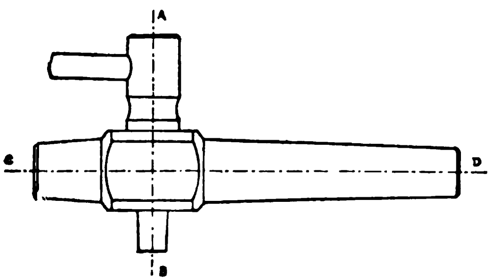


FIG. 218

Section lines representing the same piece, however, must always appear at the same angle in any part of that piece.

Exercise I. Show a longitudinal section of a hollow cylinder cut by a plane coinciding with its axis.

Exercise II. Show a transverse section of a hollow cylinder cut by a plane perpendicular to its axis.

Exercise III. Show an oblique section of a cylinder cut by a plane at 30° with its axis. Fig. 202 shows the process of obtaining the section of a cylinder cut by a plane at 45°. Lines are drawn from points A, B and C perpendicular to the plane AC. A′C′ is drawn parallel to AC. B′D′ is drawn equal to the diameter of the cylinder. The ellipse may be drawn by Problem XXXI, or as shown in Fig. 236.

Exercise IV. Fig. 216 shows the front and top views of a jack-plane with the longitudinal section. Draw a block-plane, showing similar views and sections.

Note: Bolts and small round spindles are not usually sectioned. See Fig. 217 and the drawings on page 171.

Exercise V. Fig. 217 shows the front and end views of an ice-pick, with a longitudinal section. Draw similar views of a screw-driver.

Exercise VI. Fig. 218 shows a side view of a spigot. Draw the sections as they would appear if cut on AB and on CD.

Exercise VII. Draw the front and end views of the oil-stone shown in Fig. 219, and show a transverse section.

Exercise VIII. Draw the front and end views of an ordinary tack-hammer and a transverse section of the handle at its greatest width.

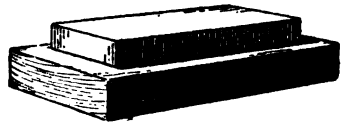
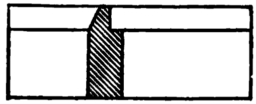


FIG. 219



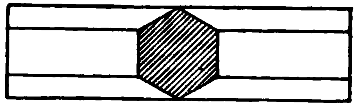


FIG. 220

Note: Transverse sections are sometimes shown on one of the views, instead of appearing in a separate drawing (Fig. 220).

The Development of Surfaces

When objects are made of sheet material, such as paper, cloth, leather, tin, sheet iron, copper, etc., the entire surface has first to be laid out flat and then folded, rolled or moulded into the required form. The surfaces of objects whose faces are flat, such as prisms and pyramids, and of those that curve in but one direction, as the cylinder and cone, can be drawn in a flat pattern, or developed. When a surface is curved in more than one direction, a pattern may be made that will approximate the surface, and may then be stretched or compressed into shape. A ball, for instance, may be covered with leather which may first be cut from a pattern and then, by wetting and shaping, be made to ft closely (Fig. 221). A bowl may be hammered into shape from a flat piece of copper (Fig. 222).

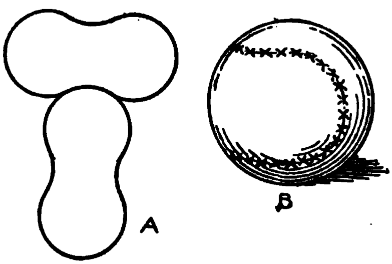


FIG. 221

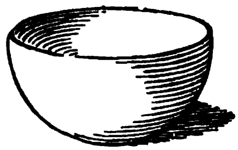


FIG. 222

The simplest forms from which

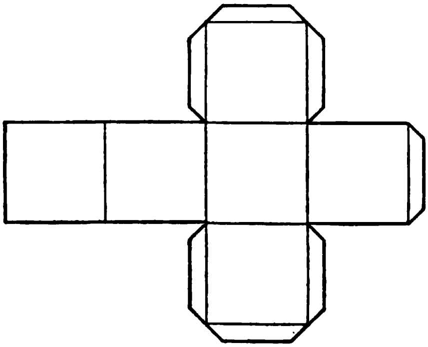


FIG. 223

patterns may be developed are the geometric solids. The six faces of the cube, for example, may be laid out as indicated in Fig. 223. Laps are added so that the pattern may be cut out, folded and pasted to form a hollow cube. In a similar way, patterns for the square, triangular and hexagonal prisms may be developed.

Exercise I. Make a pattern for a box 4″ long, $2\frac{1}{2}$″ wide and $1\frac{1}{4}$″ deep.

Exercise II. Make a cover $\frac{1}{2}$″ deep, to fit the box made in Exercise I. If stiff paper is the material used, the cover should be made the width of a pencil line larger than the box. If cardboard is used, the cover should be made the thickness of the cardboard larger on each side. Before folding thick paper or cardboard the edges should be scored.

Exercise III. Develop the surface of a cylinder 2″ in diameter and 4″ long.

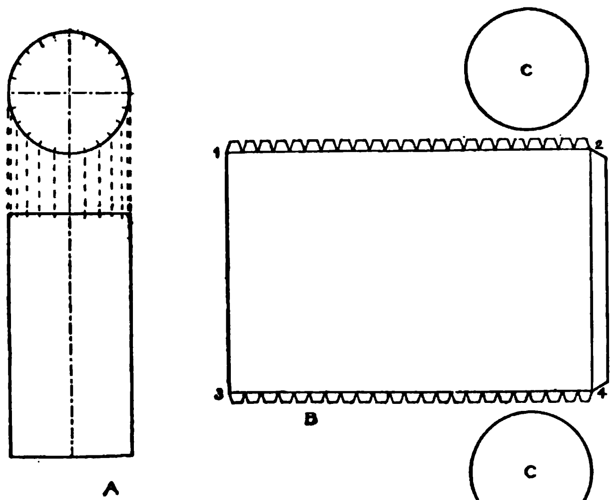


FIG. 224

Demonstration: the ends of the cylinder are circles (C and C, Fig. 224). The curved surface of the cylinder, if unrolled, would form a rectangle as wide as the cylinder is long and as long as the distance around the cylinder. To find this distance, divide the circle into any number of equal parts, as 24 (Problem XII). Measure $\frac{1}{24}$ with the dividers, and step off this distance twenty-four times on a horizontal line. The entire distance thus set off will represent the circumference of the cylinder. To make a hollow cylinder, leave a lap at one end of this rectangle and on the edges that are to be pasted to the circular ends, as in B, Fig. 224. Score 1–2 and 3–4, but not 2–4. To make the paper construction more perfect, two circular pieces should be pasted at each end, one inside and one outside. The inside circle will keep the cylinder round, and the outside one will cover the laps.

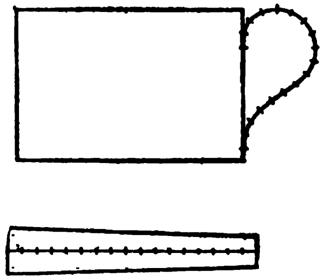


FIG. 225

Exercise IV. Make a pattern for a tin cup, 3″ in diameter and 2″ high. Draw a well-shaped handle and space it off with the dividers, making the strip of paper as long as the handle (Fig. 225).

Exercise V. Develop the surface of a cone. Divide the base of the cone into a number of equal parts, as in the cylinder. In the cone, however, these parts are not set off on a horizontal line, but upon an arc, the radius of which is the slant height of the cone, Fig. 226.

Note. In developing surfaces it is best to draw first the views of the object.

Exercise VI. Develop the surface of the frustum of a cone (Fig. 227). Produce the sides until they meet at the apex of the cone at A, and proceed as in the case of the cone.

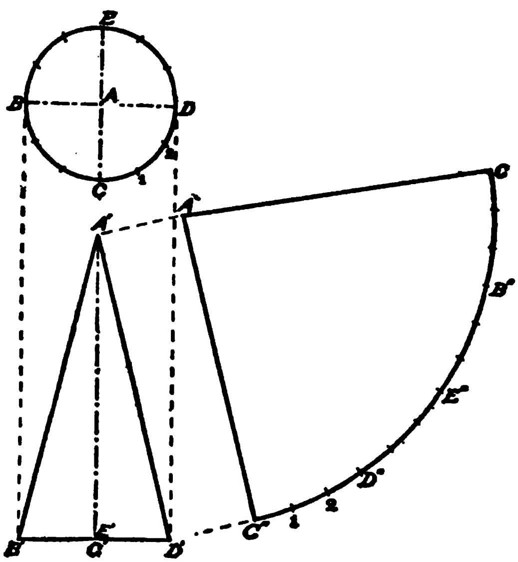


FIG. 226

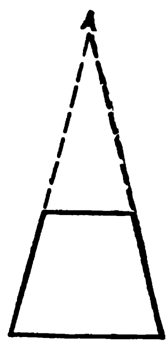


FIG. 227

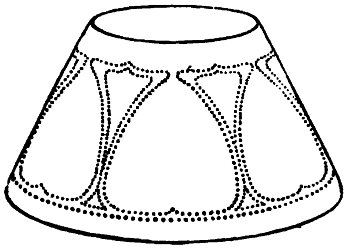


Fig. 228

Exercise VII. Make a pattern for the lamp-shade shown in Fig. 228.

Exercise VIII. Develop the surface of a square pyramid. Draw the top view with the sides of the base at an angle of 45° with the vertical plane (Fig. 229). In the front view the line A′ C′ is not its true length, but the line A′ B′, which is parallel with V, is. We can, therefore, take the line A′ B′ or A′ D′ for a radius and draw an arc of a circle (Fig. 230). Set off the sides of the base on this arc, and connect these points with straight lines. On any one of these lines draw a square equal to the base of the pyramid.

To make the pattern of a frustum of a pyramid (Fig. 231), produce the sides to form a pyramid and proceed as in the case of the pyramid. If the frustum is inverted it may be developed in the same way.

Exercise IX. Make a pattern for a square pan, shown in Fig. 232. Method shown in Fig. 233.

Exercise X. Make a pattern for a pan 3″ long and 2″ wide at the

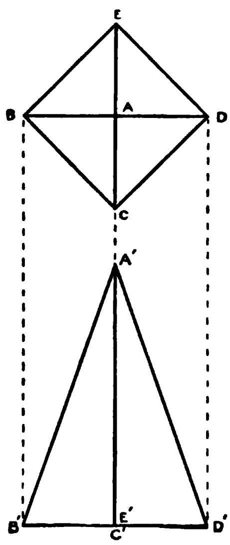


Fig. 229

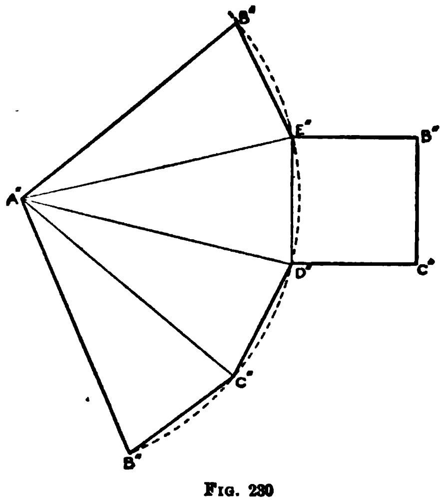


Fig. 230

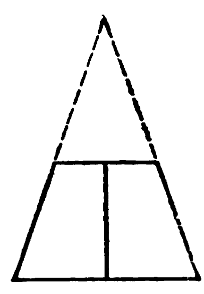


Fig. 231

bottom The sides are 1″ wide, and slant outward at an angle of 120° with the bottom.

Exercise XI. Draw the top and front views and the developed surface of a vertical square prism, cut by a plane at 45° with its axis (Fig. 234). Two of these sections put together will make an elbow in a square pipe (Fig. 235 *a* and *b*).

Exercise XII. Draw the top and front views and the developed surface of an equilateral triangular prism, cut by a plane at 45° with its axis.

Exercise XIII. Draw the top and front views and the developed surface of a hexagonal prism cut by a plane at 45° with its axis.

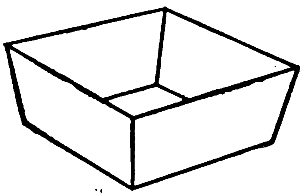


Fig. 232

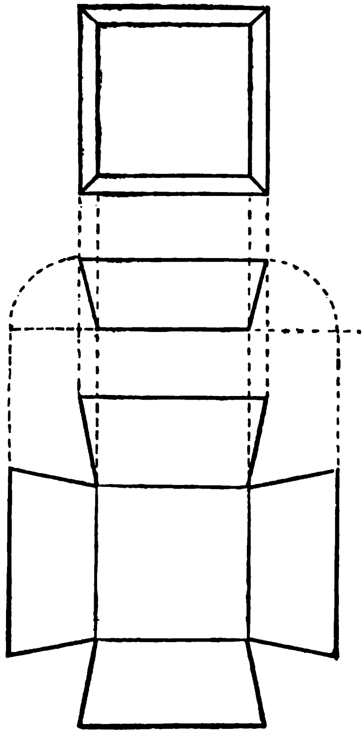


Fig. 233

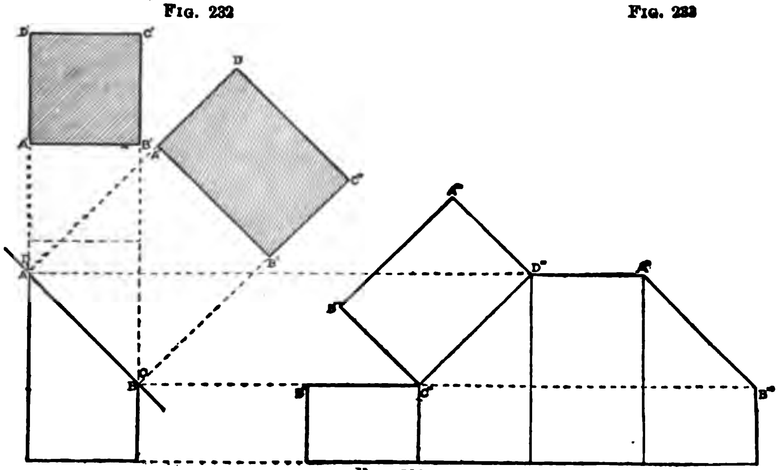
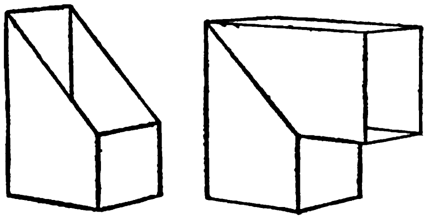


Fig. 234



a FIG. 235 b

Exercise XIV. Draw the top and front views and the developed surface of a square prism standing with its vertical faces at 45° with V. The cutting-plane enters the prism at an angle of 45°.

Exercise XV. Draw the top and front views and the developed surface of a cylinder cut by a plane at 45° with its axis (Fig. 236). Two of these together make an elbow of a stove-pipe (Fig. 237).

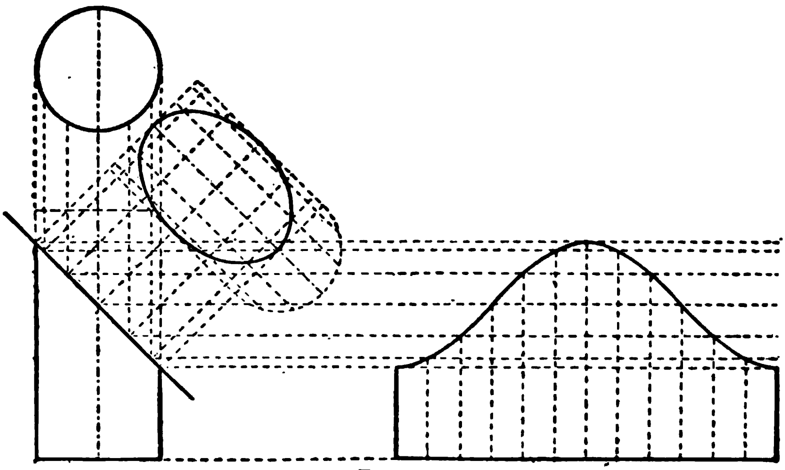


FIG. 236

Exercise XVI. Draw the same views, with developments, of a cylinder cut by a plane at 60° with its axis. Make a jointed pipe, as shown in Fig. 238.

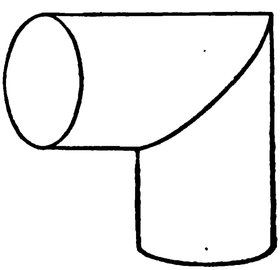


FIG. 237

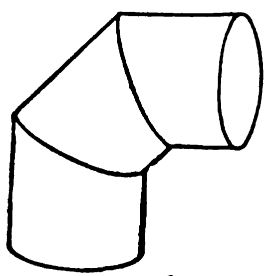


FIG. 238

Exercise XVII. Make a pattern for the can, with cover, shown in Fig. 239.

Exercise XVIII. Draw the views and the developed surface of a square pyramid standing vertically, the sides of the base making angles of 45° with V. The pyramid is cut by a plane oblique to its axis. Show the true shape of the section (Fig. 240).

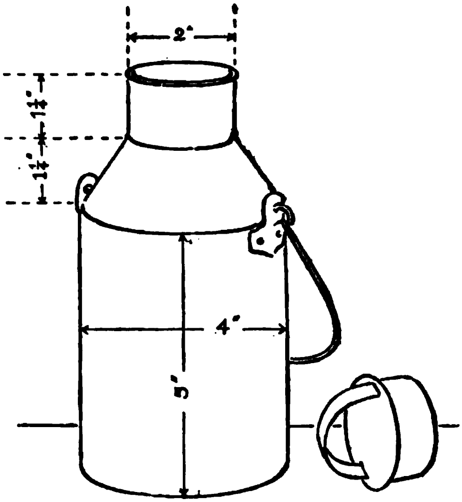


Fig. 239

Demonstration: Letter the points where the cutting-plane cuts the edges of the pyramid in the front view, F, G, H and I. To show where the plane cuts the edges in the top view, project lines upward from F and H, obtaining points F′ and H′ in the top view. To find points G′ and I′ in the top view, draw a line through G parallel with the base of the pyramid, to cut lines A′B′ and A′D′ in points J and K. It is evident that the width of the pyramid at this point is equal to JK; therefore,

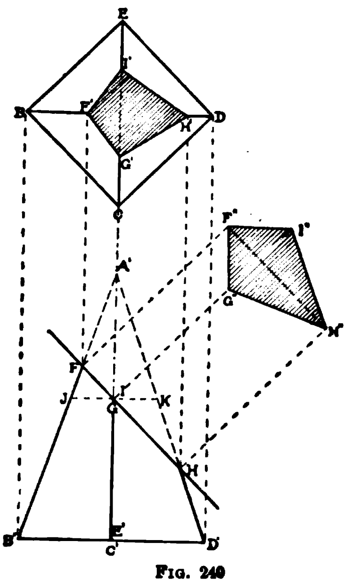


Fig. 240

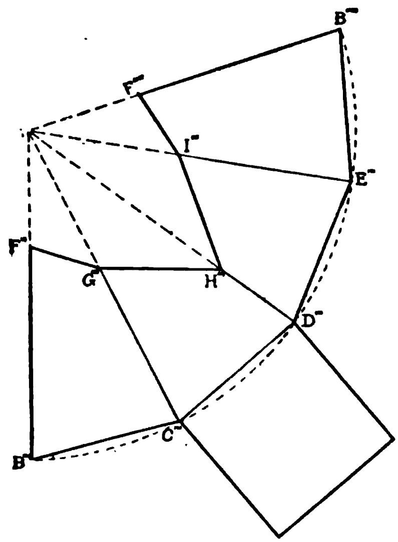


Fig. 241

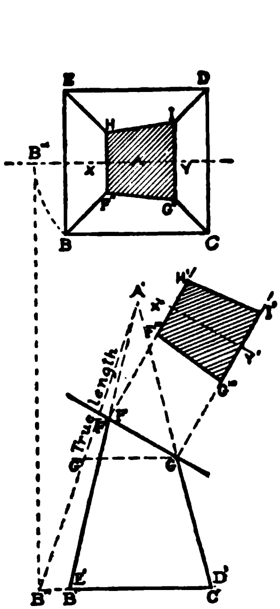


FIG. 242

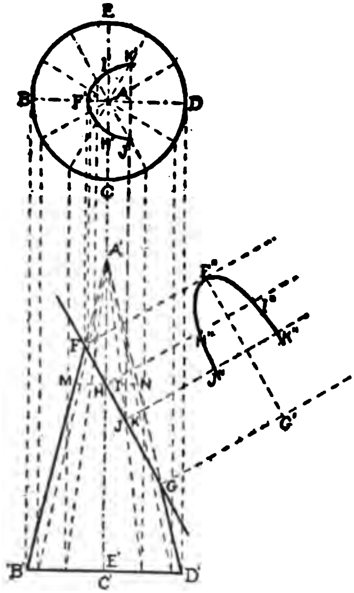


FIG. 243

make G'I' in the top view equal to JK.

To find the true shape of the section, draw lines from F, G, H and I, perpendicular to the plane FH. Draw F'H' parallel with FH. Make G''I'' equal to JK, and F''G''H''I'' will be the true shape of the section.

To develop the surface of the truncated pyramid. (Fig. 241.) With radius A'B' or A'D', which is the true length of the edge A'B', describe an arc of a circle. On this arc set off the sides of the base of the pyramid, in points B''', C''', D''', E''' and B''''. Make A'''F''' and A'''F'''' equal to A'F, and A''' H''' equal to A'H. As the line A'G and the line behind it, A'I, are oblique to both V and H, they are not shown in their true length. This may be found as in Fig. 176, page 148, but the line A'J is the true length of the line A'G' and A'I; therefore make A''' G''' and A''' I''' equal to A'J.

Exercise XIX. Draw two views and the developed surface of a square pyramid standing with one of its triangular faces directly in front of the observer. Cut the pyramid by a plane making an angle of 30° with its base (Fig. 242).

Note: It must be remembered that the lines AB, AC, etc., are not shown in their true length. To obtain the true length of line A'B' and A'C' refer to demonstration of Fig. 176, page 148.

Exercise XX. Draw two views of a cone cut by an oblique plane (Fig. 243). Show the true shape of the section. In the top view, the distance

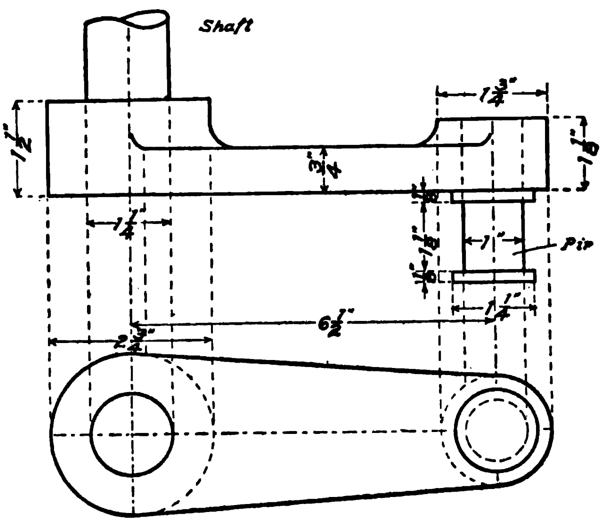
H′I′ is equal to the distance MN in the front view. The reason for this may be understood by referring to the demonstration illustrated in Fig. 240. To find the section, the distance H″I″ is transferred from H′I′ in the top view, J″K″ is transferred from J′K′ in the top view, and the other widths in like manner, because these distances appear in their true length in the top view. Only the two outside lines A′B′ and A′D′ are shown in their true length. Develop the surface of the lower part of the cone.

Exercise XXI. Draw the top, front and side views of a hexagonal pyramid, cut by a plane at 60° with its base.

Machine Details

The various mechanical devices for the production of motion, such as the lever, crank, eccentric, cam, pulley and gear, enter very largely into machinery, and therefore into the making of drawings showing the construction and details of machinery. In such work the general language of working drawings is employed, and some of the more common details of machinery are given here in order to show the various conventions used and the usual way of representing such objects.

Cranks. The crank is a lever used mostly to obtain rotary motion, or to convert straight motion into rotary motion, as in the case of the steam engine; or to convert rotary motion into straight motion, as in the case of the jig-saw. The length of a crank is the distance between the center of the shaft and the center of the pin (Fig. 244). The throw of a crank is twice the



Engine Crank

FIG. 244

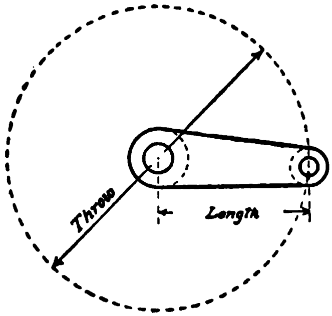
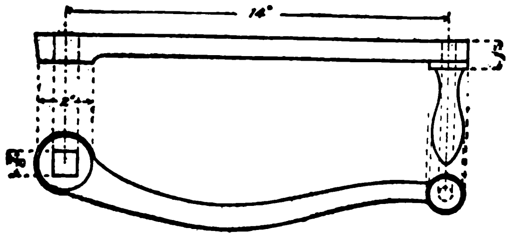


FIG. 245



Hand Crank
FIG. 246

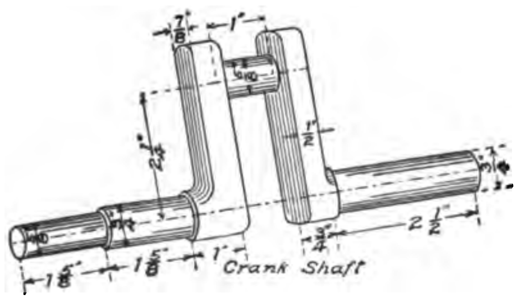
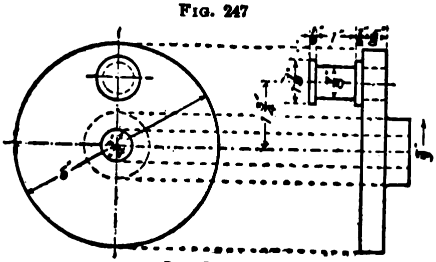


FIG. 247



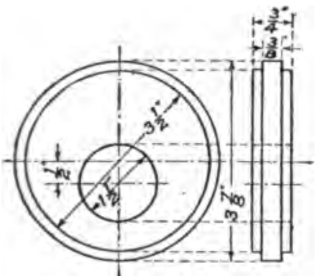
Disc Crank
FIG. 248

length of the crank (Fig. 245). Figs. 244, 246, 247 and 248 show some of the common forms of cranks. For practice in drawing, select similar parts, and make working drawings directly from them.

Eccentrics. The eccentric is another form of crank, and is used, principally, to slide the valve in a steam-engine. The complete eccentric has two parts, the eccentric (Fig. 249) and the strap (Fig. 250). The student may draw two views of the eccentric and strap when connected.

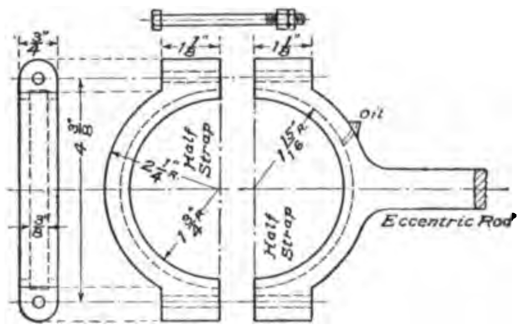
Screws. The screw, which is based on the principle of the inclined plane applied to a cylinder, is used for raising weights, and for fastening parts together. The motion is uniform, and in a plane parallel with the axis of the cylinder. The threads on a screw are usually V shaped or square (Figs. 251 and 252). In the V thread, the pitch is the space between threads, and in the square thread the pitch includes a thread and a space. In either case, the pitch represents the distance the screw would move during one revolution. The most common forms of bolts, screws and nuts are shown on page 171.

Figure 253 shows the method of drawing a V-thread screw. Let the diameter be 5″ and the pitch 1″. Draw the front view of the cylinder, as ABCD. On AB describe a semicircle, A3B. Set off the pitch AE and divide it into any number of equal parts, as twelve. Through these points draw lines perpendicular to the axis of the cylinder. Divide the semicircle A3B into six equal parts. Project lines from 1, 2, 3, 4 and 5 parallel to the axis of the cylinder. The intersection of these lines with the lines that divide the pitch will give the points 1′, 2′, 3′, 4′ and 5′, through which the required curve of the thread may be drawn. Sketch this curve with the free hand.



Eccentric

Fig. 249



Strap

Fig. 250

With the dividers set equal to the pitch, locate points 1″, 2″, 3″, 4″ and 5″ above 1′, 2′, 3′, etc. In a similar way, set the dividers equal to two pitches, and locate points above 1″, 2″, 3″, etc. Repeat this operation, always measuring from 1′, 2′, 3′, etc. The curve obtained by this process is called a helix. With the 60° triangle and the T square draw the lines EG and AG, obtaining point G, and FH and KH, obtaining point H. These points locate the root of the thread. Through G and H draw lines parallel to the axis of the cylinder, cutting the line AB in points I and J. Draw another semicircle on IJ, and find the points for the inner curve. When the curves have been carefully drawn with the free hand, use the French curve to finish.

Figure 254 shows the method of drawing the square-thread screw. The width and depth of the groove is equal to the thread or half the pitch.

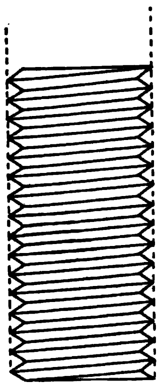


FIG. 251

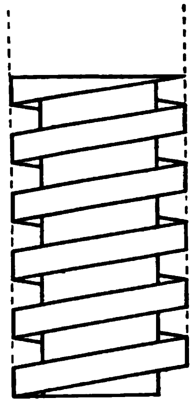


FIG. 252

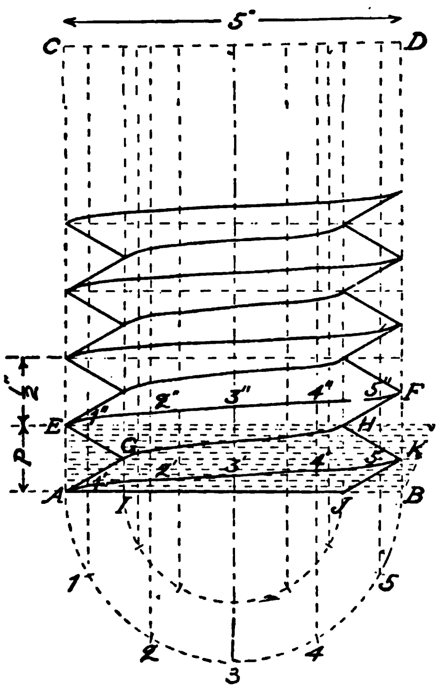


FIG. 253

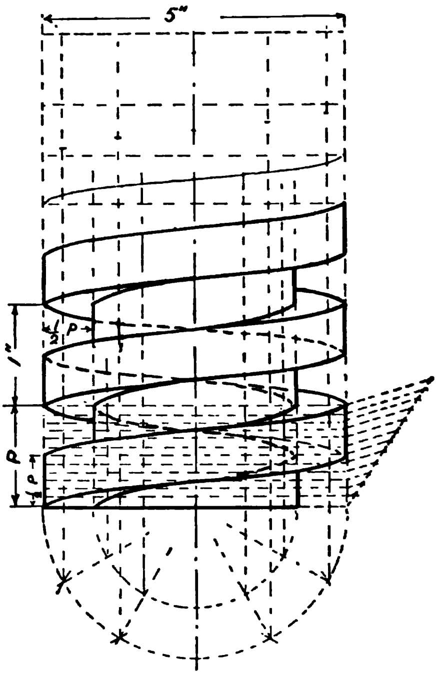
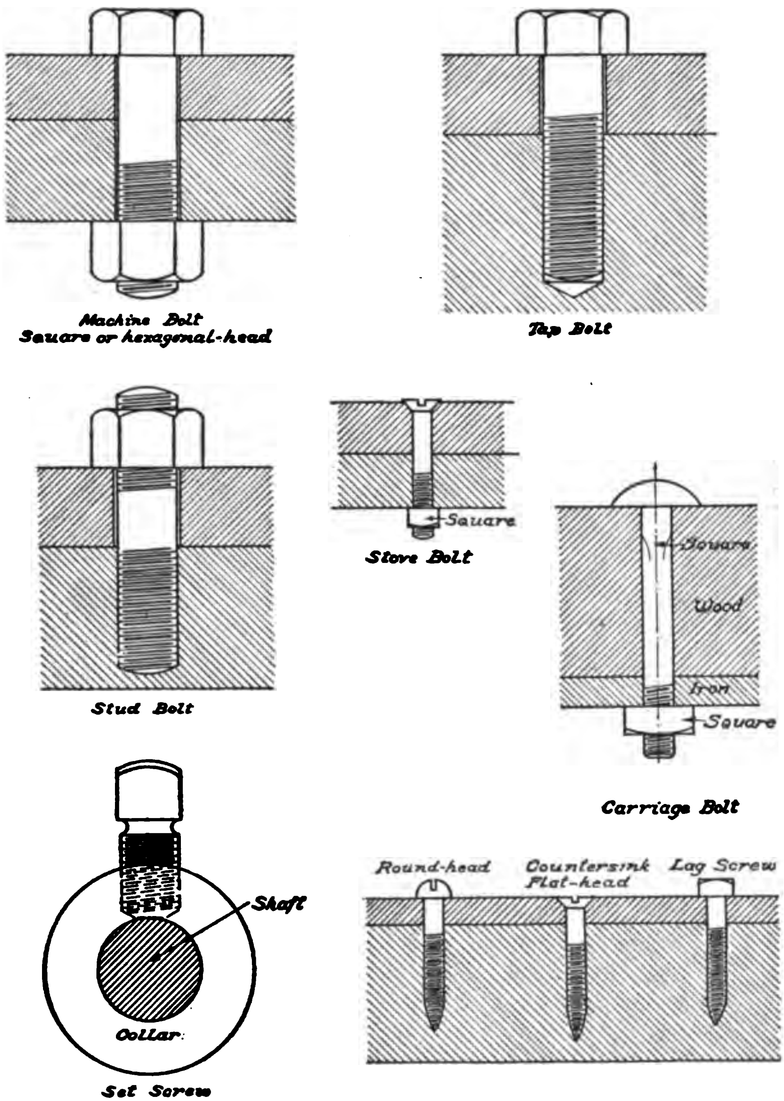


FIG. 254

Bolts, Screws and Nuts.



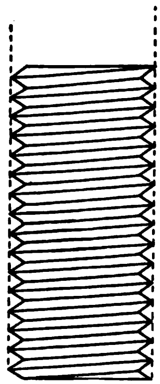


FIG. 251

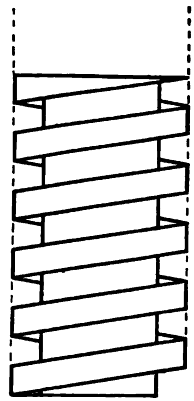


FIG. 252

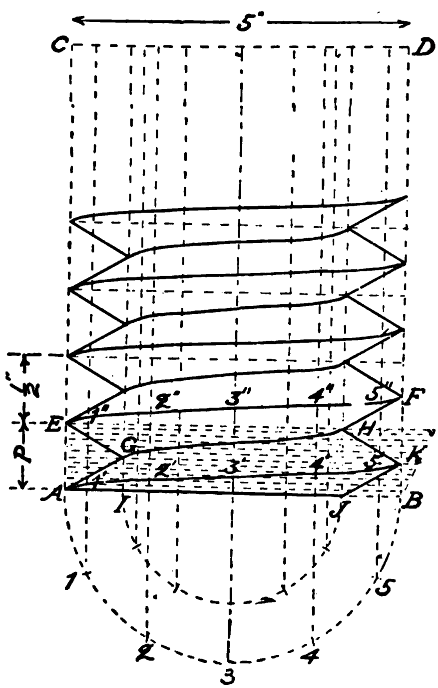


FIG. 253

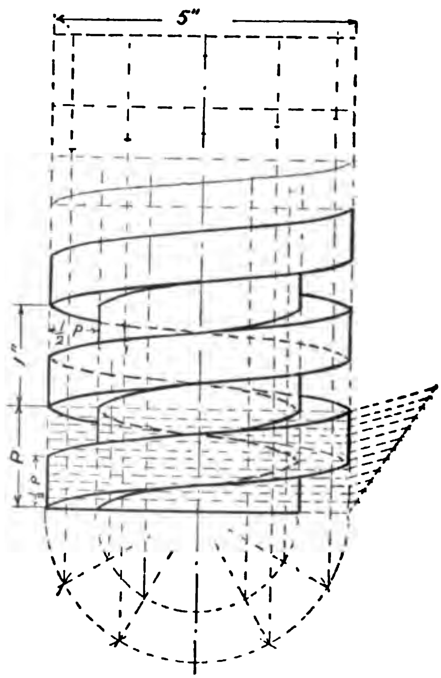


FIG. 254

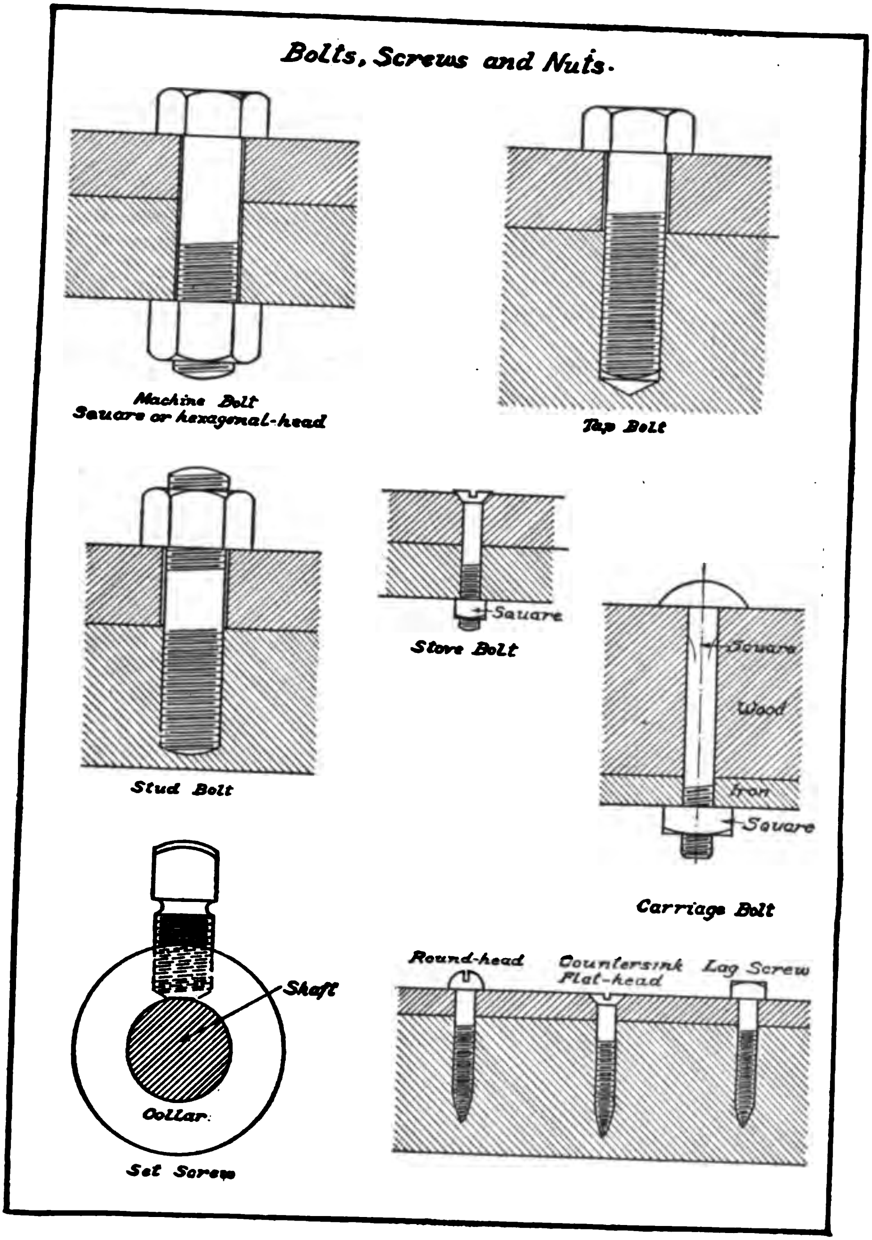

Bolts, Screws and Nuts.
Machine Bolt
Square or hexagonal-head
Tap Bolt
Stud Bolt
Square
Stove Bolt
Square
Wood
Iron
Square
Carriage Bolt
Shaft
Collar
Set Screw
Round-head
Countersink
Flat-head
Lag Screw

FIG. 255

In practice, the curves of screw threads are not worked out, but are represented by the convention of straight lines, shown in Figs. 251 and 252. In the case of small screws and bolts the convention is as shown in Fig. 255.

Note: For tables giving the number of threads to the inch, sizes of bolt-heads and nuts in proportion to the diameter of the bolt, and for other information of this kind the student should consult some standard work on Mechanics.

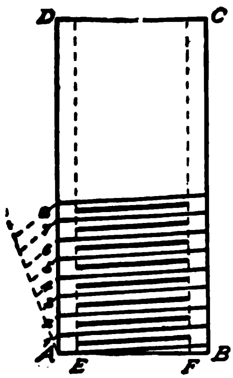


FIG. 256

To draw the thread on a bolt. Let AB (Fig. 256) be the diameter of a 1″ bolt. From a table of standard threads, it will be seen that there should be eight threads to an inch. Lay off 1″ on the line AD and divide it into eight equal parts, each part representing the pitch of the screw. Through points 1, 2, 3, etc., draw light parallel lines at an inclination equal to one half the pitch, as shown in Fig. 256. From A and B, lay off the points E and F, equal to the pitch. Through points E and F, draw lines parallel to AD and BC. This makes the roots of the threads. Draw the heavy lines halfway between the light parallels.

In drawing screw threads, the lines must slant upward to the right for a right-hand screw, and downward to the right for a left-hand screw.

In practice, draughtsmen do not space off to get the exact number of threads to the inch, but it is well for the student to do this until he is accustomed to the right spacing.

The size of bolt-heads and nuts is in proportion to the size of the bolt. The proportion varies in different bolts, and also in different shops, but those proportions most commonly used are given as follows: Let D equal the diameter of the bolt. The short diameter of the nut and bolt is equal to $1\frac{1}{2}$ D plus $\frac{1}{8}$ of an inch ($1\frac{1}{2}D + \frac{1}{8}''$). The thickness of the nut is equal to D. The thickness of the head (square or hexagonal) is equal to $\frac{3}{4}$ of D plus $\frac{1}{16}$ of an inch ($\frac{3}{4}D + \frac{1}{16}''$).

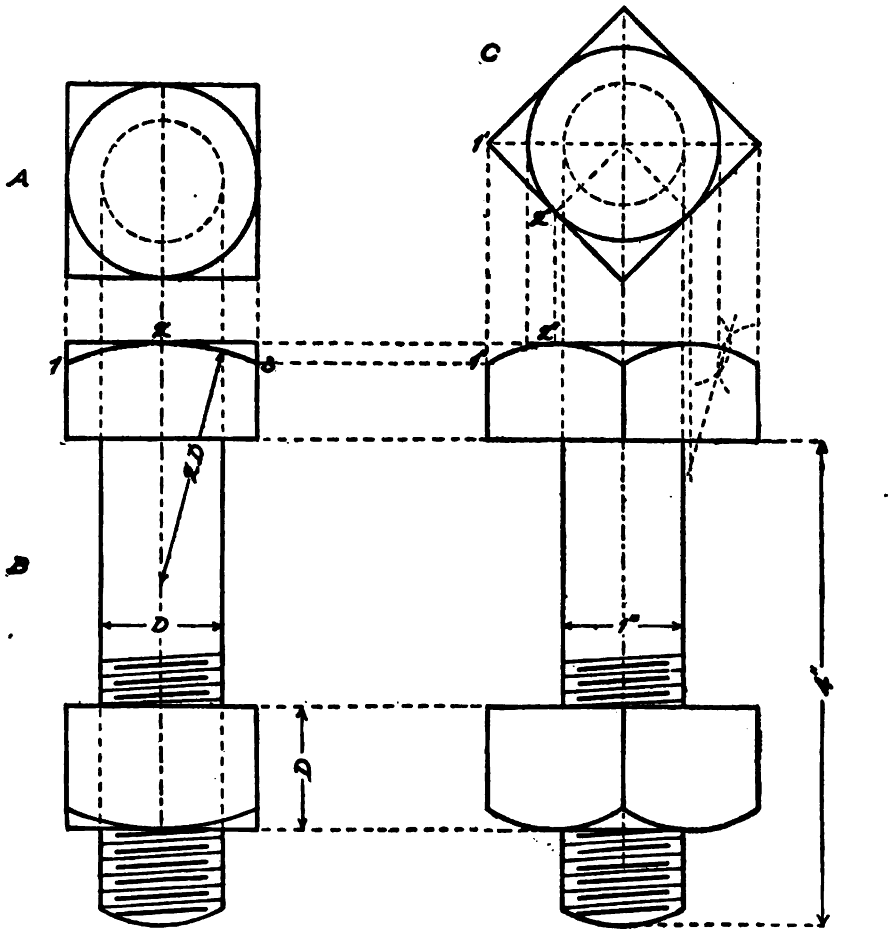


FIG. 257

To draw the square head or nut. Draw the top view A and the front view B (Fig. 257). With radius equal to twice D, draw the curve 1–2–3. Draw the top view C. To find the points necessary in completing the drawing, project the points over from the front view, B, and down from the top view, C. This process was explained under Projections.

To draw a hexagonal bolt-head and nut, turned so as to show three faces of the head and nut, the thickness of the bolt being given.

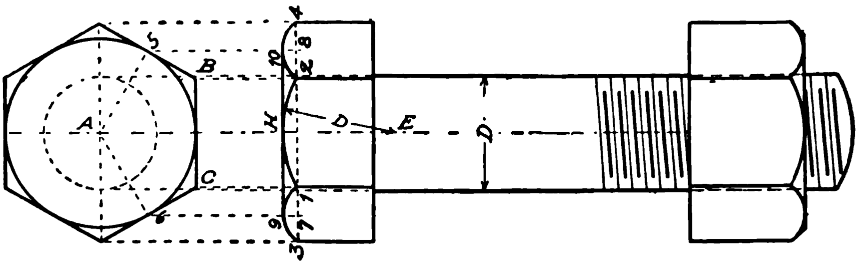


FIG. 258

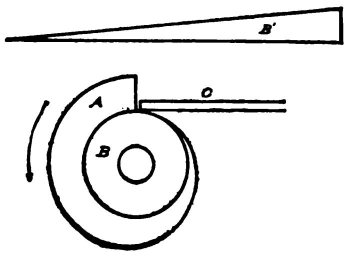


FIG. 259

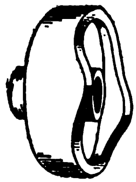


FIG. 260

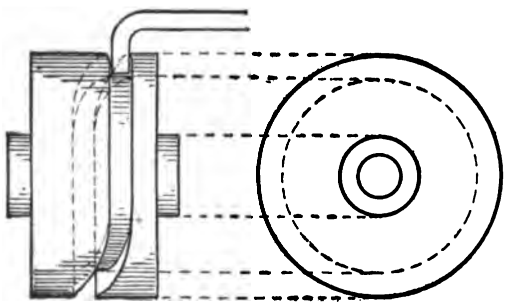


FIG. 261

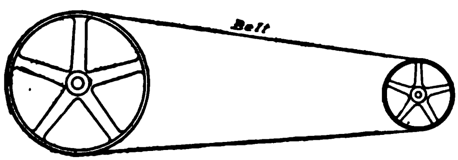


FIG. 262

(Fig. 258.) Draw the circle A, with diameter equal to the diameter of the bolt. With the same center draw a circle whose diameter is $1\frac{1}{2}$ times $D + \frac{1}{8}''$. Through A, project to the right, the axis line of the bolt. About the second circle, circumscribe a hexagon, making one of its sides, as BC, perpendicular to the axis of the bolt. Draw the front view of the bolt, projecting the necessary lines for the head and nut from the end view. Make the thickness of the head equal to $\frac{3}{4}$D plus $\frac{1}{16}''$, and the thickness of the nut equal to D. Establish E by laying off D from H, on the axis line. With E as center and a radius equal to D, describe the arc 1–2. Draw a line through 1–2, extending it in both directions to find points 3 and 4. Bisect the sides of the hexagon in points 5 and 6, and project from these points lines

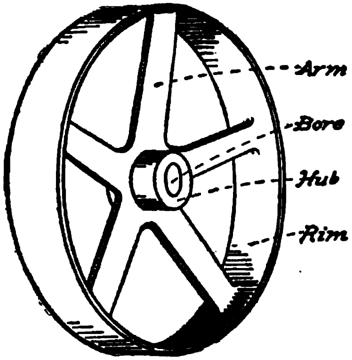


FIG. 263

intersecting the line 3–4 in 7 and 8. Find the center for the curves 1–9–3 and 2–10–4 by Problem XXII, Ex. I. Complete the curves, and draw the line 9–10 tangent to the curves.

Cams. It will be seen that the motions produced by the crank, eccentric and screw, are regular. The cam is a device by which either regular or irregular motion may be obtained. The cam is based on the principle of the inclined plane applied to a cylinder or disc. If the inclined plane A (Fig. 259) is applied to the periphery of the cylinder or circular disc B, and the whole made to revolve in the direction of the arrow-head, it will raise the bar C at a uniform motion during one revolution of the cylinder or cam. The bar would then drop back suddenly to the starting point, repeating this motion at each revolution. If the inclined plane had been irregular, as shown in Fig. 260, the motion would be irregular. In this way almost any motion can be produced.

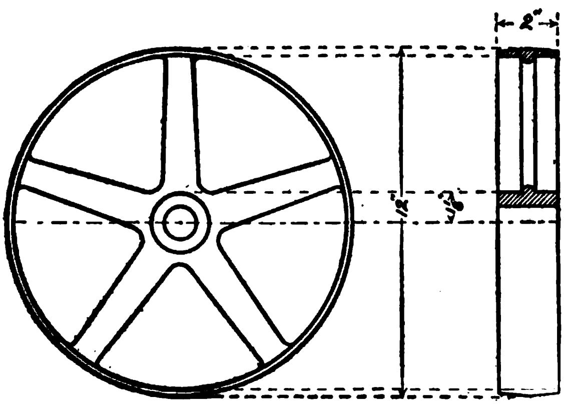


FIG. 264

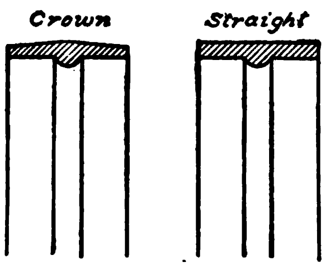


FIG. 265

In the cam shown in Fig. 259, the motion is in a plane at right angles to the shaft. When the motion is to be parallel with the shaft, it is applied to the face of the disc, as in Fig. 260, or applied in the form of a groove, as shown in Fig. 261. This is the form of cam used in the sewing-machine.

The Pulley. The pulley is used for the transmission of power by means of a belt or cable (Fig. 262). If the pulleys are of the same size both will revolve at the same rate of speed. If one is twice as large as the other, the smaller will make two revolutions in the same time that the larger makes one. The speed is in proportion to the diameter of the pulley. Pulleys are usually made of iron or wood. They are sometimes made in two parts, and are then called split pulleys. The parts of a pulley, with the names, are shown in Fig. 263. Fig. 264 represents a five-arm pulley, showing a half elevation and a half section. The diameter of the hub is usually twice the diameter of the bore. The faces of pulleys are made either "crown" or straight (Fig. 265).

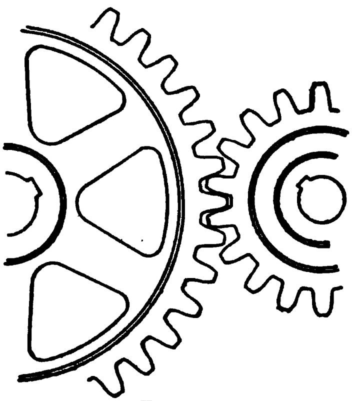


FIG. 266

Gears. Gears are wheels having teeth or cogs which mesh into each other. They are sometimes called cog-wheels (Fig. 266). Like pulleys, gears are used for the transmission of power and to increase or decrease speed.

Duplicating Drawings

It is always desirable and usually necessary to have several copies of a drawing. It is not necessary to redraw each one, but a tracing may be made on transparent paper or cloth, and from it blue-prints made in any quantity required.

Tracing. To make a tracing, place the drawing to be copied upon the board, and over it place the tracing cloth or paper, tacking both firmly to the board. Many grades of tracing paper and cloth are in the market, but for durability, cloth should be used, the weight of it depending upon the use to which the prints are put. Drawings to be traced are usually made in pencil and not inked on the original. The inking is done directly upon the tracing cloth. Care must be taken to have the drawing accurate and complete before tracing it. Erasures and changes upon the tracing always mar the surface. Either side of the cloth may be used. If the ink does not flow well, rub powdered chalk over the surface of the cloth.

In tracing, follow the usual process of inking-in the drawing.

Blue-Printing. Blue-printing is a photographic process. The tracing is placed face upward, over a piece of sensitized paper, known as blue-print paper, and exposed to the light for a short time, according to the sensitiveness of the paper and the strength of the light. From one to five minutes is sufficient in strong sunlight, though on a gray day a much longer time is required, as experiment will determine. The sensitized paper is then

FIG. 267

removed and washed for several minutes in running water. The chemical coating of the paper is affected by the light, and after washing it changes in color from the original green gray to a strong blue. The lines covered by the black lines of the drawing become white, as the coating not exposed to the light readily washes off, leaving the white paper. Fig. 267 shows a blue-print frame. Fig. 268, on the next page, is a reproduction of a blue-print from a drawing. The blue ground of the print is represented in Fig. 268 by a dark gray tone, although the white lines in the print are also white in the reproduction.

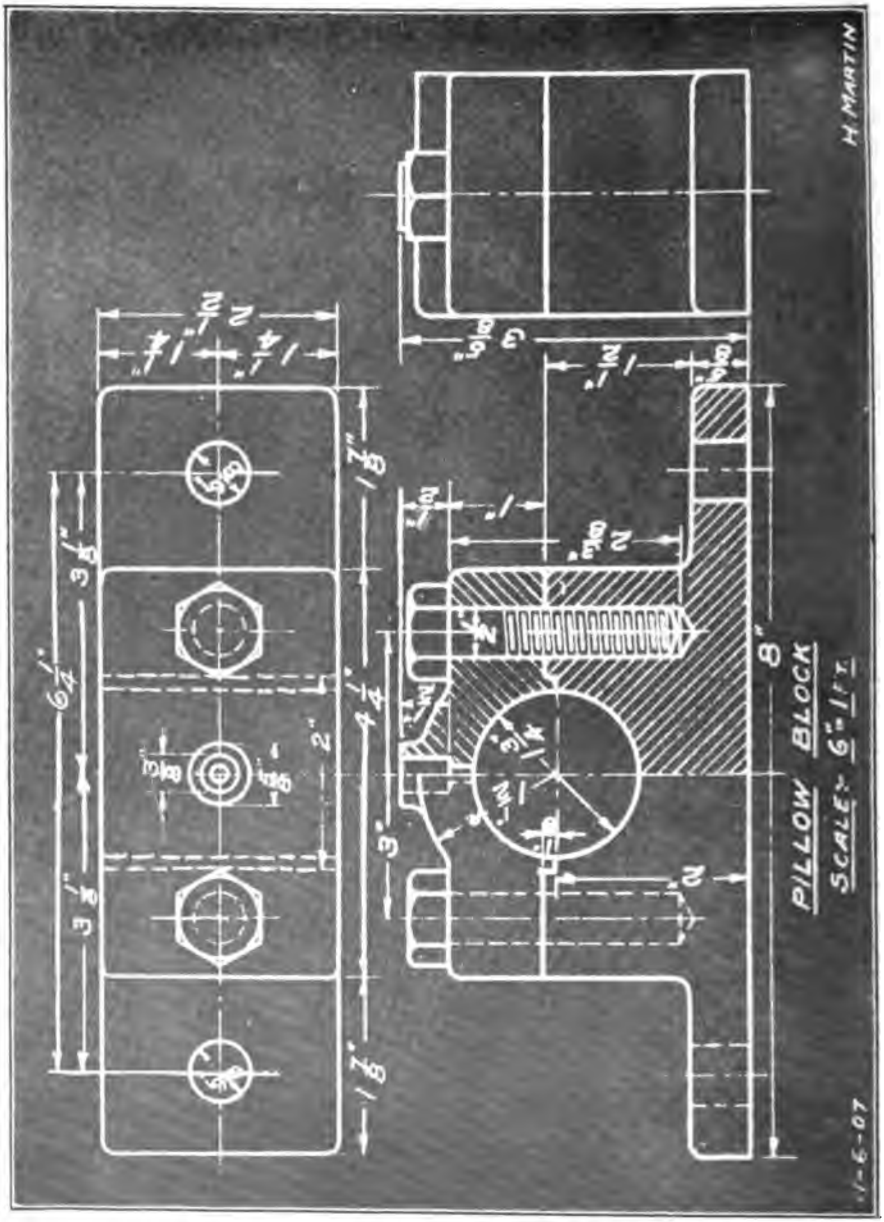


Fig. 268

CHAPTER V

ARCHITECTURAL DRAWING

A Brief Course in the Fundamentals of the Subject

The Need of Buildings. Painting, sculpture, and architecture are usually spoken of as the fine arts, and of these three, architecture is easily the most essential, because it is concerned with the construction of the many different kinds of buildings necessary to serve the needs developed by the civilized human race. In the city, the homes of the people are built to suit their various conditions of life, and we find the tenement building, the apartment house, the detached dwelling and the city mansion. There are also buildings for public utility, such as the school-houses, the public libraries, the churches, the railway stations, the hotels and the theatres. In the city, also, are buildings demanded by manufacturing and business, such as factories and warehouses, office buildings and banks. Buildings must be constructed to meet an almost endless variety of needs, and in planning a structure the architect must know for what purpose it is intended and where it is to be located, so that he may consider the comfort and convenience of those who are to use it, as well as its external beauty and its environment.

Conditions of Construction. As almost every civilized human being occupies some sort of a house, let us consider a few of the questions which the architect must take into account before he can draw suitable plans for a dwelling. He must know the number of rooms required by the owner, and the size and shape of the lot upon which the house is to be built. If the home is to be in the city, where land is valuable, the building will probably be planned so as to utilize, if not to cover, the entire lot. If in the country, where the land is less valuable, the location of the house may be governed by the local topography of the land, and the questions of drainage, water supply, ease of access, and the proper setting of the house become important. The question of building material must also be met by the architect; he must know whether the dwelling is to be constructed of wood, brick, stone, or cement; he must understand the relative quality and strength of these materials, and his knowledge of these things must enter into and influence his plans.

Another problem that confronts him is the matter of light. The majority of city dwellings must be constructed with the narrowest dimension toward the street, making it necessary to construct wells and areas in large buildings for the admission of light and air to inner rooms. In the country, the dwelling should be so planned as to admit the health-giving sunlight to those rooms which are to be most occupied during the day—the living-room, the dining-room, and the kitchen. This thoughtful division of space into the required number of rooms becomes the basis of the first drawing or plan for the proposed house. As the architect proceeds with his work, it is necessary for him to express in his drawings all the information needed by the builders in constructing the house.

Conventions. He does this by means of conventions, which, as with working drawings of other kinds, have been accepted as a sign language conveying briefly and accurately the information necessary for the builders. The study of a simple problem in house-building is the surest way of arriving at an understanding of an architectural design in its most elementary form, and of gaining a knowledge of the conventions used in this kind of work.

Problem I — A Miniature House

Plan and Elevation. Let us assume that we wish to plan a house of one room, to be built of wood, with stone foundation, shingled roof, and with a brick chimney in the center. Let the house be 9′–6″ x 17′–0″, in outside measurements. If we add the ell, as in Fig. 1, the house will be more attractive and the problem more interesting. There should be at least three views in our working drawings of the house; one to show the size and shape of the floor space, called a plan, and two views of the

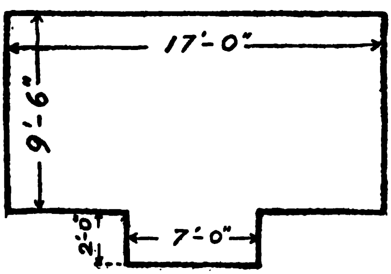


Fig. 1

outside, called elevations. All drawings of plans and elevations are drawn to a scale. In this case we will take a scale of $\frac{1}{4}''$ to the foot (written $\frac{1}{4}''=1'$), thus making our drawings in each view $\frac{1}{48}$ of the actual size of the house.

Make a free-hand technical sketch of these views, placing the plan above the front elevation, and the end elevation at the side of the front. The plan is most important, for it controls all the other views. Although it is called a plan, it is really a sectional view, as by common consent and long usage it is taken to mean that which would be seen if the house were cut by a horizontal plane at the level of the eye, and the upper part removed. Such a cut would reveal the length and breadth of all parts of the house when viewed from above, and it would be in a drawing of this sectional view or plan that we would look for thickness of walls and partitions, widths of windows and doors, chimney dimensions, etc. The outside walls of frame houses are about 7″ thick, made up of 2″ x 4″ upright props or studs, with lathing and plaster on the inside, and rough boarding and clap-boarding or shingles on the outside (Fig. 2).

FIG. 2

Doors and Windows. From the free-hand sketch, make a finished drawing with instruments (see Plate I). Draw a marginal line, as with other carefully finished working drawings, and locate and draw the outline of the plan. Inside of this, draw the thickness of the walls, 7″ (to scale) from the first set of lines. Plan for five windows and one door, locating them in the center of the spaces as indicated in the plan. As this is a miniature house, make the windows 1′–6″ x 3′–0″, and the door 2′–0″ x 4′–0″ (to scale). To distinguish doors from windows special signs or conventions are used; two or three lines across a space represent a window (Fig. 3). Doors are symbolized by an oblique line, swung away from one side of the opening, and usually drawn at a slant of 30° (Fig. 4). If the floor is on the same level each side of the door, no line is shown across the gap, but if we step up or down in passing through the door, a line across the opening will indicate the difference in level, as shown in the plan. The door should be hung to that side of the wall towards which it is intended to

FIG. 3

FIG. 4

swing. In dwelling houses, outside doors usually swing in, in order that they may be protected from the weather, but in public buildings the law requires that outside doors should swing out, as, in case of a panic or stampede, a door swinging out would form a better exit for the people. In architectural design, it will be seen that all possible conditions must be considered. Occasionally we desire to use doors that swing both ways. This is indicated in the drawing as

FIG. 5

shown in Fig. 5. If sliding doors are needed, pockets must be provided for them to slide in, necessitating a thickening of the wall to about 10″. A pocket for a sliding door is indicated in

FIG. 6

Fig. 6. Doors are known as right-hand or left-hand, according as they are fitted up. A right-hand door swings away from a person entering, and towards the right (Fig. 7), while the movement of a left-hand door is just the reverse (Fig. 8). A right-hand door must be provided with a right-hand lock, and vice versa, unless a modern interchangeable lock is used. Decide

FIG. 7

whether the door in this house shall be a right-hand, a left-hand, or a double-swing door, and draw the proper convention in the plan. As this is to be a one-room house, there will be no interior walls

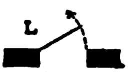


FIG. 8

except those of the chimney. In planning the size of the chimney, we must remember that bricks are about 2″ x 4″ x 8″, and our brick walls for the chimney should be constructed in some multiple of those figures, so that cutting the brick may be avoided. Let us draw the flue of this chimney 12″ square, with 4″ brick walls.

Front and End Elevation. We are now ready to draw the front, and the end elevation of our structure. In practical draughting, it is well to carry all views along together, referring back and forth from one view to another, rather than to finish any one part. In this way the relation of all parts to one another and to the whole is kept in mind.

Project the extreme length of the plan downward, and draw the ground line, AB, Plate I. As there is to be no cellar, all our measurements will be upward from the ground line. Before proceeding further with the front elevation, set off the width of the house E F in the space at the right of the front elevation. The floor level is to be set up 12″ to 14″ from the ground line, as the timbers must rest on a stone foundation

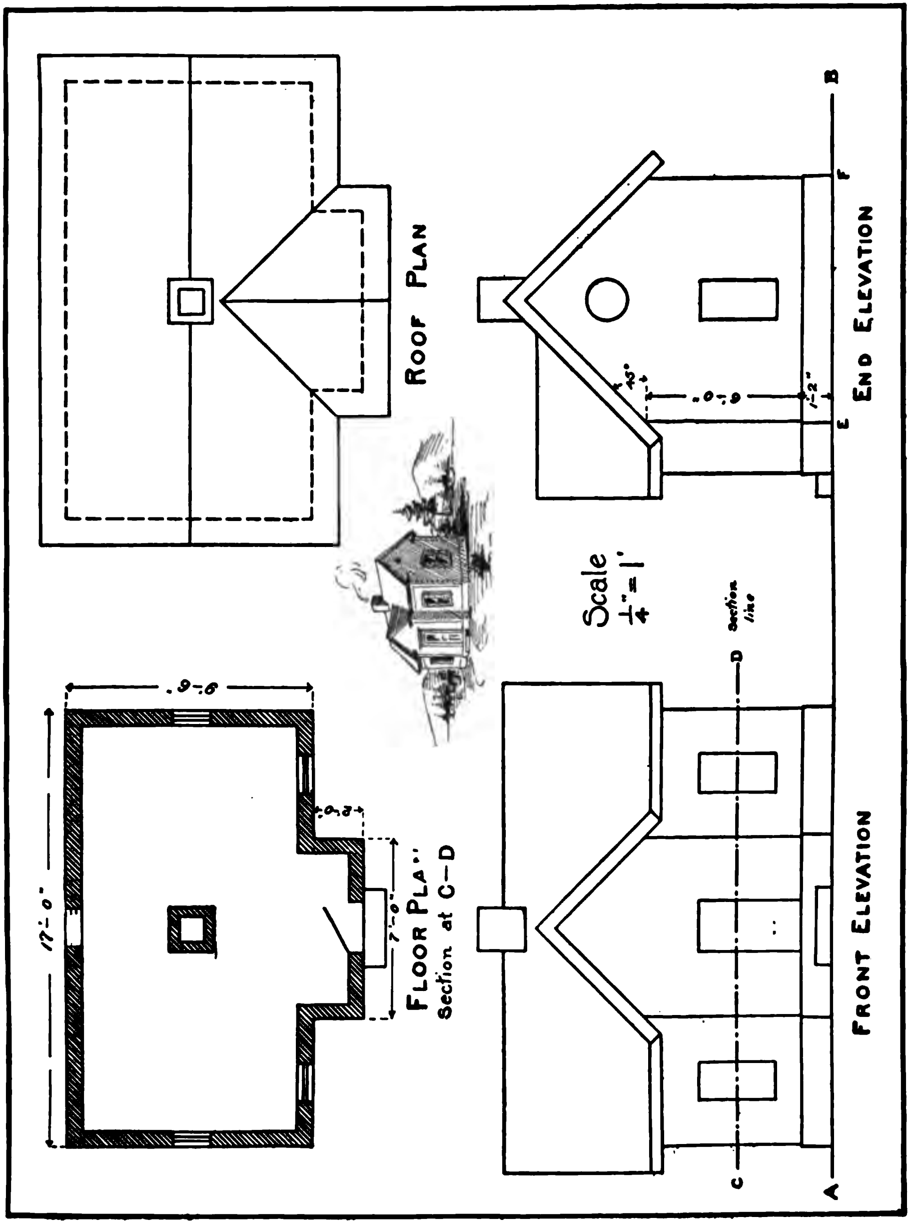

Roof Plan
End Elevation
Scale
1/4" = 1'
Section line
Floor Plan
Section at C—D
Front Elevation
17'-0"
9'-6"
7'-0"
6'-0"
1'-2"
A
B
C
D
E
F

Plate I

to protect them from dampness. Measure 6′–0″ (to scale) from floor level to the beginning of the slant of the roof. The slant, or pitch, is sometimes determined by choice, although the matter of climate has a great deal to do with it. In Egypt, for instance, where there is no rainfall, the roofs are flat, while in Sweden and Norway the pitch of the roof is steep, so that the heavy snows may be easily shed instead of forming an insupportable weight. In our own latitude the slant for a shingled roof should not be less than 30° from the horizontal. For our present problem a slant of 45°, called a square pitch, as shown in the end elevation, will be found satisfactory. Draw two slopes of the roof, meeting at the ridge. The triangular space enclosed between the two sides of the roof is known as the gable. Make the thickness of the roof equal to the thickness of the walls in the plan. The lower edges of the roof are called the eaves and they should project over the sides of the house, forming what is known as the overhang, and containing the gutter, or rain trough, when one is needed. In the absence of the gutter, the overhang serves to carry water from the roof, so that it will fall beyond the walls of the house, thus preserving them from decay and discoloration and making less liable the possibility of leakage. Besides serving all these uses, the overhang has artistic value, for its shadow draws a strong, definite line on the building, accenting an important structural feature.

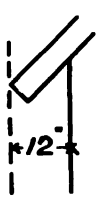


FIG. 9

Determine the projection of the overhang by drawing a plumb-line 12″ outside the building line (measuring horizontally), and continuing the slant of the roof until it meets this line (Fig. 9).

We now have the ridge and eaves levels established. Project them across to the front elevation, allowing 12″ for the overhang beyond each end of the house. Erect the ell in the front elevation, giving its roof the same slant and overhang as the main roof. Project the ridge of the ell roof back to the end view, until it intersects the slant of the main roof. Find the projection of the ell in the end view and give its roof the proper overhang at the left. The top of the foundation may be considered as coinciding with the floor level, but it may project very slightly, thus giving the effect of a base for the house to rest upon, as shown in the front and in the end elevation.

Get the width of the chimney from the plan, and locate it in the end view. Let the chimney run up 1′–0″ above the ridge, and draw the vertical lines down until they meet the slant lines of the roof. Project the points obtained across to the front view, and bring down the width from the plan. Project the windows and the door from the plan, using the heights already specified. Add a small window in the gable end.

The door-step is a feature that needs to be shown in the plan and in the front and end elevations. The height of a step is called its rise and the width is known as the tread. The rise of a step is usually 7″ high, and the tread is usually 10″ wide (Fig. 10). Where an easier ascent or an imposing effect is desired the rise is reduced and the tread is correspondingly increased. In our problem, the floor is so close to the ground level that but one step will be necessary. This is to be of stone, with riser and tread of the usual measurements. In length, the step is to be a little more than the width of the door.

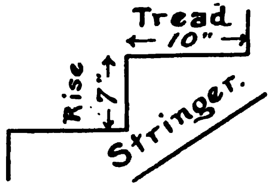


FIG. 10

Roof Plan. A plan of the roof, which in this problem would not be essential to the builder, is an interesting feature, and will make our set of views more complete. Project the lines from the floor plan to the right, representing in dash lines the outline of the floor plan, but invisible when viewed from above. Measure the overhang outside of those lines and draw the lines representing the eaves of the roof, all around the dash lines. By reference to the end elevation, locate and draw the main ridge in the roof plan. The ell also has a ridge, which should be drawn. Get its length from the end view and draw the line backward from the middle of the front overhang of the ell. From the back end of this ridge must be drawn lines representing the valleys, or lines of intersection of the two roofs. Draw these lines one to the right and one to the left, down and forward to the juncture of the eaves of the house with those of the ell. Locate and draw the rectangles for the top view of the chimney, and the roof plan is complete.

Inking In. Up to this point, the views and their parts have been expressed in light pencil lines. Ink in the whole problem after the views are completed in pencil and all corrections made. As the floor plan is really a sectional view, all the parts cut by the horizontal plane should be section lined, or colored with a wash, to indicate the surfaces actually cut. In this process, windows and doors are omitted, as shown in the plan, as they are open spaces. Indicate the path of the cutting plane by a special line drawn in the front elevation (see C — D in Plate I).

The name of each view should be printed below it, and the principal dimensions expressed in plain figures. Be careful to separate feet from inches, using the signs or conventions accurately, and locating arrow-heads at the exact points which mark the extremes of measurements. The scale in which the drawing is made should also be plainly indicated.

A Free-hand Perspective Sketch. As a finishing touch to your problem, draw a small free-hand perspective sketch, as shown in Plate I, to translate what you have expressed in the technical language of the views. Every one understands a good pictorial representation of a house, — it is like a photograph. In drawing the perspective sketch, assume a point of view that will show the house in a comprehensive and advantageous position. Locate the horizon line, and carefully consider proportion, convergence and foreshortening, as in any other perspective study. Assume, also, that the light falls so that one side of the house is in shadow, and indicate simply the effect of shade and shadow. Add blinds or other accessories to finish the sketch and suggest an attractive environment. Many architects do a large part of their designing in perspective.

Problem II — A One-story Cottage

The one-room house that formed the basis of our first problem, while it illustrates the elementary features of house construction, would hardly be adequate for the needs of even a very simple home. Such a house might answer for a summer camp or a hunter's lodge, or it might serve as a shop or a studio of some kind, but for the requirements of a family it would be found lacking in many essentials. In the early days of civilization the one-room house served as a shelter, it is true, and the people it housed were warm, and, in a sense, comfortable, although the single room was made to serve the purposes of kitchen, dining-room, sleeping-room, and reception-room or parlor, all in one. But as the social life developed the

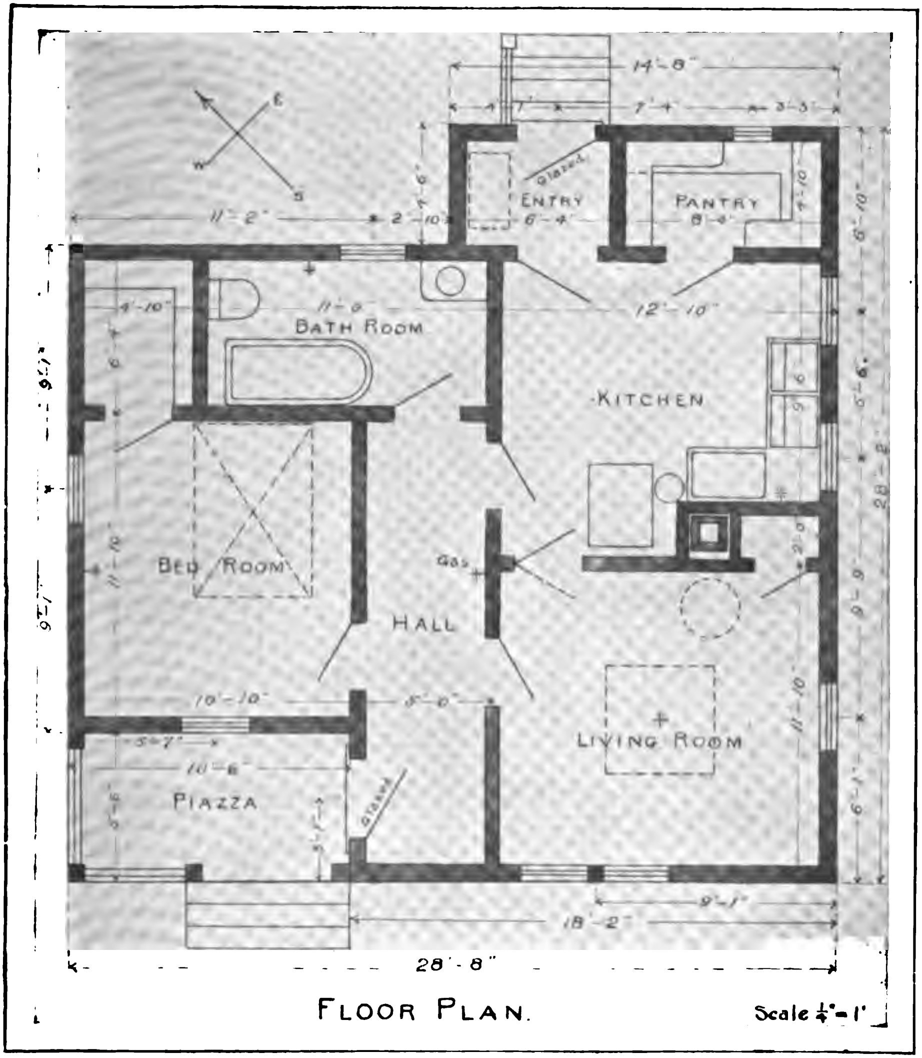
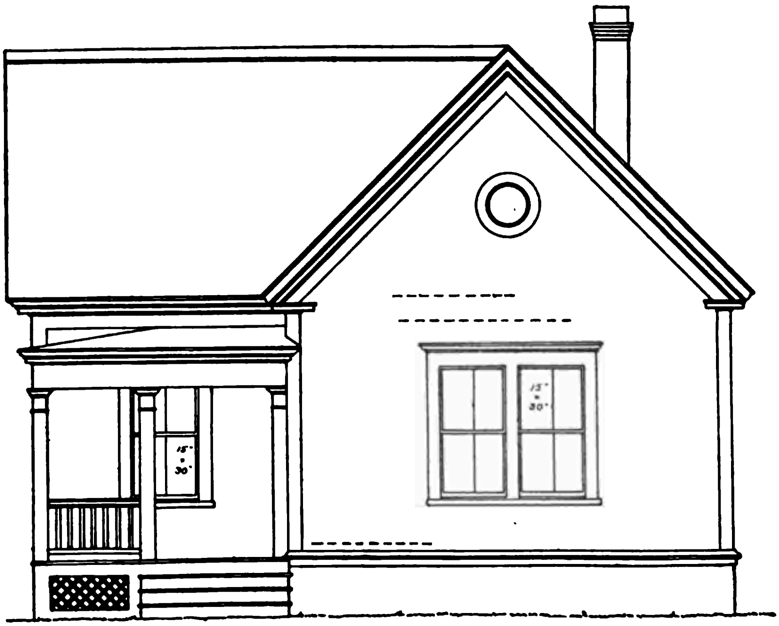


FIG. 11

need for more apartments became insistent, and the gradual addition of a room for sleeping, another for cooking, another for the reception of guests or strangers, led to the development of the modern dwelling house.

Essential Features. In our second problem we are to consider the essential features of a simple house, one in which a working man could live in comfort and cleanliness. The requirements for such a home would seem to be, first, a kitchen, to serve as the general laboratory or workshop of the house; second, there must be provided a separate sleeping-room; third, a room for eating, reading, and entertaining guests, called a living-room or

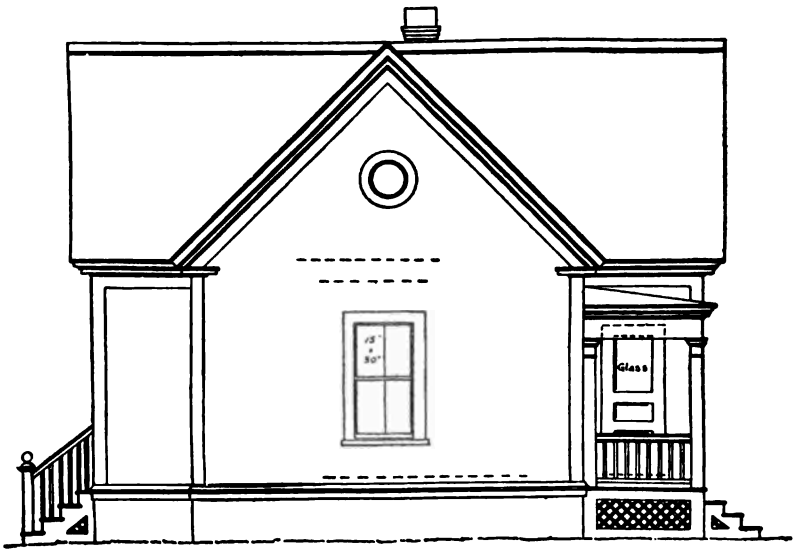


FRONT ELEVATION Scale ¼" = 1'

FIG. 12

parlor; fourth, a bathroom. A corridor or hall to lead from the front entrance to each of these rooms should also be provided. The kitchen, bed-room and living-room should each have a suitable closet. The arrangement of these units into a harmonious whole is our problem — a problem in architectural design. We must think of convenience, economy, fitness to purpose, hygienic location, and the beauty of the design when complete.

In working out the problem, we will draw the floor plan, front elevation and the elevation of an adjacent side. The plan and elevations shown in Figures 11, 12 and 13 show one way only of working out such a problem. There are many other solutions, and each student should draw a set of views that will illustrate his own ideas in planning a simple house within the restrictions stated. The specifications and suggestions that follow should be well in mind before the drawings are begun. As all the rooms are to



N.W. Elevation. Scale ¼"=1'

Fig. 13

be on one floor, and as there is to be no provision for a cellar or an attic, we shall avoid for the present the problem of stairs. Our house is to be heated by stoves, lighted by gas and supplied with modern plumbing. The most compact shape into which the various rooms can be assembled is a square or an oblong, and therefore the floor plan of the house should be a rectangle of some kind, its proportions to be determined by the size and shape of the rooms. As a general rule, it is well to have all the rooms

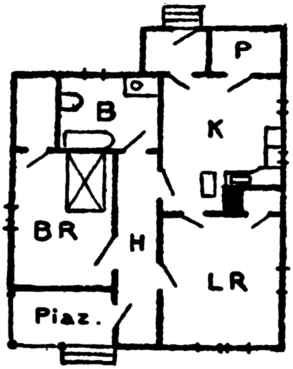


FIG. 14

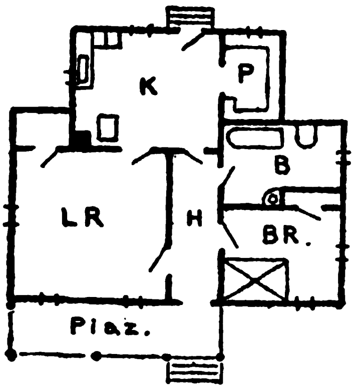


FIG. 15

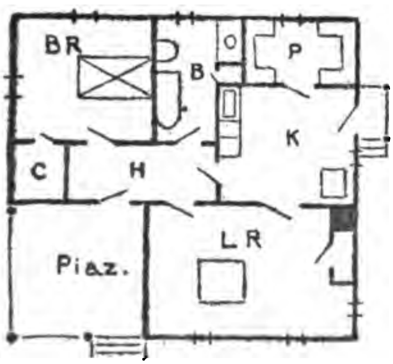


FIG. 16

open directly from the hall, that we may avoid the necessity of passing through one room in order to get to another. Have no connection between kitchen and bedroom, nor between bedroom and bath-room. The kitchen and living-room, however, should be connected and on the same side of the hall, so that one chimney will answer for both rooms.

Beauty of Exterior. With these conditions in mind, begin the work by jotting down several small preliminary sketches of floor plans, showing different possibilities in the arrangement of rooms. These are mere notes or first thoughts, and are to be drawn quickly and in free-hand (see Figures 14, 15 and 16). Put down in this way as many different ideas as come to you. Study these sketches to find what improvements or combinations can be made. Consider also what the outside appearance of the house would be if one of these sketches were worked out. While our house need not be perfectly regular in its outline, we must avoid too many projections and angles, as they seldom add to the beauty of the design, they cut up the roof badly and they are expensive to build. Simplicity is always a safe principle to follow. With this thought in mind, decide on the arrangement of your rooms.

Types of Roof. The selection of a roof for the house is next in importance. There are several well-defined types of roofs in common use, of which the simplest is the lean-to, or shed roof, which slants one way only (Fig. 17). The pitch roof is the style used in Problem I, in which the ridge is at or near the middle, with the roof slanting two ways (Fig. 18). A roof that slants four ways, like the sides of a pyramid, is called a hip roof (Fig. 19), while one that has double slants in two ways from the ridge is called a gambrel roof (Fig. 20). It is like a compound pitch roof. The mansard roof slants twice in four directions, like a compound hip roof (Fig. 21). Various combinations of these types occur in the construction of buildings. In churches, towers and other buildings of a special nature we often find the conical roof and the dome. Make several sketches showing different styles of roof, adapted to the plan selected for your house, as in Figures 22, 23 and 24. Select the style you desire to use in this problem.


FIG. 17


FIG. 18


FIG. 19


FIG. 20


FIG. 21

Divisions of Space. The sizes of the rooms will be governed largely by their specific uses. Let us take the following figures as approximate, and modify them to suit the shapes and arrangement of the rooms already decided upon: Kitchen, 130 square feet, with pantry closet 40 square feet; living-room, 150 square feet, with china closet; bedroom, 110 square feet, with clothes closet; bathroom, 40 square feet; hall not less than 4 feet wide "in the clear," so that people may pass each other easily.

Fig. 22

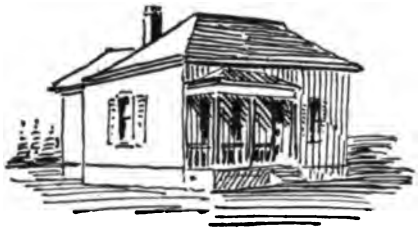


Fig. 23

Fig. 24

Before locating the plan of our house definitely, the points of the compass should be considered. If possible, plan to have the morning sun in the kitchen, and the living-room arranged with windows towards the west.

We are now ready to decide on the scale to which our plans and elevations are to be drawn. Each view will probably need to be drawn on a separate piece of paper, but the relation between them will be just as vital as though they were all on one sheet, as in Problem I. Begin as before, with the plan. We have previously settled on the approximate size of each room, so that, working from our free-hand sketch of the arrangement of the rooms, we can estimate the size of the floor plan. This estimate, although subject to change as we work out the room measurements carefully, will enable us to place our plan effectively upon the paper. After drawing the outline of the plan to scale, draw the outside walls 7″ thick, as in Problem I. Then divide the space by partitions 6″ thick, composed of 2″ x 4″ studs, plastered on both sides. First, measure a room, then a wall, then a room again. Make the necessary changes, if any, in adapting your estimates to the accurately drawn plan. After the partitions are placed, cut openings through them and through the outside walls, for doors and windows. Make outside doors 3′–0″ wide, and inside doors

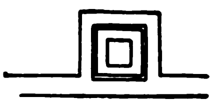


Fig. 25

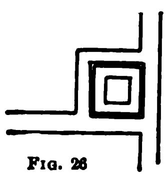


Fig. 26

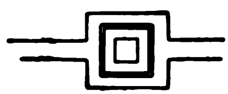


Fig. 27

2′–6″ wide. The placing of the windows is a matter of importance both from the inside and outside points of view. As a rule, they should be 2′–6″ wide. Next locate the chimney, planning its position so that both kitchen and living-room can connect with it. (No heat need be provided for the bedroom.) Of the three ways of locating a chimney, shown in Figures 25, 26 and 27, Fig. 26 shows the fewest corners in the room. This is important when the questions of placing base-boards, cutting carpets and cleaning corners are considered. Place the chimney where you think the space can be most easily spared and will interfere the least with the straight lines of the walls. Give it an 8″ x 8″ flue, with 4″ brick walls. The chimney should be covered or shielded by walls built around it but not touching it, the protecting wall being kept 1″ from the chimney, thus allowing a free circulation of air. This is a safeguard against fire, and will prevent cracks in the plastering. No timbers should be built into the chimney. This construction of the chimney is shown in the plan by drawing the walls around the chimney 1″ thinner than the other plastered walls, as here, plastering is placed only on one side.

The Kitchen. We are now ready to particularize in our plans for the individual rooms. As the kitchen is the work-room of the house, it should be fitted with appliances that will enable the housekeeper to do her work conveniently. The placing of sink, range, tubs, plumbing, etc. must all be done with the idea of convenience in mind. The kitchen plumbing should be placed near the light, and yet it should be located along an inside wall, so that the danger of frozen pipes will be lessened. The sink should be placed so that it will not be exposed to view when the front door opens to receive a visitor. A long telescopic view through the house should be avoided, either by the plan of the hall or by the method of hanging doors.

Opening from the kitchen should be a good-sized closet or pantry, fitted with shelves, drawers and lockers, or cupboards, in which dishes and cooking utensils, provisions and food of various kinds may be kept. A place should also be planned for a refrigerator, as ice is a necessity in every family. The refrigerator should be placed near the back entrance, so that it may be conveniently filled (see Fig. 11). A small entry is added, and the ice-box placed in that. The location of the laundry tubs will be determined by the plumbing. In Fig. 11, notice the grouping of range, hot-water tank, sink, drain-board and tubs. The average size of a kitchen sink is 20″ x 36″; of a range, 2′–6″ x 3′–0″; of stationary tubs, 2′–0″ square over all, with 1″ walls. Place gas outlets where they will shed light to the greatest advantage, at the same time considering convenience of location and direction of cast shadows.

The Living Room. In planning furniture spaces for the living-room, remember that in our problem the dining-table must be accommodated here. An average size of 4′–0″ square when closed may be taken for the table, allowing for an extension of 4′–0″ in addition. Sufficient space should be allowed for chairs about the table. Probably the center of the room will be the best space for the table, and the gas may come from fixtures suspended from the ceiling above (see Fig. 11). Between kitchen and living-room there may be a double-swing door, while between living-room and hall the door should be hung so as to disclose to the entering guest the attractive room within. In a private room, such as a bedroom, the door should be hung so that, when partly open, it may serve as a screen to the greater part of the room. If you desire to place a piano in the living-room, plan for a space against an inside wall, measuring 5′–0″ x 2′–0″, where light may be obtained. Locate other pieces of furniture as the space and shape of your living-room will permit. Express the proportions and general shapes of the furniture by dotted lines, and draw all such blocked-in shapes to scale. To do this, you must know the average sizes of the pieces of furniture you wish to place. The closet to the living-room may be a shallow one, fitted with shelves, to serve as a china closet. The door should open so as to swing back against a dead wall.

The Bedroom. Plan the fixtures and furniture of the bedroom in the same way. A full-sized bed is, on the average, 4′–6″ x 6′–6″, and requires about 8′–0″ of space in which it may be turned. Be careful that draughts between windows do not fall across the head of the bed. Locate the gas jet conveniently in relation to the bureau or dresser. The closet to the bedroom should be fitted with a shelf, and the door should swing in such a way as to admit the most light when open.

The Bathroom. Average sizes for bathroom fixtures are: bathtub, 2′–0″ x 5′–0″ inside measurements, with 3″ rim; bowl, 12″ diameter, with

3″ of marble slab outside of it; seat, 18″ x 18″, with 6″ behind it. Plan the location of these fixtures carefully, as well as the placing of the gas-jet and the swing of the door.

Outside doorways show a slight projecting sill (Fig. 11), and 3′–0″ will be found a good height from the ground level to the house floor.

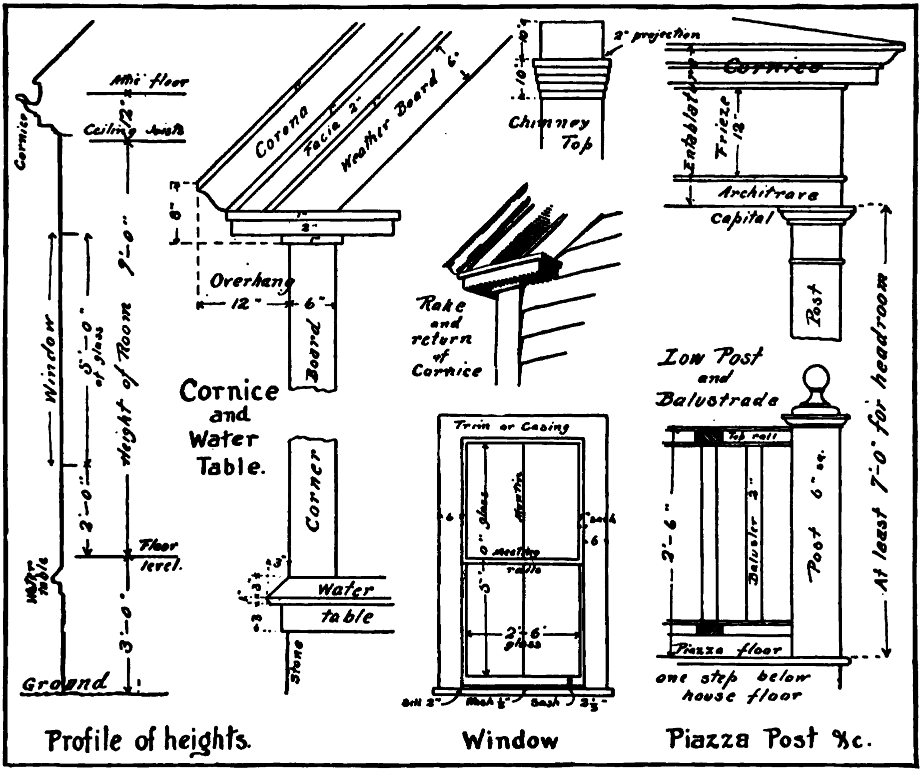


PLATE II

Ceilings. In drawing the front and adjacent side elevations you will need to know the height of the ceiling. In our problem a 9′–0″ ceiling will answer. Allow 1′–0″ for ceiling beams, and place the roof as in the first problem. The eaves may be any height above the ceiling that is desired. Usually the eaves, or cornice as it is called, is composed of a series of mouldings, with the gutter forming a part of the series

(Plate II, page 195). A board at the corners provides a good stopping-place for the clapboards. Part of the cornice returns around the corner and across the top of the corner board, giving a suggestion of support, like a primitive capital. Weather-boards show below all cornices, whether they run "on the rake" or level. (The rake of a roof is its pitch or slope.) At the ridge of the roof, show saddle-boards, which emphasize this important line.

To cover the joint between the foundation wall and the wood-work, a simple group of mouldings, called a water-table, is used (Plate II). This keeps the weather from driving in under the sills, and also serves as a strong structural line to mark the base of the building.

Windows and Doors. In locating and drawing the windows, draw first the lower line of the window glass, placing it 2′–0″ above the floor level. Draw the glass size first, and work outward in all directions for the finish. The windows are to be twice as high as they are wide. Make outside doors 7′–0″ high. Each opening is usually surrounded by a more or less ornamental margin called the trim, or casing. This serves the double purpose of providing a tight joint against the weather and of emphasizing the opening as a decorative feature in the design. The casing for doors and windows should be of the same design, and the panelling of the doors should correspond in style. Tops of piazza posts are supplied with a moulding, called a capital, which serves as an ornamental feature also.

Chimneys. Chimneys are generally given a simple ornamental line near the top. This must not project far, as ice will lodge on the shelf and force the joints. In order to secure a good draught, and also to prevent sparks from striking the roof, the top of the chimney should be well above the ridge. A chimney should never be built in a valley of a roof, as the snow and ice would in that case fill in behind it, eventually causing leakage through the roof to the ceiling underneath.

The Piazza. If your plan calls for a piazza, you will need to know that piazza posts are usually 6″ square or round; that balusters are 2″ wide, set 6″ apart on centers; — the classical rule is that the space between must equal the size of the baluster. The hand-rail is 3″ wide. For sizes of other parts, see Plate II. The width of the piazza floor should not be less than 4′–0″.

Piazza balustrades should be made with two rails: the hand-rail already spoken of, and a lower one, built up from the piazza floor, so that a broom or brush may pass under it. Around the piazza there are usually some openwork panels or a lattice work of some kind (Fig. 12). Some such construction allows a free circulation of air under the piazza floor and also forms a decorative finish. For decorative purposes, also, the treads of steps are made to project slightly over the risers, forming a "nosing."

Specifications. Although innumerable joints are necessary in the construction of a house, we should not attempt to show them all in the plans and elevations. Accompanying the drawings of the plans and elevations for a building is usually a set of specifications written out by the architect, stating the materials to be used in all parts of the house, how walls are to be covered, and giving all other facts that cannot be expressed in the drawings.

When all pencil lines are drawn in the plan and in the two elevations of the problem, go over each view carefully to see that they relate properly and that all measurements are drawn accurately to scale. When corrections are made, we are ready to color and ink in our work. The thickness of walls in the plan may be section lined, or expressed by a thin wash of yellow ochre water-color, with red for the brick work. When the color washes are dry, ink in all pencil lines as in Problem I.

Indicate the grade line and all stone work by free-hand lines, rather than by mechanical means.

Lettering and Planning Dimensions. Add the necessary lettering and the date. The lettering should be uniform in all views, as all are parts of one design.

In the plan, place the name of each room as near the center as possible (Fig. 11). All walls should be definitely located by figures. The dimensions thus stated are not those we used in drawing the rooms, for builders generally work from centers. But if our calculations have been correctly made, the finished size "in the clear" will result exactly as planned.

Run dimension lines through the entire house so as to cross as many partitions as possible without conflicting with any line of the drawing.

Allowing 7″ for outside walls and 6″ for inside walls, figure from outside of house to center of first partition; then measure from center to center until you come to the opposite outside wall, continuing the measurement through to the outside of the wall. The sum of these figures will show the size of the house. The dimensions should be placed far enough away from the lines of the plan to avoid confusion and to be plainly read.

It is important that the windows and doors be located exactly in accordance with the original design. Just outside of each side of the drawing show a series of measurements which will locate all outside openings (doors and windows). Starting from an outside corner of the house, figure to the center of the nearest opening; then to the center of the next opening, and so on until the entire side of the house is measured. The sum of these measurements must tally with the total of the inside measurements. If we give the builders the centers and the size of the glass, the size of the windows will in this way be determined. Inside doors are not, as a rule, figured.

For the sake of simplifying this problem, fractions of inches have been omitted in the sketches shown; but in practical or advanced work, of course, fractions of inches are necessary factors.

Problem III — A Two-story Dwelling

We are now ready to undertake the planning of a more complete house, — one that will more nearly meet the needs of the average family. Our plans in Problem III will include a cellar, first and second floors, stairways and a heating apparatus. In carrying out such a problem, many of the steps taken will be the same as in Problem II, the added difficulty being the location and drawing of the stairways.

In our first floor plan we can now introduce a parlor as a separate room, leaving the dining-room to be devoted to its specific uses. The bathroom may now be located on the second floor, with as many bedrooms as the size of our house will permit. The heating plant we will assume to be a hot-air furnace.

Make preliminary free-hand sketches of floor plans, as in Problem II, but carry along the plans of the two floors together, being careful to see that their outlines closely agree. When you have settled upon the

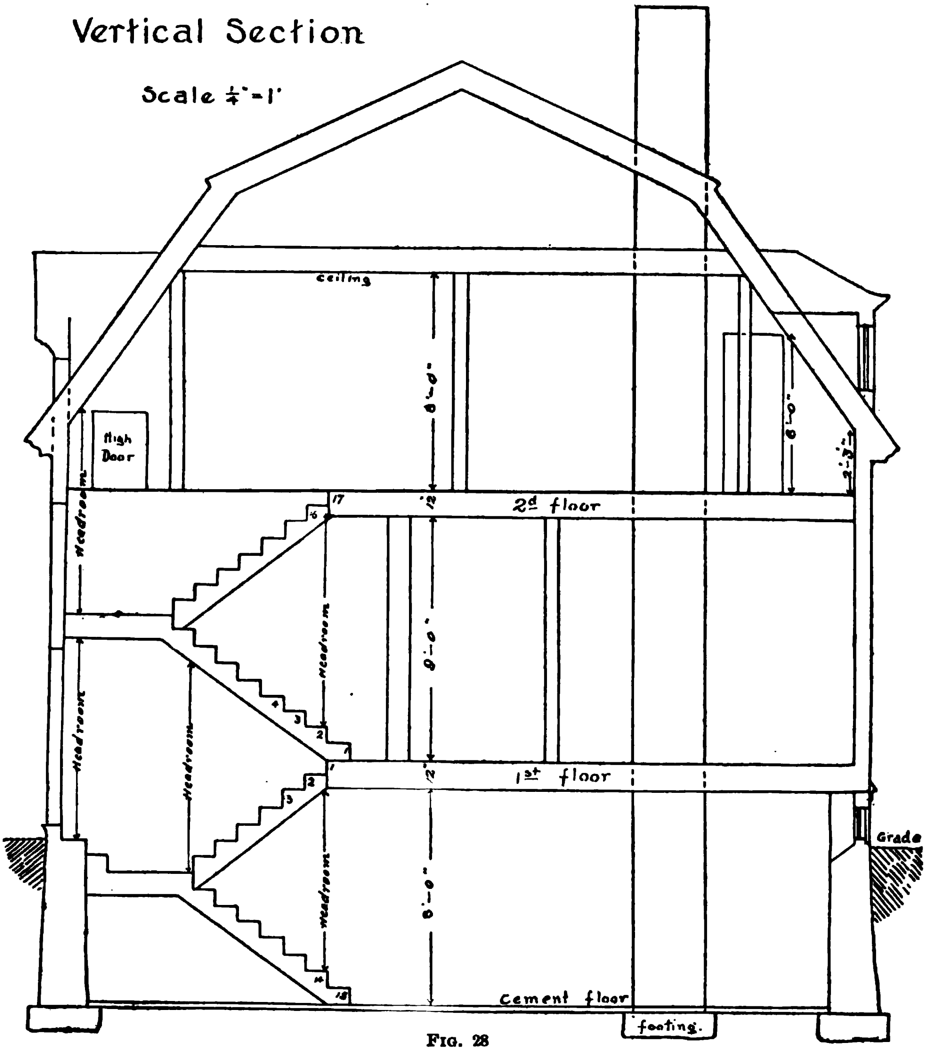


Fig. 28

arrangement of rooms on each floor, and have estimated their sizes and proportions, you are ready to draw the carefully measured plans.

A Vertical Section. Before you proceed very far with the "lay out" you will need to consider the heights of various parts of the house, as in planning stairways as well as in two-story elevations the up-and-down measurements are of much importance. These measurements are best determined by making an extra drawing, called a vertical section, showing the heights of floors, ceilings, windows, cornices, etc. (Fig. 28).

For the rooms in the first story, let us assume a height of 9′–0″, with 8′–0″ ceilings for the second story. The thickness of the floors may be estimated as 12″. This includes beams, floor-boards and ceilings, and the thickness varies according to circumstances.

In drawing this vertical section of the house, begin with the ground level or "grade." Place the first floor level about 3′–0″ above the grade line, thus allowing space for cellar windows. From the first floor level, measure up for the heights of the first and second stories and down for the depth of the cellar, allowing for the thickness of floors. Draw the floor lines across from wall to wall.

The Stairway. To find the number of risers required in a flight of stairs, divide the height from floor level to floor level by 7, as 7″ is the accepted average height of a riser. In our problem the height of the first story is 9′–0″ and the thickness of the floor is 1′–0″. Reduced to inches, this distance is 120″. Dividing by 7, we have a result of 17, with 1″ over. Therefore, we shall require 17 risers, each measuring $7\frac{1}{17}$″ in height, for the stairway leading from the first to the second floors.

The problem of planning and locating a stairway is often a perplexing one, and in working out this exercise you may find it necessary to try a number of ways before you settle upon one which is satisfactory. A straight "run" of stairs is the simplest, of course, but it often develops awkward proportions, and interferes with other parts of the plan. In the effort to economize room, however, the opposite extreme should be avoided, in the stairway involving "winders," or treads which taper at one end. Such construction is a source of danger. Stairways should be so planned as to bring the second floor landing in a central location, otherwise much room will be wasted in halls and corridors. If the construction of the stairway necessitates a turn in direction, aim to provide a good-sized landing at the turning point. In shape, this landing may be square; or, if the stairs are to make a complete reversal in direction, a double square landing will be much better. Every precaution must be taken to avoid stumbling points

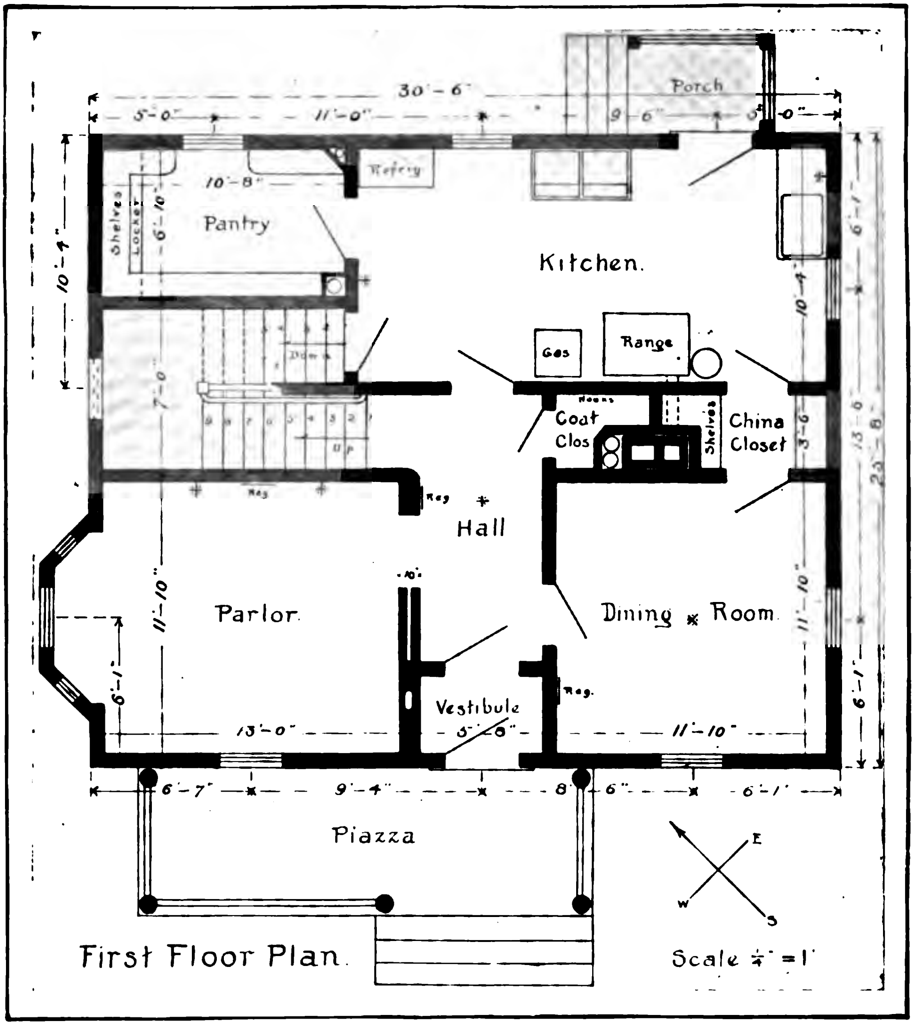


FIG. 29

in the construction of a stairway, and every riser must measure exactly the same in height.

The most economical construction is that in which one flight of stairs follows under another. The vertical section drawing will in such a case

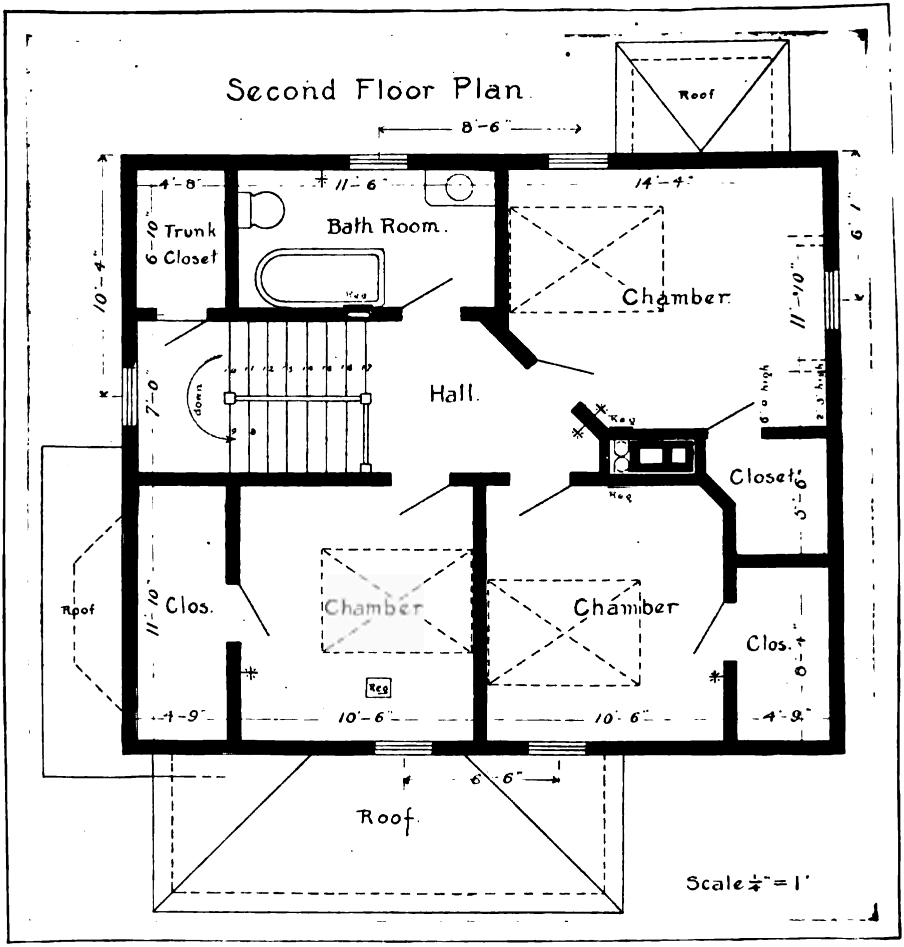


Fig. 80

help us to estimate the proper amount of headroom which must be allowed between them. About 7'–0" is a sufficient space. In drawing the plan, stairs going up above the head are usually dotted above the 6'–0" level (Fig. 29).

The height of the eaves will depend upon the general proportions of the house as a whole, and also upon the headroom allowed for the stairs. The eaves should be so placed as to add to the feeling of stability in the

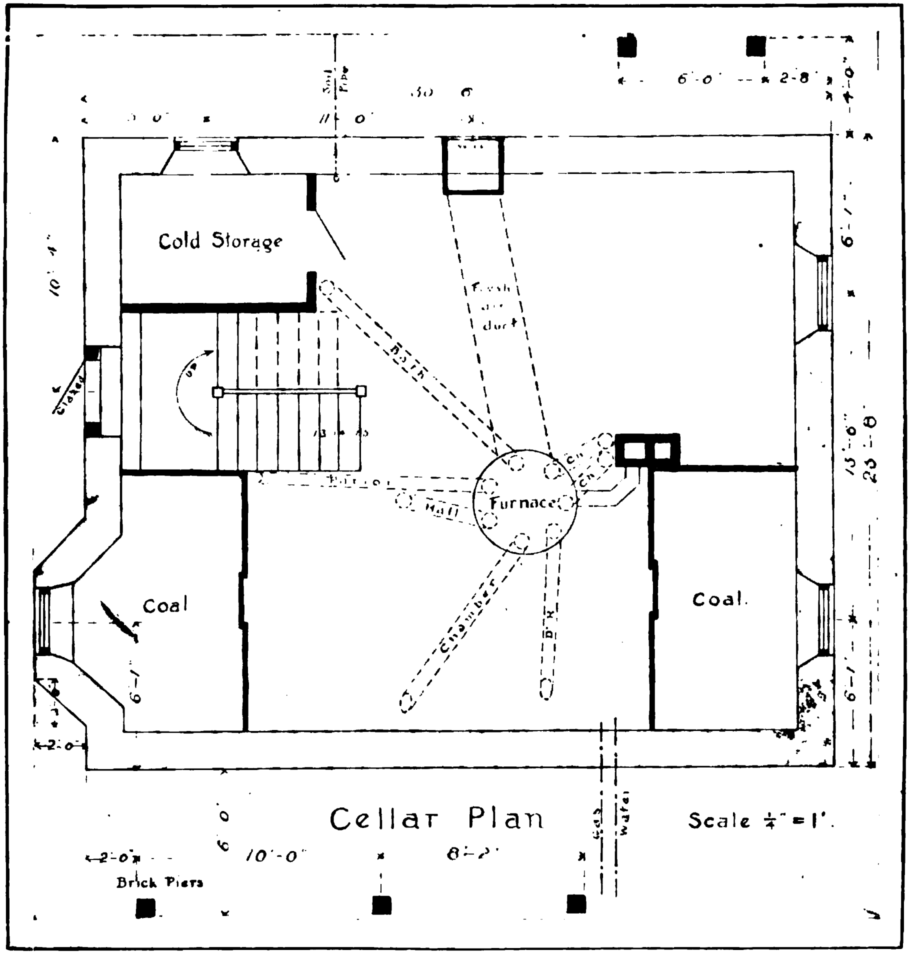


FIG. 81

appearance of the house, avoiding a top-heavy or unbalanced effect. The matter of the general proportions of the house as seen from the outside is very important. In the city, conditions prevail which make it impossible for us to govern the proportions of the average city house, and they are universally high and narrow. But in the country the question of beauty of proportion should receive great attention.

Front Elevation Scale ¼"=1'

FIG. 32

Location of Windows. Two important requirements should govern the placing of windows in the plans. In the first place, they must meet the requirements of the life within the house; they must be sufficient in number and so disposed as to provide the proper amount of light and ventilation. At the same time, they must not be so numerous nor so placed as to destroy wall spaces for furniture. Secondly, windows should be so placed as to enhance the exterior design of the house. Often it is possible to move a window a few inches to the right or left, securing in

S.E. Elevation.

FIG. 83

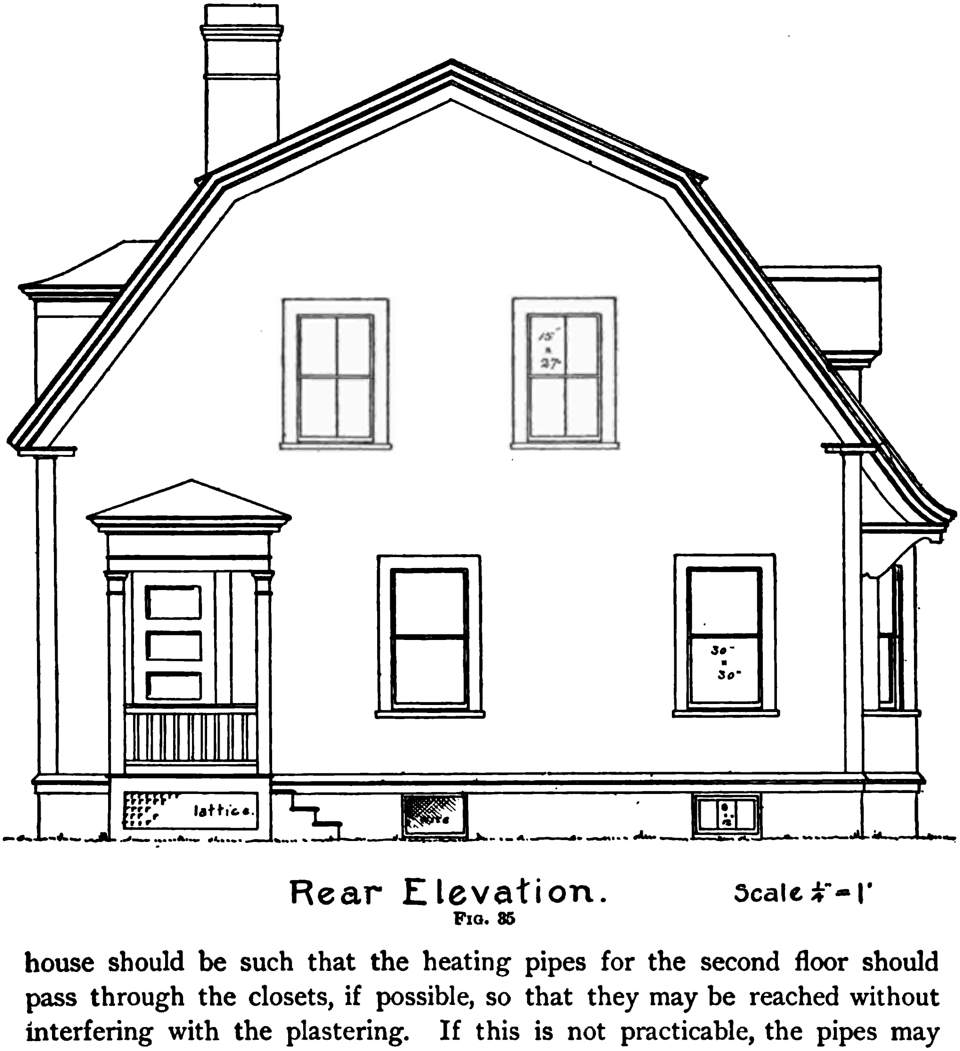
this way an improved appearance of the outside, without interfering with comfort or convenience.

The Cellar Plan. After the plans for the first and second floors are made to harmonize in all the parts considered, the plan for the cellar should be drawn. The wall, if of stone, should be about 18″ thick. If there is a bay-window on the first floor, the foundation for it need not necessarily be continued to the depth of the cellar. It should, however, be carried below the reach of frost, about 3′–0″ below grade. The location of the chimney is determined from the plan of the first floor. Remember that two flues must be constructed, one for the furnace and one for the kitchen range. Locate the furnace as near the center of its work as

N.W. Elevation. Scale ¼"=1'

FIG. 84

possible, so as to avoid the necessity of very long pipes; the shorter the pipe the more direct will be the delivery of heat. The furnace pipes should have as much of an inclination or pitch as possible, in order to assist the natural tendency of heated air to rise. The degree of inclination necessary to secure the best results from furnace pipes is a question that helps to determine the depth of the cellar. The pipes conveying the heat to the first-floor rooms should open into the rooms near the floor level. Sometimes registers are placed in the floor, and by this means the heat is carried more directly than is possible with wall registers; but there are objections to offset this, as registers are liable to collect dust and dirt, and they often interfere with the placing of carpets and rugs. The construction of the



Rear Elevation. Scale ¼" = 1'

FIG. 85

house should be such that the heating pipes for the second floor should pass through the closets, if possible, so that they may be reached without interfering with the plastering. If this is not practicable, the pipes may be somewhat flattened and carried up between the studs of a partition. The location of registers should be plainly marked in the plans (see Figures 29 and 30).

While planning the heating apparatus we must remember that a very important feature is the duct which conveys fresh air from out of doors to

FIG. 36

the furnace. This duct should open towards the direction of the prevailing winds and should be of generous size, for all the air to be heated for the entire house must come through this duct. Many a house is poorly heated because the fresh-air supply is inadequate. In the cellar there should be constructed, also, bins for fuel. These bins should be located at or near the cellar windows, so that they may be filled from the outside of the house. Another desirable feature of the house would be a room shut off from the heat of the furnace, where vegetables, fruits and other provisions may be kept (Fig. 31). A doorway should be cut in the cellar wall, so that ashes may be conveniently removed. Plan carefully the places where gas and water pipes shall enter, and where the drain-pipe shall leave the cellar.

Roof and Chimney Construction. In the accompanying elevations, Figures 32, 33, 34 and 35, the gambrel roof is used, although any other style desired by the student may be adapted to the problem (Fig. 36). When the slant of the roof cuts off the height of the chambers, the dormer window is often used. This construction admits light, allows headroom, and also gives variety to the otherwise severe appearance of the roof on the outside. Two examples of dormer windows are shown in the accompanying elevations, one with a pitch roof and one with a hip roof construction.

The chimney should rest firmly upon a solid footing of stone or cement built under the cellar floor. If this foundation is not sufficiently solid there is apt to be unequal settling, causing cracks in the plastering about the chimney.

Avoid any construction that will locate the chimney in a valley of the roof, and see that the chimney top rises well above the ridge, so that the currents of air passing over the house will cause a partial vacuum in the chimney and so induce an up draught.

Comfort and Beauty of Interior. Thus far in our problem we have dealt only with the essential features of house construction; but a good architect in planning a house would add many features pertaining both to comfort and to beauty. For instance, there may be a window-seat here, a built-in bookcase there, a hall closet for coats and umbrellas, a genuine hearth and fireplace, instead of the imitations to be seen in many modern houses. There may be linen closets, kitchen and bathroom cabinets, moth-proof cedar closets, and a host of other household conveniences planned as part of the construction, all tending to enhance the individuality of the house and helping to make it a real home.

As a result of these problems, the student will be led to observe more closely houses in process of construction, and will gain information at first hand which may be applied to similar problems, thus leading to a better understanding of the importance of architecture as related to practical life.

Problem IV — A City House

In planning the drawings for a city house the architect is obliged to work under many restrictions, and under conditions that may be termed unnatural. The streets are paved from curb to curb, and often the open space at the rear of the dwelling is heavily flagged also, so that there is no chance for grass or trees or flowers to grow. The building lots are of

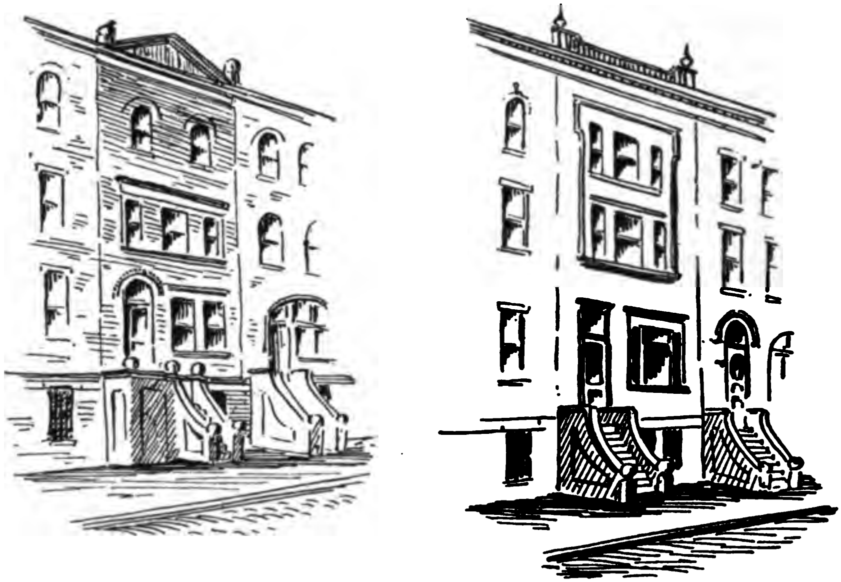


FIG. 87

uniform size and shape, and the lines of frontage must be kept with mathematical precision. The houses are built close together, in compact blocks, instead of being placed in separate lots, with a grass-plot or area of air and light around each dwelling. There are so many people and land is valued at so high a figure that the great danger, in crowded tenement districts, is that sanitary or health-preserving conditions will be neglected or impossible. Human beings, like plants, require sunlight and air, in order that they may grow strong and vigorous.

Every city has its code of building laws, made for the mutual protection of all its people, and these laws must be borne in mind by the architect when he is planning a structure. For instance, in many cities there is a law which requires every building to be made of some non-inflammable material, such as brick, stone or cement, in order that fire may be resisted or impeded. Before he can draw the plans of a house the architect must know of what it is to be constructed, and he must also be able to use in his drawings the conventions or symbols which indicate these various materials, as shown in Plate III, on the opposite page.

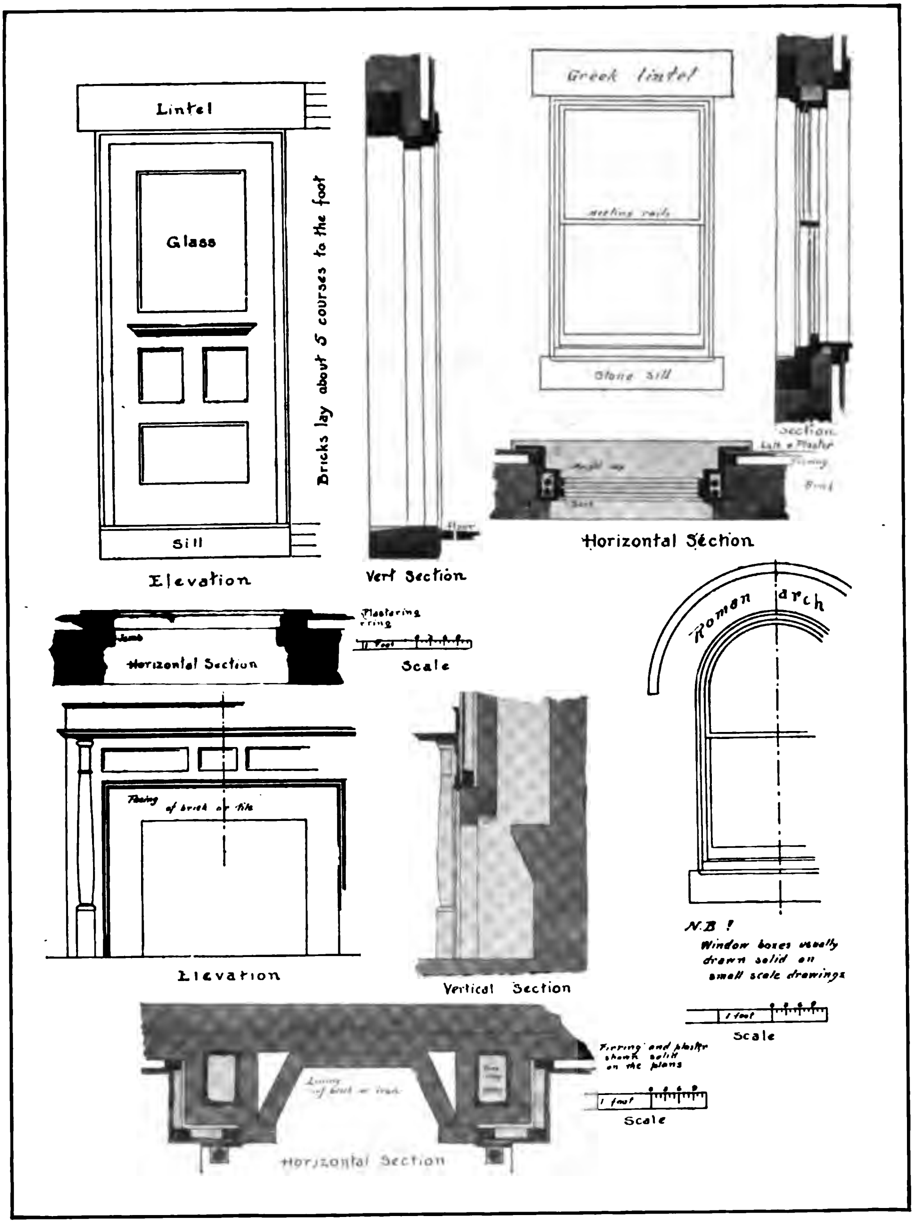

Lintel
Glass
Sill
Bricks lay about 5 courses to the foot
Elevation
Vert Section
Greek lintel
Stone sill
Section
Horizontal Section
Horizontal Section
Plastering
Scale
Elevation
Vertical Section
Roman arch
N.B.!
Window boxes usually drawn solid on small scale drawings
Scale
Furring and plaster shown solid on the plans
Scale
Horizontal Section

PLATE III

Walls and Chimneys. Walls separating the individual houses in a block are known as party-walls, because they are the property of the owners of the respective houses, and the width of the lot upon which a city building stands is measured from center to center of these party-walls. Twenty feet is the average width of a city lot, although this standard varies in different cities. The chimneys of city houses are usually built into the side, or party-walls, and very often they connect with fireplaces in the different rooms, designed not so much for heating purposes as for ventilation and ornament. A good fireplace and mantel of simple and sincere construction in a room is always an attractive feature in its furnishings. The back wall of the fireplace, according to building laws, must not be built nearer than four inches from the party-line. Each fireplace connecting with the chimney should have its separate flue, and this necessitates a "topping out" of each chimney with as many flues as there are fireplaces in the house.

Light and Ventilation. As there are no side yards, the city house must be lighted from the two ends or from the top, and it is in the placing of windows and in the location and proportion of the entrance that the designer finds almost his sole opportunity for giving individuality or distinction to the exterior of the structure. The windows need not follow with mathematical order in every story, but some device of grouping may be used so that the spaces may not be monotonous. Several windows grouped together, as in Fig. 37, not only furnish an attractive feature in the room, but they apparently reduce the height of the exterior and add dignity to the whole design. Avoid the commonplace and uninteresting, at the same time keeping close to simplicity and to structural lines. Over doors and windows there may be placed a lintel, as in Greek examples, or the openings may be arched, as in Roman styles (Plate III, page 211).

When a room is so located that it cannot be lighted from the front or back windows of the house it is necessary to introduce shafts or wells to let in the light and air from above, as in Fig. 38. No room should be constructed which does not in some way have access to light and air. Here, again, the designer finds himself greatly limited. If we plan to have many rooms on a floor, our design, if it admits daylight and ventilation into every room, will be long from front to back, and thus not adapted to the ordinary city lot. If, on the other hand, we bring all rooms to the front or back of the house, we can plan but few rooms on a floor, and several stories will be needed to provide the rooms which the needs of the family demand. This is the plan usually followed, and city houses are built high and narrow, instead of occupying the ground space that is available in the town or country. Stairs, therefore, become an important factor in city houses.

Strength and Solidity. In designing the front of a brick building it is very important that supporting piers be preserved in uninterrupted lines, especially at the juncture with party-walls. We often see a store front, with a large mass of masonry apparently resting upon the first story, of plate glass. This does not seem reasonable and does not satisfy our sense of fitness. We know that there are different ways of supporting walls, and that sometimes the means of support do not appear in the finished house, yet the appearance as well as

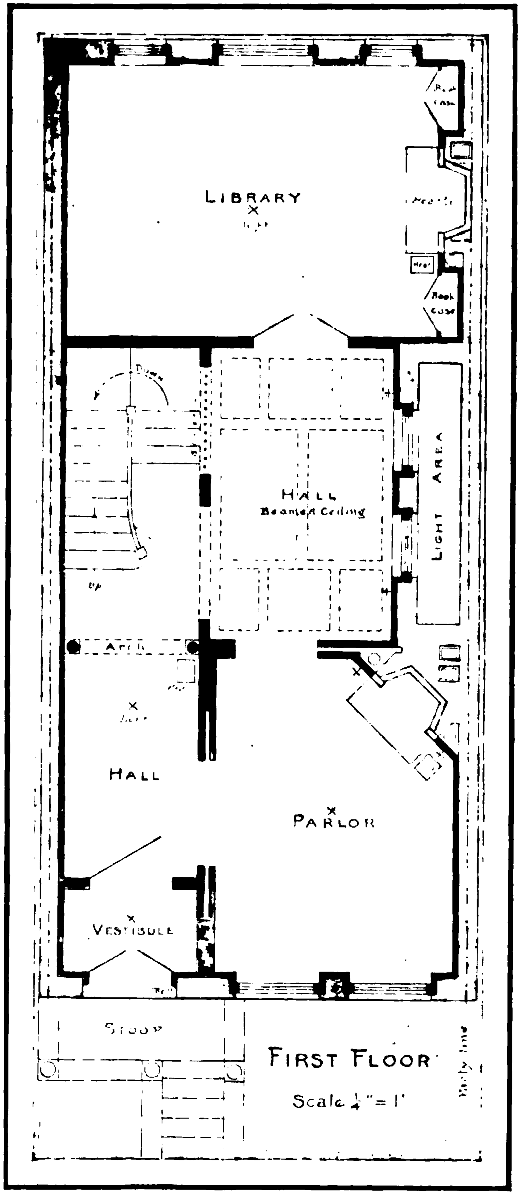


FIG. 88

the fact of strength and solidity is necessary in house construction. We do not consider a house beautiful or well designed if something of the construction is not apparent in the completed building.

Arrangement of Rooms. The arrangement of rooms in a city house is a problem that requires careful planning. For instance, the parlor, or reception-room, hall, and possibly the library, may be grouped on the first floor. The kitchen and dining-room may be in the basement, or at the top of the house, if there is an elevator, while the bedrooms and bathroom may properly be placed on the intermediate floors.

Before attempting a problem of this kind, study some city houses in the process of building, and try to get all the information you can at first hand. Then draw the plans and elevations necessary to make a complete set of drawings for a typical city house. Try to introduce some individuality into the problem, at the same time giving full consideration to city conditions and to the immediate environment of the proposed structure. As a person can at all times preserve his individuality while recognizing the customs and laws of his country, so a house may be an integral part of a city block and yet retain its own unique characteristics.

Problem V — A Public Building

In addition to buildings used as homes and dwelling-places, many other kinds of structures are necessary in the life of any community. Certain classes of buildings, such as stores, banks, factories and shops, are for the use of private corporations, while others are for the use of the general public. Every city or town requires buildings for public use, such as a town-hall, court-house, post-office, library, school or church, and the services of a good architect are frequently employed upon problems of this nature. Definite knowledge of the purpose of such a building, its contents, the uses it is to serve, an estimate of its necessary size, together with an understanding of its location and of its relation to surrounding buildings, are points which the architect must settle before he begins to make even preliminary sketches. Suppose, for instance, he is asked to submit drawings for a fire-engine house,—an important if not indispensable public building in any village, town or city. The architect must know whether the house is to contain the engine alone, or a hose-cart and ladder-truck as well. Provision must be made for stalls for the horses, and for sleeping accommodations for the men, if the town is large enough to support a permanent corps of firemen. When these conditions and requirements are ascertained, estimates must be made of the amount of space necessary to accommodate all needs. This estimate must be adapted to suit the size and shape of the plot upon which the building is to stand. In planning spaces it is unsafe to trust to luck or even to theory. The minimum space for each requirement should be determined, and then a considerable margin should be allowed for working room. For instance, a fire-engine requires a floor space of 22′–6″ x 6′–0″, with a height of 8′–8″, but at least three feet of working room should be allowed on each side of the floor space. The stalls for the horses must be made either small enough to compel the horses to stand at all times, or large enough to permit them to lie down and get up with ease. It is possible to construct a stall, which, because of its size or shape, allows a horse to become bound or "cast" when he lies down. This is of course a source of great danger to the safety and life of a horse. Uninterrupted runways are also indispensable, so that a horse may run from his stall and take his place instantly at the sound of the alarm. Other practical features, such as a hose-tower for drying hose, a rack for storing it, a heating apparatus and many devices for aiding quick and effective adjustment must be familiar to the architect who would attempt to draw the plans for a building of this kind. You see that an architect must possess a great fund of information along many lines.

Design for a Public Library. The problem chosen for the last of this series is to design a building to be used for a public library in a country town. The student is to draw plans and elevations similar to those shown in Figures 39, 40, 41, and 42. Before making preliminary sketches, consider the purposes for which the building is to be used. Primarily, it is to serve as a repository and storehouse for books, and in addition it will naturally be used as a public club-house, where the citizens of the town may come to read or study undisturbed. Start, then, with the idea of a general reading-room. In a very simple library building the books may be kept in cases or stacks placed against or near the walls of this room, but if the books are numerous, or the town is growing and able to support an ever-increasing library, a separate room or alcove should be

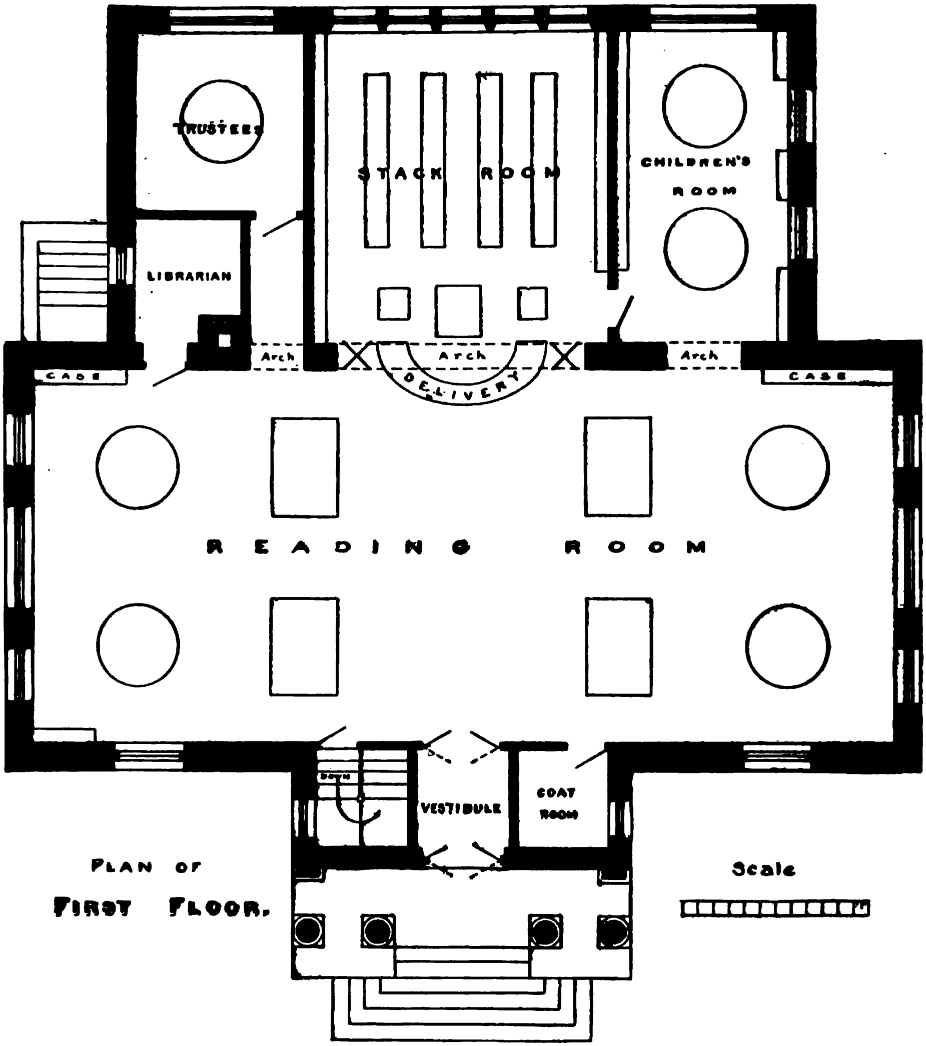


FIG. 39

provided, as shown in Fig. 39. Other desirable features would be a room for children's use, a reference-room, in which to keep books which may be used in the building but which may not be borrowed, a

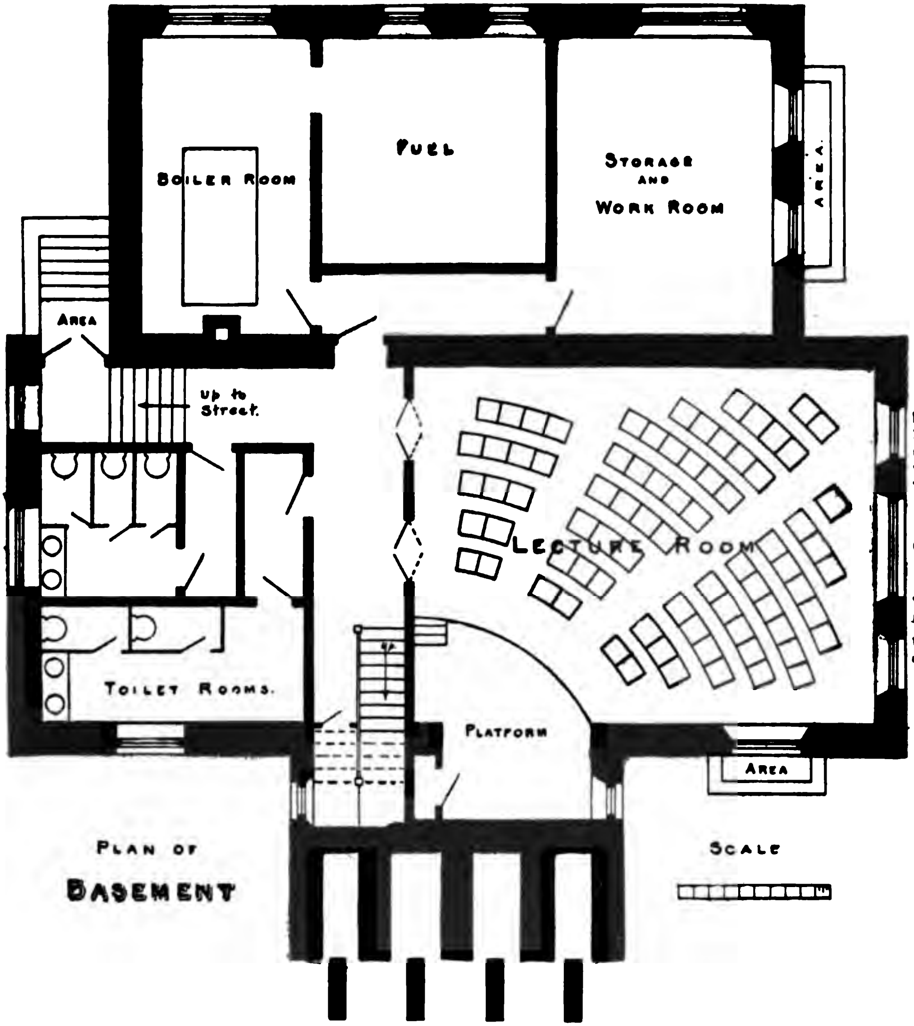


Fig. 40

lecture-room, a museum, an art gallery, etc. It will be a good plan to make a list of rooms which it would be desirable to provide in connection with a library, and, as you work, incorporate or eliminate these ideas as seems best. Rarely will you be able to use the first sketches you make in

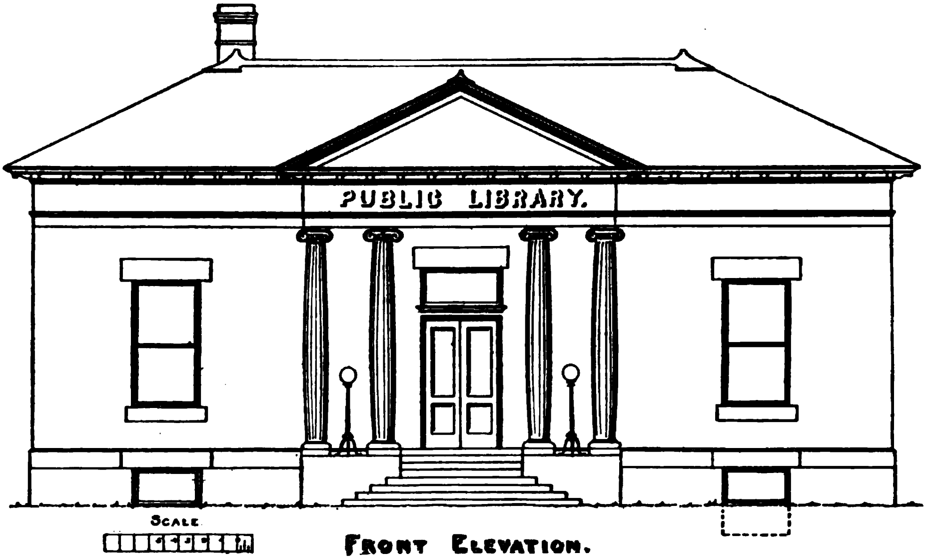


Fig. 41

planning a building. An architect is willing to revise and readjust his sketches many times, in the effort to adapt his ideas to conditions that he must meet.

There must be adequate provision for heating the building, for lavatories, for storing fuel and for a storage or work-room, and these features you will probably wish to locate in the basement (Fig. 40). This, of course, necessitates a stairway, which must be indicated in the plans.

Style of Architecture. If our building were to be a storehouse for grain, coal, or for other commodities, the idea of strength and utility would determine to a large extent the design of the exterior. But a library is associated with everything that is worthy and noble. It is a record of the best thoughts of all ages, and the building which houses such treasures should be beautiful, refined and dignified. Its architecture may appropriately be classical in style, for, as a library of books is a compilation of the records of civilization, it seems fitting that its receptacle should suggest something of the ancient origin of its contents. Again, the architecture of the Greeks has never been surpassed. It is simple, dignified and

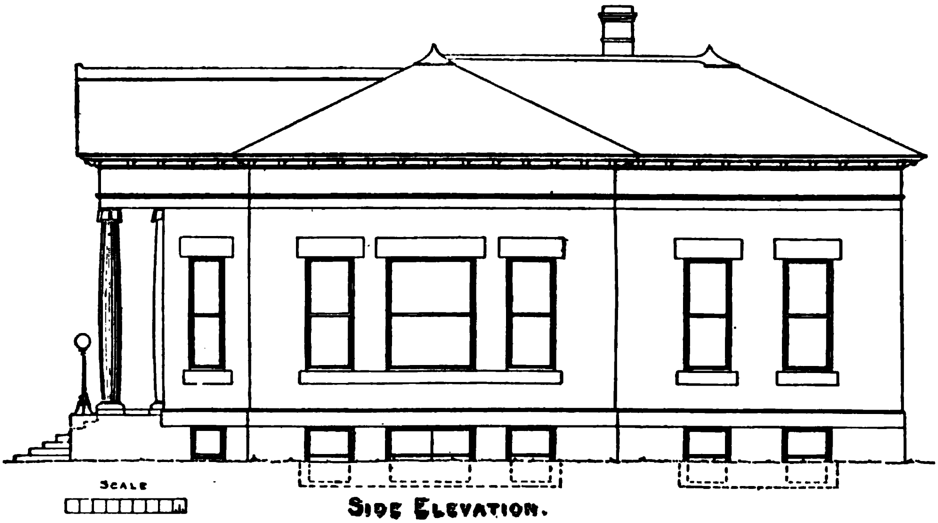


FIG. 42

sincere, and though we would not desire to have all the buildings in a town based on Greek ideas, the presence of one fine example will set a high standard and mark our library with individuality and distinction.

One way of emphasizing the entrance to a public building, so that it will become an important feature in the general architectural effect, is by means of a portico or covered platform (Figures 41, 42 and 43). If we use this feature the question of columns becomes important. In Grecian architecture there are three distinct types of columns, known as the Doric, the Ionic and the Corinthian (page 307). The Ionic style or order, easily recognized by the spiral curves or volutes in the capital, has been chosen for use in the problem illustrated. The size of the column is regulated by rules of the order, and the module or unit of measure is the radius of the shaft, each part of the column being some fraction or some multiple of the module. The Ionic column as used by the Greeks was 18 modules, or 9 diameters, high, and we must keep close to these proportions if we wish to preserve the harmony of the whole design.

Having established the height of our portico, we obtain the diameter by dividing by 9, if we wish to use full-length columns. We can, if we

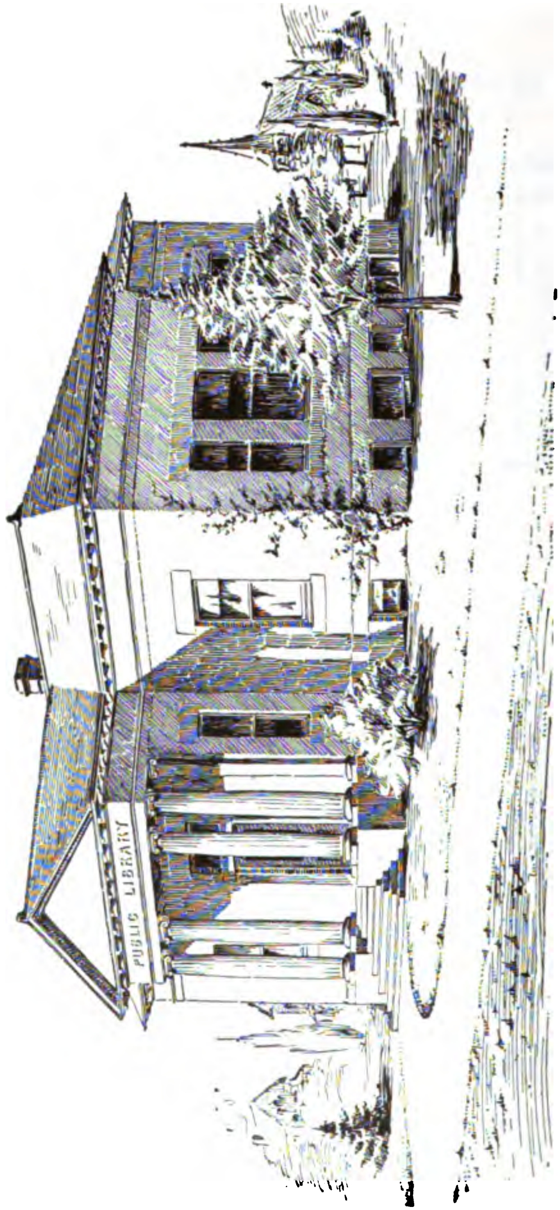


FIG. 43

choose, introduce pedestals to lessen the height of the columns, dividing the remaining distance by 9, to obtain the diameter. This, of course, would result in smaller columns. For the building illustrated in Fig. 43 full-length columns were used, because of the simplicity and dignity of the unbroken lines of the shaft.

Greek columns usually taper slightly toward the top, and here again their inventors have given evidence of fine thinking, for the tapering is not straight, but is expressed by means of a subtle curve, called the "entasis." The largest diameter, instead of being at the base, is about one third of the way up. This peculiar construction of the column serves to correct an optical illusion and makes the column appear straight. If its construction were really straight and uniform the column would not appear so.

Some weight, real or apparent, must be upheld by the columns, and so the pediment or gable is used, offering a space that is highly suitable for sculptured ornament. The pediment also serves to break the otherwise monotonous structure of the roof, and furnishes oblique lines, which seem to reconcile the opposing forces of the strong vertical and horizontal lines.

The only remaining ornamental feature which we may with propriety use in this problem is the cornice. This is a moulded projection, which is used to crown or finish an outside or inside wall. The Greeks made much of the cornice, and produced many beautiful mouldings in which the effects of light and shade were considered important, as well as the proportion and arrangement of the forms themselves. Notice the cornice used in Fig. 43. The little brackets or modillions, each beautifully proportioned and modelled, are introduced at regular intervals, making a well-marked and effective line at that level.

Light. The windows of the library should provide a plentiful supply of light, and as it is desirable that the light should be admitted, as far as is possible, above the heads of people, we will plan our windows full size to their tops, finishing them with the flat lintel of Greek usage, rather than with the Roman arch.

A perspective drawing of a proposed building is often made from the working drawings by mechanical means. Fig. 43 was made in this way. If you wish to make a similar perspective view from your own plans, follow the methods illustrated in Fig. 56 in the chapter on "Perspective Drawing."

CHAPTER VI

DESIGN

A Brief Course in the Fundamentals of the Subject

Origin of Design. In the civilized world we are surrounded by objects that have been made for some definite purpose. Many of these objects are so necessary to our comfort and convenience that we have grown to think of them, not as the work of man's brain, but as natural conditions without which existence itself would hardly be possible. We consider houses, clothing and cooked food almost as essential to us as air, water and light, for civilized man needs a house to shelter him, clothing to protect his body from cold and heat, and utensils with which to prepare and serve his food. Vehicles for the transportation of himself and the numerous commodities which he requires are also necessary to the conduct of his business, and so are the various devices employed for the transmission of his ideas to his fellow-man. All these things we now consider indispensable, and we forget that for every manufactured object in the world there must have been an originator, a creator. Some mind must have planned, centuries ago, the rude hut which has developed into the modern dwelling-house, with all its appointments for use and beauty. The canoe of the savage or the raft of the barbarian was the result of man's desire to transport a weight over the water, and the modern steamship has been evolved from this primitive idea.

Expression of Ideas. In the early days, the designer was also the manufacturer of the product. We can imagine that the first manifestation of his idea was by means of some tangible material, and that he did not express his thought in a drawing. But that expression of his thought, whether it was in wood, stone or metal, or set down on paper by means of a drawing, was a design. The derivation of the word suggests its broad meaning, for we find that it comes from a root that means *to mark out for a purpose.*

Obedience to Law. In the study of design we seek to understand the underlying principles that govern artistic expression of all kinds. As in spoken or written language, there are essential laws that every writer and speaker observes, and, as in musical art, there must be strict conformity to fixed principles or rules, so in graphic art there are certain principles of beauty that the student must grasp before he can arrive at genuine art appreciation, and before he can himself produce creative or original work of merit. Beauty is the result of obedience to law; it is not the result of chance or accident.

Statement of Principles. It is the aim of this chapter briefly to define and illustrate these principles, so that the student may be equipped to some extent with standards or tests by which he may estimate the beauty or the merit of created objects in the world about him. There are three heads under which the work of a designer may be classified, according to the various motives that actuate his work. We know that some designs are purely constructive in their character, such as plans for buildings, for bridges, for machinery or for various kinds of furniture. Other designs are pictorial, and under this head may be placed all landscapes, illustrations, portraits and whatever is done from purely representative motives. If the designer has a decorative purpose in mind, his work will be of still another character, and he may plan ornament, such as sculptured pillars for buildings, patterns for textiles or wall-coverings, or mural decorations. But in whatever field he may operate, the designer must work in conformity to principles of law and order. These principles have been variously defined by different authorities, and the different terminology employed has led to more or less confusion, but it is evident to the student that the end and aim of each authority is the same. All are united in the effort to formulate a statement of the principles governing design. In this book these principles are known as the principles of Rhythm, Balance and Harmony.

The Principle of Rhythm. By rhythm is meant a consistent relation and connection of parts that enables the eye to find its way through all the details of a design. Rhythm is often spoken of as related movement, and the decorative arrangement of units known as borders illustrates the principle in a simple and elementary way. Fig. 1 is an orderly arrangement of lines by means of which the eye is carried from one unit to another, agreeably

Fig. 1

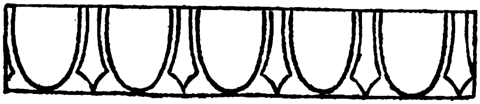


Fig. 2

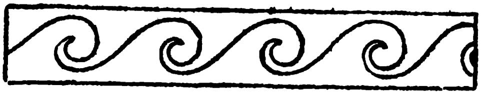


Fig. 3

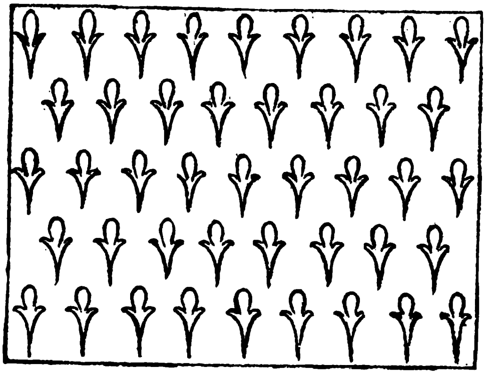


Fig. 4

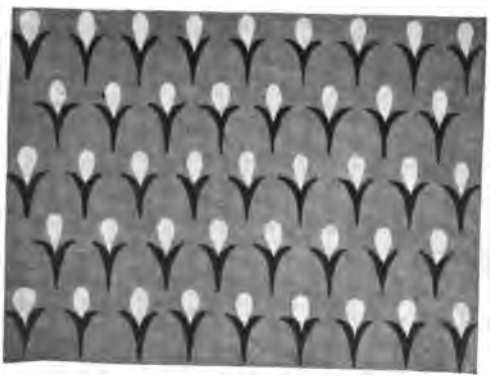


Fig. 5

and without interruption. Continuous and related movement is established by the order in which these units appear. It would be easy to imagine this movement interrupted by a confused arrangement of these same units or by a disturbance of their uniform spacing. The Greek egg-and-dart ornament and the scroll motive shown in Figs. 2 and 3 are classic examples often used at the present time that show fine rhythmic movement, although they possess other elements of beauty in addition to rhythm. Fig. 4 shows a surface pattern in which a unit is distributed over a space in such a way as to lead the eye consistently through all parts of the pattern. The units occur at regular intervals, like rhythmic heartbeats. Fig. 5 shows the same design in values.

Exercise I. On squared paper make a rhythmic arrangement for a border, using only vertical and horizontal lines. The width of the border and the relative lengths of the lines in the unit may be determined by the student. Make several arrangements and transfer the best of these to tinted paper. Ink in with brush and black water-color.

Note. Designs may be transferred by means of carbon paper, or by covering the back of the design with a "rubbing" of very soft graphite or lead. Place the rubbed surface next to the paper or other material upon which the decoration is to be transferred, and trace the design with a hard lead pencil. The impression thus made may be covered with brush lines or washes.

Exercise II. On tinted paper make two tracings of the border selected in Exercise I. Finish one tracing with a brush line of medium width, and in the other use a line two or three times as wide. Note the difference in effect.

Exercise III. Repeat these same ideas in surface rhythms, using only vertical and horizontal lines in the unit. Figs. 6, 7, 8 and 9 show examples of simple border and surface rhythms, designed on squared paper and transferred to tinted paper for finishing in ink.

Another Form of Rhythm. We have seen that the repetition of lines or units carries the eye in continuous movement, and that the direction of this movement depends upon the arrangement or placing of the units employed. Rhythm is obtained whenever related movement is established, and it does not depend solely on

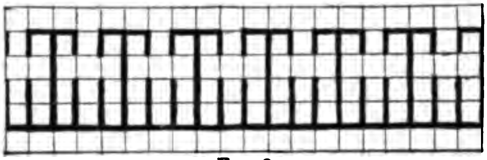


FIG. 6

FIG. 7

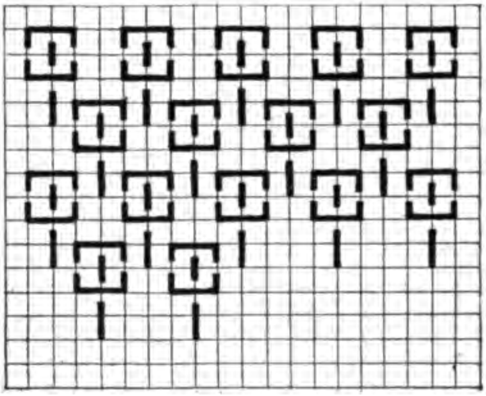


FIG. 8

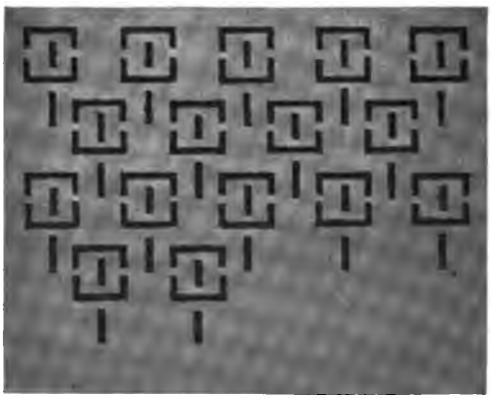


FIG. 9

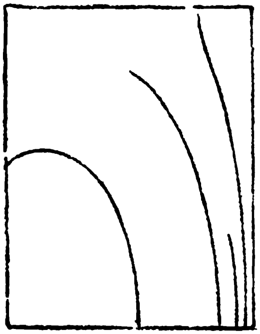


Fig. 10

Fig. 11

Fig. 12. From the Japanese

simple repetition. The curling of smoke as it issues from a chimney, the flowing waters of a stream, the flight of birds, the action of fish as they swim, all suggest a movement that is rhythmic in its quality. In nature we see related movement in the consistent lines of direction taken by tree trunks and branches, in the growths of grains and grasses, and in the graceful movement of many animals, such as the cat and the tiger or lion. Fig. 10 is a diagram that shows a certain relationship between the curved lines and the structural or boundary lines of the space. The enclosed lines are not parallel to each other nor to the sides of the rectangle, yet the eye meets no resistance when it travels along the direction indicated by all these lines; its movement is rhythmic. Fig. 11 shows a flower arrangement based on these same lines. The lines of growth are consistent with one another and with the structural lines by which they are enclosed. Such a design is rhythmic, and the principle illustrated here is the governing principle of many works of art. Fig. 12 is from a Japanese print in which the rhythmic arrangement of line is very apparent.

The placing of the sky-line in the landscape composition begun in Fig. 13 suggests rhythm because of its relationship to the leading lines of the enclosing space, and this quality is emphasized in Fig. 14 by flowing lines that may become a brook or roadway. The addition of trees in Fig. 15 recognizes the vertical lines of the enclosure, and supplies, also, a feeling of balance. The elements presented in Fig. 15 are structural, though they are capable of infinite variety, and are lines upon which almost all landscape compositions are based. In the "Cumæan Sibyl," by Elihu Vedder (Fig. 16), we see that the important lines of the landscape are all tending in the direction of the horizontal lines of the enclosing rectangle, and that the wind-blown drapery and hair assist this movement, while the lines of the figure form a rhythmic system that echoes the vertical movement of the rectangle.

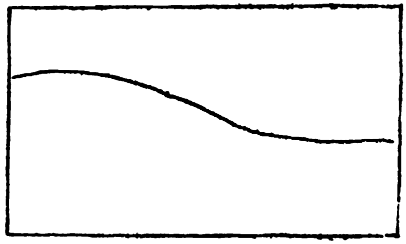


Fig. 13

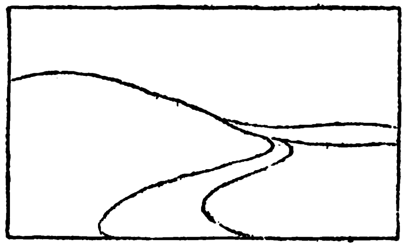


Fig. 14

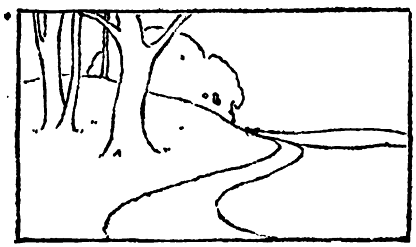


Fig. 15

Exercise IV. On a panel of tinted paper of some light grayed tone draw a narrow vertical rectangle, not less than 10 inches high. Select a growth of grass or grain that shows an interesting seed-head and several long, narrow leaves. Paint in with water-color the main stem, placing it within the rectangle so that its direction is rhythmic with the vertical sides, dividing the space into interesting relationships. Add the seed-head and leaves, making these elements, also, rhythmic with the structural lines of the rectangle, at the same time being sure that they retain the characteristic growth of the plant. Cut out the composition and mount it artistically.

Exercise V. Draw a horizontal oblong of pleasing proportions upon paper of

Fig. 16 Cumæan Sibyl, by Elihu Vedder
Copley Print

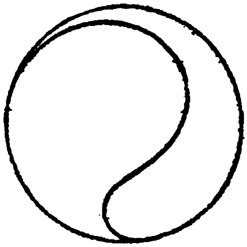


Fig. 17

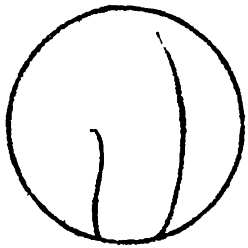


Fig. 18

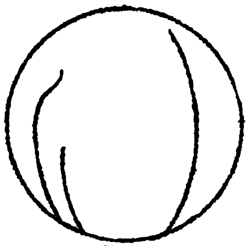


Fig. 19

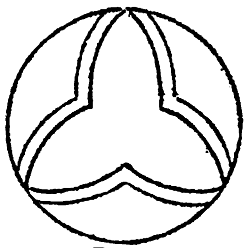


Fig. 20

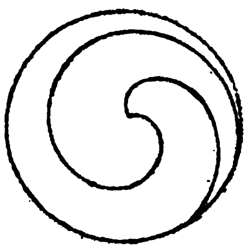


Fig. 21

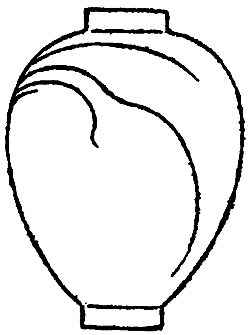


Fig. 22

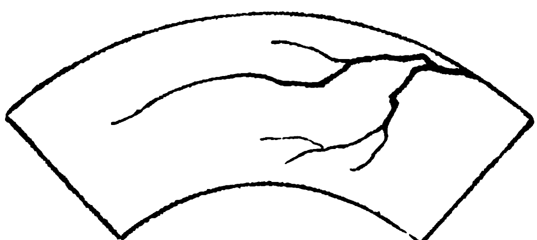


Fig. 23

grayed tone. Make a rhythmic division of the space, similar to the suggestion in Fig. 14. Lay in the masses with charcoal, and add to the sky a touch of chalk or colored crayon, to give a sunset or cloud effect. Cut out the composition and mount it artistically.

Structural Rhythm. We have spoken of the boundary lines in Figs. 13, 14, 15 and 16 as *structural* lines because these lines determine the shape and proportions, or structure of the area enclosed. We have seen that rhythm is produced when the main lines of a composition are consistent in direction with the structural lines. We may obtain rhythm by a similar process when the structural lines are not straight, and when the area enclosed is not rectangular. Fig. 17 shows a circle, divided by a line that is rhythmic with the boundary, and which might form the basis of a decorative motive. Figs. 18 and 19 show lines of a different character, still rhythmic with the circular outline. Flower or leaf motives might be applied on such a foundation with satisfactory results. Fig. 20 shows a leaf motive that, while retaining its characteristic shape, is still adapted to the structural lines in such a way as to produce rhythm. Fig. 21 is the basis of many arabesques, or abstract arrangements of lines or masses. In decorating the Japanese lantern (Fig. 22) the first thought was to secure a system of lines that would be rhythmic with the structural lines and with each other before applying definite shapes. Fig. 23 shows a similar plan for the decoration of a fan; the decoration selected may be a branch of plum blossoms, a spray of wisteria or any other motive desired; but whatever it is, the principle of rhythm should be apparent in adapting the decoration to the structural lines.

Exercise VI. In a circle whose diameter is about 4 inches, draw two or three rhythmic lines, similar to those in Figs. 18 and 19. Arrange on these lines a flower motive. Compose the design on practice paper, then transfer it to tinted paper, finishing with thin washes of the natural colors of the plant.

Exercise VII Make an abstract design in a circle, similar to Fig. 21. Transfer to tinted paper and finish in masses of black, or dark gray, allowing the tint of the paper to form a part of the design.

Exercise VIII. Using a 10-inch radius for the outer curve and a 5½-inch radius for the inner curve, plan a design for a fan,

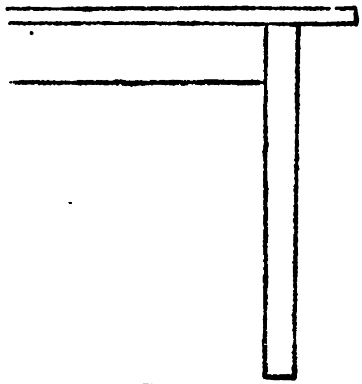


FIG. 24

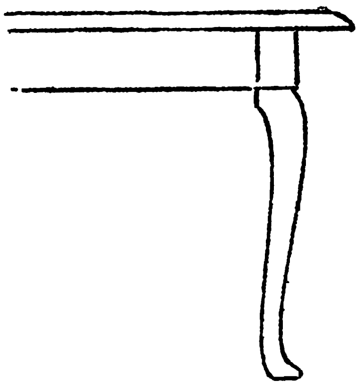


FIG. 25

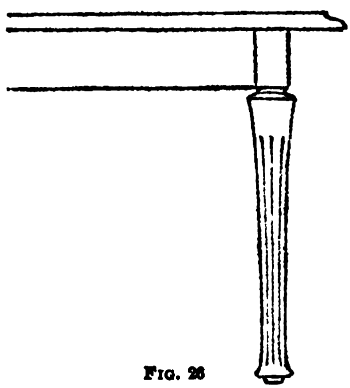


FIG. 26

FIG. 27

FIG. 28

similar to Fig. 23. Place a rhythmic system of lines in the space and adapt a plant motive to these lines. Transfer to Japanese paper and finish in light tints of naturalistic colors.

Rhythm in Constructive Design. Rhythm is a principle that must be observed in constructive, as well as in decorative and pictorial design. Fig. 24 shows the essential elements of a table, the horizontal top, the box or frame, and the vertical leg. Upon these constructive elements no decoration should be placed that would lead the eye away from the general direction of these elements. For this reason vioient curves in table legs and realistic carving are out of place. Figs. 25 and 26 show two legitimate modifications that add grace and refinement to the design, and at the same time do not depart very far from the essential structural lines shown in Fig. 24.

In contrast with the realistic decoration often placed upon vases, bowls and other forms of pottery is the simple ornament of the vases shown in Figs. 27 and 28. In each, the leaf motive is so well adapted to the surface that it seems a part of the form itself, and the eye is not distracted by any disturbance of the sense of rhythm that the beautiful curves of the vase forms suggest, as would be the case were realistic roses, birds or landscape effects employed as decorations. Compare the two pieces of classical furniture in Figs. 29 and 30. The bride-chest (Fig. 29) shows carving that is planned with direct reference to the surface and space to be decorated. It

Fig. 29. French Bride-chest — Bavarian National Museum

is in low relief, and the general directions of its lines are rhythmic with the structural lines of the chest. Variety is obtained by the division of the front space into four areas, making the end arrangements differ from the central spaces. Within each of these spaces a design of rhythmic quality has been placed and a fine relation is established between these panels and the surrounding simple areas. The effect of the whole is unified, dignified and beautiful.

In the Venetian table (Fig. 30) almost every constructive element is lost in the elaborate ornament. Leaves, flowers, garlands, the human face are all carved in wood, and used with every effort to disguise the structural lines and to obtain a showy and ornate effect. While there is exaggerated rhythm in the ornament, there is no recognition of the structural elements of the table. Furniture, of all things, should be fitted for its uses, simple in line, good in proportion, and its ornament or finish should not hide nor obscure its structural lines. A table like this is retained in museums as an example of the expression of a period when art was at a low ebb (the XVII century). It serves now as an example of what should be avoided in furniture construction.

Exercise IX. Draw on tinted paper the outline of a vase form, planned to hold long-stemmed flowers. Place within this outline some leaf or flower motive, whose growth permits adaptation to the form. Finish with water-colors of a darker tint.

Note: Vase forms may be designed by folding a sheet of paper on a vertical diameter and cutting, freehand, the contour or profile of the vase. Unfold the paper and a symmetrical design will result.

FIG. 30. VENETIAN TABLE—CORSICAN GALLERY, FLORENCE

Exercise X. In a similar way, design a low bowl for short-stemmed flowers. Use rhythmically an abstract line motive for the decoration, and finish as directed in Exercise IX.

Rhythm of Values. It has been demonstrated that related movement is established by placing lines or shapes in an orderly arrangement, such as in the making of borders and surface patterns, and also by observing in any composition a relationship between the structural lines and the lines appearing as a part of the composition. It is apparent that related movement can be produced by tones of color or of light and dark values. The Prang Color Charts are examples of color rhythm, because we find in them gradations of color passing from one hue to another. If we begin at yellow, for instance, we may pass through orange, which is closely related to yellow, to red, which is closely related to orange, and so through violet and blue to green and around to yellow again, the colors being arranged in this orderly progression. In Fig. 31 we see a graded wash of tones between the extremes

FIG. 81

VALUE SCALE

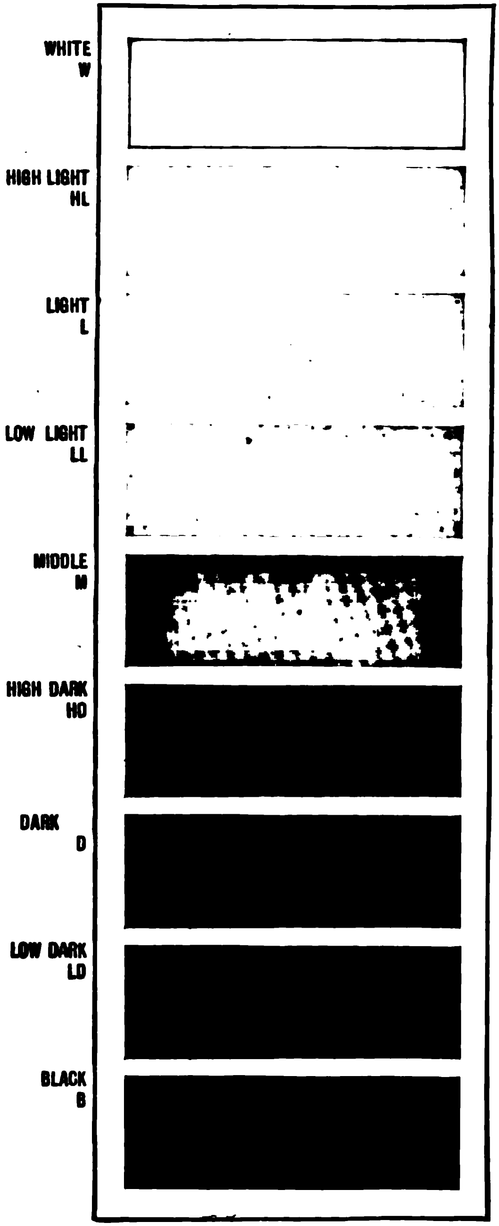


FIG. 82

FIG. 33. WAVE, BY HOKUSAI

of black and white. This forms a rhythm of gray tones, and from this gradation have been selected the nine separate steps that form the value scale. Of course there are many more degrees between white and black than the seven represented by the scale, but the tones of the scale have been accepted and named as standards, just as in music a scale whose parts can be definitely located is essential to musical composition and interpretation.

In any arrangement of values, whether in a scale, in a photograph or other reproduction, the eye will travel toward the point of greatest contrast. In Fig. 33, the Japanese artist, Hokusai, has skilfully arranged rhythmic lines and values so that the eye is carried by their movement along the undulating lines of the wave to its beautiful crest, where it breaks into foam. This forms the climax of the picture.

Exercise XI. Upon a sheet of white paper draw five circles, each an inch or more in diameter, placing them in a vertical row. Leave the upper circle white and paint the lower circle black, using charcoal-gray water-color. Make the middle circle a tone half way between white and black. This will be middle gray, and should match the tone marked Middle (M) in the scale, Fig. 32. Fill the circle between middle and white with a tone half way between these two values. This should match the tone marked Light (L) in the scale. Fill the circle between middle and black with a tone that matches Dark (D) in the scale. You will then have a value scale of five tones, including white, black and three tones or values of gray. Mark the circles to correspond with the tones they match in the printed scale.

Exercise XII. In a circle of about 3 inches diameter draw the leaf design in Fig. 20. Make three tracings of this. Finish each tracing in a rhythm of three steps, taken from your own value scale. Note the difference in effect that different arrangements of values will produce in the same design.

The Principle of Balance. By balance is meant the result of an arrangement of parts in a design that permits each part to keep its proper place without undue emphasis. Balance means the

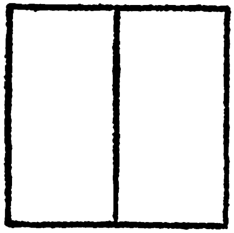


FIG. 34

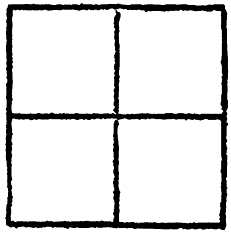


FIG. 35

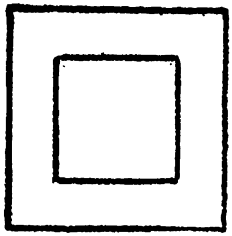


FIG. 36

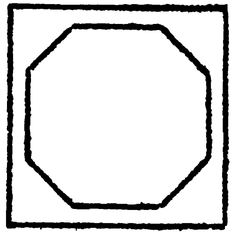


FIG. 37

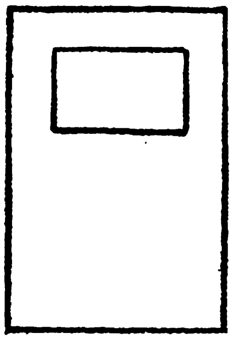


FIG. 38

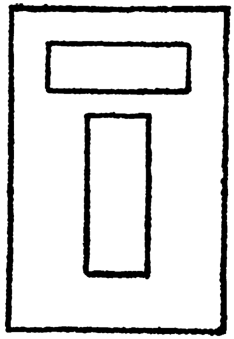


FIG. 39

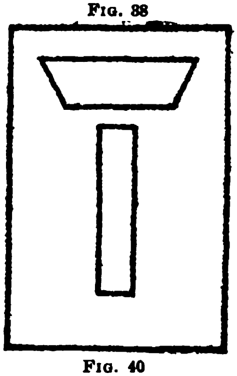


FIG. 40

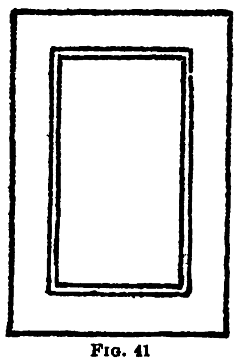


FIG. 41

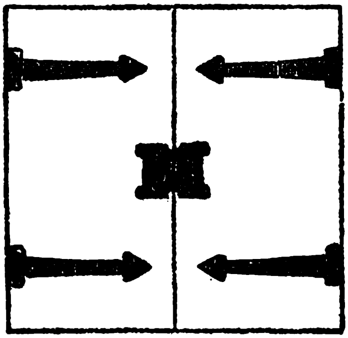


Fig. 42

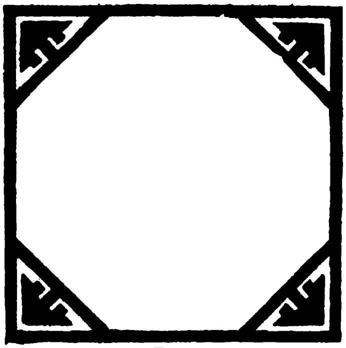


Fig. 43

Fig. 44

equalization of forces. Every work of art is made up of certain elements, or parts, and each element exercises upon the eye and the attention a certain attractive force. These attractions may be of many kinds; we may find in a work of art attractions of shape, attractions of value, attractions of color, attractions of line, attractions of technique, movement, interest, etc. If any one of these attractions is emphasized too much, the equalization or balance of the whole is destroyed.

Balance of Abstract Areas. An elementary form of balance is seen in Fig. 34. Here a line divides a certain space into two areas exactly alike in size, shape and tone. The attractive forces of these two areas are therefore equal, and perfect balance results. In Fig. 35 the two diameters of the square divide the space into four areas that are balanced against one another. In Fig. 36 the inner square balances the area around it. In Fig. 37 the corners and the connecting spaces on the sides balance the area within. A prototype of a bookcover is shown in Fig. 38, and here balance is assisted by the position of the smaller rectangle. In Figs. 39 and 40 balance is attained by the sizes of the two rectangles and by their relation to each other and to the background. The two rectangles appear as a T shaped group, and the eye takes them in as a unit. Fig. 41 shows a balanced arrangement that is the basis of many rug designs, bookcovers, door-panels, etc. Here we have a border within a rectangle, and balance results from an equalization of the forces exerted by the border, the inner field and the outer margin.

Applied Balance. Fig. 42 shows a design for the doors of a wall cabinet. The decorative hinges and lock are balanced against the quiet spaces of the wood. If the hinges and lock were larger they would appear too prominent; if they were smaller, the doors would lack interest, unless this element were supplied by some other means, such as the finish of the wood, the color or ornament of the hinges, etc. In the desk-pad (Fig. 43) the decorated corners are balanced against the quiet area of the blotter. We see that a comparatively large area of quiet space is needed to balance a comparatively small area of ornament. This is manifested, also, in Fig. 44, where the light and dark shades of the inner rectangle form a balanced group that is in its turn balanced against a large space of gray background. This is why the mounting of a study adds so much to its effectiveness.

Figs. 45 and 46 show balanced arrangements of a motive chosen from the buckeye, or horse-chestnut. In Fig. 45 straight lines only were employed in making a symmetrical unit. (When a motive is arranged in a right and left balance upon a vertical axis, symmetry is produced.) In Fig. 46 curved lines were used, and the result is somewhat less

Fig. 45

Fig. 46

Fig. 47

FIG. 48. FROM THE SQUARE BOOK OF ANIMALS, BY WILLIAM NICHOLSON

FIG. 49. FROM THE JAPANESE

conventional. While not symmetrical it is balanced; the dark shapes of the unit are in equilibrium with the light spaces of the background. We see, therefore, that balance is not a question of the symmetrical arrangement of shapes about a center or upon an axis. Fig. 47 shows a decorative treatment of a drawing from a moth; this is both balanced and symmetrical. It was planned for printing with a wood-block, while the two arrangements from the horse-chestnut were designed for stencils. Fig. 48 is from one of William Nicholson's drawings of animals, and shows a fine balance of irregular shapes. Observe how skilfully the artist has treated the large mass of light in making it express the drawing of the swan and the motion of the water. In this balanced arrangement, rhythm is also an important factor, as evinced in the related movement of the lines of the water and of the swan. Fig. 49 is from the Japanese. Here we find, first of all, a daring exposition of the characteristic qualities of the turnip. The large light mass formed by the vegetable and its leaves is finely balanced by the large dark mass of the background. The beauty of the composition is further enhanced by the vigorous rhythm of the growth.

Exercise XIII. From a motive taken from the poppy leaf, flower, bud or seedpod, make a balanced arrangement on a vertical axis of five inches. Transfer this drawing to tinted paper and finish with a dark wash of india-ink or charcoal-gray.

Exercise XIV. Using another tracing of the same design, paint the shapes with one color on tinted paper, as dark green on gray-green paper, blue-green on gray-orange paper, etc.

Exercise XV. Finish another tracing of the same design in one color and gray, on bogus paper.

Exercise XVI. Draw the same motive on squared paper, reducing all curves to straight lines, after the manner of Fig. 45. Transfer several tracings to tinted paper and finish in the different color schemes indicated in the preceding problems.

Exercise XVII. From some familiar animal, such as the duck, the raven, the rabbit, etc., make a line drawing on squared paper and reduce it to a straight line motive. Balance this on a vertical axis, for a tail-piece. Finish with a dark wash of charcoal-gray.

Exercise XVIII. Develop several corner motives on squared paper, similar to Fig. 43. Transfer these to tinted paper, and finish one with gray wash; another with gray wash and one color; another in a color scheme of two colors.

FIG. 50

FIG. 51

Further Applications of Balance. Interesting problems in balance may be worked out by means of still-life objects arranged against a suitable background. In Fig. 50, the teapot was first sketched in outline and a

FIG. 52. LANDSCAPE BY GEORGE INNESS. FROM A COPLEY PRINT PUBLISHED BY CURTIS & CAMERON

balance of areas obtained. This was done by means of a finder placed over the drawing and adjusted until the best effect was decided upon. (In a composition of this kind the rectangle is often drawn first, and the objects or shapes are then adjusted to suit the space. This is a more difficult process than obtaining a balanced arrangement with a finder, although it is the method generally followed by artists, in planning compositions.) A balance of values was then considered and the dark drip decoration was laid on with charcoal, the value of the paper being assumed as the general tone of the teapot. The light handle, the lid and the high-light were then put in with white chalk, and the attractive forces of gray, black and white seemed to balance one another in the finished sketch.

In Fig. 51 we see an effect often observed when looking from a boat at a city sky-line. The details of the tall buildings, their values and colors are all simplified into one dark mass that rises against the sky and is reflected in the water beneath. This mass of dark with its irregular outline forms an interesting pathway through the middle of the rectangular space, and balances the light pathways made by the water and the sky. Such an arrangement of masses is in itself interesting to the painter whose knowledge of color harmonies, together with a mastery of technique, may combine to make such a composition a creation of great beauty.

In Inness's "Georgia Pines" we have a masterly example of the balancing of large, simple masses against one another. The group of pine trees appears as one mass in which the main interest centers. Starting with this group, the eye is led by various incidents in the foreground to the little house half hidden by bushes at the left, then across the stretch of misty distance to the group of trees again, completing a rhythmic journey through the various details of the picture. If any change were made in the disposition of these masses, such as moving the group of trees further to the right, the center of interest would be disturbed. As the picture is now, there is a very evident balance of interests, and this is no small factor in the feeling of unity and completeness that we receive from the composition. In it we find an example of various balances: there is balance of areas, balance of values, balance of interests and balance of colors, although this last we cannot see in a reproduction that shows us only the light and dark values of the colors, without their rich hues.

Exercise XIX. On tinted paper make an outline drawing in life-size, of a two-toned ginger-jar, pitcher or bowl. By the use of the finder adjust the drawing to its background, obtaining balance. Let the tone of the paper represent the lighter tone of the object, and lay in the dark masses with charcoal, adding the high-lights with white chalk. Line in the rectangle and mount the composition in the style suggested by the color plates in this book.

Exercise XX. Repeat the preceding exercise, using a group of two suitable objects, and adding a touch of color, if either of the objects suggests an opportunity for using it.

Exercise XXI. Draw on water-color paper a rectangle. Sketch in an arrangement of roofs, with their chimneys, dormer windows, steeples, etc., to form an interesting sky-line. Lay in the sky in sunset effects. Paint the roof masses in gray-violet tones, showing little or no detail, and obtaining a balance of masses. Cut out the finished composition and mount it.

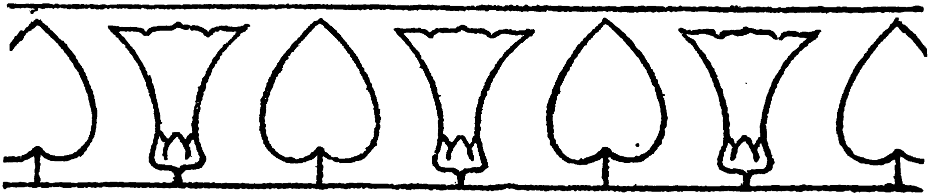


FIG. 53

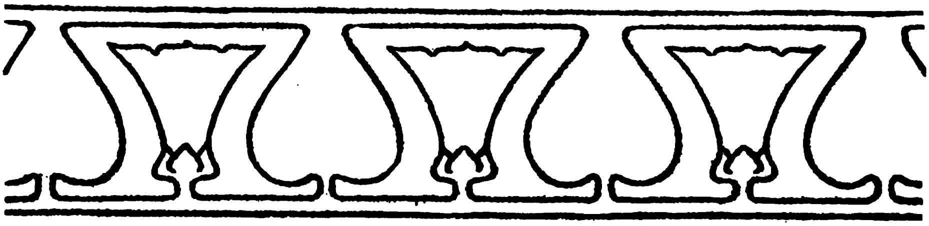


FIG. 54

Exercise XXII. Select from a photograph of the landscape, or from the landscape itself, an arrangement showing sky, a pool of water in the foreground, distance, and trees rising against the sky. Balance these elements in a composition on tinted paper, using charcoal, white chalk and a touch of color, to suggest sunset clouds.

Exercise XXIII. Sketch from the pose the figure of a child with a toy of some kind. The costume of the child, and possibly the toy should suggest a note of color. Arrange these shapes in a balanced composition, and finish in pencil and water-color wash. If you do not have water colors you may get attractive results from the use of colored crayons.

The Principle of Harmony. By harmony is meant fitness to purpose; consistency in character; having something in common; the unity of all parts. Harmony may be expressed in shapes and areas; by relating the mode of treatment to the thought to be expressed; in related objects; in values and in colors.

Harmony in Shapes and Areas. In Fig. 53 the morning-glory and its leaf have been used as alternating units in a border. The units have been well spaced, and the line movement is unmistakably rhythmic; yet in looking at the border as a whole, it is evident that the leaf and flower shapes

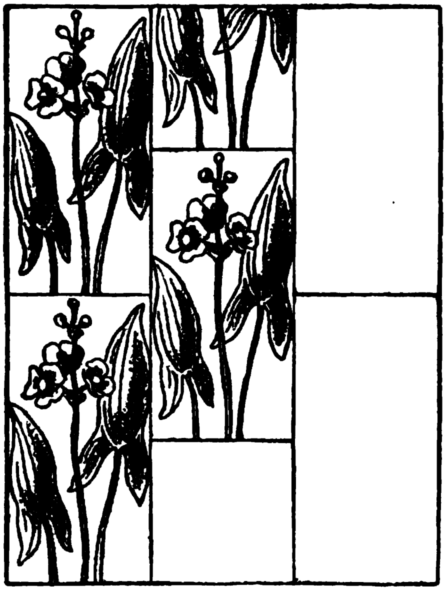


Fig. 55

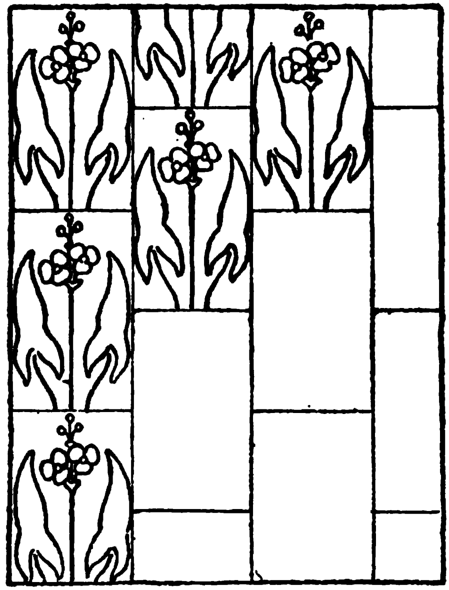


Fig. 56

have been considered important, and that the background shapes have been left to take care of themselves. The units have evidently been laid against a background with no attempt of uniting their shapes with those of the background. In a border of this kind where realistic quality is not desirable, background shapes are as important as the units themselves, and should be treated as elements in the arrangement. Compare Fig. 53 with Fig. 54. In the latter the units were modified both in shape and in position, so as to bring them into harmony with the background shapes.

In Figs. 55, 56 and 57 are shown three different modes of treating a motive from the sagittaria, or arrow-leaf. In Fig. 55 the naturalistic growth and appearance of the plant have been retained, even to the extent of showing modelling, or the effects of light and shade. While this arrangement is rhythmic and balanced, the design is out of harmony for two reasons: first, because a naturalistic treatment is inconsistent with the purposes of decoration, and second, because relationships between the shapes of the unit and the shapes of the background have not been considered. In Fig. 56 a

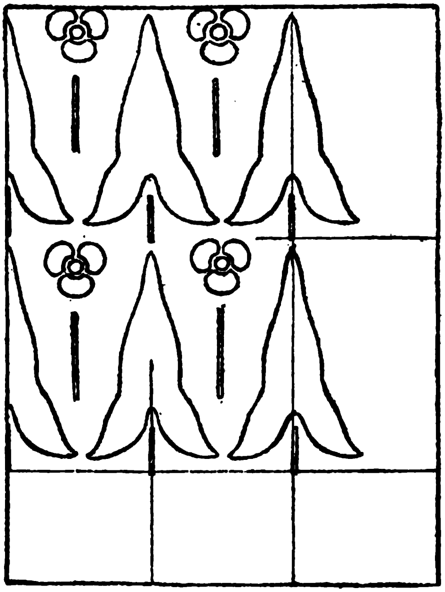


FIG. 57

FIG. 58

certain conventional treatment has been followed, and the unit has become symmetrical. Light and shade effects are omitted, the design is rhythmic and balanced, but we feel that in this arrangement also it is the unit only which has been considered; the background is still unrelated. In Fig. 57 we see a decided improvement. Both elements, the unit and the background, have been brought into harmonious relationship, and there is a simplicity and unity in the result that is lacking in the two previous examples. A finer rhythm and a better balance are also apparent, and this, in addition to the closer agreement and interrelation between all parts of the design, makes it the most harmonious and satisfying of the treatments.

Mode of Treatment. We know that drawings from nature, from objects, from animals or from the pose may be treated in two different ways: they may be pictorial in their quality, representing fact, appearances, effects of light and shade, etc., or they may be decorative. By decorative treatment is meant a general simplification of shapes, values, colors and other details. Natural irregularities in outlines are omitted, the simplified outlines are emphasized, and values and colors are rendered flat. It is a law of design that pictorial effects shall not be used in the decoration of objects. If we desire a picture, there are certain principles of pictorial composition which we must observe, as has already been explained. If we desire a decoration, the mode of treatment of that decoration must not be pictorial. In Fig. 58 we see an example of realistic treatment imposed upon a piece of pottery. The grapes are modelled in high relief, the stems are twisted into handles, and the leaf imitates the undulating surface of the natural growth. The vase stands as an example of the violation of the law of harmony, in contrast to the beautiful examples shown on page 16.

Fig. 59 shows a style of decoration that is often seen upon china and porcelain. In this example the form and proportion of the cup are excellent, the handle is well constructed, the clover blossoms and the bee are well painted; yet the cup as it stands is not artistic because the mode of treatment of the decoration violates harmony. We should not seek to represent on a tea-cup a picture of a flower or insect. We may

Fig. 59

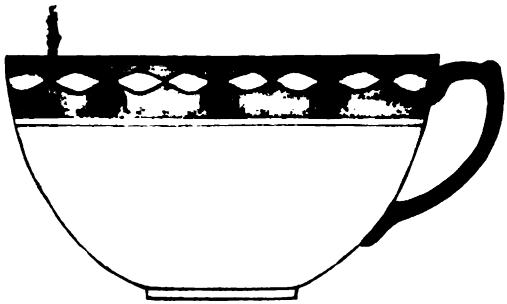


Fig. 60

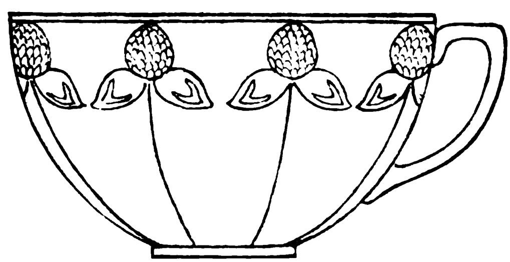


Fig. 61

FIG. 62. SIXTEENTH CENTURY CHEST

take the shapes suggested by these natural growths and adapt them to legitimate decorative use, as shown in Figs. 60 and 61. In Fig. 60 the width of the border, its relation to the spaces of the cup, the placing of the units and the flat treatment of values were all carefully planned by the designer. In Fig. 61 the flower, leaf and stem shapes were related to one another and to the background shapes. Both of these examples show harmony because there is unity between the decoration and the object upon which the decoration is placed.

In the carved chest shown in Fig. 62 we see an example of harmony between all parts of the constructed object. The chest has an atmosphere of simple, unpretentious dignity, chiefly because of its fine proportions and of the treatment of its structural lines. Balance is apparent between the three locks of ornamented metal and the quiet spaces of wood surrounding them, and these elements are in their turn balanced by a base of appropriate weight and solidity. In the base, the ornament is carved in low relief, and its motive follows the structural lines in a well thought out and rhythmic arrangement. Observe that the ornament is kept subordinate to the main idea — the idea of the chest — and does not obtrude itself upon the attention, as does the realistic ornament of the vase (Fig. 58). This chest dates from the sixteenth century and is to-day considered a fine type of good construction, appropriately ornamented.

Harmony in Related Objects. Any study of art principles that does not help us to solve the every day problems of house furnishing and dress, and that does not develop discriminating judgment in all matters connected with arrangements of objects, values or colors, fails to attain its most important end. In rare instances "good taste" is instinctive or inherited, but it is seldom that a person so endowed can give reasons for his choice of certain combinations of objects or colors. The statement that a particular arrangement looks well, and for that reason is chosen, is an unsatisfactory answer. We should know *why* certain combinations are more harmonious than others. By the study of art principles we learn to appreciate the beauty of fine proportions, the power of line, the value of masses, the importance of color adjustments. We learn that these qualities are not restricted to paintings and the fine arts generally, but may be applied as tests in many practical problems. The arrangement of a room is one of these, and the principles explained in this chapter may be used as standards to measure the artistic merit of such a design. Figs. 63 and 64 show the same room under two different treatments. In Fig. 63 the ceiling, the walls and the carpet show trailing sprays of flowers and leaves in naturalistic treatment. If we furnish our room in obedience to the principle of harmony we shall look to ceiling, walls and floor for our large, quiet spaces, against which the furniture, pictures and objects of ornament are balanced. It is of first importance, then, that in a problem of room furnishing, the walls, ceiling and floor spaces are brought into harmonious relationship. A wall should be flat and quiet in effect; flat because of the nature of its construction, and quiet because it must serve as a background for the furnishings of a room. A carpet in its design should suggest nothing that detracts from the idea of service. It is to be walked on, and a realistic treatment of flowers, animals or landscapes is manifestly out of place here. In Fig. 63, the tables, the

Fig. 63. A Violation of Harmony

sofa and the chair are elaborately carved with figures that seek to disguise the structural elements. The frame of the mirror, the clock and the ornaments upon the mantel-shelf are characterized by meaningless lines and showy decorations. There is nothing in this room that creates an atmosphere of quietness and repose. We feel, it is true, that there has been a desire to make things beautiful, but when we contrast this interior with the simple quiet comfort of the room shown in Fig. 64 — the same room under different treatment — we see the value of trained judgment, and we recognize the power of right selection.

In matters of dress or personal attire we are controlled very largely by custom or fashion; yet a knowledge of these principles of rhythm, balance and harmony may be used as a guide in our choice of attire that is suitable, becoming and artistic. We know that fitness to purpose must be considered when choosing a costume for business. There are certain styles of garments that would be appropriate in one case, but utterly out of place in another.

FIG. 64. THE SAME ROOM, IN HARMONY

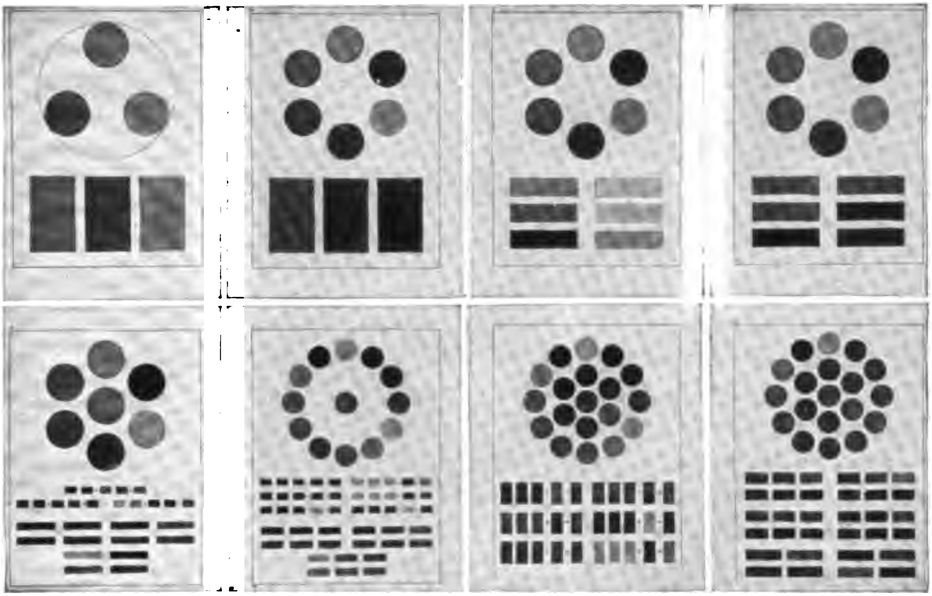
But beside this question of fitness or consistency are the questions of line, value and color,—questions that should be considered in the choosing of a costume as well as in the painting of a picture. In some famous portraits, such as that by John S. Sargent, in Fig. 65, the artist has arranged the sitter in such a way as to emphasize a rhythmic quality in the composition. The attitude of the pose, the placing of the hand, the adjustment of the drapery, the selection of the hat, all combine to make a system of rhythmic lines, a balancing of masses, and a harmony of color. Although a hat of the pattern shown in the picture may not follow the fashion of the day, its artistic merit cannot be questioned. It is true that we will not find it wise to depart too far from the prevailing custom, yet we should insist on some consideration of artistic qualities in the designing of articles of dress.

Harmony in Values and Colors. Harmony is manifested in color combinations more directly than in any other way. Everything in the world about us has color of some kind. It is by means of color that we

FIG. 65. PORTRAIT BY JOHN S. SARGENT

distinguish one object from another. We may study color theoretically by experiment with light, and we may study it practically by means of paint or pigment. If we place a glass prism in the sun so that a ray of light passing through the prism is thrown on a white or black surface, we shall see upon that surface the rainbow series of colors. These colors, red, orange, yellow, green, blue and violet, appear in the order named and are called the spectrum colors. Each color at its greatest strength or intensity is called the standard, and these standards together with the intermediate colors seen between them are shown in the Prang Color Chart No. 6. We find that three of the six standard colors are the basis for all other colors. These three, red, yellow and blue, we call primary colors, because they cannot be produced by mixture. Whatever primary color is selected, the remaining two primaries mixed together form its complement. For example, if we select the primary red, we find that a combination of the remaining two primaries forms the complement of red, which is green; if the primary blue is selected, its complement is orange; if yellow, its complement is violet.

Color may be either warm or cold in quality. The coldest color is blue, and its complement, orange, is the warmest color. Every color adjusts itself in this way to its complement; if a primary is cold, its complement is warm; if a primary is warm, its complement is cold.



Prang Hand-Colored Charts

Owing to the impossibility of reproducing color charts accurately by any known mechanical process, all references in the text are to the series of eight *hand-colored* charts, published by The Prang Company. For convenience of reference, miniatures of the eight color charts are shown above in black and white. Students desiring a fuller discussion of Color are referred to "The Theory and Practice of Color" by Snow and Froehlich, published by The Prang Company. This book includes a set of the eight hand-colored charts with a hand-colored value scale. The titles of the charts are as follows:

Chart I—Primary Colors.

Chart II—Binary Colors.

Chart III—Normal Colors and Tints.

Chart IV—Normal Colors, Tints and Shades.

Chart V—Complementary Colors and Neutral Gray.

Chart VI—Primary Colors, Binary Colors and Hues—Analogous Color Schemes.

Chart VII—Colors in Full Intensity and Grayer Colors.

Chart VIII—Colors in One-half and One-fourth Intensities—Monochromatic Color Schemes—Complementary Color Schemes.

The size of each chart is 7x10 inches.

Color Properties. The three properties of color are hue, value and intensity or chroma.

Hue is that property which distinguishes one color from another, and gives it individuality and identity. For example: If, when yellow and red water-color are combined, the mixture inclines more to the red than it does to the yellow, a hue of red is formed; if it inclines more to the yellow, a hue of yellow is formed, etc.

Value has already been defined as the degree of light or dark expressed by a color. Although the Value Scale is made in neutral grays, it must not be assumed that value can be expressed only in gray tones. Every color has value and could be related to a value scale that showed a sufficient number of degrees of light and dark. For example, the primary colors of Prang Color Chart No. 6 are arranged so as to show this relation. Yellow appears as High Light, yellow-orange and yellow-green appear as Light, orange and green as Low Light, red-orange and blue-green as Middle, etc. We can thus name the color values.

Any value of a standard color that is lighter than the standard is a tint of that color; any value that is darker than the standard is a shade. Chart No. 4 shows the standards of yellow, red, green and blue, with tints and shades of red, green and blue, and shades of yellow, all related to the Value Scale. The tints of yellow cannot be related to the value scale, because the standard yellow appears at High Light, and the tints of yellow would lie between High Light and White. These degrees are not shown in the scale commonly used.

Exercise XXIV. With water-color paint, arrange a scale from light to dark of standard red, or any other spectrum color. Plan to show five values, arranging five rectangles in a vertical row. In the middle rectangle, place a wash of the full strength or standard of the color. Add a little water to this for the wash to be placed in the rectangle directly above, and still more water for the first rectangle. Add black or charcoal-gray paint to the standard color for the shades.

Color Intensity or Chroma. By the intensity or chroma of a color we mean the degree of its removal from absolute neutrality or grayness.

Note. For a fuller presentation of the whole subject of "Color Intensity" see "The Theory and Practice of Color" by Bonnie E. Snow and Hugo B. Froehlich, published by The Prang Company, Price $4.00.

The colors of the spectrum represented in the outer circle in Chart No. 7 are in full intensity. In the outer circle of Chart No. 8 the colors of the spectrum are shown in one-half their full intensity. In the inner circle the six Binary Colors are shown reduced to one-quarter intensity. Scales of color in eighth intensity or in three-quarter intensity could be produced by varying the quantity of gray added to colors in full intensity.*

The addition of a complement to its color will gray it, producing a less intensity of that color, according to the quantity of the complement used. This can be demonstrated in the following exercises: —

Exercise XXV. Make a horizontal row of five two-inch squares, arranging them at equal distances. In the square at the left place a wash of a primary color in full intensity, as red. In the square at the right place a wash of its complement in full intensity, as green. Mix equal quantities of the primary and its complement, producing Middle Gray. Place a wash of this in the middle square. Mix Middle Gray and the primary color. It will make a tone of the primary in half intensity. Place a wash of this in the square between Middle Gray and the primary. Mix the complement and the Middle Gray, making a tone of the complement in half intensity. Place this in the remaining square. You now have a scale or gradation of color from a primary through neutral gray to the complement of the primary.

We see that color may be estimated as to its hue, as to its value, and as to its intensity. In naming or locating a color, therefore, it is necessary to indicate these three qualities in order to establish a definite idea of what is meant. By the use of symbols we can write color in much the same way that we write music. If, in Fig. 66, for example, we were told to fill the rectangle simply with a wash of red, we would not know what value nor what intensity of red was meant, for red has many degrees of light and dark and many degrees of brightness. It is, therefore, necessary that after stating the required color or hue in a formula, we state also its value and its intensity. For the sake of acquaintance with color terms, the formulas in Figs. 66, 67 and 68 are written out in full. After some experience abbreviations may be used. When no value of a color is named, the standard or spectrum value is understood.

Exercise XXVI. Draw a series of three horizontal oblongs, a

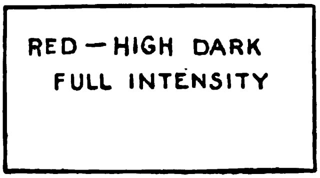


Fig. 66

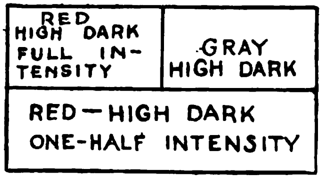


Fig. 67

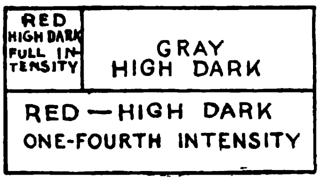


Fig. 68

quarter-inch apart, each oblong measuring 2½ by 1½ inches. Divide the second and third oblongs as indicated in Figs. 67 and 68. (In Fig. 68, the space marked "red" is one fourth the width.) Fill the first oblong with a wash of red, High Dark, full intensity. (See Prang Color Chart No. 1.) In the second oblong, place the same wash in the space corresponding to the space marked red in Fig. 67. Fill the space corresponding to that marked gray, High Dark, with a wash of charcoal-gray in High Dark value, the value of red at full intensity. (See Value Scale, page 233.) Mix equal quantities of these two washes, obtaining a wash of gray-red, or red, High Dark, one-half intensity. Place this in the space corresponding to the lower half of Fig. 67. In the third oblong carry out the formula as indicated. You will have made three intensities of red, in High Dark value. Observe that the grayest color has the smallest fraction of intensity. Write under each intensity its name, or degree.

Color Schemes. The color chart as it stands is useful as an aid to a scientific knowledge of color and to the understanding of theories about color. In a scientific sense it is a complete color harmony, for in it we find the elements of all color. In an artistic sense, it may more properly be called a color rhythm, for here, starting with any color, we may pass by related steps around the circle to the starting point again. Although the development of the color sense and of taste in the use of color, results from experience and from trained judgment, there are certain color schemes developed by a study of the color chart that may be relied upon as resulting in harmonious effects. The simplest of these schemes are those known as monochromatic, complementary and analogous, and the scheme of dominant harmony.

Monochromatic Color Schemes. A monochromatic color scheme is a group of different tones of one color. It may be different values of a color or different intensities of a color.

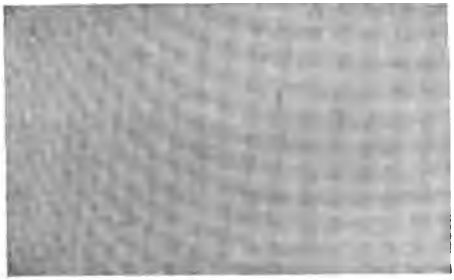


FIG. 69

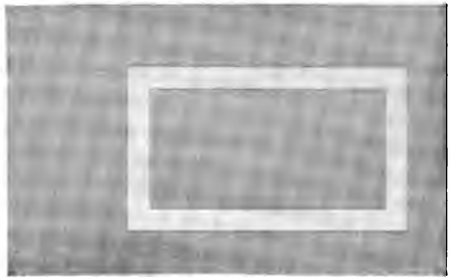


FIG. 70

Exercise XXVII. Make a monochromatic color scheme consisting of five values of green, starting at Light. (See Prang Color Chart, No. 8.) Arrange the scheme in oblongs, placed in a vertical row. (See Figs. 71 to 75.)

Note. In preparing washes of color for scaling, it is best to wash the desired tone over a piece of paper larger than the shape desired for that part of the scale (Fig. 69). Then place over this wash a finder of the required size and shape, moving it about until an even tone is found (Fig. 70). Mark this shape and cut it out. Prepare the other tones of the scale in the same way, and mount the scheme on light gray paper.

Exercise XXVIII. Draw on white paper an enlarged copy of the surface pattern shown in Fig. 57. Fill in these shapes with three steps taken from the monochromatic color scheme made in the preceding exercise.

Complementary Color Schemes. Complementary colors show strong contrast and possess the quality of enriching or emphasizing each other. The Prang Color Chart, No. 8, is arranged to show, at opposite ends of the six diameters, the colors that are complementary to each other; violet appears opposite yellow, blue-violet opposite yellow-orange, blue opposite orange, blue-green opposite red-orange, green opposite red, and yellow-green opposite red-violet. Two complementary colors at full intensity balance each other, but they do not form a harmony, and

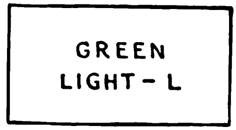


FIG. 71

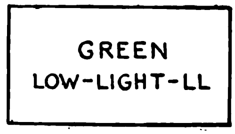


FIG. 72

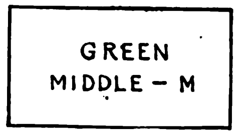


FIG. 73

FIG. 74

FIG. 75

they are seldom employed as color schemes. There must enter into each member of a complementary pair some unifying element. To form a harmony, they must possess something in common. This unifying or harmonizing element can be supplied by mixing gray with both colors, or by mixing a little of one with the other. For example, a little red added to green and a little green added to red will soften the extreme contrast of red and green as they are seen in the Color Chart, and the grayed red and green that result will form a harmony. Some interesting color schemes may be worked out on this basis, as indicated in the following exercises: —

Exercise XXIX. Draw a rectangle about 2½ inches wide and 1½ inches high, and divide it as indicated in Fig. 76. Fill the space corresponding to the space marked "red" with a wash of red in full strength, and the space corresponding to that marked "green" with a wash of green in full strength. Mix equal quantities of these washes, producing neutral gray. Place this wash in the lower half of the rectangle.

Exercise XXX. Draw a rectangle and divide it as indicated in Fig. 77. Notice that the space for red is smaller than in Fig. 76, and the space for green is larger. Spread the washes in full strength in the corresponding spaces of your diagram. Mix the two colors, not in equal quantities, but in the proportions indicated by the spaces just filled. This mixture will produce a gray-green, or green of about one-fourth intensity.

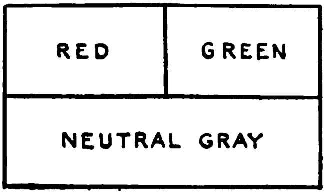


FIG. 76

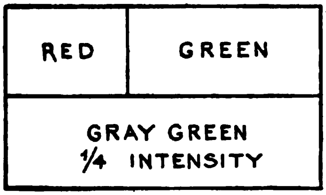


FIG. 77

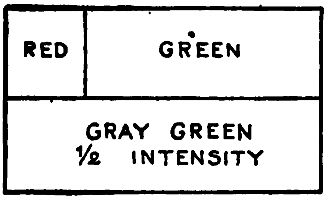


FIG. 78

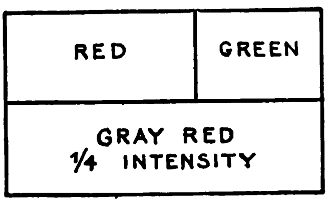


FIG. 79

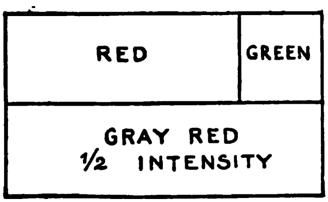


FIG. 80

Exercise XXXI. Draw a rectangle and divide it as in Fig. 78. Notice that the space for red is still smaller in this diagram, and the space for green larger. Fill the corresponding spaces as before. Mix the two washes in the proportions indicated. The result will be a greener gray than that produced in the last exercise, or green of about one-half intensity.

Exercise XXXII. Draw a rectangle and divide it as in Fig. 79. Here, the space for red is larger and the space for green smaller. Place the washes as before. Mix them in the proportions indicated. The result will be a gray that inclines toward red, or red of about one-fourth intensity.

Exercise XXXIII. Draw a rectangle and divide it as in Fig. 80. Paint in the red and green washes as indicated, and mix them in the given proportions. The result will be a redder gray than that produced by the proportions given in Fig. 79, or red of about one-half intensity.

Note. After working out the above problems it will be seen that when two complementaries are used in equal quantities of their full strength a neutral gray is produced. When the quantities are not equal, the resultant gray will assume the hue of the larger quantity.

Exercise XXXIV. Draw rectangles and divide them as indicated in Figs. 81, 82, 83, 84 and 85. Fill them with the complementaries yellow and violet, using the proportions indicated in the diagrams. The results will form a number of interesting and usable color schemes.

Note. The hues, values and intensities of these combinations will be influenced by the quality of the paint used.

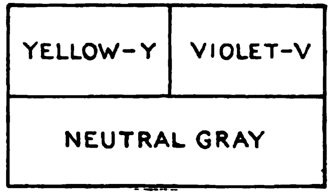


FIG. 81

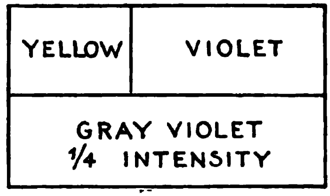


FIG. 82

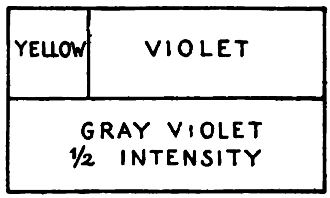


FIG. 83

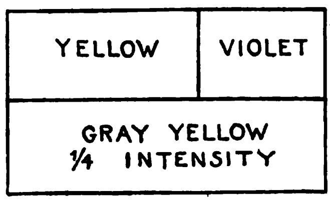


FIG. 84

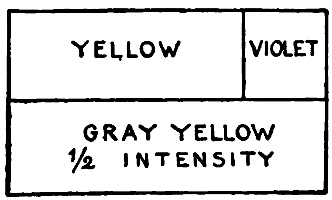


FIG. 85

Different makes of paints will produce different effects, so that uniform results cannot be attained. This is not necessary, however, nor does it in any way affect the truth of the theory.

Exercise XXXV. Make a tracing of the surface pattern shown on page 29. Transfer it carefully to tinted paper. Fill in the shapes with a color scheme chosen from the diagrams which you worked out in Exercise XXXIV.*

Exercise XXXVI. From a flower motive, such as the nasturtium or geranium, arrange a border similar in character to that shown in Fig. 54. Transfer it to tinted paper, and fill in the shapes with a complementary color scheme, made from combinations of blue and orange.

Analogous Color Schemes. Analogous colors are those which are adjacent or neighboring in the color circle. For example, red, red-violet and violet form one group of analogous colors, and yellow, yellow-green and green form another. Several such color schemes can be selected from the circle. (See Prang Color Chart, No. 6.) These analogous or related colors form a color rhythm, and are also harmonious, because they possess, in different quantities, a common element. For example, blue is the common element contained in the analogous colors blue-green, blue, blue-violet and violet, and, though these colors make a harmony, even in full intensity, they are seldom used without being further united by a second common factor of gray. Analogous color schemes of grayed intensities may be used without fear of violating any principles of color harmony.

Exercise XXXVII. Draw three rectangles and arrange them as indicated in Fig. 86. Place in the first rectangle a wash of yellow-green, Light Value, one-half intensity (YG, L, ½); in the second, place a wash of green, Low Light, one-half intensity (G, LL, ½); in the third, place a wash of blue-green, Middle, one-half intensity (BG, M, ½). (These colors can be found in Prang Color Chart, No. 8.)

Exercise XXXVIII. Enlarge the design given in Fig. 87. Trace it on Japanese paper. Fill in the shapes with washes of the color scheme found in the preceding problem.

Exercise XXXIX. Make another tracing of the same design. Use in this exercise the same color scheme, changing the values of the colors.

Note. For a fuller presentation of the whole subject of "Color Schemes" see "The Theory and Practice of Color," by Bonnie E. Snow and Hugo B. Froehlich, published by The Prang Company. Price $4.00.

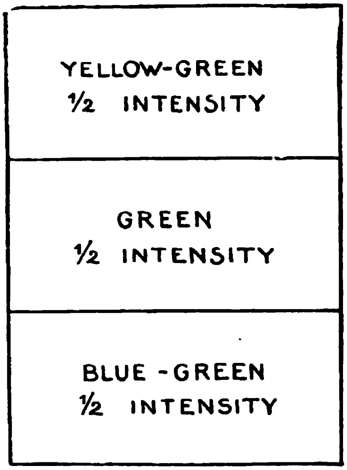


FIG. 86

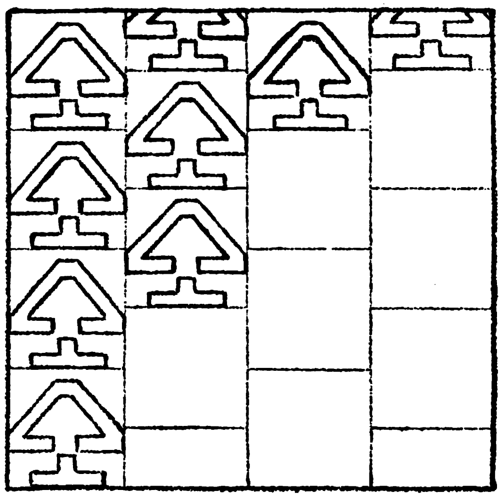


FIG. 87

For example, yellow may be used at High Light, green at Middle, and blue-green at Low Dark. Note the difference in effect in the two exercises.

Dominant Harmony. A dominant harmony is formed when a group of colors is enveloped or influenced by some one color. When, for instance, we look at the landscape through the mists of morning, we see different color effects, according to the conditions of the atmosphere and the resulting color of the air. This enveloping mist enters into or qualifies every local color seen, and a dominant harmony is formed. (See pages 10 and 11 of "Pictorial Representation," discussion of Color Quality.) The same landscape may be seen under different atmospheric conditions. In one case the dominant color may be pearly gray, and this "grays" the color of the sky, the water, the grass, the trees and the distance. In another case gray-violet seems to be the dominant color, and another and quite different effect is seen. In a third case the dominant color is gray-yellow, and again it may be gray-orange.

By comparing these four effects, we see that in each one of them harmony has been attained by the all-pervading, all-enveloping color of the atmosphere. The ever-changing aspect of nature is what makes the study of landscape of so much interest. We learn how different a familiar landscape may appear, when seen through the atmospheres of winter, summer, autumn and spring, or under the effect of noonday, of twilight, of moonlight or of dawn. Painters recognize this charm in landscape, and try to represent effects as they see them. Claude Monet, a French artist of note, has made himself famous by the masterly way in which he has portrayed this principle of dominant harmony. Some years ago he painted the same landscape under twelve different atmospheric conditions.

The use of dominant harmony is not confined to landscape paintings, but is apparent in the general work of many artists. In the famous "Night Watch," by Rembrandt, a golden glow seems to permeate every object in the painting, affecting the color of the armor, the texture of velvet, satin and silk, and the mysterious depth of the room beyond.

A color scheme or composition that presents red, yellow and blue in some form is of a higher order than one in which any one of the primaries is lacking. For instance, monochromatic and analogous color schemes are agreeable and effective when properly used, but the most complete harmonies are formed when all the color elements are present.

In working out color schemes, dominant harmony is recognized, and is very generally used, as, for example, in planning a room interior, a costume, or the color scheme of a church or theatre.

Exercise XL. Draw three horizontal rectangles, each measuring about 2½ x 1½ inches, and arrange them in a vertical row. Prepare washes of red, yellow and blue in full intensity. Modify each of these with the same mixture of gray-violet. Spread these three modified washes in the rectangles prepared. This will give you three colors so related or harmonized as to form a safe color scheme for a design.

Note. Gray-violet can be made by mixing blue, red and black. A scheme such as the above can be varied by changing the value of the dominating color.

Exercise XLI. Make another color scheme in dominant harmony, using orange, green and violet, modifying these washes by a gray-violet mixture. Spread in rectangles as before.

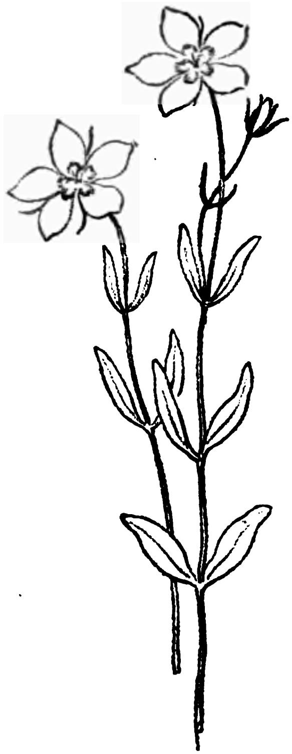
Exercise XLII. Design a straight line surface pattern similar to Fig. 87, and make two tracings of it on Japanese paper. In one tracing fill in the shapes with the color scheme found in Exercise XL. In the other, fill the shapes with the color scheme found in Exercise XLI.

Other Color Sources. When a color scheme is desired for use in decoration, we may turn for suggestions to three different color sources: By our knowledge of the color chart and of color relationships we can work out color harmonies, as has been explained in the last few pages; we can go to nature, and find there harmonious color combinations in infinite variety; and we can turn for suggestion to the artistic products of the past. It is an interesting task to search for such color schemes, and to attempt to scale them. A note-book might be filled with color schemes taken from flowers, weeds, autumn leaves, the bark of trees, the plumage of birds, from shells and minerals and many other sources, making a collection of valuable material for use in design.

In museums and in other collections of artistic products we may find beautiful examples of color harmonies. The lower sketch on the color plate facing this page shows a piece of silk, dating from the XVI century, in which a complementary color scheme has been used. Japanese prints, hand-printed from wood-blocks, are often so complete in color harmony that we may select from almost any part of them a rectangle containing a color scheme of much beauty and of unusual quality.

EXERCISES. A number of exercises in constructive design are suggested in the pages that follow. They involve the use of different materials, such as cardboard, cloth, leather, clay wood and metal, and are adapted to the ability of average high school students in localities where the necessary equipment is supplied. But even if it is not possible to make the articles, the student will gain an understanding of the application of design to articles of daily use by working out the problems on paper. By doing this, his judgment and taste will be proportionately developed, although his experience will be far richer if he is able to construct the articles from appropriate materials.

The Development of a Stencil. The stencil as a practical means for transferring or repeating a decorative unit has been in use for many years, particularly among the Japanese, whose designs are characterized by



ROSE
OF PLYMOUTH
FIG. 88

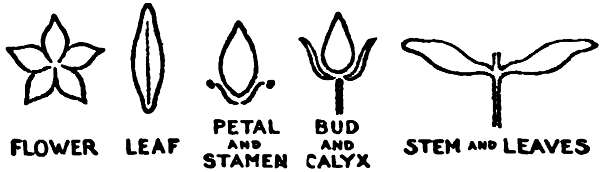


FIG. 89

great delicacy of treatment and by marvellous workmanship. The modern crafts movement, apparently, has revived the use of the stencil, for it is now employed quite generally in interior decoration, and in the application of designs to fabrics of many kinds. Curtains, table-covers, pillow-tops, neck-scarfs, bags of silk, linen or of heavier material are among the many articles of practical use that may be decorated by means of a stencil.

Stencils may be made from a motive of any kind. We may go to nature, to historic ornament, to geometry, or we may make a unit that is purely abstract. Fig. 88 shows the source from which was designed a simple stencil for the decoration of a neck-scarf. The slender sabbatia, or rose of Plymouth, was selected for the motive, and a careful drawing made of its growth and principal parts (Figs. 88 and 89). The stencil shown in Fig. 90 is the result of a simplification or adaptation of the growth to a decorative use.

In planning a stencil it is necessary that the shapes to be cut out shall be separated from one another, and that all parts of the background shall be connected.

To illustrate: If the leaf shapes in Fig. 90 had been connected with the stem, it would have been difficult to keep the parts of the stencil from shifting when the color was applied. The same is true of the flower shape; each petal was drawn separate from its neighbor and from the center, for the reason just stated.

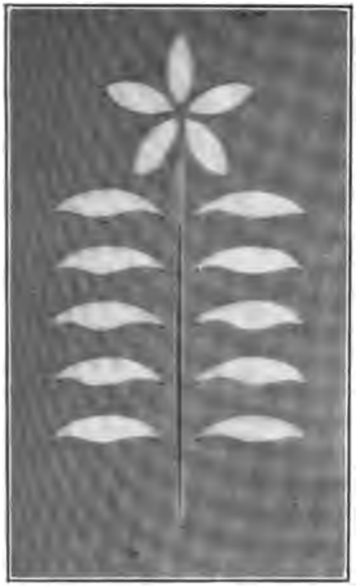


FIG. 90

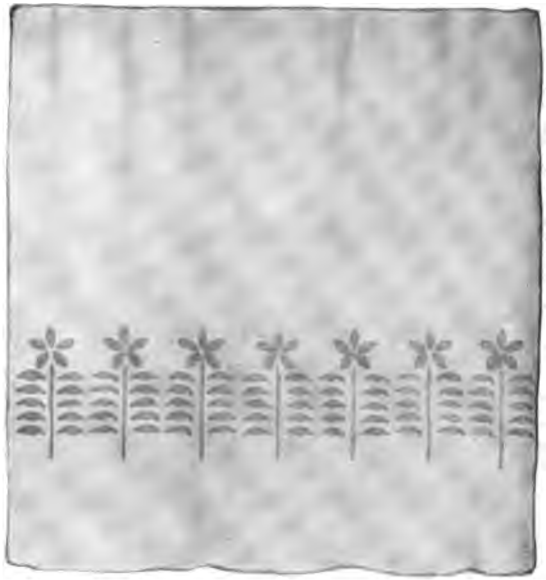


FIG. 91

After the design is drawn, transfer it to stencil paper. This may be prepared by spreading a coating of boiled linseed oil upon both sides of heavy manila paper, allowing it to dry thoroughly before using; or, the design may be dipped in melted paraffine. Place the tracing upon a hard surface, and with the sharp point of the blade of a penknife cut the shapes. Fasten the stencil over that part of the cloth which is to receive the decoration, fixing it firmly in place with pin points. Every part of the stencil must lie flat against the cloth, so that the color, when applied, will not creep under the stencil and blur the design. With a small, flat bristle brush (a clean mucilage brush will answer) containing very little color, brush the color back and forth over the openings. When the cloth is very thin, it will be well to place a piece of blotting paper under the goods to absorb the excess of moisture. Tube oil colors thinned with turpentine are the most satisfactory to use, although water-colors or dyes may be employed with good results.

Exercise XLIII. Select one or two of the facts of the plant growth shown in Fig. 89, and arrange from these motives a design for a stencil.

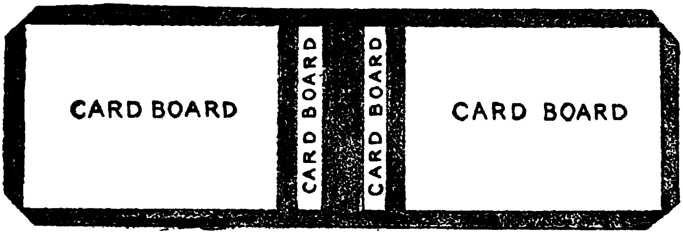


FIG. 92

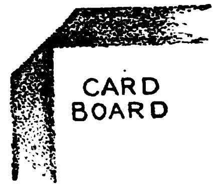


FIG. 93

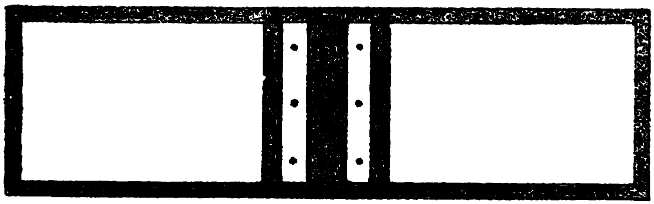


FIG. 94

Apply this unit in a border on a scarf or a sash curtain, using some light, delicate material and a color scheme of grayed complementaries in light value.

The Development of a Note-Book Cover. Book-covers, portfolios, desk-pads, memorandum tablets, calendar-backs, wall-pockets of various kinds and boxes are a few of the useful and attractive articles that can be made with an equipment of cardboard, book-linen, or chambray-gingham and library paste. Fig. 92 shows the position of four pieces of cardboard on a piece of book-linen cut large enough to allow for margins, thickness and hinges. The pieces of cardboard are pasted down firmly, paste being spread over the entire surface of the linen. Fig. 93 is a detail drawing showing the position of a corner of the board in relation to the linen. In order to ensure a neat fold, the cloth is cut on a diagonal line, but the corner of the board is a little distance from this edge. Fig. 94 shows the margins of linen pasted over the edges of the boards and pressed down flat. The perforations in the strips of cardboard are for the cord that is to be passed through the leaves of the book and tied on the outside, as shown in Fig. 95. Tinted paper of a tone to harmonize with the linen may be pasted over the inner faces of the cover.

Exercise XLIV. Make a design for a note-book cover, its proportions to fit some definite need. The decoration is to be a straight line corner

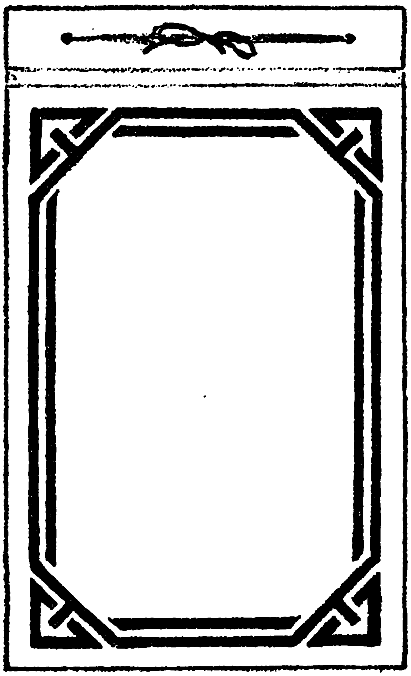


FIG. 95

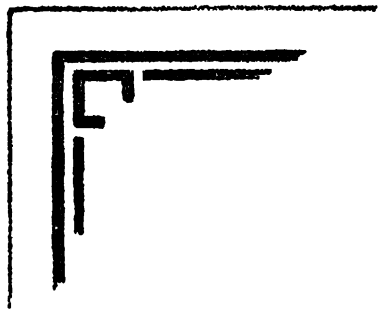


FIG. 96

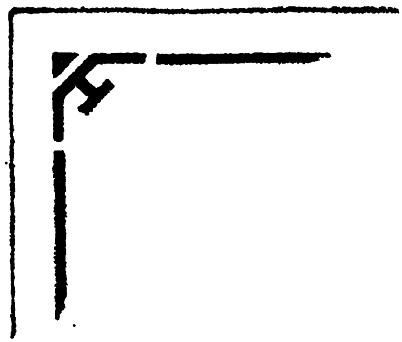


FIG. 97

motive, similar to the examples shown in Figs. 95, 96 and 97. Construct the cover of cardboard and a suitable textile, planning a monochromatic color scheme. The color of the cloth is to represent one of the values in the scheme.

Wood-Block Printing. Printing with the wood-block is an ancient art which, like the art of stencilling, has recently experienced a revival of interest. The Japanese and Chinese peoples have given the world some wonderful examples of prints from the wood-block, both in color and in light and dark effects. The Japanese prints that are so highly prized to-day and that are referred to as masterpieces of color and of composition are printed from wood-blocks, and so are many of the fabrics from Japan. The designing and cutting of the wood-block, the preparation of the color pad and the printing of the pattern are all practical exercises which may be worked out

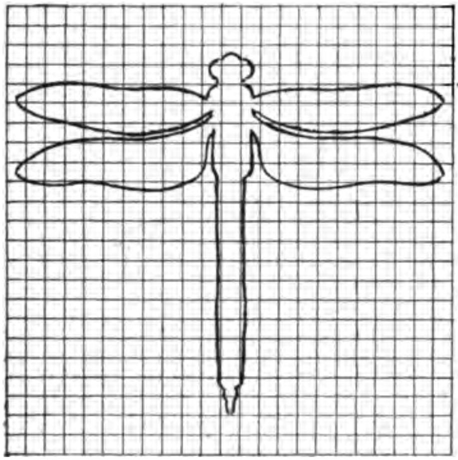


Fig. 98

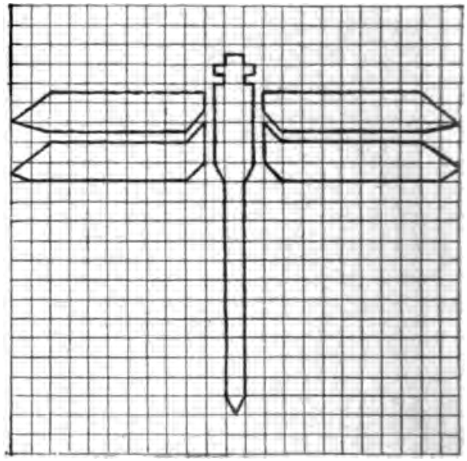


Fig. 99

in the schoolroom, and many are the interesting decorative effects that may be accomplished by the use of this craft.

Figs. 98 and 99 show one way of developing a design for a wood-block. The naturalistic form of an insect was drawn on squared paper, and the various shapes were then modified and made to follow the straight lines of the squares. In this way the motive was made conventional and suitable for decorative use.

To prepare a wood-block, select $\frac{7}{8}''$ stock of clear, soft wood, such as basswood, and cut blocks of a size to accommodate the design. Sandpaper very carefully that face of the block which is to receive the design, and transfer the design to this face by means of carbon paper. With a sharp pocket knife, cut vertically on the lines of the design (Fig. 100). Then, with an oblique cut, begin to chip away that part of the block not included in the pattern. (A gouging tool would be of great assistance here, although the whole block is often carved with a common pocket knife.) Keep up this process until you have cut the background away to a depth of a quarter-inch (Fig. 101). Be sure that the lines of the design are sharp and true, and that the background is of even depth (Fig. 102). The color pad is made by placing several thicknesses of cheese-cloth, cut somewhat longer than the block, over blotting-paper. Saturate the pad thus formed with

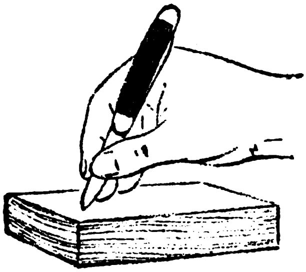


Fig. 100

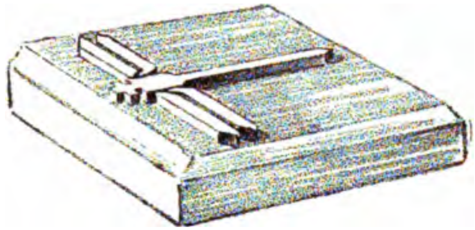


Fig. 101

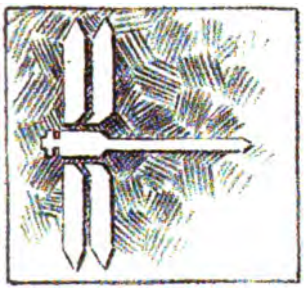


Fig. 102

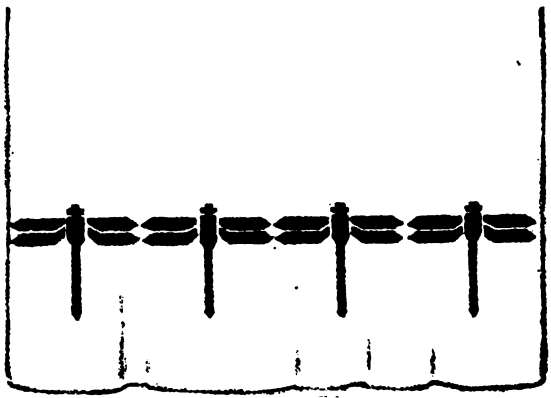


Fig. 103

water-color, dye, or with oil-color thinned with turpentine. The pad should be wet enough with color to secure a good print, but not so wet as to blur the impression. The block and pad should be used in much the same way as are a rubber stamp and pad, and several trials should be made on paper before attempting to print upon a fabric. In case two colors are desired in the print, it is necessary to apply them to the block by means of a brush.

Exercise XLV. From a flower or insect motive, plan a design for wood-block printing. Prepare the block as described in the preceding paragraph, and print a border decoration on some material suitable for a sash-curtain. (See Fig. 103.) (Write for circular on "Ruco Block Printing.")

Leather Modelling. Leather is another material that may be easily adapted to schoolroom conditions, and many designs may be developed through this medium into articles of use and of beauty. Two kinds of

FIG. 104

FIG. 105

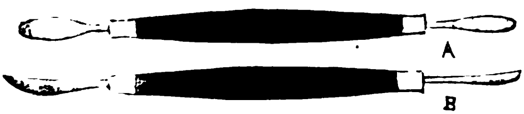


FIG. 106

leather are in general use, giving very different results. One kind, sheepskin, is inexpensive, and is used for bags of various kinds, for moccasins, for photograph and toilet-cases, etc. It can be decorated with pierced designs (designs that are expressed by means of shapes cut out, as in a stencil) or it may be painted or stained. Sheepskin is not satisfactory for modelling, however, and for this purpose the skin known as Russian calf is usually selected. Figs. 104 and 105 show two designs for belts; the dark background represents the parts pressed down with the modelling tool, and the light parts represent the design left by this process in relief. In planning the design it is best to make the shapes a little wider than you desire them to appear in the finished article, for in modelling the tendency is to encroach upon the parts in relief. The modelling tools shown in Fig. 106 may be purchased, but often home-made substitutes, developed from common nut-picks set in wooden handles are shaped by filing and by finishing with emery cloth into instruments that answer quite as well as do the more expensive tools. Before transferring the pattern, the leather should be moistened with a damp sponge, and the pattern, drawn on paper, should be

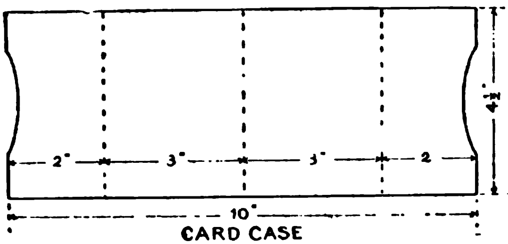


FIG. 107

FIG. 108

laid over the damp surface of the leather and traced with a hard pencil. The impression on the leather will be enough to permit the lines of the design to be easily followed. Carbon paper should not be used as a means of transfer. After the pattern is clearly traced, make a strong line around the design, using the sharp pointed tool. With the blunt, rounding tool press down the background, modelling away from the design in short strokes. When finished, the background should present a smooth, even texture. The leather must be repeatedly dampened while modelling, to keep it in a pliable condition.

Exercise XLVI. Plan a simple design for a belt or a card-case, as suggested in Figs. 104 and 105, or in Figs. 107 and 108. In carrying out the design in leather, the belt may be finished with a suitable buckle; the card-case should be lined with silk and stitched on a sewing-machine.

Modelling in Clay. The designer's knowledge and skill are needed in the manufacture of common articles of daily use even more than they are needed in the planning of ornament. Questions of materials, proportions, shapes and colors are very important in the making of the objects with which we furnish our homes, and a person's artistic taste and judgment are evidenced in the selection of things with which he surrounds himself.

Clay is an interesting material in which to work out designs for various kinds of pottery. While it is always a part of the soil of the earth, clay varies in the proportions of the substances that compose it. Some kinds

FIG. 109

FIG. 110

are fit for fine china, some for heavier pottery, some for common earthenware, and some only for drain-pipes and flower-pots.

Figs. 109 and 110 show two designs for tiles. The first is a straight-line design, that repeats with some variety the structural lines of the square. In working out the design the decoration appears in relief; the background is lowered by scraping away certain portions of the clay while it is in a leather-hard condition. Fig. 110 shows a motive, also in relief, which is taken from historic ornament of the Romanesque period. Tiles similar to those shown in the sketches may be made by patting and working the clay to form a smooth, flat square, about half an inch thick. When leather-hard, use a sharp point to outline the design with a line sunk into the surface of the clay. With a wooden modelling tool scrape away the background until the ornament is about $\frac{1}{8}''$ or $\frac{1}{4}''$ in relief. When the tile is thoroughly dry it may be fired for the first time. After this, apply a colored glaze and fire the second time.

The inkstand (Fig. 111) is made by taking a lump of moist clay of a size that approximates the size of the desired article, and rolling it with the palms of the hands into a ball. To start the hollow of the ink-well, press the thumb into the ball. Then wet the thumb and fingers slightly, sprinkling a few drops of water into the hollow. With the thumb on the inside

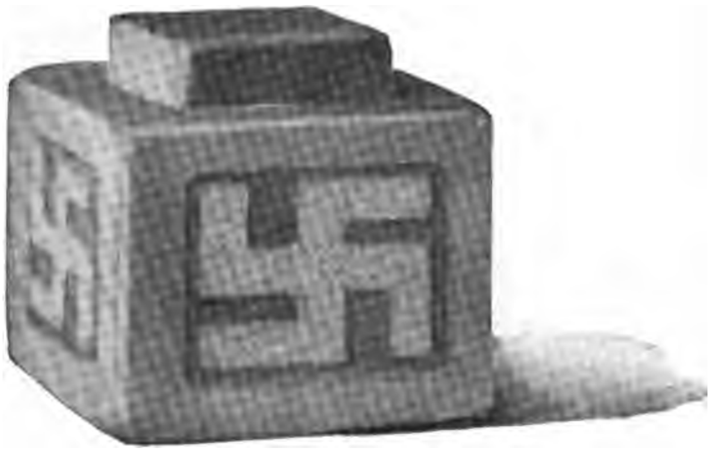


FIG. 111

and the fingers on the outside, manipulate the mass to form a cube, striving to keep the hollow or well exactly in the centre of the mass. By adding to or cutting away from the clay, correct the form and proportions when necessary. When leather-hard, apply the decoration as described in the making of the tiles. The lid or cover is made separately, somewhat larger than the size of the opening. After drying thoroughly, give the piece the first firing; then apply the glaze and fire again.

Exercise XLVII. Make a design for a tile, using as a decoration some straight-line or historic motive. Trace this design on water-color paper and apply a wash of some grayed color. Try to show the ornament in relief, by means of shading with a darker value of the same color, as suggested in Figs. 109 and 110. If it is possible to work this out in clay, make a tracing of the design, transfer it to clay, and proceed as previously directed.

Exercise XLVIII. Design an ink-well, showing it in color, in a perspective sketch. Carry out this exercise in clay if possible.

Designs for Metal Work. Designs for metal work can be fully developed only when a special room and equipment are devoted to this purpose. A heavy table or solid bench is necessary for the setting up of vises in order to facilitate the processes of hammering, sawing and filing.

FIG. 112

FIG. 113

Certain tools, especially adapted to such work are indispensable. In schools that are supplied with a manual training equipment or a shop, metal work can be done, but it should not be attempted in an ordinary studio or class-room.

The decoration for the tray shown in Fig. 112 is an abstract design worked out in a circular space by means of structural lines. The tray itself was made from a flat piece of 20-gauge copper, formed by hammering the metal over a wooden block. The decoration was etched with diluted perchloride of iron, and the copper was colored with a solution of barium sulphide.

The process of making the circular tray shown in the sketch was as follows: With the compasses, a circle of the required size of the tray was drawn on a piece of sheet-copper. This circular shape was cut out with tinner's shears, and the edge made "true" by filing. A second circle was then drawn on the part cut out, having the same center and a radius as much less than the radius of the first circle as the required depth of the tray. In this case, the distance between the two circumferences was about $\frac{5}{8}''$.

This outer margin of the disk was then placed over the curved end of a wooden block which had been shaped to fit the required curvature of the tray. The block was held in a vise, and the margin was hammered with light blows, and was continually moved over the surface of the block until the rounding edge of the tray was "formed up." To facilitate this part of the work, a hammer with a convex face was used, and its blows fell between the inner circle and the outer edge of the disk. The form was corrected and the curvature made uniform by repeated hammering. The tray was

FIG. 114

then cleansed by immersing it in a bath called a "pickle," consisting of two tablespoonfuls of sulphuric acid to one gallon of water. It was left in this solution until bright, then washed in water and dried with a cloth. The decorative unit was then traced on the center of the tray by means of carbon paper. With a brush and a varnish known as asphaltum, all the parts *not to be etched* were then covered. A solution of perchloride of iron and water in equal parts was then poured into the tray, in sufficient quantity to cover the decoration. The acid was allowed to act until the pattern was properly etched. (In this case the time allowed was about thirty minutes.) Then the acid was poured off and the tray rinsed in water, after which the varnish was removed by burning with a flame. The tray was was returned to the pickle, cleaned as before and then polished with worn emery-cloth, grade 00. A rich brown coloring was obtained by dipping the tray in a solution of barium sulphide. Finally the tray was again thoroughly washed.

The tea-stand shown in Fig. 114 was made by fitting to a tile a strip of 26-gauge copper, cut twice as wide as the thickness of the tile This strip was fitted to the tile and the corners mitred. The upper edge of the strip was bent over the straight edge of a flat iron block, until it fitted the edges of the tile. With a pattern the legs were then cut from 20-gauge copper, using a metal saw. They were bent to fit the corners by the use of the vise and hammer. Holes for rivets were drilled in the legs and strips, and brass rivets, which can be purchased in a hardware store, were cut to the proper length and hammered into place. The tile was put into this frame, turned face downward, and, by gentle blows of a wooden hammer, the lower edge of the strip was bent over to hold the tile. The metal was then rubbed and polished by the use of 00 emery-cloth, somewhat worn. A coloring of

FIG. 115

antique green was obtained by painting the metal with the following solution: —

Copper nitrate	48 grains.
Ammonia Chloride	48 grains.
Calcium Chloride	48 grains.
Water	3 oz.

Exercise XLIX. Plan an abstract design for the decoration of a shallow circular tray. Make a perspective sketch of the top and side views of the proposed tray, using two values of brown water-color, similar in effect to the sketches shown in Figs. 112 and 113.

The Use of Several Mediums. A knowledge of several different mediums will enable the student to make interesting combinations of material in developing designs. Fig. 115 shows an inkstand of wood with an ink-well of pottery and a cover of metal. Fig. 116 is a sketch of a jewel casket of wood, reinforced with metal trimmings. Many other combinations may be arranged, such as a leather opera or shopping bag, made of ooze-finished sheepskin or cowhide, lined with satin or silk; a screen of wood with set-in panels of modelled leather; a wall cabinet of wood, metal and glass; a lantern of stained glass and copper; a lamp-shade of metal lined with silk; a book-rack of wood, with metal trimmings, etc.

Exercise L. Make a design for a leather shopping or opera bag, the decoration to be pierced or cut out, showing an undertone or lining in some harmonious color. Plan the design on manila paper; then, on water-color paper make a perspective sketch, transferring the decoration to the sketch. Paint the bag in some grayed tone, to represent leather, leaving uncolored the shape to be cut out. When dry, color these shapes to represent a silk or satin lining in harmonious tone.

If it is possible to carry out this design in leather, make a paper pattern for the bag, allowing for seams, and planning for the draw-string. Cut this out of ooze, and transfer the decoration to the leather. With a sharp pocket-knife, cut out the stencil-like shapes. Under the openings, glue the silk undertone. Make an inside bag of silk or satin to fit the leather covering. Cut slits for the draw-string, planning them at regular intervals, and cutting them simultaneously in the leather and silk. Insert the draw-string of leather or silk cord.

Exercise LI. Plan a work-bag with a circular bottom to be made of coiled rattan covered with raffia, in the stitch known as the "lazy squaw" or "strap" stitch. Make this bottom about four inches in diameter.

The bag is to be made of a straight piece of chambray gingham, linen, or pongee silk, in soft brown or "natural" colors, to harmonize with the raffia bottom. This strip of material, after a one-inch hem is turned at the top, should measure about seven inches in width, and should be long enough to gather slightly about the outer edge of the disk. A little below the middle of the strip, print with a wood-block, in dark brown coloring, a well spaced border from an interesting unit. (For the preparation of the wood-block, see pages 266 and 267. The unit may be an animal form, such as a rabbit, a duck, a chicken, a stork, a cat, a dog or an insect.) When the printing is done, sew the short edges of the strip together, and gather the bottom edge to fit the disk. Sew it firmly in place. For a draw-string use a brown silk cord. The addition to the cord of one or two Indian beads will add an attractive color note.

To know how to combine and manipulate such materials as are mentioned in the preceding exercises, to be conscious of their limitations as well as of their possibilities, to be able to select fine color arrangements and to possess artistic judgment regarding the merit of objects that every one must use and at some time purchase, are some of the results that come from the the training of the appreciation through a study of design. Design should manifest itself wherever the art question is present. It is an effort of the mind to create something in which order and interrelation, and therefore beauty, shall predominate. No matter what the occupation, beauty should

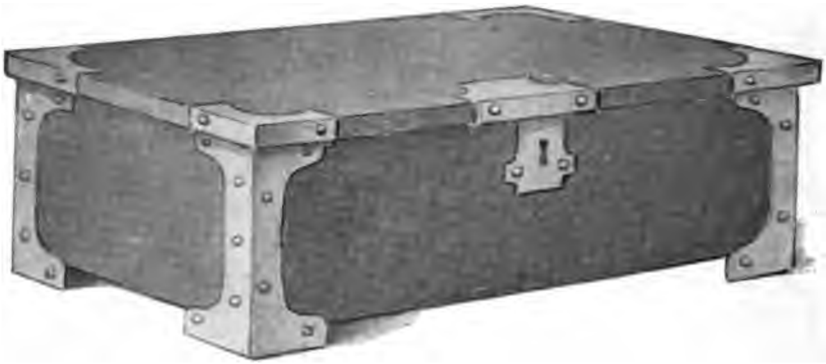


FIG. 116

be a present element. Every home is an expression of good or of poor taste, and marks the designer, who is in this case the occupant, either as a person possessing artistic discrimination, or as one to whom the gateway of beauty remains closed

CHAPTER VII

HISTORIC ORNAMENT

Primitive Decoration. Various opinions are held by archæologists as to the origin of ornament, or of the origin of the motive or impulse which led to its use. Carlyle says that the first spiritual want of a barbarous man is decoration. We have evidences that this want manifested itself in prehistoric times, for earthen bowls and other utensils have been found, fashioned evidently for daily use, and decorated with rude shapes scratched on the hard surface of the burnt clay. Primitive man wished to beautify the objects about him. As he became more skilful he used signs and symbols to express his ideas, as is shown in Egyptian hieroglyphics and in the sign language of

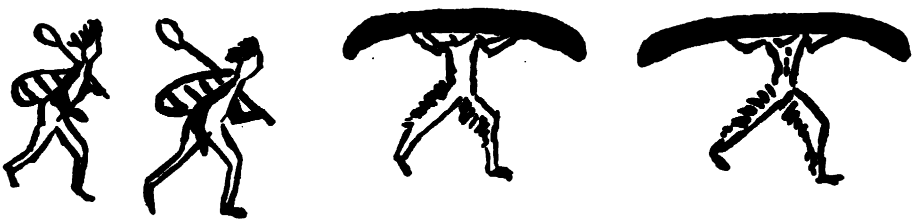


Fig. 1. Indian Symbols

other races in different parts of the world. The North American Indian, for instance, would sometimes cut a message upon the bark of a tree. It might be an invitation to attend a council where the pipe of peace was to be smoked, and this idea would be expressed by a sketch of a pipe upon the bark, together with the symbols of the moon and sun, to designate, perhaps, the time. Or, if the message were to be one of war, a sketch of a tomahawk would signify a threat or challenge. Even at the present time the Indian uses symbols in his decoration, and depicts the scenes that interest him in his daily life. A birch-bark box made by an Indian of the Penobscot tribe, in Maine, was decorated with symbols representing a wild-cat and an Indian with bow and arrows, together with borders made of semicircles and triangles, which may or may not have had added meaning. Fig. 1 shows some of the symbols used by American Indians in their decoration and picture-writing.

A savage does not always follow his own creative impulse; he is very apt to imitate some decoration that has pleased his fancy. Often the decorations that originated in one tribe or nation were copied by a neighboring tribe, and the real significance of the symbols was in this way lost. A comparatively modern example of such imitation is recorded in the account of a shipwreck which occurred nearly a hundred years ago. The ship, which was a whaling vessel, was wrecked on the shores of the South Sea Islands, and among the spoils of wreckage were some pieces of the sails. The captain of the ship, for want of other occupation, made some stains of leaves and bark, and painted upon one of these pieces of cloth a rude picture of a whale spouting and a full-rigged ship. His work was greatly admired by the natives, and was speedily imitated until the supply of sail-cloth was exhausted. If such forms of decoration are still in use there, they surely did not originate with the natives. In similar ways, many other forms of decoration have been carried from tribe to tribe and from country to country, although, in the beginning, conditions of life, surroundings and religious belief suggested, undoubtedly, the decorative motives. The American Indian in the northeast, for instance, used the deer, the moose, the wild-cat and the owl, while we find in the decorations of the western tribes the buffalo, the bear and the mountain lion.

Primitive decoration had one admirable characteristic, in that it was never overdone; the ornament upon paddle, tomahawk or knife was never allowed to interfere with its usefulness as a tool or weapon.

Every nation that has lived upon the earth has left in some form a record of its life. Sometimes this record appears in the nation's architecture and ornament. When a general style of ornament has become closely identified with the life of a race or nation it is called historic. The three most important styles of historic ornament are the Egyptian, the Greek and the Roman.

Egyptian

People and Customs. If we look at the map of Africa we find that the country called Egypt is limited to the region lying along the shores of the Nile, a river which has many mouths, forming a delta (Fig. 2). On one side of Egypt is the Libyan desert, and on the other the Nubian desert. In area, Egypt itself is only a little larger than the State of Maryland. Except in the Delta of the Nile, it rarely if ever rains in Egypt, but moisture and fertility are supplied to the soil by means of the overflowing waters of the river. The Nile rises in the interior of Africa, and it is fed by lakes and mountain streams. These sources or feeders of the Nile become so swollen by the annual rains of that strange region that the river cannot carry the waters in its natural channels, and therefore overflows its banks. Not only water is carried to the burning sands of the desert, but a rich deposit of alluvial mud is made on either side of the river. A very primitive system of irrigation carries the water back some distance into the country. When the water subsides, vegetation springs up, and many flowers and plants appear, chief of which is the lotus. The people rejoice at the appearance of the lotus, as we do at the coming of spring, for it is to them the promise of the harvest. At rare intervals the inundation is not complete, and such a condition is always followed by famine and much distress. The people of Egypt depend for their harvest on the rich mud and its abundant

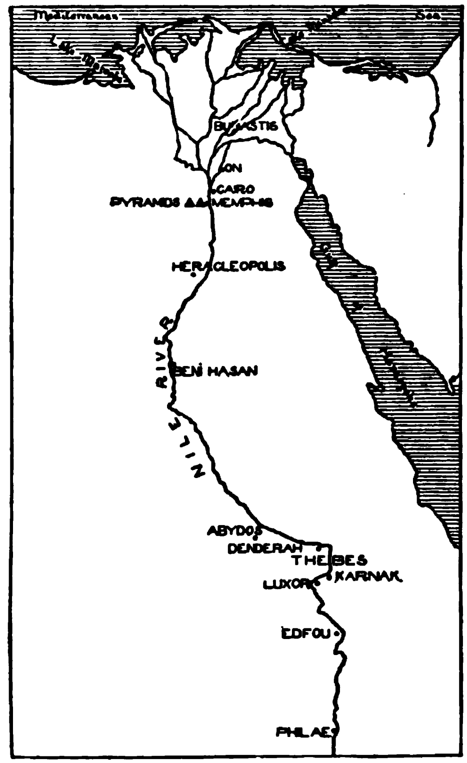


Fig. 2. Map of Egypt. From Mariette Bey

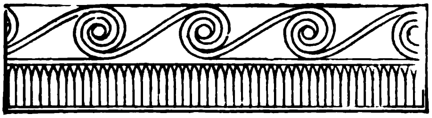


FIG. 3. EGYPTIAN SYMBOL, SCROLL

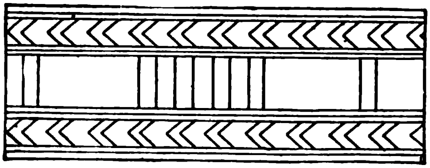


FIG. 4. EGYPTIAN SYMBOL, ZIGZAG

deposit. The river Nile, with its beneficent action, came to be looked upon as a supernatural power, and the people worshipped it, and used in their decoration a peculiar symbol to typify it. This was sometimes a scroll, to indicate the slightly winding course of the river, and sometimes a zigzag (Figs. 3 and 4).

It will be seen that the Egyptians were dependent upon the various forces and aspects of nature, and, like other primitive races, they deified what they did not understand, and worshipped as gods the sun and other heavenly bodies, the river, many animals and some plants. The lotus was an emblem of especial sacredness, and they attached to it the idea of immortality and resurrection. Fig. 5 shows several motives taken from the lotus. Some form of its growth is seen in almost every ornament that they employed, from the decorations of objects in daily use to the magnificent capitals of their columns.

Architecture and Decoration. The earliest dwellings of the Egyptians and their first temples and tombs were cut out of rock, but later they built huts of clay, with walls supported by reeds. These supports are typified in some of their columns, which bear a conventional resemblance to reeds bound near the top by bands (Fig. 6). Climatic conditions in Egypt made

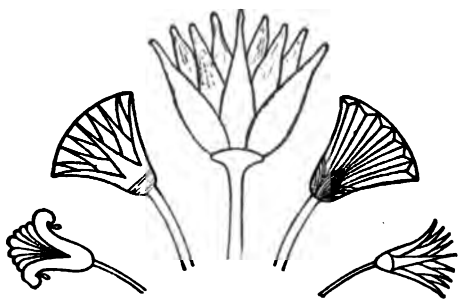


FIG. 5. THE LOTUS, CONVENTIONALIZED

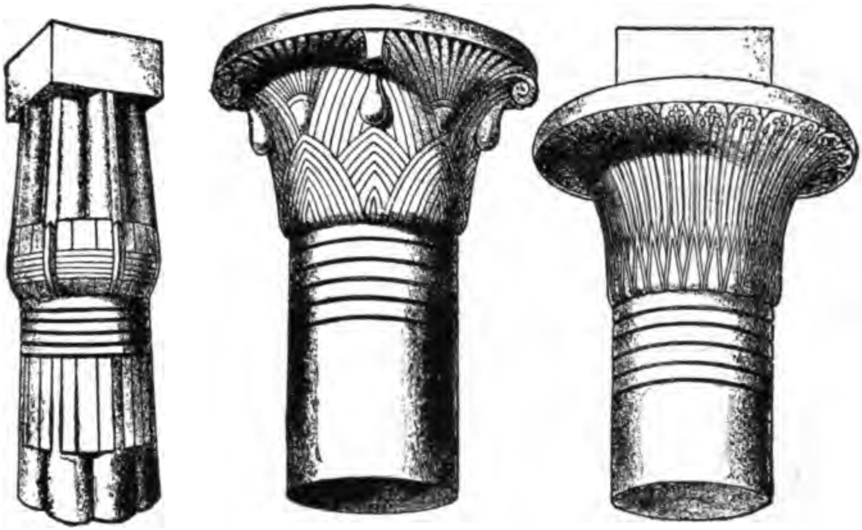


FIG. 6. FROM TEMPLE NEAR THEBES

it possible for dwellings to be constructed with flat roofs supported by pillars. Often the spaces between these pillars were left open, and in them were hung richly colored rugs; or if clay walls were used between the pillars, colored decorations were placed upon the surface thus formed. The scheme of coloring for these decorations was always strong and rich, consisting, mainly, of yellow, red, blue, green, dark brown and black. The gorgeous coloring in decoration which is noticeable in Egypt, Arabia, India and Mexico seems to be characteristic of southern nations generally. Nature apparently assists this choice, for the building materials found there — the stone and marble from their quarries — are more richly colored than are similar materials found in the north.

Egyptian architecture was especially characterized by the colossal size of temples, tombs, pyramids and obelisks, all richly ornamented. Thousands of slaves, over which the rulers of Egypt had unlimited power, were employed for years in building these structures. The three great pyramids of Gizeh, seen from the river Nile, were tombs built by three great kings. As soon as a king came into power he set about building his tomb, and it was his aim to excel all others in the magnificence of this monument. Upon its walls were carved and pictured the great achievements of his reign, his conquests, his glories and the spoils of war. East of the middle pyramid may be seen also the strange figure of the gigantic Sphinx, with its human head and with the body of a lion. This statue is cut from solid rock, and is now half buried by the shifting sands of the desert. It is supposed to have been made in honor of some god or ruler, and to symbolize intelligence and strength (Fig. 7).

FIG. 7. SPHINX AND PYRAMIDS

All the sculptured figures of the Egyptians, whether in the round, in relief or in incised carving, were conventional in the extreme and symbolic in character. So were their drawings and decorations in color. The winged globe, often placed over doorways, signified protection, and the oft-repeated scarabeus or beetle was emblematic of the idea of creation. Besides these forms of animals, plants and the human figure, the Egyptians produced ornament by the use of simple line arrangements, obtaining variety by means of spacing. Everything they made was ornamented, and richly decorated with color.

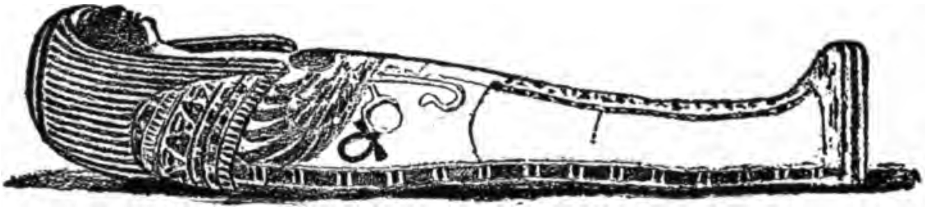


Fig. 8. Mummy-Case — Art Museum, Boston

The religion of the Egyptians led them to preserve their dead. A body was first embalmed with great care, then swathed in bandages and placed in a wooden case, which was shaped to indicate the form of the body and was covered with painted ornament. In earlier times the face was shaped in wood and placed above the head, but a later custom was to insert a portrait in the case, in place of the shaped and painted face. This portrait was painted from life and hung upon the wall of the home until death, when it was used in the manner just described (Fig. 8).

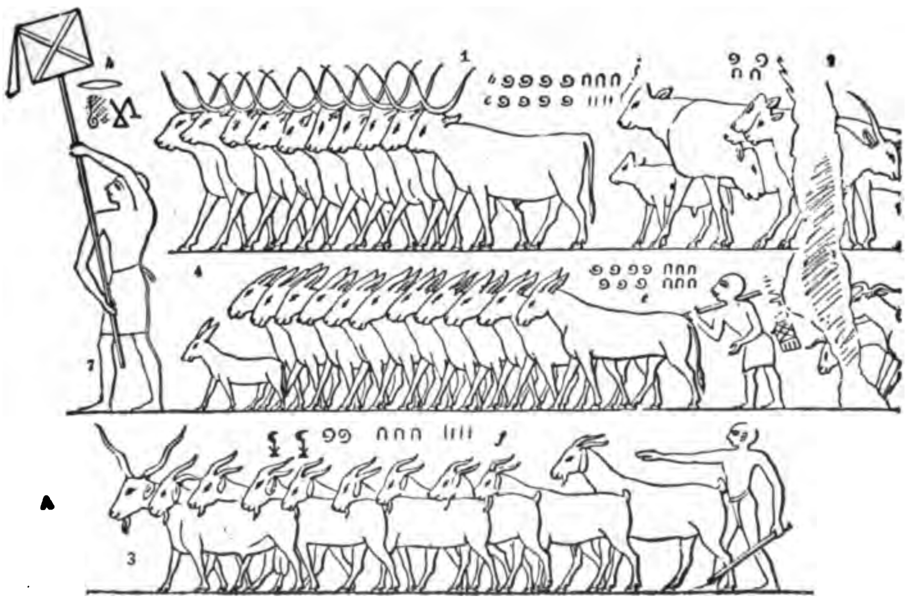


Fig. 9. Example of Egyptian Wall Decoration

FIG. 10. ORNAMENT FROM EGYPTIAN TEMPLE

Following the example of the kings, the life of the common people, their manners, customs and amusements were represented upon the walls of their tombs, together with somewhat boastful suggestions of their possessions, such as herds of cattle, horses and goats. Fig. 9 is an example of this peculiar and characteristic form of decoration. Fig. 10 is an illustration of ornament, taken from the temple of Abydos. It represents the great Egyptian king, Seti I, in royal array, holding an image of Truth. This image has on its head the ostrich feather, which signifies justice. In its hands is the hooped cross, symbol of divine life. It is by means of this symbolic ornament, as well as by other forms of picture-writing carved or painted upon imperishable stone, that we have learned so much of the history of this ancient nation.

Greek

Architecture and Ornament. The Grecian people lived in a country very different from that which lies along the banks of the Nile. Their climate, instead of being mild and dry with little difference in temperature throughout the year, was full of variations, like our own. It was hot in summer and cold in winter, and the surface of the country was broken and mountainous, bounded by an irregular coast-line. Although the people and their characteristics were as different as the countries, we can trace the influence of the older nations upon the art of the Greeks. As a people the Greeks were esthetic; they were lovers of beauty, expressing these qualities in their architecture and their ornament. Unlike the Egyptian style, their decoration was ideal rather than symbolic. Architecture was their grandest achievement, and in this they have never been surpassed. The most beautiful of their temples was the Parthenon on the Acropolis at Athens, now in ruins. It was built of marble and adorned with exquisitely sculptured ornament.

FIG. 11. THE PARTHENON RESTORED

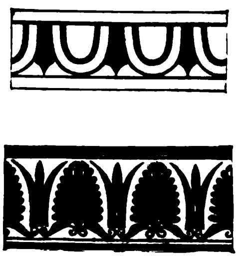
The rare beauty of its perfect proportions is apparent in the illustration (Fig. 11), which gives a view of the east front of the structure as it appeared in its original splendor. A frieze running around the upper part of the inner wall illustrates one of their great ceremonial processions held once in four years in honor of Athene, their favorite goddess. In this frieze twelve gods are represented, seated, with the procession of horses, riders, and bearers of offerings moving towards them. The sculpture is in low relief, and although it is now greatly mutilated, the fragments are still of marvelous beauty (Fig. 12).

Three styles of columns were used in Greek architecture as supports to the roofs of the temples, and they are called the classic orders, known as the Doric, the Ionic and the Corinthian. These columns (page 307), as well as the Parthenon and the decorative frieze upon its walls, are still influencing and inspiring the architecture of the present day. The ornament of the

FIG. 12. SCULPTURED ORNAMENT FROM THE PARTHENON FRIEZE

Greeks was thoroughly related to their beautiful architecture. The favorite motives were the scroll, the acanthus, the egg-and-dart and the anthemion, and these were employed on capitals and mouldings, upon vase forms, lamps, and other objects of daily use. While Egyptian ornament was generally expressed in line filled in with color, the Grecian forms were often carried out with the brush alone (Fig. 13).

EGYPTIAN



GREEK

FIG. 13

Roman

Roman Art. The Roman Empire was the next to develop great ascendency and to make notable contributions to

FIG. 14. PANTHEON, ROME

architecture and general building. The Egyptian and Grecian nations built their temples and dwellings without the use of the arch or the dome, confining their construction to buildings of one story and depending upon the lintel and the column as chief elements. With the arch and the dome, the Romans were able to surpass in magnitude and in utility the buildings of the older nations, and their aqueducts, baths, triumphal arches and temples were splendid monuments to their skill as a nation of builders (Figs. 14 and 15). The Romans were ambitious, proud and powerful. Their emperors were conquerors, returning from war and conquests with many prisoners and with rich spoils. Their slaves, many of them Greeks, brought with them the art of their mother country, but under Roman influence this art soon lost its simplicity and refinement, and became heavy and ornate. While some Roman ornament is beautiful,

FIG. 15. ARCH OF CONSTANTINE, ROME

ROMAN ORNAMENT FROM THE ARCH OF CONSTANTINE

FIG. 16. ORNAMENT FROM THE TEMPLE OF PEACE, ROME

it lacks as a whole the elegance and purity of the Grecian styles. The Romans adopted to some extent the Doric and Ionic orders, but they preferred the Corinthian, and this style was further elaborated by them, until it became magnificent in its wealth of ornament. They combined rosettes, scrolls, wreaths, ribbons and masks, sometimes introducing human and animal figures and often suggesting features of their festival or triumphal marches (Fig. 16). In architecture and ornament, the Egyptian, Greek and Roman styles are classed as belonging to ancient times. The principal medieval styles are known as Romanesque, Byzantine, Saracenic and Gothic.

Romanesque and Byzantine

Romanesque Art. As the Romanesque and the Byzantine styles of ornament both sprang from the same source, they are often confused, and in order to understand their distinction we must know something of the history of those times, and of the influence of the early Christian religion upon architecture and decoration. Throughout the period of their persecution the Christians held their meetings in the catacombs, or underground burial vaults, in Rome. Here they buried their martyred dead, and held communion in memory of the Last Supper. The slab-like table placed over graves in ancient churchyards is a symbol of this custom. In their communications with one another the early Christians were often obliged to use secret means, or signs, because of their persecution by the Romans. In this way certain forms, such as the cross, the trefoil, a fish, the vine, and many other shapes came to have special significance, and were often employed in marking the burial-place of a Christian. Later, these symbols were embodied in their ornament, which was styled Romanesque. As time passed the Christians gained in numbers and many rich and powerful Romans were converted to the new faith, so that they dared to come forth and hold their meetings openly in the Roman halls of justice, called basilicas. They were finally able to build churches, and to convert the ancient basilicas into temples of worship. When the Emperor Constantine became a Christian he acknowledged his religion formally, and transferred the capitol of the empire from Rome to Byzantium, a city on the Bosporus, in European Turkey. A new city was built on the site of the old one, and the emperor named it Constantinople. The architecture and ornament which sprang from this new impulse were called

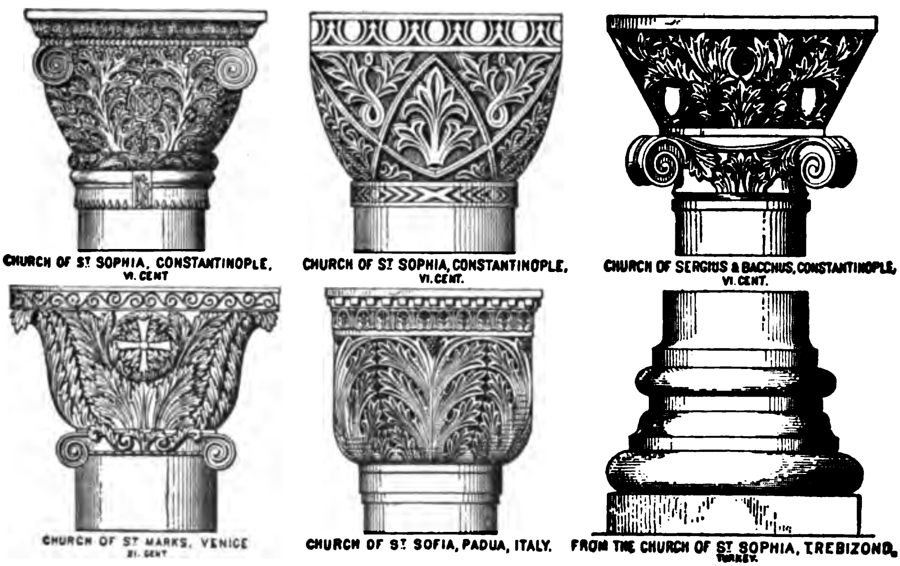


Fig. 17. Byzantine Capitals and Base

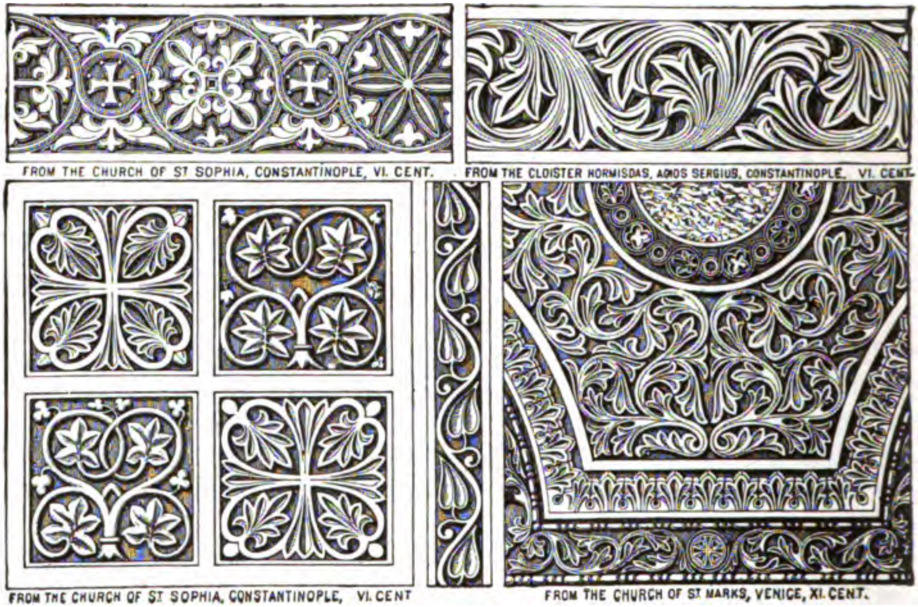


FIG. 18. BYZANTINE ORNAMENT

Byzantine, and the finest example of the art achieved by those builders was St. Sophia, a temple of worship, now a mosque, located in Constantinople. The beautiful cathedral of St. Mark's, in Venice, is also Byzantine in its style. In this development of ornament little attention was given to the decoration of the outside of the church, but the interiors were rich with color. Mosaics and tiles were favorite materials, used with backgrounds of gold, blue, delicate green and blue-green. The designs were usually symbolic in character, and the color scheme was strong and harmonious. The Byzantine style may be said to be a product of Christian influence working in the east, while the Romanesque style prevailed in Italy, passing north to France, Germany and England (Figs. 17 and 18).

Saracenic

The Art of the Saracens. The Arabs or Saracens were followers of Mohammed, and the signs and symbols of their religion were prominent features of their ornament. Sentences or texts from the great religious book of the Mohammedans, the Koran, were freely used in their decorations, and added much to the effectiveness of the otherwise geometric character of their ornament, for their religion forbade them to copy the forms of flowers, trees, animals or the human figure.

FIG. 19. ARABIC INSCRIPTION

The Arabic language, like the Hebrew, is Semitic in origin, and their characters or letters of the alphabet are graceful and decorative. Fig. 19 shows an Arabic inscription, often used as a wall decoration. Their ornament in stone was usually in slight relief, either undercut, or at right angles with the surface. This gave strong light and shade, while in the flat colored ornament which they so often applied, outlines were accented at the right and underneath, giving a similar effect (Figs. 20 and 21). In coloring, Saracenic ornament was strong and brilliant, consisting of gold and silver combined with red, yellow and blue, and often, as in mosaics, with orange, green and purple. As in all Oriental coloring, however, these bright hues were modified by juxtaposition or intermingling, so that the effects obtained, while rich and gorgeous, were harmonious. Examples showing results of such combinations are found in Oriental rugs and draperies.

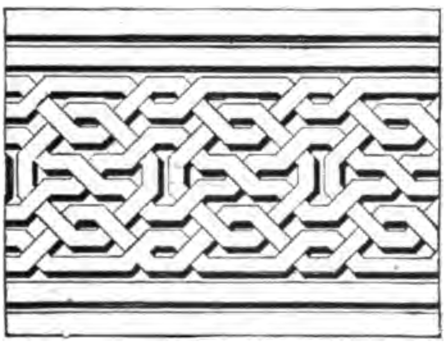


FIG. 20

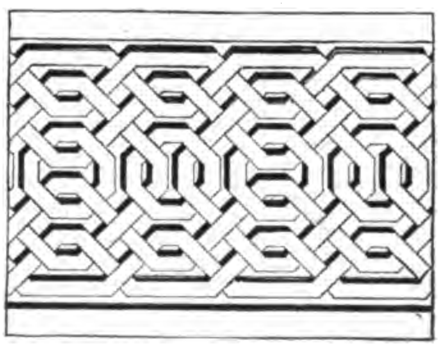


FIG. 21

SARACENIC WALL ORNAMENT—FROM THE ALHAMBRA

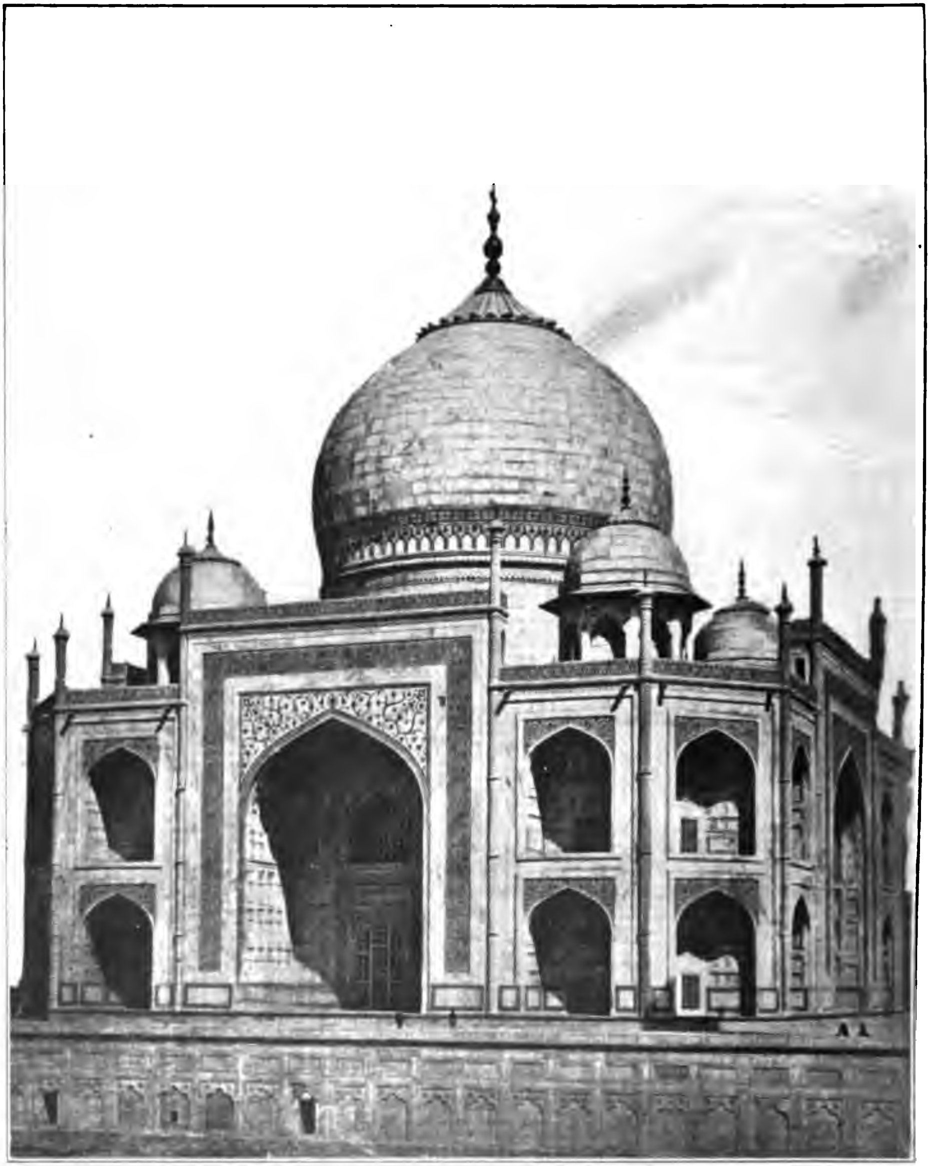


FIG. 22. TAJ MEHAL

The dome was adopted by the Saracens and was modified somewhat in form, so that it became pointed and tapering. The Saracens introduced many tall towers and minarets in their building, and these pointed domes, rising against the sky, made a striking and picturesque effect. The Saracenic arch is sometimes pointed, as shown in Fig. 22, and sometimes shaped like a horseshoe (Fig. 27). It is often used today, when an elaborate or ornate effect is desired.

The best examples of Saracenic architecture are found in mosques and tombs, although the Alhambra palace, built by the Moors in Southern Spain, is still admired for its purity of style and for its great beauty, though it stands in ruins. Fig. 22 shows the wonderful Taj Mehal, "Gem of buildings," built at Agra, India, by Shah Jehan, for a mausoleum.

Gothic

Cathedrals. Gothic architecture and ornament were outgrowths from the Romanesque style, and became a much fuller and freer expression of Christian art than were either Romanesque or Byzantine art. Egypt, Greece and Rome had built for the glory of their kings, their gods or their empire, and they employed slaves and captives as builders, counting their lives and happiness as naught. But the great Gothic cathedrals show a different influence; they were built by the people and for the people. The builders

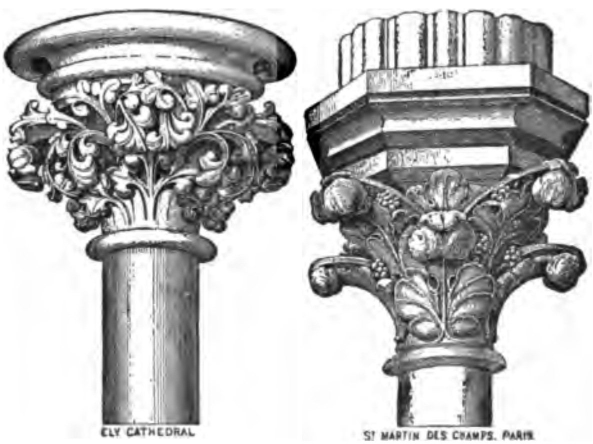
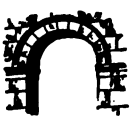


FIG. 23

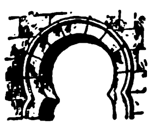
FIG. 24. GOTHIC ORNAMENT—PAINTED

FIG. 25. GARGOIL—FROM NOTRE DAME, PARIS

ARCHES



ROMAN AND ROMANESQUE
FIG. 26



SARACENIC
FIG. 27

GOTHIC
FIG. 28

believed in the religion which the cathedrals expressed, and they assembled in those vast structures to worship.

In their ornament, they used motives from nature, together with various geometric forms which were symbolic. For instance, the trefoil, or three-parted leaf, signified the Trinity; the quatrefoil, the four evangelists; the circle, eternity, etc. Grotesque figures of birds, beasts and devils were also applied to decorative uses, both within and without these splendid cathedrals. Sculptured saints and angels decorated the doorways, and the windows were brilliant with stained glass (Figs. 23, 24 and 25).

The ground-plan of the cathedral was in the shape of a cross; the walls were of great height, the ceiling vaulted, and the roof sloping at a sharp angle. To support

FIG. 29. COLOGNE CATHEDRAL, EXTERIOR

FIG. 30. COLOGNE CATHEDRAL, INTERIOR

the vaulting, buttresses were constructed at the sides. Generally, a tower was built to hold the bells, and smaller towers appeared elsewhere in the structure, to repeat the form and to contribute to architectural usefulness and beauty. In the construction of doorways and windows there were many variations of the pointed arch, and this was another element that distinguished Gothic architecture from Romanesque and Byzantine styles (Figs. 26, 27 and 28). Gothic art developed the greatest activity in England, France, Germany and Italy, from the twelfth to the thirteenth centuries. Notable examples of Gothic cathedrals are those of Canterbury, Lincoln, Salisbury, York and Westminster Abbey, all in England; the Cologne Cathedral in Germany and the Cathedral of Notre Dame in Paris, France. Figs. 29 and 30 show an exterior and an interior view of the Cologne cathedral.

Renaissance

Famous Artists and Architecture. The Renaissance, as its name signifies, was a period of awakening; a "new birth" of interest in learning, in discovery, in literature, and in art. Its beginning was in the fourteenth century, and it extended over a period which included the lifetime of Columbus, Galileo, Dante, Shakspere, Michelangelo, Raphael and Leonardo da Vinci. During this time the art of printing was invented, and commerce between nations and countries was very active. Different peoples learned more about each other, and the appreciation of classic architecture, sculpture and ornament became widespread. The great artists of this period were architects and decorators. In Rome, Michelangelo designed the dome of St. Peter's; in London the cathedral of

Fig. 31. St. Peter's, Rome

Fig. 82. The Louvre, Paris

From manuscript.

From Raphael.

From San Michele, Venice.

From manuscript.

From Raphael.

Fig. 83

St. Paul was built and in Paris was constructed the beautiful art gallery called the Louvre, and later, the Grand Opera House, all in the Renaissance style (Figs. 31 and 32). Both lintel and arch were used in this new development and columns were often employed as a decorative feature, rather than as part of the construction. Ornament was often quite naturalistic in treatment, and bright colors were well distributed. As wealth and luxury increased, the moral tone of the people declined and a reflection of the times was seen in the ornament which became more realistic in tendency, and less structural in its character (Fig. 33).

Modern Architecture and Ornament

Influence of Environment. We have seen that in any country conditions of climate and of life affect the architecture. In rainless Egypt, a flat roof was possible; in Greece, we find the roofs built with a slight pitch or slope. As we go farther north, this slope increases until we have the sharp angle of the Gothic style, so rich with religious association and with learning that we still feel its appropriateness for church and college architecture. We find it adapted to governmental usage, in the dignified and impressive Houses of Parliament, in London. Many of the buildings of English universities are Gothic in style and in America we see examples in the various buildings of Chicago University, and in Trinity and Grace churches and St. Patrick's Cathedral in New York City. A modern example of the French Romanesque style is the beautiful Trinity Church in Boston, with appropriate interior decorations by John La Farge (Fig. 34).

FIG. 34. TRINITY CHURCH, BOSTON

Classic Styles. In Europe, as a recoil from the decadence of the late Renaissance, a revival of interest in classic art occurred in the eighteenth century, and extended in some degree, to this country. Belonging to this revival, we find in Paris, the Pantheon, the Arc de Triomphe, and the Church of the Madeleine; in London, the British Museum; in America, the Capitol at Washington (Fig. 35), the State House at Albany, and the State House at Boston. The Boston Public Library and the Field Columbian Museum at Chicago (Fig. 36) are more recent examples that show the influence of beautiful classic styles. The finest dwellings of pre-revolutionary times echoed this Greek revival, creating what is known as the Colonial style. This is well illustrated in Mount Vernon, the home of Washington, and also in many dwellings built in New England, New York, Pennsylvania, Maryland, and Virginia. No style more appropriately embodies the attributes of a home in its simplicity, its ample proportions, and in its effect of comfort and dignity.

Fig. 35. Capitol, Washington

FIG. 86. FIELD COLUMBIAN MUSEUM, CHICAGO

Steel Construction. There is as yet no distinctly American architecture, unless we except the commercial office building with its twenty and more stories. This style has arisen more from necessity than from choice, in order to meet the conditions of urban life in the congested districts of our large cities. It is, in its way, a wonderful exposition of the American ability to overcome obstacles and to meet a perplexing situation. Cramped for ground space, it pushes upward, this being possible with the modern steel construction, which, while comparatively light, is very strong, rising many stories in height from a solid foundation. Each story is supported or hung upon the steel frame, and does not rest upon the exterior walls. Heavy stone ornament is usually placed near the base, where it can rest upon the foundations; while above, either a stone or terra-cotta sheathing is used. In architecture this style of building presents a different problem. It must have many windows and numerous means of exit, and the prismatic shape cannot be greatly changed without weakening the structure.

Much of the decoration in office and public buildings in the future promises to be expressed in iron more than in any other material, because of its great strength and the ease with which it can be made a part of the construction. Iron combined with cement may develop great decorative possibilities.

Mural Decoration. In mural decorations we have much that is notable, such as the work of William Hunt upon the walls of the State House at Albany; the decorations in the Boston Public Library by Sargent, Abbey and Puvis de Chavannes; those by American artists in the Congressional Library in Washington; those in the State Capitol at St. Paul, Minn., and in many other public buildings.

FIG. 87. CITY INVESTING COMPANY BUILDING, BROADWAY, NEAR CORTLAND ST., NEW YORK

Photograph by Underwood & Underwood, New York

In the various arts and crafts original and excellent results are seen in stained glass, tiles, pottery, wood carving, metal, leather, bookbinding, jewelry, etc. In all our ornament the influence of the Japanese has been felt in better composition, greater nicety of execution, quality of line and simplicity of general effect.

Much can be gained through the study of historic ornament, not only for adaptation to practical use, but as a means of general culture. We learn to see what styles are opposed to each other and what styles are in harmony. We cannot combine, for instance, the Egyptian and Gothic, or the Saracenic and Gothic and produce harmony of spirit or structure. Through the study of historic ornament we read the story of the people. We see that their best art expression occurred at a time when their purpose and effort were highest. This should be a lesson to us for the present and for the future.

FIG. 38. MOSAIC FROM THE CONGRESSIONAL LIBRARY, WASHINGTON

CHAPTER VIII

ART HISTORY

A COMPLETE story of art would cover the attempts of individuals of practically all races in all ages to produce things, which, to quote a phrase made familiar by the English artist, William Morris, they "knew to be useful and believed to be beautiful." Every object fashioned by hand or with the assistance of simple machinery, if it has been created in a spirit of joy and enthusiasm, has, of necessity, artistic qualities.

Although the general term Art includes many arts and crafts besides architecture, sculpture and painting,— since things of the humblest usefulness may be beautiful,— these three arts, which, in nearly all periods have naturally drawn to their service the most gifted artists of the time, illustrate perfectly the principles underlying all artistic expression. By common consent, therefore, they are known as the Fine Arts, and individuals who excel in them are regarded as equally important with the great statesmen, generals, poets, historians, scientists and others whom mankind especially honors. Each of these arts, it should always be remembered, is useful as well as beautiful,— architecture in making orderly and agreeable what would otherwise be nothing but shelter from the elements; painting and sculpture in giving added cheerfulness, spaciousness and variety to the architect's plans, at the same time serving by representation of actual things to stimulate memory and imagination.

Architecture the Fundamental Art. Architecture is in many respects the most important of the fine arts. The prime physical needs of mankind are food, clothing and shelter, the last of which must be efficiently served by the architect. Much more, however, than protection is involved in architecture, for men in all times have had an instinct leading them to beautify the buildings in which they themselves have purposed to live or which they have constructed as the abodes of their divinities. Thus every historical period has produced temples and palaces as its finest types of buildings.

The requirements imposed upon builders in different climates and civilizations have given rise to differences in architectural style. The character of a building, if it is good architecture, is accommodated to the needs of the people who are to use it. The design and ornamentation of a house or church in a cold country, where steep pitched roofs are required to shed the snow, differ necessarily from the planning and decoration of a structure in the tropics, where protection from heat and earthquake must first be considered. A nation devoted to hard work and simple living, will create for itself an architectural style that may be refined and beautiful, but which will certainly be less showy than that prevailing in a country whose people are luxurious and pleasure-loving.

Among those nations and at these times in which life was fullest and richest, a noble architecture, suited to the requirements of the people, has invariably arisen. Such eras, pre-eminently, were the ages of Pericles in Greece; of the good emperors, Titus, Trajan, Hadrian and the Antonines at Rome; the Crusades in France, Germany and England; the Renaissance, or classic revival, in Italy and other countries; and again, the awakening of art in France in the nineteenth century. That our own country is entering upon a period in which it will, for the first time, have a truly important national architecture, is confidently predicted by many critics.

Sculpture and Painting as related to Architecture. Every national school of sculpture or painting has been the result of the employment of artists to adorn the work of architects. Not every age of notable architecture has produced both sculpture and painting of equal merit. In the best period of Greek art, sculpture was somewhat in advance of painting, reaching, in fact, an excellence that has never since been surpassed. The powerful and original architecture of the Roman Empire was accompanied by little sculptural or pictorial work of especial merit. The erection in the Middle Ages of the marvellous cathedrals of France made opportunities for many able sculptors, while practically the only painters whose work could be utilized were those who embodied their ideas in stained glass. The era of magnificent architecture in Italy during the fifteenth and sixteenth centuries was one in which there appeared the chief school of painters the world has known, as well as of sculptors who rank as inferior only to the Greeks. The same artistic movement, spreading to the northern countries of Europe, produced, particularly in Germany and the Netherlands, many strong painters and fewer sculptors. The intellectual supremacy of Paris in the nineteenth century is expressed in its architecture, complete and harmonious beyond that of any other modern capital. During the same century a body of the most competent professional painters of Europe practised its profession in France, and in the later decades a group of good sculptors arose. In Oriental countries, and particularly among the Japanese, for many centuries a highly artistic people, the three arts have risen and fallen together.

Our Indebtedness to the Ancients. From the ancient Greeks and Romans most of the existing methods and practices of the three allied arts have been derived. Architectural construction — except for forms recently made possibie by use of steel framing — is of two kinds: that in which the walls and roof of a building are made by joining upright posts or columns with cross-pieces, and that in which one block of material rests upon another block in the form of an arch. The first of these two types of construction was brought to practical perfection by the Greeks; the second, so far at least as the round arch is concerned, by the Romans.

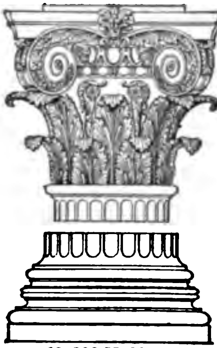
Every modern sculptor looks for information and inspiration to the comparatively small number of statues and sculptured reliefs which time has spared from the days of the best Greek art. Even painting, although no pictures of considerable value have survived, is known to have been brought by the Greeks for the first time in any country to a state of more than ordinary excellence. Again, most of the so-called minor or applied arts were first perfected in Greece or in Italy. Such achievements were the outgrowth of profound professional knowledge. In Greece, men first learned the art of drawing — or designing, which is really the same thing — and their technical skill gave them mastery of all the arts which they practised.

The Originality of Greek Art. Historians agree, in citing as a reason why the Greeks were an art-loving nation, that they were a lofty-minded and physically fine race that had settled in a varied and beautiful country and had there developed the institutions of a free people. A dispute exists, indeed, as to the extent to which the artists of the Greek cities were indebted to the craftsmen of earlier civilizations — specifically to the

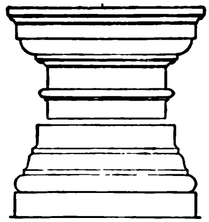
COLOSSI OF AMENOPHIS III, THEBES

Egyptians, Assyrians and Phœnicians. Seafaring men and merchants from Grecian cities unquestionably, long before 776 B. C., the date of the first Olympiad from which the Greeks reckoned their chronology, visited the lands across the Mediterranean and saw in Egypt the pyramids, temples and rock-hewn tombs, the gigantic sculptured and pictorial decorations, some of which are still preserved, or again, in the valley of the Tigris and Euphrates, vast cities with buildings of sun-dried brick bearing bas-reliefs which depict the exploits of Assyrian monarchs. After witnessing such wonders they may, no doubt, have wished to convert their own rude buildings into magnificent architecture and to adorn these with sculptures and paintings. Yet in fulfilling the wish they certainly did not to any considerable extent imitate the strange, grotesque creations of the older lands. Greek art, even in its crude

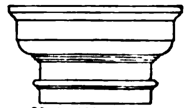
ASSYRIAN BAS-RELIEF



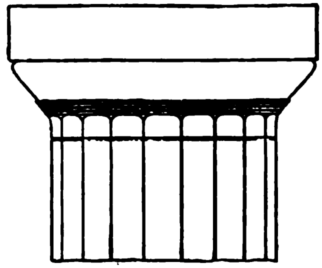
COMPOSITE ORDER
ARCH OF TITUS, ROME



TUSCAN, OR ROMAN DORIC
FROM THE COLISEUM, ROME

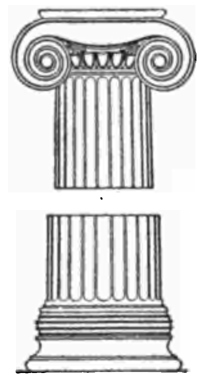


ROMAN DORIC ORDER.
THEATRE OF MARCELLUS, ROME



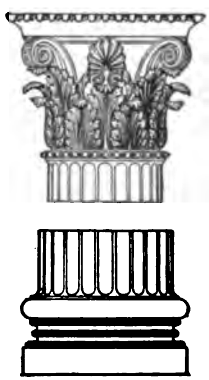
Doric Capital — Parthenon.

beginnings, shows that the effort of the artists was always to be cheerful, orderly, and free from exaggeration or eccentricity. These characteristics are prominent in all their arts, literary as well as graphic.



IONIC.
TEMPLE OF NIKE APTEROS.

Greek architecture very early became well proportioned, symmetrical and graceful. The first buildings were of wood, oftentimes with tall shafts of timber connected at the top by beams, forming porches or porticos. Out of these wooden pillars were evolved the columns of stone that are so prominent an element in all classic architecture; the unadorned Doric, surmounted by a square tile or abacus, resting under the architrave or principal horizontal beam of the upper part of the building; the Ionic, with scroll-like capital; and the Corinthian, with capital of the conventionalized leaves of the acanthus, or Grecian thistle. In later days two other kinds of columns were employed: the composite, a combination of the Ionic and Corinthian, and the Tuscan, a variety of the Roman Doric with unfluted shaft. Each of these five types, or architectural orders, as they are called, is in common use today, and may be seen in public and private buildings of every modern city. In this country



CORINTHIAN.
TEMPLE OF APOLLO AT MILETUS

METOPES FROM TEMPLE AT SELINUS

we have Corinthian capitals on the Capitol at Washington, the Ionic on the Treasury Department, the Doric on the Patent Office. Such examples could, of course, be multiplied indefinitely.

The Greeks, in constructing of marble or other material, either temples for their gods or structures for their own uses, employed the architectural orders with ever-increasing refinement of proportions and details. Knowing the diameter of the base of one of the columns, a clever architect could—and can—work out the dimensions of a whole building by rule and formula. The delicate accuracy with which these relations were established, along with almost numberless little intentional variations from mathematical exactness, is held to be proof of the extreme sensitiveness of the Greeks to the beautiful. The ruins of such temples as those at Selinus in Sicily (which was a Greek city), at Ægina, on the island of Ægina near Athens, and at Bassæ, in Arcadia, still give abundant instruction and inspiration to architects.

The Parthenon at Athens. But the Parthenon, or temple of the goddess, Athene, stands, though in ruins, as the finest relic of classic architecture. It was erected on the Acropolis, a rocky height commanding the city of Athens, in the stirring days when Greece was reconstructing the cities that had been demolished during the Persian invasion. Built in accordance with plans by Ictinos and with the co-operation of Pheidias, the leading sculptor of the age of Pericles, it was completed about 437 B. C. Down to 1687 it was in a comparatively good state of preservation, but an explosion at that date of some barrels of gunpowder which the Turks, who were holding the city of Athens against an invading force of Venetians, had placed within its walls, did irreparable damage to the beautiful edifice.

Early Greek Sculpture. Remarkable as the architecture of the Greeks was, the nation reached as high, perhaps even higher, achievements in the art of sculpture. At all events the growth of the two arts was on similar lines. Carving of rude figures in wood was an early mode of adorning the temples. Later, the use of marble, which was found in Greece in almost unlimited quantity and of superlative quality, made rapid improvement of the art possible. About the beginning of the sixth century B. C. methods of casting in bronze and of inlaying gold and ivory on a wooden framework were invented. Thereafter, through a line of sculptors, some of whose names have come down to us, the art advanced to essential perfection in the fifth century.

THE ACROPOLIS AT ATHENS

Two main circumstances made abundant work for the Greek sculptors. The first was the demand for representations of mythological subjects suitable for the adornment of temples and other important buildings. The second was the custom that had arisen of honoring the winners of victories at the Olympic and other games with statues which, as far as possible, were actual likenesses of the persons depicted. Between these two kinds of sculpture there was a certain opposition, though the difference in principles has often been overstated. The religious and decorative art has been called ideal; the representative art, realistic.

DISCUS THROWER — MYRON

FROM THE EAST PEDIMENT OF THE PARTHENON

Each type had its adherents. Myron, a bronze founder, who made elaborate studies of athletes, and whose spirited Discus Thrower, in the shape of a late copy, is very familiar, was the leader of the realistic school.

Pheidias, the Greatest of Greek Sculptors. Of the idealistic sculptors, by far the ablest and the most famous of all times was Pheidias, an Athenian by birth, whom Pericles, when he entered upon his celebrated presidency in 444 B. C., made superintendent of the whole work of adorning the Acropolis with a group of temples and their approaches. In this position the sculptor, already famed for his accomplishments, directed the production of the noblest series of sculptural works ever executed anywhere.

HEAD OF ZEUS FROM MYLASA

Nothing, to be sure, that is definitely known to have come from Pheidias' hand has been preserved, but the very beautiful statues and high and low reliefs of the Parthenon, many of which were carried from Athens to England by Lord Elgin in 1812 and are now in the British Museum, were all executed by sculptors supervised by him, and many of the works no doubt received his personal attention. Among statues by Pheidias that have been lost but that had world-wide fame among the ancients were several representations of the goddess Athene at Athens and one of the Panhellenic Zeus at Olympia, the scene of the national games. An original marble now in the Boston Museum of Fine Arts is believed to be a copy, by an unknown sculptor, of the head of Pheidias' Zeus.

Pheidias was an idealist in the sense that he sought not so much to present to the world the carefully studied likenesses of human beings — though he had abundant knowledge of the facts of the human form — as to embody his conceptions of the various divinities worshipped by his fellow countrymen.

Other Sculptors of the best Period. At the same time with and immediately after Pheidias, many sculptors executed, each in his own way, works of which the few remaining examples are among the most valued of all art treasures. Among such men were Polycleitos of Argos; Praxiteles, whose Hermes with the infant Dionysos is perhaps the finest of all surely authenticated Greek sculptures; Lysippus, the only sculptor by whom Alexander the Great would be represented, and Chares of Lindos, designer of the colossal bronze statue, 105 feet high, which for many years stood at the entrance of the chief harbor of the island of Rhodes, and which centuries later was carried away in pieces by Arabs for the sake of the valuable metal.

HERMES AND THE INFANT DIONYSOS — PRAXITELES

In spite of increasing skill and understanding of technical processes among Greek sculptors, the art gradually degenerated with the degeneration of the national life. The artists, more and more as a concession to public taste, gave their attention to representing sensational and even revolting subjects, often in a spectacular and repulsive manner. During what is known as the Hellenistic age of

GREEK VASE

sculpture, comprising the centuries after Greece had ceased to be a nation and had become subject to foreigners, very little meritorious sculpture was produced.

Painting Among the Greeks. The art of painting in color may, as some critics believe, have been nearly as highly developed as sculpture in ancient Greece. Nothing of the art, however, except almost innumerable paintings in flat tones on pottery, has survived to this time. Our knowledge, therefore, is confined practically to the names of a number of painters, about several of whom pretty anecdotes are recorded, and to literary descriptions, not usually trustworthy, of their works. Among the most celebrated painters were Polygnotos of Thasos (415 to 455 B. C.), whose representations of mythical events adorned many public buildings in Athens and other cities; Zeuxis and Parrhasios, rival realists about whom is told the well-known story that the one rendered a study of grapes so naturally that birds came and pecked at them, while Parrhasios painted a curtain which deceived even Zeuxis himself; and Apelles, the most renowned of all painters of antiquity, a favorite of Alexander the Great and universally esteemed for his allegorical representations. Apelles had a few worthy successors, but the art of painting steadily declined during the Hellenistic period, as did all the arts.

Architecture the Characteristic Art of the Romans. Although the Romans had practically no painting or sculpture of their own, being content to hire Greek craftsmen to perform what they regarded as menial labor, they created an architecture which, although it resembled that of the Greeks in its details, was thoroughly original in spirit. The difference may perhaps be expressed by saying that the Romans conceived of architecture primarily as an engineering proposition.

The exquisite architectural forms derived from the best period of Greek art, together with the round arch which had been extensively used

ROMAN COLOSSEUM

by the Etruscans in the section of Italy immediately to the north of Rome, were tastefully applied to almost innumerable useful projects — to the building of city walls, sewers and bridges, to aqueducts for bringing pure water across the plains from distant mountains, to the public baths which played an important part in Roman living, and to outdoor amphitheatres, such as the celebrated Colosseum, the remains of which, covering about five acres of ground, are still a landmark of the Imperial City. Two famous and beautiful examples of Roman memorial architecture are the Triumphal Arch of Constantine at Rome and the Arch of Trajan at Beneventum.

A prominent characteristic of the Roman, which was manifested in his plan of government as well as in the style of his spoken and written language, was his love of antithesis — of balancing one element against another and thus securing strong contrasts. This same liking has made his architecture well balanced, formal and very usable. Modern architects and engineers acknowledge indebtedness to their Roman predecessors. Particularly in the United States, where many large public works of an engineering nature have been installed, the principles of Roman architecture are in constant application. The span of Cabin John's Bridge near Washington, the arched High Bridge over the Harlem in New York City, Echo Bridge on the Charles near Boston and many approaches to State capitols and other public buildings illustrate the ancient axiom that "all roads lead to Rome."

The only department of sculpture in which the artists working under the Romans excelled, was in portraiture. Bronze and marble likenesses of emperors and other distinguished personages which have been preserved, show usually a right understanding of the character of the sitter, good knowledge of the facts of anatomy, and appreciation of picturesque effect. No other remarkable achievements in sculpture or painting are to be noted either

PORTRAIT BUST OF AUGUSTUS

under the Republic or the Empire, though the uncovering of the city of Pompeii, buried in 79 A. D. by an eruption of Vesuvius, has revealed much art of moderate merit.

Romanesque Architecture. The fine arts degenerated during and after the decline of the Roman Empire, — architecture to a rather less extent than the other arts, for even in the disturbed centuries, the Christian Church continued to build churches and monasteries. The style of architecture that was developed from the time of the Emperor Constantine (about 328 A. D.) to the death of Gregory the Great, in 604, and that was continued for several centuries more, is known as the Romanesque, a name indicating its Roman origin. The builders made much use of the round arch, and of extremely massive walls and towers. Meantime, in the eastern division of the Roman Empire of which Constantinople was the capital, down to its capture by the Turks in the fifteenth century, another architecture, the most apparent characteristic of which was the extensive use of the dome, grew into considerable splendor. This style is called Byzantine, from Byzantium, the ancient name of Constantinople. The most

CHURCH OF SANTA SOPHIA, CONSTANTINOPLE

famous example is the church of St. Sophia in the Turkish capital, a vast structure consecrated more than thirteen centuries ago by the Roman emperor Justinian. The Romanesque style was at one time very popular in the United States. A notable example is Trinity Church, Boston (page 298).

The Gothic Period. In western Europe, from the seventh to the fifteenth centuries during the Middle Ages which succeeded the dark ages, there arose and flourished a beautiful and logical type of architecture known as the Gothic, from the name of the Germanic invaders of the Roman Empire. Especially after the year 1000 A. D., at which time it was generally believed the world would come to an end, a mania for building seemed to seize all Christian lands, and many great religious structures were reared.

The distinguishing marks of Gothic architecture, as found in churches and cathedrals of France, Germany, Italy, Spain and England, are its lightness and its aspiring qualities. The builders departed from the heavy massive style of the Romanesque period, using pointed as well as round arches and seeking to secure lofty towers, spacious interiors and broad window spaces, all with the very minimum of building material needed to accomplish the desired result. It was a frank architectural style, one in which every element of the construction was made to show its use. Great variety in detail resulted from the fact that the architects were guided by few of the fixed rules that had prevailed in Greek and Roman architecture, and designed an ornamentation based on all manner of natural and grotesque forms. Gothic building reached its perfection in French structures erected for religious purposes in the twelfth and thirteenth centuries.


NOTRE DAME, PARIS

Gothic architecture has been very generally employed in church building in this country. A familiar structure is St. Patrick's Cathedral, in New York City, which illustrates many of the details of the best Middle Age buildings. Trinity Church, New York, is also Gothic, and the great pile of the cathedral of St. John the Divine, on Morningside Heights, which will require half a century to build, represents a combination of Gothic and Romanesque. The buildings of the United States military academy at West Point are being remodeled in accordance with Gothic designs.

Gothic Sculpture and Painting. Gothic edifices of the best type contained so much window space that they offered very little opportunity for display of mural paintings. The art of stained, or painted, glass, however, which began to be practised about 800, came to be regarded as an essential part of church decoration. Many windows of the later Middle Ages still furnish models of exquisite color and design. This art is one of especial interest to Americans, since our workers in stained glass have come to surpass those of any other modern nation and to rival the Middle Age artisans.

Among the slender columns, piers and buttresses of Gothic churches many niches or recesses were necessarily created, and the custom grew up of filling these with sculptured figures of angels, saints or important dignitaries of the church. Great wealth of architectural ornament was applied at the same time to both interior and exterior parts of the churches. Sculpture consequently reached a larger importance than it had had since the centuries in which it flourished in ancient Greece. Such works as those in the cathedrals of Rheims, Amiens and Paris in France and of Strasburg and Freiburg in Germany, even though the names of the sculptors have generally not been preserved, are to be accounted hardly inferior to the sculpture with which the finest Greek temples were decorated.

CHOIR STALLS, CATHEDRAL OF AMIENS
From Stereograph, Copyright, 1907, by Underwood & Underwood, N. Y.

Italy and Gothic Art. The Gothic architecture and sculpture which were accepted for a time by every country of western Europe made less impression upon

Italy than upon any other. Rome continued to be devoted to the Romanesque during all the Gothic centuries, and Ravenna, for a long time a thriving city situated near the head of the Adriatic Sea, was proud of an art somewhat resembling that of the nations of western Asia. In other Italian cities, although forms of Gothic were employed in both religious and civil buildings, they were quite different in spirit from corresponding structures in the countries to the north of the Alps. They were more massive, with smaller windows, and offered greater expanses of wall space for decoration with illustrated lessons from the Bible or with scenes from the history of the church.

The fact of this architectural difference, which was due both to the Italian climate with its abundance of strong sunlight and to the traditions of the older Roman style, may have accounted for the beginning of the Italian school of painting, which finally surpassed every other school.

Mural Paintings and Easel Pictures. In Italy, at all events, the ancient art of figure painting on wall surfaces, or mural painting, as it is called, which had been all but lost in the dark ages, was gloriously revived in the thirteenth century. The favorite method up to this time had involved the use of "fresco," whereby carefully ground colors were laid on wet plaster into which they soaked and spread. Fresco is still employed in the decoration of buildings. One of the objections to it is that there is no chance to correct mistakes or improve on the original design. Once on the wall the color is there to stay.

Another method of the painter's art came into popularity about 1350. Panel, or easel pictures, hung on the wall instead of being painted upon it, began to be commonly produced. These were executed at first in distemper, a preparation consisting of colors mixed with size or weak glue; but later it was discovered that oil furnished a more convenient medium in which to grind the pigments.

Encouraged by a widespread popular demand for the decoration of buildings, a succession of distinguished painters arose, each of whom contributed something to the sum total of professional knowledge and skill. The Italian master, as a rule, had pupils or apprentices in his shop who learned all that he could teach, and who later often improved upon his instruction. In the chief cities of Italy, furthermore, there grew up painters' guilds, which gave the artists the benefit of co-operative effort.

The Revival of Learning. The Renaissance, or revival of learning, which developed in Italy somewhat before the beginning of the fifteenth century and reached its height about a century later, was very helpful to the art of painting. A revolt from the ignorance of the Middle Ages led men to renewed study of the almost forgotten literature and art of the Greeks. Interest in science was aroused at the same time. Great trading towns had grown up. Connecting a number of cities of northern Italy, such as Venice, Milan and Florence, with the Rhine Valley was a definite route across the Alps, traversed by wandering merchants. Along this route, in Italy, Germany and the Low Countries, the art of painting as it exists at this day was first developed.

The Early Painters. The beginning of the revival of the painter's art dates back into the days of chivalry. Even Italy was still in the Middle Ages at the time when Cimabue, born in Florence, in 1240, painted his famous picture of the "Madonna Enthroned," now in the Florentine church of Santa Maria Novella, which entitled him to be called "the father of modern painting." His work is now remarkable chiefly because the artist, though aiming, as the elder painters aimed, to produce an interesting pattern of lines and tints, departed from their conventional practice in rendering his figures, which he tried, even if not very successfully, to draw in a natural life-like manner.

MADONNA BY CIMABUE IN SANTA MARIA NOVELLA, FLORENCE

Cimabue's great successor, Giotto (1266–1337), was a contemporary of the most eloquent exponent of mediæval philosophy, the poet Dante, whose portrait indeed is one of the most cherished works preserved from the period. Giotto, like most of the Italian artists, was many-sided in his talents, being a competent architect as well as painter. His Campanile, or bell tower, in Florence, illustrates excellently the beautiful way in which the Italians selected such of the Gothic principles as suited their requirements. As a painter, Giotto studied the human figure carefully and sought to convey a sense of motion and vitality in many of his pictures.

PAINTING OF DANTE BY GIOTTO

A succession of painters followed at Florence, then one of the most prosperous and intellectual of Italian cities, amongst them Fra Angelico (1387–1455), an inspired monk, whose works are esteemed for their spiritual character; Massaccio (1401–1428), whose pictures, filled with evidences of striving after exact knowledge of the facts of anatomy, are nevertheless extremely poetic and refined; Sandro Botticelli (1447–1515), one of the most impressionable characters of his time, a follower in late life of the reforming monk, Savonarola, and, throughout, a painter of exquisite works that bear traces of his early training as a goldsmith.

CAMPANILE BY GIOTTO

In such a painting as Botticelli's "Coronation of the Madonna" in the Uffizi Gallery, Florence, the striving of the fifteenth century Florentine artists after the beauty of well-studied form is epitomized. The grouping of the five figures within the circle is such that the attention is necessarily led to the radiant Christ Child. Every other part of the composition has, at the same time, been made interesting. The three youthful

CORONATION OF THE MADONNA BY SANDRO BOTTICELLI

heads, which, together with the hands and arms above Mary's head, make a circle within the circle, are all beautifully wrought. Even in the black-and-white reproduction something of the richness and splendor appropriate to a coronation is to be observed.

The Venetians. Meantime, Venice, the wealthiest of Italian trading cities, situated on a group of islands at the head of the Adriatic Sea, was not far behind Florence in devotion to the fine arts. Leaders of the Venetian school were the Bellini family, the first member of which to be distinguished as a painter was Jacopo Bellini (1395–1470), whose even more famous sons were Gentile and Giovanni. The latter of these, in particular, who painted noble, dignified works of church decoration, has sometimes been proclaimed to be the greatest of all decorative painters. One of his younger contemporaries was Carpaccio, a painter whose work appears strikingly modern. The figure of a boy playing a mandolin, a detail of a picture in the Venice Academy, is one of the most popular works of the early Renaissance.

Rival Schools of Painting. Groups of artists appeared in other Italian

BOY PLAYING MANDOLIN, BY CARPACCIO

cities also, as in Siena, Perugia, Ferrara, Bologna and Padua. The rivalry among these was doubtless as potent a cause of artistic improvement as rivalry among modern schools and colleges has been of athletic development. Cities often competed for the services of a master of painting or sculpture. Thus the Duke of Milan for many years entertained one of the most remarkable men of the period of the awakening, Leonardo da Vinci (1452–1519), a Florentine by birth, described on a monument erected in his honor in Milan as the "Renewer of the Arts and Sciences." Leonardo, more than perhaps any other man, embodied the eager, inquiring disposition of the Renaissance. He took such interest in engineering projects, mathematics, natural history and kindred subjects that he accomplished less in painting than might have been expected from a man of his wonderful talents. His is, nevertheless, regarded as one of the foremost names in the history of art. His "Last Supper," now practically in a state of ruin on the walls of a convent in Milan, and the portrait of Mona Lisa in the Louvre at Paris have been made very well known through popular reproductions. The latter work is one upon which the painter spent years of effort, and which he left unfinished. The technical reasons for the fascination which it has exercised upon many generations are to be sought in the delicate blending of light and shade, in the skill with which the individual

MONA LISA, BY LEONARDO DA VINCI

MOSES, BY MICHELANGELO

character of the head and hands has been rendered, and in the suggestiveness of the incomplete background. Withal, the whole picture seems to be filled with indescribable sentiment and mystery.

Raphael and Michelangelo. Leonardo's reputation was somewhat overshadowed in his own time by that of two other Florentine artists, Michelangelo, whose surname was Buonarroti (1475–1564), and Raphael Sanzio (1483–1520). These names are generally considered the greatest in the history of Italian art. Each of the men had personal peculiarities which historians have liked to set in contrast, but they were alike in giving adequate expression to the spirit of the age.

Michelangelo was versatile, energetic and industrious; successful in sculpture, architecture and literature, to each of which he applied himself with enthusiasm and with full confidence in his powers. In his long lifetime he executed a series of grandiose statues which, though quite different in conception, came near to rivaling the works of the Greeks, both in understanding

Portrait of Himself, Raphael

Delphic Sibyl, by Michelangelo

of anatomy and in expression of sublime attitudes. His "Moses" is one of the most famous sculptural works in the world. Representing the prophet seated, it gives by means of the largeness of his body and limbs and the firm poise of the long bearded head a sense of the personal power necessary to lead a nation out of bondage.

Michelangelo's painting was only slightly inferior to his sculpture. Summoned in 1508 to paint the ceiling of the Sistine Chapel in the Vatican at Rome he produced decorations of astonishing invention and sublimity. Among these, the representations of the Delphic and Cumæan sibyls have been made particularly familiar through reproduction.

Michelangelo was also a skilled architect and engineer to whom the important work of fortifying both Rome and Florence was entrusted. His career, though saddened by infirmities of temper, was uniformly fortunate, so far as artistic achievement could make it so.

Raphael, unquestionably the most popular of all painters, is generally held to stand at the culmination of advance in Italian art. Before him there were

SISTINE MADONNA, BY RAPHAEL

progress and improvement; after him came centuries of deterioration. Perhaps because of this position which Raphael occupies in art history, the attitude of many present-day critics toward him is by no means cordial. His painting certainly contains defects and mannerisms which his followers exaggerated into very serious faults. He was nevertheless a marvellously able painter, quick, receptive, daring and original. Several of his representations of Mother and Child, including the Sistine Madonna and the popular "Madonna of the Chair," are not only among the best liked of pictures but are among the best painted. His portrait of himself reveals a youth of singularly noble countenance. Study of the Sistine Madonna shows that it excels particularly in qualities of line, that is, in separation of the different masses of the picture by graceful, flowing contours, which, as in nature, are now hard and sharp, now almost lost.

Raphael's brief life was full of honors and successes. The serenity of his disposition is reflected in his pure, spiritualized art.

The Great Venetians. Despite the leadership in painting of the city of Florence, Venice continued to be a vigorous rival. Giorgione, or George the Great, the popular name of Giorgio Barbarelli (1477–1511), was a strong painter whose work was interrupted by an untimely death. He introduced new processes, technically known as scumbling and glazing, which increased the range of the painter's powers of expression. He excelled particularly in portraying richly apparelled residents of the island city in which he lived.

The Entombment of Christ, by Titian

The most wonderful painter, unquestionably, of the Venetian school was Tiziano Vecelli, more generally called Titian (1477–1576), a pupil of the Bellini. Titian practised his profession continuously from boyhood almost to the day of his death, in his ninety-ninth year. He was strong, as were most of the Venetians, in color. His drawing, too, though less severe than that of the great Florentines, was well-nigh faultless, and his composition, or grouping of figures, very effective. The "Entombment of Christ" in the Louvre, Paris, is considered by many critics to be his greatest picture.

Of nearly equal reputation among the critics of later days are Paul Veronese (1528–1588), whose immense "Marriage at Cana" is one of the capital possessions of the Louvre, and Tintoretto (1518–1594), one of the most prolific of Italian painters, whose speed of execution gave him the nickname of "Il Furioso" (the Inspired). His best work is "The Miracle of St. Mark" in Venice.

Holy Night, by Correggio

Somewhat outside of the regular schools of Italian painters was Correggio (1494–1534), who did valuable work in various cities of northern Italy. No artist before his time had ever so completely mastered the problem of light and shadow. Space, light, and motion were what he sought to express. Certain frescoes in churches and convents of the city of Parma, where he was born, lived and

ONE OF THE DOORS OF THE BAPTISTERY

died, represent him at his best. The celebrated "Holy Night" in the Dresden Gallery, in which a sweet-faced mother leans with brooding tenderness over her babe, illustrates the manner in which Correggio often throws a strong white light upon the portion of the picture which he wants to emphasize.

Italian Sculpture. Michelangelo was by no means the only important sculptor of the Italian Renaissance. The art of sculpture reached, in fact, a development only a little inferior to that of painting. One of the earliest of the masters was Lorenzo Ghiberti (1378–1455), of whose sculptured gates at the Baptistery of St. John in Pisa Michelangelo once said, "They are worthy to be the Gates of Paradise."

A great artist of the fifteenth century was Donatello (1386–1466), a sculptor who modelled the human form as nearly as possible exactly as he saw it. Among other things for which Donatello is famous is the first equestrian statue ever erected, one at Padua, representing a Venetian general on horseback. Since his day equestrian statues have become numerous in nearly all cities of Europe and America.

Members of the Della Robbia family were able sculptors of Florence in the fifteenth century. Notable not only for works which he left behind, such as his statue of "Perseus," but for one of the most interesting autobiographies ever written, was Benvenuto Cellini (1500–1571).

Flemish and German Art. Along the route followed by the merchants from North Italy to London, over the Alps and thence down the river Rhine, were several cities which were early aroused by the same awakened interest in arts and sciences that was felt in Italy. The architecture of these towns began to differ from that of places off the main line of travel. Schools of painting and sculpture sprang up, often with healthful competition among themselves.

Especially in painting, individual German, Flemish and Dutch artists attained a celebrity surpassed only by the Italians. Patience, love of fine work and great technical ability marked all their efforts. The invention of oil colors is attributed to the artist members of the Van Eyck family of Ghent, in Belgium (about 1330 A. D.). Previously various vehicles, such as size and white of egg, had been used as a means of conveying pigments over flat surfaces of plaster, stone, wood or canvas. The new medium made possible a degree of finish that had never before been attained. Oil colors speedily came into use among the painters of all lands.

The Van Eycks — Hubert (1366–1426) and Jan (1386–1440) — were very capable painters, noted for delicacy and fineness of technique. Similar characteristics appear in their successors, of whom Hans Memling (1450–1494) was a painter of peculiarly refined perceptions.

The Greatest German Master. Nearer to Italy a school of strong artists arose in the German city of Nüremburg. Among these, Albert Dürer, an efficient man, poet and architect as well as engraver and painter, represented the Renaissance in Germany quite as faithfully as Michelangelo or Titian in the land on the other side of the mountains. Dürer's art was distinctly national. He painted for a short time in Venice about 1505 and came under the influence of the colorists of that city, but throughout his life he affected in the choice of his subjects the strange, weird imaginings, executed with a high degree of finish, which the northern races of Europe have always admired. His great altarpiece in the Dresden Gallery, in the central panel of which the Virgin is seen praying over the Child, has distinct unity of design and rhythm of light and shade despite the complexity of the detail. Dürer was particularly

ST. MARK AND ST. PAUL, BY ALBERT DÜRER (Munich Gallery)

PORTRAIT OF A MAN, BY HOLBEIN

BURGOMASTER MEIER MADONNA, BY HOLBEIN

eminent as a wood-carver. His engraving entitled "The Triumphal Arch of Maximilian," composed of 92 separate blocks, the whole wood-cut being 9′ x 10½′, was regarded in his lifetime as a marvellous technical achievement.

Another very powerful German painter was Hans Holbein, "the younger" (1497–1543), the third of a family of the town of Augsburg to become noted for artistic attainments. Holbein made his permanent home at Basle, but spent many years at the court of Henry VIII, in London, where he died during the prevalence of a plague. His most popular work, undoubtedly, is the "Dance of Death," a series of wood-cuts, in each of which a skeleton is depicted in the act of drawing some victim from the scene of his earthly activities. Holbein is accounted one of the ablest of the world's portrait painters. He executed also, compositions of sacred subjects. Probably his most meritorious painting of this character is the Burgomaster Meier Madonna, now at Dresden, which takes its name from a German official for whom it was painted. The members of the Burgomaster's family are represented as kneeling before Mary, who stands in an architectural niche holding the infant Christ. The arrangement or composition of the figures, so that no one is unduly prominent, and the careful characterization of the individual heads, are marks of Holbein's best manner.

Rubens, Van Dyck and Frans Hals. The commercial prosperity of the Netherlands, then the trading center of northern Europe, was favorable to art. The cities of what are now Holland and Belgium, vied with each other in decoration of their churches, town-halls, and private houses. Antwerp was particularly proud of being the home of Peter Paul Rubens (1577–1640), painter, linguist and diplomat, hundreds of whose vigorous canvases abound in the quaint Flemish city. No other man of northern lineage so adequately represented the spirit of the Italian Renaissance. He was master of the culture of his day, a skilful politician, and still he found time to paint more than 1,800 pictures, some of them of enormous size. Such a canvas as his "Descent from the Cross" at Antwerp is admirable for the evidences it contains of all-conquering energy and technical facility that made stupendous tasks easy of accomplishment. Rubens' painting was never pretty, not always beautiful, but it was consistently robust and masterful.

THREE CHILDREN OF CHARLES I, PAINTED BY VAN DYCK
(Royal Gallery, Dresden)

Rubens had many pupils. Of these the most distinguished was Anthony Van Dyck (1599–1641), who, as court painter of Charles I of England, is now represented by hundreds of portraits of gay cavaliers in British museums and manor-houses.

One of the greatest of the men of this age, in the estimation of nearly

A JOLLY MAN, BY FRANS HALS

all modern painters, was a merry, dissolute fellow of the Dutch city of Haarlem, Frans Hals (1584–1666), who painted with remarkable facility and strength, not only individuals, but also groups and associations of Dutch business men, sometimes containing thirty or forty half-length or three-quarter length figures. A gallery at Haarlem is filled with these big "corporation pieces," as they are called, which reveal in Hals a portrait painter who was able to secure singularly complete truthfulness and fidelity to the character of the solid, well-conditioned people among whom he lived. Frans Hals set the pace for many very competent artists who followed during the years in which Holland was one of the principal powers of Europe.

Rembrandt. Of all these Dutchmen the most noted was Rembrandt van Rijn (of the Rhine, 1606–1669), the three hundredth anniversary of whose birth was celebrated in Holland in the summer of 1906. Rembrandt was recognized by his contemporaries as a very original artist. His reputation has steadily grown in the last two centuries.

A citizen of the Dutch city of Amsterdam, in Holland, Rembrandt, like other artists of his time, painted portraits of substantial dignitaries and their wives with a method — much imitated since his day — of throwing strong light on the faces and other important parts while casting the rest of the picture into deep shadow. His group portraits, sometimes involving a score or more of individual likenesses, give usually a sense of sunlight vibrating in a darkened room. Using this method as a means of expression, Rembrandt was able to make wonderful display of his penetrating knowledge of human nature and of landscape effects. He was quick to seize upon dramatic action of the head or hand. "The Anatomy Lesson," a study of a group of physicians gathered about a nearly nude figure, a work which was painted when the artist was only twenty-six years old, is interesting in its setting forth of scientific earnestness, and very beautiful in the contrasts of strongly illumined faces, reinforced by white ruffs and dark velvety cloaks. Equally effective are such pictures as "The Syndics," a group of the six directors of a Dutch dry-goods corporation, and "The Night Watch," a turbulent band of armed men led by a certain Captain Cocq. Rembrandt painted mythological subjects and a few landscapes as well as portraits. He has also been called the "Prince of Etchers," since he was the first to discover the full possibilities of the art of copper-plate etching.

Dutch art reached its highest development in Rembrandt though he had several very able younger contemporaries. One of these was the cattle painter, Paul Potter (1625–1654), whose untimely death interrupted a promising career. The "Young Bull" at The Hague is a famous canvas. Peter de Hoogh (1632–1681) was a painter of interiors depicting scenes of common life, which are in high favor both with artists and collectors of today, as are the somewhat similar works of Jan van der Meer of Delft (1632–1675). Jacob Ruysdael (1625–1681) is held to be the most gifted of the early painters of landscape, a branch of art which had never before been painted independently, — the great Italians and their followers using it simply with reference to the background of figure compositions.

MAN WITH FUR CAP, BY REMBRANDT

Spanish Art. Spain, a country in which a fine type of Gothic architecture was created in the later Middle Ages, was slow to feel the effects of the awakening which swept Italy and the Rhine Valley in the fifteenth and sixteenth centuries. Several moderately good painters, however, appeared during and after the reign of Ferdinand and Isabella. El Greco (1548–1625) was an Italian-trained artist of originality and power. Finally in Velasquez (1599–1660) Spain acclaims perhaps the greatest of all the world's painters. An untiring and observing student of nature, of strong will

PORTRAIT OF POPE INNOCENT X, BY VELASQUEZ
(Museum l'ermitage, St. Petersburg)

power and lovable disposition, Velasquez — so most painters of the present assert — mastered his art as hardly any other man has acquired it. Chosen while still a young man to be court painter of Philip IV, he had every possible advantage in advancing toward perfection; opportunity to study the works of his Italian predecessors, friendly intercourse with painters of his own time and, above all, the encouragement of intelligent and discriminating patrons. His early training in very careful drawing and painting of studies of common life stood him in good stead when he was obliged to work under great pressure, and, though he was forced to adopt a method, he never fell into mannerisms of execution. His art, as shown in "Las Meninas (The Maids of Honor)," "The Tapestry Weavers," "The Surrender at Breda," "The Topers" and scores of other works, very many of which are now in the Prado, a museum at Madrid, included about everything with which the painter may legitimately concern himself, while it is singularly free from artificiality and false sentiment. No other painter has so successfully conveyed a complete impression of form as revealed in atmosphere. Even the portraits of his young manhood, such as "The Laughing Peasant," depicting a plain-visaged and roughly-clad youth upholding a flower in his right hand, are executed with excellent understanding of all the steps necessary to secure correct relationships of light and dark and of color, of hard and soft edges, of rough and smooth surfaces. In such canvases as "The Surrender at Breda" the pomp and splendor of a great military event are depicted with all the complexity of detail in so final a way that the alteration or addition of a single lance would be almost unthinkable.

No great school of Spanish art followed Velasquez, just as none had preceded him. The only other important name is that of Murillo (1618–1682), a painter at first of hard, severe studies of humble life and later in his career of capable, though rather insipid, religious compositions.

The Arts in France. Powerful country though France was in the sixteenth and seventeenth centuries and filled with meritorious works executed in the Gothic period, the art flourished mainly through imitation of the Italians. No French artists of this era can in any way be compared with Titian and Holbein, Velasquez and Rembrandt. Claude Lorraine (1600–1628), a very interesting landscape painter, who rendered outdoor scenes suffused with beautiful golden haze, was indeed a Frenchman by birth but an Italian by residence and sentiment. Many of the painters who worked in Paris under Louis XIV are significant in the eyes of the French, but not of the world at large. Even in the eighteenth century, when the gay life of the French capital was mirrored in more or less appropriate forms of architecture, painting and sculpture, there were no artists who now stand out as vital figures in the progress of the fine arts. Dainty representations of unreal shepherdesses with flaunting ribbons tied about their crooks were what the artificial age of Louis XV and Louis XVI admired. Even the French Revolution, occurring at the end of the century, was accompanied in art only by a reaction in favor of the severest styles of the ancient Greeks and Romans. It seemed for a time to be believed that whatever beauty there lies in form had all been discovered in the age of Pericles, and that modern artists could legitimately do nothing but follow the examples of that time. Hence the severely classical pictures of David (1748–1825) and of his distinguished pupil Ingres (1780–1867), the latter one of the most accomplished draughtsmen of the human figure that has ever lived.

Drawing by Ingres

Finally, in the early nineteenth

century, there began a new enthusiasm, a popular interest in the work of different groups of artists which, with the increase of the material prosperity of its thrifty people, presently made France the leading country of modern Europe in all the fine arts.

This outcome has been attended by a long running fight in each of the arts between the adherents of the classical style on the one hand and of the romantic movement on the other. The extreme followers of the one contention have believed in doing, so far as modern conditions allow, just what the ancients did or would have done in the circumstances; the adherents of the other point of view in freely expressing ideas, according to present needs, with less regard for the classical traditions, and with more consideration of the artist's moods and likings.

This contest between two opposite ideas has undoubtedly been valuable. It has helped to render French art thoroughly progressive and in some respects not unworthy to compare with the art of the best periods of the past. The architecture of present-day France, while not highly original, is the most consistent and attractive national architecture of our times. French painting and sculpture throughout the nineteenth century always afforded the standard by which the art of other countries was judged. German art, to be sure, has of late years begun to show vitality, and there are interesting groups of artists in other European countries, but Paris is still the art center of the world.

THE RAFT OF THE MEDUSA, BY GERICAULT

The Romantic Movement. The revolt against classicism in French painting was headed by Jean Louis Gericault (1791–1824) and Eugene Delacroix (1791–1863). The former died young, and left principally his dramatic picture, "The Raft of the Medusa," to perpetuate his fame. This work depicts the moment of deliverance of fifteen survivors from a band of one hundred and fifty who embarked on a raft after the wreck of the frigate Medusa, in 1816. From amidst piles of the emaciated dead the few who are still alive signal for help to a distant vessel. Working upon so dramatic a theme, the painter produced a masterpiece that caught the fancy of all the radicals of his time, while it greatly shocked the conservatives.

Delacroix painted for many years with almost Oriental splendor of color, and exerted a strong influence over the imaginations of younger men. The appearance of his picture, "The Massacre of Scio," began the feud between romanticists and classicists.

Among those who derived special inspiration from the romantic movement was Jean François Millet (1814–1875), a Breton peasant and painter of peasants, in the lines of whose toil-bowed backs he believed that he had found the same beautiful curves that ennoble Greek statuary. His fellow countrymen were slow to appreciate a man who deliberately chose to live and paint among humble field workers, but reverence for his memory has steadily increased since his death, and his best pictures, "The Sower," "The Gleaners," "The Angelus" and others are now held in universal admiration. If "The Gleaners" is carefully studied, Millet's fine feeling for the planes, the rounded surfaces and the long, sweeping contours of the human figure, together with his determination to convey something of the dignity of labor, can hardly fail to be discovered.

THE GLEANERS, BY MILLET

Of the same time with Millet were several painters of high standing, among others, Rousseau (1812–1867), Daubigny (1817–1878) and Diaz (1807–1876). Constant Troyan (1810–1865) painted landscape, usually containing cattle, with excellent sentiment

LANDSCAPE, BY COROT

and understanding. Perhaps the most remarkable woman painter of the nineteenth century was Rosa Bonheur, whose animal pictures are extremely popular. One of the best known is "The Horse Fair," in the Metropolitan Museum, New York.

One of the most gifted of all the artists of the middle nineteenth century was Camille Corot (1796–1875), son of a prosperous hairdresser, who, by granting an unbusinesslike lad an annual income for life of fifteen hundred francs, made the way easy for the most poetic landscape painter of modern times. Living quietly in a Parisian suburb, Corot made a lifelong study of the misty vaporous effects of early morning and evening. He was a man of beautiful personality, simple and unaffected, and his art, as a great critic has remarked, has limitations but no faults.

THE BOY WITH THE SWORD, BY MANET

Great names abound in the list of French artists of the nineteenth century. Among the most significant are those of Edouard Manet (1832–1883) and Claude Monet, a contemporary painter.

Manet was the father of "impressionism," a new point of view in painting which has altered the professional practices of many modern artists. All painters before his time had been in the habit, though recognizing that white paint is dark as compared with nature's high lights, and black paint light as compared with the depth of some natural shadows, of seeking to get exact relations within a scale of "values" between these two extremes of black and white. Manet completely threw away the scale, painted all that he was able to paint exactly as he saw it, and the rest with the nearest approach to correctness that his pigments would allow. In this way he secured very striking reality for the objects of his representation.

Manet's valuable discovery, which he applied mainly to indoor painting, has been successfully worked out in its application to landscape by Monet, the first painter adequately to represent effects of broad sunlight which had hitherto been regarded as beyond the artist's powers to depict. Monet has had many followers in France and in other countries.

British Art. The people of Great Britain and Ireland, though very appreciative of literary attainments, have never been pre-eminent in encouraging the highest manifestations of the fine arts. British architecture, though interesting at certain periods, has at no time been great and original. The English Gothic cathedrals are very beautiful, but not quite so beautiful, and not quite so good Gothic, as the best French structures of the same centuries. The classical revival of the seventeenth century produced clever imitations of the work of Italian architects who were themselves endeavoring to imitate the ancient Romans. Sculpture has never flourished in the island kingdom since the days of the cathedral builders in the centuries immediately following the Norman Conquest (1066), when unknown native and foreign artisans produced sculptural decorations of considerable merit.

There is at least a fairly long list of competent painters, for a considerable class of the English people have long taken an interest in pictorial representation. Painting was largely in the hands of foreigners down to the time of William Hogarth (1697–1764), the first original English artist of any note, whose "Rake's Progress" is one of the classics of illustrative art. A famous painter of the eighteenth century was Sir Joshua Reynolds (1723–1792), friend of the literary men and the statesmen of his time. He was a very clever man at portrait painting and very learned in the history and theory of the art he practised. His attempts, however, to rival the design and color of the great Venetians were quite unsuccessful. He believed thoroughly in what

THE BLUE BOY, BY GAINSBOROUGH

he called "the grand style," though he was unable to attain to it.

Thomas Gainsborough (1727–1788) was perhaps the most truly artistic of English painters of the eighteenth century. His landscapes and portraits show prettiness and charm as well as general faithfulness to the impression. Gainsborough was influenced mainly by the works of Van Dyck and by close study of nature. One of his celebrated pictures was "The Blue Boy," painted in defiance of a rule then prevailing among British artists that the principal object in a composition should be of a warm color.

Of a somewhat later period was J. M. W. Turner (1775–1851), a vigorous and versatile landscape painter regarding the merits of whose work there has been more or less controversy ever since the English art critic, John Ruskin, first praised him extravagantly and eloquently. His "Slave Ship," now in the Boston Museum of Fine Arts, has been the subject of, probably, more disagreement than any other picture in America. It is a lurid representation of the casting overboard of a number of slaves from a ship threatened by storm.

ROSA TRIPLEX, BY ROSSETTI

The Pre-Raphaelites,

a little group of painters who aimed to work in the spirit of the earlier Italian artists, were also first proclaimed to the world at large by Ruskin's facile pen. The principal men in this movement were Rossetti (1828–1882), J. E. Millais (1829–1896) and Holman Hunt, born in 1827 and is still at the present time (1907) a veteran English painter. Another artist of the mid-Victorian age was Sir Edwin Landseer, a capable painter of animals, whose works have been appreciated by hundreds of thousands of people who may or may not have cared for art but who have liked to look at well-executed dogs and Scotch cattle. English art, within the last generation, has begun to be influenced by the art of France.

The Arts in the United States. American art has also during the past forty years depended greatly upon the French for instruction. It resembled English art at the outset, as was natural in a collection of British colonies. The so-called "Colonial" architecture and furniture were based upon the classic revival which temporarily put an end to Gothic building in England in the latter part of the seventeenth century. The portrait painters of the Colonial and Revolutionary Periods looked upon London as the art center of the world. John Singleton Copley (1737–1815) and Benjamin West (1738–1820) were American born painters who achieved their triumphs in England. Washington Allston (1779–1843), who, during a temporary residence in London, appeared to be a painter of marked promise, is generally believed to have made a serious mistake in returning to a life harassed by debts and misunderstandings in his native country. Gilbert Stuart (1754–1828), whose portraits of Washington and other celebrities have become classic, was technically one of the ablest of early American artists. His unfinished Athenæum portrait of Washington is singularly pure and fresh in color and well modelled.

PORTRAIT OF GEORGE WASHINGTON, BY STUART

Although the United States had a

number of intelligent and scholarly landscape painters prior to and during the Civil War period, the real awakening of art interest in this country began in the "seventies," when a number of young Americans who had been studying painting or architecture in Paris returned to apply at home the lessons they had learned abroad. Prominent among them was William Morris Hunt (1824–1879), who had become acquainted with Millet at Barbizon and who regarded it as part of his life work to make his fellow-countrymen better acquainted with the pictures of the contemporary French painters. Hunt himself painted some notable canvases, "The Bathers" being perhaps his best-known composition, and, as an inspiring and conscientious teacher of art, he led many American young men and young women to study drawing and painting in the thorough-going, serious manner in which art is studied in France.

Because of the seriousness with which American artists have accustomed themselves to pursue their professions, — whereas in some countries practice of the Fine Arts is, unfortunately, regarded as a sort of polite accomplishment, — the United States already has schools of architects, painters and sculptors that may be believed to be the most promising of any in the twentieth century. Our men are still perhaps a little imitative of the French, but the principles that they learned in Paris are being gradually readapted to American needs. A particularly encouraging circumstance is the reunion of the allied arts in the adornment of public buildings, as in the Boston Public Library, the Library of Congress at Washington, the Appellate Court, New York, and very many others. Whenever, in fact, a State capitol or a large public library is erected the architects now, as was done in all the best periods of art, summon to their assistance clever painters and sculptors who can be relied upon to execute their ideas. In that co-operation of the artists lies the hope of the future.

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